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## Appendix

# Summary International Reports, July 1992-June 1993

July 1992-June 1993

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The Tenth World Conference  
on Earthquake Engineering,  
July 19-24, 1992, Madrid,  
SPAIN

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**Dynamic Discrete Modeling and Computer Simulation of  
Seismic Response of Concrete Stave Silos  
With Structural Discontinuity**

Yasuhiko SASAKI and Jin YOSHIMURA  
Department of Civil Engineering, Hokkaido University, Sapporo, Japan

Concrete stave silos are segmental silo structures which are cylindrically assembled from precast concrete blocks and held together by exterior post-tensioned steel hoops. For dynamic analysis of concrete stave silos with such structural discontinuity, a new discrete model named "stave silo element" is contrived. A procedure for determining the stiffness of springs in a stave silo element is also proposed. To verify the validity of the equivalent stiffness and its reduction factor in the procedure, seismic response analyses of a reduced scale model stave silo are carried out and compared with its experimental results. Furthermore, an effective mass coefficient of stored material during earthquakes available for seismic design is obtained.

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The 10th World Conference  
on Earthquake Engineering,  
Madrid, Spain, July 19-24,  
1992

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**Directional behavior of strong ground motions during the Loma Prieta earthquake**

T. KANEKO & T. MIKAMI  
Hokkaido College, Senshu University, Bibai, Japan  
T. HAYASHIKAWA  
Hokkaido University, Sapporo, Japan  
Y. MATSUI  
Chuoh Consultants Co., Ltd, Sapporo, Japan

Records of the Loma Prieta Earthquake which were published at the USGS and CDMG in California on the wave form analysis of the strong motion seismograms are selected. The directional behavior and the rectilinear characteristics of the ground motion were investigated with the focus of attention on the direction of the principal axis and values of the rectilinearity. These were analyzed with special care. The three components of the main axis are taken into consideration and the rectilinearity formula is proposed. The maximal acceleration of the direction of the major principal axis is calculated and the results are compared with the maximal acceleration of the original seismograms.

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The 10th World Conference  
on Earthquake Engineering,  
Madrid, Spain, July 19-24,  
1992

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### **Calculation of natural periods of bridge structures by using static frame method**

Y. MATSUI

Chuoh Consultants Co., Ltd, Sapporo, Japan

T. HAYASHIKAWA & Y. KAKUTA

Hokkaido University, Sapporo, Japan

T. KANEKO

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N. SUGAWARA

Kitami Institute of Technology, Japan

Two different matrix methods for determining natural periods and mode shapes of three-dimensional vibrating continuous beam bridges are presented. One method is the consistent mass method based on the finite element approach of space frame structures. The other method is a simple calculation procedure based on the Rayleigh's method, and it is called the static frame method. Numerical examples are presented to illustrate the applicability of the static frame method and to discuss the dynamic characteristics of space bridges. The numerical results computed by two different matrix methods are given in tabular form, and the approximate quantity of natural periods obtained by the static frame method is investigated.

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The 10th World Conference  
on Earthquake Engineering,  
Madrid, Spain, July 19-24,  
1992

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### **Dynamic response analysis of three-dimensional strutted rigid-frame bridge with horizontally bent-angles**

T. HAYASHIKAWA & Y. KAKUTA

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T. KANEKO

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Kitami Institute of Technology, Japan

Natural vibration analysis of a space strutted rigid-frame bridge with horizontally bent

-angles is presented by using the lumped and consistent mass methods. In three-dimensional free vibration, it is estimated that there is considerably effect of the flexural rigidity of lateral bracing members and effective widths of floor beam systems. The effect of warping deformation is indicated clearly the eigenvalues of torsional mode shapes of three-dimensional vibrating bridges. In the response spectrum calculations of the complete quadratic combination method, the values of modal cross-correlation coefficients estimated by some higher modes are larger than those estimated by the first few lower modes.

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The 1st Sino-Japan Workshop on Cable-Stayed Bridges, Sapporo, Japan, Oct. 2 1992

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**Vibration experiments and natural vibration analysis of prestressed concrete cable-stayed pedestrian bridge**

Takashi OBATA

Research Associate, Hokkaido University, Sapporo, Japan

Masafumi KATO

Professor, Kyusyu Tokai University, Kumamoto, Japan

Toshiro HAYASHIKAWA

Associate Professor, Hokkaido University, Sapporo, Japan

Yoshio KAKUTA

Professor, Hokkaido University, Sapporo, Japan

In general, cable-stayed bridges have distinctive feature of the complex vibration characteristics. The Seiun bridge is two-span continuous prestressed concrete cable-stayed pedestrian bridge that the Sapporo city constructed in March 1990. The various vibration experiments and numerical analysis of Seiun bridge are executed to examine into the vibration characteristics and serviceability.

In the vibration experiments, the first sixth mode orders of natural vibrations and damping constants are obtained. The results of the vibration experiments correspond with those of numerical analysis. The vibration serviceability is confirmed that it is no problem.

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The 1st Sino-Japan Workshop on Cable-Stayed Bridges, Sapporo, Japan, Oct. 2 1992

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**Dynamic behavior of suspension bridges under moving loads  
and estimation of impact factor**

Toshiro HAYASHIKAWA  
Associate Professor, Hokkaido University, Sapporo, Japan

This study deals with the free vertical vibration of suspension bridges having the hinged or continuous stiffening girders. This analytical method is formulated by means of the differential equation method. Namely, this method determines the eigenvalues and eigenfunctions of suspension bridges by using a general solution for the fourth order differential equations of motion based on the linearized deflection theory. In numerical examples, the effects of boundary conditions and the cable saddles on free vibration are discussed. The dynamic response analysis of suspension bridges subjected to moving loads is conducted by the method of modal analysis. The calculation formula of impact factors is proposed as a primary piece of information needed in the design of suspension bridges.

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The 3rd Pacific Structural Steel Conference, Tokyo, Japan, Oct. 26-28, 1992

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**Free vibration analysis of steel bridge structures and  
accuracy of eigenvalues**

Toshiro HAYASHIKAWA  
Hokkaido University, Sapporo

Three different mass matrix methods for determining natural frequencies and mode shapes of plane framework structures are presented. One mass matrix method is the exact method based on the general solutions of the differential equations of motion for both axial and flexural vibrations, and it is called the *continuous mass method*. The other two mass matrix methods are the lumped and consistent mass methods based on the approximate finite element approach. The accuracy of the eigenvalues obtained by three different mass matrix methods is investigated. Some typical continuous beams, arch bridges, and rigid-frame bridges are analyzed to illustrate the applicability of the lumped, consistent, and continuous mass methods, and the computed results are also given in tabular form and figures.

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Colloque Europeen Lyon Construction and Rehabilitation  
Apport des Polymeres Organiques Lyon. Sep. 8-10,  
1992

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**Strengthening of Damaged Concrete Beams by  
Injection of Epoxy Resin, and by External  
Prestressing of Aramid Fiber Cable**

Noboru SAEKI\*, Takashi Horiguchi\*\*  
Kazuo EGUCHI\*\*\* and Shigenobu HATA\*\*\*\*

\* Hokkaido University

\*\* Hokkaido Institute of Technology

\*\*\* Sho-Bond Corporation

\*\*\*\* Nihon High Strength Concrete

An experimental study of rehabilitation methods is investigated with using artificially damaged concrete beams. As a first stage of rehabilitation, special injection method, which is called BICS method, is applied for repairing several size of cracks with epoxy resin. And then, the second stage of rehabilitation is applied to strengthen the damaged concrete beams by external post-tensioning.

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Internationnal Symposium on  
Non-Metallic Continuous  
Reinforcement Vancouver, B.  
C. Canada, March 29-31,  
1993

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**Strengthening of Damaged Concrete Beams by  
External Prestressing of Aramid Fiber Cable**

Noboru SAEKI\*, Takashi Horiguchi\*\*,  
Minoru INOMATA\*\*, Shigeru HATA\*\*\* and Toshirou IKEDA\*

\* Hokkaido University

\*\* Hokkaido Institute of Technology

\*\*\* Nihon High Strength Concrete

An experimental study of rehabilitation methods is investigated with using artificially damaged concrete beams. The rehabilitation is applied to strengthen the damaged concrete beams by external post-tensioning, and some beams are carried out external prestressing combined with the special injection method which is applied for repairing several size of cracks with epoxy resin. Statical as well as fatigue test for three point bending are conducted with

these concrete beams in order to investigate the effect of these rehabilitation methods.

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The 1st International Conference on Advanced Composite Materials in Bridges and Structures, Sherbrooke, Canada, Oct. 6-9, 1992

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### **Proposed Japanese Design Code for Steel-Concrete Sandwich Structures**

Hajime OKAMURA\*, Yoshio KAKUTA\*\* and Tamon UEDA\*\*

\* Faculty of Engineering, University of Tokyo  
Tokyo 113, Japan

\*\* Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

The proposed Design Code for Steel-Concrete Sandwich Structures, which was specified for the first time in Japan, is presented. This structure is defined as a composite structure in which core concrete is sandwiched by steel skin plates. The limit state design method is applied in the code. The ultimate member capacities for axial, flexural and shear forces are newly given.

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The 1st International Conference on Advanced Composite Materials in Bridges and Structures, Sherbrooke, Canada, Oct. 6-9, 1992

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### **Proposed Shear Strength Equations for Steel-Concrete Sandwich Structures**

Tamon UEDA

Faculty of Engineering, Hokkaido University, Sapporo 060, Japan

This paper presents the shear strength equations recently specified in the proposed Japanese Code for Steel-Concrete Sandwich Structures, as well as the background where the equations are introduced. In the sandwich structure shear reinforcing steel plates are usually placed either parallel or normal to the member axis. With shear reinforcing steel plates truss-like mechanisms are formed to resist shear force. The shear strength equations conservatively predict the results reported in previous tests.

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International Symposium on  
FRP Reinforcement for Con-  
crete Structures, Vancouver,  
Canada, March 29-31, 1993

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**Design Concept for Concrete Members Using  
Continuous Fiber Reinforcing Materials**

Hajime OKAMURA\*, Yoshio KAKUTA\*\*,  
Taketo UOMOTO\* and Hiroshi MUTSUYOSHI\*\*\*

\* University of Tokyo

\*\* Hokkaido University

\*\*\* Saitama University

Many attempts are being made to utilize continuous fiber reinforcing materials (CFRP) in reinforced and prestressed concrete structures. The Concrete Committee of the Japan Society of Civil Engineers organized a committee on CFRP in 1989. This paper describes the design concept for concrete structures using CFRP, based on the committee report published in 1992. Design values of materials, ultimate limit states for bending moment, axial force, shear force and torsion, serviceability limit states for cracking and stress intensity, and general structural details are dealt with.

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The 3rd International Confer-  
ence on Ice Technology  
(ITC 92) MIT, Cambridge  
USA, Aug. 11-13, 1992

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**Nonsimultaneous Failure and Local  
Pressure of Ice in Ice/Vertical Structure  
Interaction**

T. TAKEUCHI

Institute of Technology, Shimizu Co.

T. TERASHIMA, H. SAEKI

S. OKAMOTO, T. YAMASHITA

Hokkaido University

The evaluation of Ice load acting on a wide structure in an ice-infested sea area requires calculation of ice force at nonsimultaneous failure of an ice sheet. In a small-scale indentations test on an ice sheet, when the ice sheet indents a vertical structure it transmits a first peak force which is on maximum value, and after that, transmits a subsequent force arising from nonsimultaneous failure of the ice sheet. In this study, field indentation tests were conducted under conditions of aspect ratio (structure width/ice thickness) of 14.3 using fresh-

water lake ice to investigate the ice sheet failure characteristics under subsequent force.

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The 3rd International Conference on Ice Technology (ITC 92) MIT, Cambridge USA, Aug. 11-13 1992

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**Determination of Compressive Strength, Flexural Strength and Static Elastic Modulus of Sea Ice by Sonic Method**

Y. TAKAHASHI

Hokkaido University

K. ENOKI

Akita National College of Technology

H. SAEKI

Hokkaido University

N. ORITANI

Hokkaido University

S. AKIHARA

Hokkaido University

This paper suggests an instrument package portable on a small helicopter (under 250 kg) which will permit speedy measurements at low ambient temperatures. The package measures the dynamic coefficient of elasticity, which provides an estimate of uniaxial compressive strength and flexural strength.

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The 23rd International Coastal Engineering Conference Venice, 4-9 Oct. 1992

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**Quasi-turbulent boundary layer of oscillating over ripples**

Yukio SATO

Kitami Inst. of Tech.

Ken-ichiro HAMANAKA

Hokkaido University

A particular attention is paid to investigate the mean velocity, the Reynolds stress and turbulent viscosity. It is found that the turbulent viscosity varies along the time during the period of the oscillation. And not only it diversifies as the space derivative of the mean velocity diminishes, but also it has a complex distribution in space and time.

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The 8th International Symposium on Okhotsk Sea & Sea Ice, Monbetu, Hokkaido, Japan, Feb. 1-5, 1993

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### **Arch Formation of Ice Floes at Structures**

F. HARA

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S. KUNIMATSU

Hokkaido University

T. FUJII

Hokkaido University

K. ENOKI

Akita National College of Technology

Hiroshi SAEKI

Hokkaido University

It is important to study conditions of arch formation by ice floes for the purpose of preventing the formation of ice jams as well as controlling ice floe movement by arch formation.

The results of model experiments concerning the conditions of arch formation by an ice floe in movement at the bridge pier are reported in this research. The authors also conducted an experiment on the shape effect of ice floes and bridge piers while verifying effects depending on the difference in scales used in the experiments.

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The 8th International Symposium on Okhotsk Sea & Sea Ice, Monbetu, Hokkaido, Japan, Fed. 1-5, 1993

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**Run-up of ice floes on impermeable sloping beach due to tsunami**

Hiroshi SAEKI

Hokkaido University

Shinya AKIHARA

Hokkaido University

Yoshimasa TAKAHASHI

Hokkaido University

Fumihito HARA

Hokkaido University

Shigeki SAKAI

Iwate University

In order to clarify the ice force acting on the houses and coastal structures due to tsunami action, the size of ice floes, the compressive strength and elastic modulus of ice and the velocity of ice floes due to the run-up of tsunami on sloping beach should be clarified. In this paper, the authors experimented on the mechanisms of ice floe movement due to solitary wave on impermeable sloping beach.

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The 8th International Symposium on Okhotsk Sea & Sea Ice, Monbetu, Hokkaido, Japan, Feb. 1-5, 1993

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**Wave deformation in the ice-covered water**

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N. KANADA

Ship Research Institute, Ministry of Transportation

Hiroshi SAEKI

Hokkaido University

In the sea which is partially covered by ice, ice pieces are swayed by waves propagating from the open sea area, and hit the structures with the speed of the same order as wave motion.

To evaluate this ice impact force, the authors need to understand the wave properties in the ice-covered water. In order to clarify the purposes, the authors carried out experiments systematically, and linear theory for waves under the elastic plate is employed to evaluate changes in wave velocity and a wave height under the ice cover, and its validity is examined by comparisons with experimental data.

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The 8th International Symposium on Okhotsk Sea & Sea Ice, Monbetu, Hokkaido, Japan, Feb. 1-5, 1993

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### **Movement of Ice Floes near River Mouth on the Okhotsk Sea Coast**

Toshio YAMAUCHI  
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Yuji ONO  
Hokkaido Development Bureau  
Fumihiro HARA  
Hokkaido University  
Hiroshi SAEKI  
Hokkaido University

The bridge piers constructed in cold regions are affected by the ice action. According to Takahashi's report, the damage of bridge piers constructed near river mouths on the Okhotsk Sea coast has distinguished features. It is because the damage is caused by the complicated movement and motion of ice sheets and floes near a river mouth. The authors have observed and investigated the situations of the ice sheet and floes near river mouth on the Okhotsk Sea coast of Hokkaido. This paper deals with the movements and motions of ice near river mouths.

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The 8th International Symposium on Okhotsk Sea & Sea Ice, Monbetu, Hokkaido, Japan, Feb. 1-5, 1993

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**Determination of compressive strength and elastic modulus of sea ice by sonic method**

Hiroshi SAEKI  
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 Kunio ENOKI  
 Akita National College of Technology  
 Youichi TAKAHASHI  
 Hokkaido Road Administration Engineering Center  
 Norihiro ORITANI  
 Hokkaido University  
 Shinya AKIHARA  
 Hokkaido University

The lateral force by ice sheets which act on the structures is affected by many factors. But it's yet complicated or difficult to measure Coefficients of the Compressive Strength and the Elasticity of ice sheets.

This paper suggests a simple way to estimate the Uniaxial Compressive Strength and Flexural Strength of the ice more easily by measuring the Dynamic Coefficient of Elasticity through surveying the Primary Resonance of ice specimen sonic vibration.

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The 8th International Symposium on Okhotsk Sea & Sea Ice, Monbetu Hokkaido, Japan, Feb. 1-5, 1993

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**Development of the Sink-and-Float Type Ice Boom**

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 F. HARA  
 Hokkaido University  
 K. ENOKI  
 Akita National College of Technology  
 H. SAEKI  
 Hokkaido University

One of the measures which prevent the intrusion of pack ice into a harbor is sink-and-float

type (SFIB) ice booms which are developed by Nishimura-Gumi. This newly developed ice boom is submerged when pack ice is not on the sea. However, while the boom is submerged, it might be buried in the drift sand unable to float even though in case of emergency.

The authors experimented on the optimal cross-sectional shape of floaters which will not be buried in the sand due to the sand movement caused by wave action.

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The 3rd International  
Offshore and Polar Engineer-  
ing Conference, Singapore,  
6-11 Jun. 1993

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**Studies on the Fluid Forces Acting on and the Movement Velocity  
of Floating Ice Floes**

Kunio ENOKI  
Akita National College of Technology  
Koji HOJO  
Hokkaido Development Bureau  
Chimataro ISHII  
Akita University  
Hiroshi SAEKI  
Hokkaido University

Ice force is the dominant external force on structures constructed in the sea covered with ice floes. In this study we clarified the wind and current forces acting on ice floes.

We obtained the drag and friction coefficients of wind and current respectively by changing the sizes and thicknesses of model ice floes systematically and proved they approximate to figures obtained by field researches. In addition, we developed a formula for drifting velocity and verified that the calculation results applied to the coefficients described above approximate to the field research results.

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The 3rd International  
Offshore and Polar Engineer-  
ing Conference, Singapore,  
6-11 Jun. 1993

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### **Study on Drift Ice Control Utilizing Arch Formation of Ice Floes**

Fumihiro HARA  
Hokkaido University  
Sei KUNIMATSU  
Hokkaido University  
Hiroshi SAEKI  
Hokkaido University  
Kunio ENOKI  
Akita National College of Technology  
Yoshio MURAKI  
Hokkaido Institute of Technology

This study reports on the results of the experiments on the arching condition of ice floes in the sea or rivers which froze over.

Knowing the conditions of arch formation by ice floes is valuable because the data can be used in deciding the span of bridges that will not form ice arches artificially in order to prevent invasion of ice.

We built model bridge piers in a waterway and tested to see if arches are formed by changing (1) the proportion of water surface covered by model ice, (2) the span of bridge pier, (3) the pier's shape of cross-section and nose shape (4) thickness of model ice, and (5) the fluid velocity. Also, we conducted another experiment using models of a different scale and compared the results.

The results of the experiments showed the critical conditions of arch formation by ice floes. Also, as the results of experiment using two different scales agreed, the Froud Similitude was proved.

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The 3rd International  
Offshore and Polar Engineer-  
ing Conference, Singapore,  
6-11 Jun. 1993

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**Experimental Study on the Control of Ice Movement  
with a new Design of Ice Boom**

Kunio ENOKI

Akita National College of Technology

Chimataro ISHII

Akita University

Sei KUNIMATSU

Hokkaido University

Toshihiko YAMASHITA

Hokkaido University

Hiroshi SAEKI

Hokkaido University

Lagoons and lakes on the Okhotsk Sea coast of Hokkaido have outlets linking to the sea. The tide creates maximum fluid velocity in these outlets of 2.4 m/sec. Ice floes carried by the flow damage the aqua-culture conducted inside these lakes and lagoons.

In this study we clarified the effects of controlling ice movement using conventional-type and new-type ice booms by systematical experiments. In addition, we measured the tensile force of an ice boom cable to find out the friction coefficient of an ice boom cable to find out the friction coefficient of jammed model ice trapped by boom and water flow.

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The 3rd International  
Offshore and Polar Engineer-  
ing Conference, Singapore,  
6-11 Jun. 1993

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### **Total Ice Forces on Multi-Legged Offshore Structures**

Takahiro TAKEUCHI  
Shimizu Corporation  
Kunio ENOKI  
Akita National College of Technology  
Hiroshi SAEKI  
Hokkaido University  
Toshihiko YAMASHITA  
Hokkaido University

Total horizontal ice forces acting on multi-legged structures in ice-infested seas are estimated by calculating forces on single piles. Non-simultaneous loading of first peak force and subsequent force acting on each pile as well as simultaneous loading of first peak force are considered in the method. The result obtained is the total ice force of non-simultaneous loading, which is the more realistic case, is estimated to be approximately 80% of that of simultaneous loading.

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The 3rd International  
Offshore and Polar Engineer-  
ing Conference, Singapore,  
6-11 Jun. 1993

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### **On the Characteristic of Uniaxial Compressive Strength and Elastic Modulus of Natural Sea Ice**

Takahiro TAKEUCHI  
Shimizu Corporation  
Hiroshi SAEKI  
Hokkaido University  
Satoshi OKAMOTO  
Hokkaido University

Methods of determining typical values of uniaxial compressive strength of the ice sheet in a certain sea area are indicated based on strength tests using more than about 400 specimens collected from natural sea ice at Saroma Lagoon. Uniaxial compressive strength can be estimated from dynamic elastic modulus based on the resonance method also. Lastly, the conformities of uniaxial compressive strength and static/dynamic elastic moduli with probability

distribution are examined.

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International Conference on  
Failures of Concrete Structures,  
Strbske Pleso, Slovakia  
Jun. 14-18, 1993

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**Damage of Bridge Piers due to Movement of River Ice Sheets and  
Estimation of Abrasion Depth.**

Fumihito HARA  
Hokkaido University

Makoto NIYAMA  
Hokkaido Development Agency

Yoichi TAKAHASHI  
Hokkaido Road Administration and Engineering Center

Hiroshi SAEKI  
Hokkaido University

Abrasion damage to concrete bridge piers brought about by the movement of ice floes arises in Japan and repairs have been provided. For this known about the damage or its mechanism.

For this research an investigation of damage to concrete piers caused by ice floe movement was made of road bridges over national highways in Hokkaido using actual bridge abrasion was clarified and a comparison was made between the estimated values and field measurements.

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International Conference on  
Failures of Concrete Structures,  
Strbske Pleso, Slovakia  
Jun. 14-18, 1993

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**Experiments on the Abrasion of Concrete Surfaces  
Due to the Movement of Ice Sheets**

Fumihiko HARA  
Hokkaido University  
Hiroshi SAEKI  
Hokkaido University  
Chimataro ISHII  
Akita University  
Yoshishige ITOH  
Taisei Corporation  
Yuichiro ASAI  
Taisei Corporation

Abrasions of the nose surface of bridge piers at the upper stream side of bridges constructed over rivers which freeze in winter occurred due to the friction generated between moving ice sheets and the surface of bridge piers at the time of thawing. Abrasions may expose the reinforcing steel inside bridge piers, change dramatically the ice forces as the result of local changes in the form of bridge section or produce an angle of inclination at the part where ice sheets touch.

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The Second Summer School  
on Stability of River and  
Coastal Forms, Sapporo,  
Japan, Sept. 9-18, 1992

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**Numerical Calculation of Flow and Bed Deformation in Alluvial Channels**

Tadaoki ITAKURA  
Department of Civil Engineering, Hokkaido University

Some numerical calculation methods were investigated to evaluate the flow field and the deformation of the bed of alluvial open channels. The calculation of the flow field is performed using a set of equations; an equation of continuity and equations of motion of the flow. 1-D, 2-D or 3-D equation set is chosen depending upon the problem to be solved. The variation of the elevation of bed surface is calculated from equations of continuity of bed-load transport and the suspended sediment transport.

The calculations were applied to the flume data and field data and good agreements were

observed and the confidence limit of each calculation model was made clear.

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VIII Congress Asia and  
Pacific Regional Division,  
I. A. H. R., Pune, India Oct.  
20-23, 1992

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### **Theoretical Analysis of Wave Height of Alternating Bars**

Mikio KUROKI and Tadaoki ITAKURA  
Department of Civil Engineering, Hokkaido University

A theoretical analysis for the wave height of alternating bars was performed. In this analysis, the form of bars was expressed by the major two components and the order of amplitude of these two components were assumed to be the same. The flow over the bars was expressed by the two dimensional shallow water flow model.

The non-linear analysis up to the 2nd order of the amplitude was performed and the governing equations for the time-dependent change of amplitude of the two components were derived. The equilibrium height was evaluated using the results of the analysis and was compared with flume data. It was found that the wave height of alternating bars agreed well with the observations.

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VIII Congress Asia and  
Pacific Regional Division,  
I. A. H. R., Pune, India Oct.  
20-23, 1992

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### **Interaction between Hydraulic Jump and Turbulent Boundary Layer**

Akio MORI and Tadaoki ITAKURA  
Department of Civil Engineering, Hokkaido University

An undular jump breaks when the Froude number of the incoming flow exceeds some critical value. This limit is about 1.2, if the undular jump is considered to be a solitary wave. Actually it is stated to be 1.7 in Chow's text book. In this study, it is shown that such a large critical value is caused by an interaction between the hydraulic jump and the turbulent boundary layer (JBI). The fundamental effect of the JBI is a concentration of momentum to the central part of the channel, and it prevents the hydraulic jump from breaking.

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An International Conference  
in Honour of Professor T. E.  
Unny. Stochastic and Statis-  
tical Methods in Hydrology  
and Environmental Engineer-  
ing Waterloo, Canada, Jun.  
21-23, 1993

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**Stochastic Response of Storage Function Model  
For Flood Runoff**

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Takashi NAKAO and Mutsunobu KUDO\*  
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All real hydrologic processes are more or less stochastic. While the dynamics for the runoff process are described by differential equations. Stochastic differential equations are grouped into three classes :

- 1 Initial conditions are described as stochastic probability.
- 2 The parameters included in differential equations are random variables.
- 3 Forcing terms are random variables.

Real runoff phenomena include all three classes ; this focuses on the last class. This paper proposes a method which provides the first four central moments of discharge under the condition of given first four moments of rainfall input even if runoff system is nonlinear. It is possible to estimate the probability density function through the obtained moments of discharge.

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An International Conference  
in Honour of Professor T. E.  
Unny. Stochastic and Statistic-  
al Methods in Hydrology  
and Environmental Engineer-  
ing Waterloo, Canada, Jun.  
21-23, 1993

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**Application of Neural Networks  
to Runoff Prediction**

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Norihide HASHIMOTO  
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In this paper, a new method to forecast runoff using neural networks (NNs) is proposed and compared with the fuzzy inference method suggested previously by the authors. We first develop a NN for off-line runoff forecast. The results predicted by the NN depend closely on the training sets, this dependence is discussed here. Next, we develop a NN for on-line runoff forecast. The actual applicability of the NN to runoff forecast is assessed by making 1-hr, 2-hr and 3-hr lead time forecasts of runoff in Butternut Creek, NY. The good results indicate that using neural networks to forecast runoff is rather promising. Finally, we employ an interval runoff forecast model where the upper and lower bounds are determined using two neural networks NN\* and NN\*. The observed hydrography lies well between forecast upper and lower bounds.

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The 4th International Confer-  
ence on Microcomputers in  
Transportation, Baltimore,  
USA, July 22-24, 1992

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**Development of Self-Organizing Traffic Control System  
Using Neural Network Model**

Takashi NAKATSUJI, Syunich SEKI and Terutoshi KAKU  
Faculty of Engineering, Hokkaido University

A self-organizing traffic control system using a neural network model, a multilayer network model, was developed. The neural network inputs the control variables, such as split lengths and offsets, and outputs the measures of effectiveness, such as Performance Indexes. The operation is separated into two processes: a training process that builds up an input-out-

put relationship between the control variables and the measures of effectiveness and an optimization process that optimizes the control variables.

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International Workshop on  
Winter Road Management,  
Japan, January 26-29, 1993

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**Traffic Accident in Winter  
in Hokkaido**

Terutoshi KAKU  
Faculty of Engineering, Hokkaido University  
Sapporo, 060, Japan

There are some changes in traffic environment in Sapporo after a prohibition law against an use of studded tire is executed in April 1, 1991. Studless tire is still inferior to the studded tire in braking and hill climbing abilities especially on ice covered road surfaces. We have investigated the relationship between characteristics of skidding accidents for these five years and skidding factors in winter like climate conditions, skidding performance of studless tires, and road maintenances. Accident facts are based on the data of about 60,000 casualty accidents.

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Preprint of TRB 71st Annual  
Meeting, Washington D. C.,  
No. 301, 1992

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**Seasonal Variations in Bearing  
Capacity of Asphalt Pavements**

Masahiko ISHITANI  
Taisei Rotech Co., Ltd.  
Kenji HIMENO  
Hokkaido University  
Atsushi KASAHARA  
Hokkaido Institute of Technology

A test asphalt pavement was constructed to measure deflections by a Falling-Weight Deflectometer (FWD). Deflection measurements were made weekly at the same place on the pavement from November 1989 through January 1991. Eleven thermo-couples were buried in the pavement to measure distribution of temperatures and depth of frost penetration.

Backcalculations were made to estimate the elastic moduli of the component layers of the pavement. It was found that the seasonal variations in bearing capacity of the asphalt pave-

ment could be expressed by the variation in the elastic moduli.

The main results from this study are summarized as follows:

- 1) Freezing of the granular base and subgrade decreases the tensile strain of the asphalt mixture layer remarkably.
- 2) During the thawing season, the asphalt pavement sustains heavy damage, especially when the temperature in the asphalt mixture layer is high.

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Procs. of the 2nd International Symposium on Road Surface Characteristics, Berlin, pp. 309-324, 1992

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**Development of a New data  
Acquisition System for Measuring  
Pavement Surface Profile**

Shigeki ICHIHASHI  
Nichireki Kagaku Kogyo Co., Ltd.  
Toshihiko FUKUHARA  
Komatsu Systech Co., Ltd.  
Kenji HIMENO  
Hokkaido University  
Akira KAWAMURA  
Hakodate National College of Technology  
Atsushi KASAHARA  
Hokkaido Institute of Technology

Employment of the "sequential two point method (STP method)" enables the absolute road profile to be measured at intervals of 1 cm with accuracy of 1.2 mm. In addition, this device makes measurement possible at the normal drive speed and has many other advantages in accuracy and rapidity of measurement and also in conversion to the existing evaluation standards. The field test has confirmed these advantages and revealed the actual status of various roads including two-dimensional profile.

The macrotexture data obtained serves as the basic materials to solve the skid, noise, fuel consumption, and tire wear problems which are required for the present roads. In these aspects, the newly developed measurement device can be used to solve the other interactive problems between the road surface and vehicles.

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Procs. of the 7th International Conference on Asphalt Pavements, Nottingham, Vol. 1, pp. 106-123, 1992

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**Performance of Asphalt Pavements at Bibi New Test Road in Japan Related to their Bearing Capacity**

Atsushi KASAHARA  
Hokkaido Institute of Technology  
Kenji HIMENO  
Hokkaido University  
Kazuyuki KAWAMURA  
Hokkaido Developing Bureau  
and  
Shinichi NAKAGAWA  
Hokkaido Developing Bureau

This research was conducted to evaluate the theoretical design procedure of flexible pavements related to their fatigue properties and to compare it with conventional and empirical design method. Field test pavements were constructed to obtain long term pavement performance data to move on to a sophisticated theoretical design method. It is found that

- 1) The distributions of contact pressure, wheel load and travel speed of tires are determined using a newly developed weigh-in motion system.
- 2) The seasonal variation in the bearing capacity of the pavement was determined by backcalculating elastic moduli of the pavement structure layers.
- 3) In the freezing season, the elastic moduli of the subgrade in test pavement areas are approximately 200 MPa independent on the pavement structure.
- 4) Change in transverse wheel position and variation in mix stiffness modulus should be taken into account in pavement design procedure.

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Proceedings of The International Symposium on Earth Reinforcement Practice, Fukuoka, Kyusyu, Japan, 11-3 November, 1992

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**Estimation of in-soil deformation behavior of geogrid under pull-out loading**

T. MITACHI, Y. YAMAMOTO & S. MURAKI  
Hokkaido University, Sapporo, Japan

A method of evaluation of the in-soil deformation behavior of geogrid is discussed based on the simplified assumptions concerning frictional properties between geogrid and soil and tensile force vs. strain relationship of geogrid material. By solving the derived differential equation based on the assumptions, distribution of relative displacement, shear stresses and tensile forces acting any part of geogrid can be obtained, and the pull-out force vs. pull-out displacement can also be calculated. Comparisons of calculated with observed pull-out force vs. displacement relationship show fairly well coincidence. A method of determination of the embedment length ensuring allowable rear end displacement of geogrid is also proposed.

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Eleventh Southeast Asian Geotechnical Conference, Singapore, 4-8 May, 1993

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**Influence of Stress Release Due to Sampling on Shear Strength of Organic Soil**

M. TSUSHIMA  
Akita National College of Technology, Japan  
T. MITACHI  
Hokkaido University, Japan

The influence of stress release due to sampling on the unconfined compressive and undrained triaxial strength of peat is investigated. Based on five series of test simulating the process from sampling to the unconfined and triaxial compression tests, it has been found that the strength obtained from conventional unconfined and unconsolidated undrained triaxial compression tests decreases of the order of 30 percent compared with in-situ strength. It has also been found that the effective angle of shear resistance of peat is not affected by stress release.

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International Symposium on  
Room Air Convection and  
Ventilation Effectiveness  
Tokyo, July 22-24, 1992

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**Differential and Integral Method for  
Computing Interzonal Airflows using  
Multiple Tracer Gases**

Masamichi ENAI, Noboru ARATANI, C. Y. SHAW\*, J. T. REARDON\*  
Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

\* Institute for Research in Construction  
National Research Council Canada

The multiple tracer gas method is often used to predict interzonal airflows in buildings. The mass balances of tracer gases are expressed by a set of differential equations. These differential equations generally form the basis for calculating the airflows through the openings between zones. Two methods have been developed to solve the differential equations: the differential and integral methods.

In this paper, the two methods were evaluated by applying them to a laboratory case study with three inter-connected rooms where the interzonal airflows were controlled and measured. The tracer gases were  $\text{CH}_4$ ,  $\text{N}_2\text{O}$  and  $\text{SF}_6$ . The results are discussed

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International Symposium on  
Room Air Convection and  
Ventilation Effectiveness  
Tokyo, July 22-24, 1992

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**On Characteristics of Ventilation by Thermal  
Convection in Summer in Case of High Side  
Openings Space Using Tracer Gas Techniques**

Tetsuhiro IKENAGA, Masamichi ENAI, Noboru ARATANI, Yutaka IMANISHI  
Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

The constructional concepts for comfortable living in the summer were confirmed in the traditional "Machiya" houses in the ancient city of Kyoto. One of the concepts is thermal convection ventilation by exhausting the warm air at ceiling level. During the summer months in Hokkaido's capital city of Sapporo, the outdoor air temperature reaches  $30^\circ\text{C}$  in the daytime, but becomes very cool at night.

In this paper, the convective airflow rates to obtain the cool outdoor air through upward

openings were measured throughout the day by tracer gas techniques. The high ceiling space of the highly insulated test house was divided into five imaginary zones.

The tracer gas ( $\text{CO}_2$ ) was supplied in the bottom zone of the space. The gas concentrations in each zone were simultaneously measured and the airflow rates between one zone and the others were calculated from the measured concentrations. The results are discussed.

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Indoor Air Quality, Ventilation and Energy Conservation 5th international Jacques Cartier conference, Motreal, Canada, Oct. 7-9, 1993

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**Passive Ventilation by Thermal Convection in Insulated Houses Using the Thermal Concepts of Traditional Japanese Houses in Summer**

Masamichi ENAI, Noboru ARATANI, Katsumi KUBOTA\*,  
Tetsuhiro IKENAGA\*  
Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

\* Technical Department, Hokkaido Nikken Sekkei Ltd.  
Sapporo 060, Japan

Traditional Japanese concepts for comfortable living in the summer include the use of the thermal convection ventilation by exhausting warm air at the ceiling level. Generally outdoor temperatures during the summer months in some regions, including Hokkaido, can reach  $30^\circ\text{C}$  in the daytime, but those at night can be very cool. The convection rates of the exhausted warm air and the inflow of cool outdoor air through open windows located in the upper levels of a test house were measured throughout the day by using  $\text{CO}_2$  as a tracer gas supplied to the bottom zone of the space. The gas concentration in each of 5 zones was simultaneously measured, and the airflow rate between each zone and the others was calculated. It was confirmed that the technique is useful for measuring convective airflow rates and processes through upward openings, such as open windows, and that the vertical ventilation exhausts the stored heat of 1 kW. It was concluded that, for the purpose of energy conservation, architects and engineers should consider the utilization of passive ventilation by thermal convection in the summer in highly insulated houses located in cold regions.

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The 8th International Heat  
Pipe Conference Beijing,  
China, Sep. 14-18, 1992

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**Heat Transfer Characteristics of Water Heat Pipe  
in conjunction with Freezing or Melting of Working Fluid**

Masashi KURAMAE

Faculty of Engineering, Hokkaido University Sapporo 060, Japan

This paper deals with the transient heat transfer characteristics of water heat pipe in conjunction with freezing or melting of the working fluid. In our experiment, one end of the heat pipe is inserted into an icebox, with the temperature response of the heat pipe being measured for several conditions as a length ratio of the pipe inserted, heat mode, and a filling ratio of the working fluid and wick structure. The occurrence of supercooling of the working fluid is shown for the cooling process. Two mechanisms whereby the working fluid is redistributed are designated, and the hysteresis behaviour of the temperature response of the heat pipe appearing in the freezing or melting process is observed. Also the effect of surplus liquid which can not be held in the wick is discussed. Furthermore, the effect of the heat mode, filling charge and wick structure upon the relationship between maximum degree of supercooling and the cooling rate is also investigated.

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The First International Conference on Modern Process Mineralogy and Mineral Processing, Beijing, China, Sep. 22-25, 1993

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**Solution Chemistry, Interfacial Phenomena and Flotation Behavior  
in an Aqueous System Containing Fluorite and Calcite**

Masami TSUNEKAWA, Tsuyoshi HIRAJIMA, Etsuko OGATA  
and Naoki HABATA

Faculty of Engineering, Hokkaido University  
Sapporo, 060, Japan

Studies were made on a binary minerals-aqueous solution system using fluorite and calcite. The pH value of the suspension as a function of mixing time, and the concentration of mineral constituent ions in the supernatant were measured. Flotation tests and zeta potential measurements were carried out.

All results obtained in the binary minerals system differed from those in the singular mineral systems. The difference was caused by the effect of the ionic species dissolved from both minerals in the aqueous solution. This was interpreted in terms of the surface precipitation

and/or surface reactions between both minerals and the dissolved ionic species. The results of chemical thermodynamic calculations showed that the fluorite phase was more stable than the calcite phase below pH 8.4-9.3, where the calcite surface in the binary minerals system became similar to that of fluorite. Above this pH range, the reverse phenomenon was observed.

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The 29th International Geological Congress, Kyoto, Japan, 24 Aug. -3 Sep., 1992

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### **Geothermal Prospecting Method utilizing Geothermal Altered Minerals**

Takeshi TANAKA  
Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

The new geothermal prospecting is proposed, utilizing geothermal altered minerals which occur in the geothermal altered zone as the fossil of geothermal history.

The formation temperature of geothermal altered minerals can be estimated from the various data on mineral synthetic experiments, drilling core analyses of deep petroleum and geothermal wells, filling temperature of fluid inclusions, etc. Comparing the formation temperature of altered minerals with the measured temperature of wells, descended temperature can be gained ( $0^{\circ}\sim 228^{\circ}\text{C}$ ), and rate of descended temperature can also be calculated ( $0^{\circ}\sim 54^{\circ}\text{C}/10,000$  years), using the descended temperature and the age of volcanic host rocks of heat source.

A quadrangle diagram showing thermal potentiality can be drawn from the maximum temperature of geothermal well ( $T$ ), descended temperature ( $\Delta T$ ), activity index ( $AI$ ) and heat flow ( $HF$ ).

$$T = T_m, \Delta T = T_f - T_l, AI = \left[1 - \frac{T_b - T_m}{T_b - T_g}\right] \times 100, HF = k \frac{\Delta \theta}{\Delta Z}$$

$T_m$  : Maximum temperature of the well ( $^{\circ}\text{C}$ )

$T_f$  : Formation temperature of altered minerals ( $^{\circ}\text{C}$ )

$T_l$  : Measured temperature of the well ( $^{\circ}\text{C}$ )

$T_b$  : Boiling temperature of water at the depth ( $^{\circ}\text{C}$ )

$T_g$  : Imaginary temperature by average geothermal gradient ( $3^{\circ}\text{C}/100$  m) at the depth ( $^{\circ}\text{C}$ )

$k$  : Thermal conductivity ( $\times 10^{-3}$  cal/cm $\cdot$ sec  $^{\circ}\text{C}$ )

$\frac{\Delta \theta}{\Delta Z}$  : Geothermal gradient ( $^{\circ}\text{C}/\text{cm}$ )

Applying the prospecting method using this quadrangle diagram for Yuzawa-Okachi geothermal area in Akita Prefecture, Japan, promising ateam has been spouted.

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The 6th International Conference on Magnetic Fluids,  
Paris, France, 1992

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### **A Complete Set of Basic Equations for Magnetic Fluids**

Y. IDO, T. TANAHASHI and M. KIYA  
Hokkaido University

A new Complete set of equations for magnetic fluids was suggested. Electrical conduction and internal rotation were taken into account. The constitutive equations were determined by the thermodynamical method that was based on the free energy and the dissipation function. The principle of material frame indifference and the principle of maximal dissipation rate were used to determine the constitutive equations. A new constitutive equation of magnetization were proposed. It was shown that the magnetization depended on the magnetic field, its change in time and the averaged angular velocity of suspended particles. It was also shown that the electromagnetic pressure was independent of the dissipative parts of the magnetic flux and the electric displacement. Furthermore, a constant pressure gradient flow between two parallel plates under magnetic field was analysed by using these basic equations.

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The 6th International Conference on Magnetic Fluids,  
Paris, France, 1992

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### **Nonlinear Micropolar Theory for Electrically Conducting Fluids**

T. TANAHASHI, T. SAWADA, K. HENJES  
Keio University  
Y. IDO  
Hokkaido University

A new theory for micropolar electrically conducting fluids was presented by unifying the theories of micropolar fluids and electrically conducting fluids. This theory makes it possible to treat both magnetic and dielectric properties simultaneously. It is expected to contribute to the knowledge of the properties of ionized gases, electrically conducting viscous fluids and magnetic fluids. Using the principle of material frame indifference and the principle maximal dissipation rate, the constitutive equations were determined from the thermodynamical relations. The authors obtained the following exact representation of Maxwell's stress tensor in materials when volume strain arisen from the electromagnetic force. On the basis of these equations, interaction between fluids and electromagnetic fields became clear analytically. Thermodynamical quantities such as entropy, pressure, internal energy and enthalpy were shown as sums of the function in the non-electromagnetic field and the additional state function due to the existence of the electromagnetic field. It was also shown how electromagnetic

momentum, electromagnetic angular momentum and electromagnetic energy were converted into mechanical energy in micropolar electrically conducting fluids.

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The 5th Asian Congress of  
Fluid Mechanics Taejon,  
Korea, 1992

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### **Aerodynamic Noise Generated by Vortex-Body Interaction and Its Control**

O. MOCHIZUKI, M. KIYA and J. PARK  
Hokkaido University

A two-dimensional jet impinging on a circular cylinder was studied to obtain methods of reducing an aerodynamic noise due to vortex-body interaction. The impinging jet generates a noise which has a predominant frequency determined by the distance between the nozzle and the cylinder. Near field pressure fluctuations, surface pressure fluctuations and velocity field were measured to find major sources of the noise. An effective method of the noise reduction in this flow was to suppress pressure fluctuations at the impinging point of vortices by a sound absorbent material.

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The 5th Asian Congress of  
Fluid Mechanics Taejon,  
Korea, 1992

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### **Numerical Simulation of Three-Dimensional Vortex Motion**

M. KIYA  
Hokkaido University

A three-dimensional vortex method was introduced and applied to several vortex motions to demonstrate its usefulness and problems. The vortex motion discussed in this paper includes the deformation of pseudo-elliptic vortex rings, the unsteady separated flow around a circular disk with an angle of attack, and the interaction of multiple circular vortex rings which approximately reproduced the Kolmogorov spectrum. In the first and second cases the viscous diffusion of vorticity was included. The pseudo-elliptic vortex rings experienced the axis switching and the split into multiple vortex rings. The wake behind the disk normal to the main-flow direction reproduced the spiral and pumping modes of instability. One of the 3D vortex method is that vorticity tends to diverge at a certain stage of evolution of the vortex motion. A few methods of avoiding the divergence of vorticity are discussed.

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The 5th Asian Congress of  
Fluid Mechanics Taejon,  
Korea, 1992

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### **Bistable Flow Around Two Tandem Circular Cylinder**

M. KIYA, O. MOCHIZUKI, Y. IDO, T. SUZUKI and T. ARAI  
Hokkaido University

At sufficiently high Reynolds numbers flow around two tandem circular cylinders of the same diameter has two patterns (or modes) which switch randomly in time if the distance between their centers is in an appropriate range. For the distance at which the two modes occurred at the same probability, the interval of time during which each mode prevailed was a random variable whose probability density distribution was approximately a Gamma distribution. The average time interval for the two modes was much larger than the vortex-shedding period, being strongly dependent on the intensity of the free-stream turbulence.

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The 11th Australasian Fluid  
Mechanics Conference,  
Hobart, Australia, 1992

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### **Prediction of Sound Generated by a Two-Dimensional Jet Impinging on a Body**

O. MOCHIZUKI, M. KIYA and J. PARK  
Hokkaido University

The paper presents an analytical model to predict the sound generated by a two dimensional jet impinging on a body. The model described in this paper is based on a composite pressure field of an incident pressure associated with vortices of the jet and a pressure reflected from the surface of the body. The composite pressure field yields a standing wave between a nozzle and the body whose position corresponds to the anti-nodes of the pressure fluctuation. The frequency of the standing wave  $f$  is obtained in terms of the convection velocity of the vortex  $U_c$ , the speed of sound  $c$ , and the distance between nozzle and the body  $l$  in the form  $f = N(U_c/l) (1 + U_c/c)$ , where  $N$  is an integer. This relation coincides with the results deduced from the feedback mechanism. The sound pressure level (SPL) can be predicted as a function of the amplitude of the standing wave at the nose of the body. The analytical model can explain the mechanism which determines the frequency and the SPL. Moreover, the expression for the SPL involves the reflection coefficient of a material of the surface of the body, so that it indicates a method to suppress the sound generated by the feedback mechanism by the surface of the body constructing by a sound absorption material.

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The 11th Australasian Fluid  
Mechanics Conference,  
Hobart, Australia, 1992

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### **Sinusoidal Forcing of an Axisymmetric Leading Edge Separation Bubble**

M. KIYA, M. SHIMIZU, O. MOCHIZUKI, and Y. IDO  
Hokkaido University

The leading-edge separation zone of a blunt circular cylinder was forced by single-frequency sinusoidal disturbances of different frequencies and levels at Reynolds numbers of the order of  $10^5$ . The disturbance was introduced along the square-cut leading edge of the cylinder. For low levels of the forcing, the reattachment length attained a minimum at a forcing frequency which was approximately five times the frequency of shedding of large-scale vortices from the reattachment region, and a maximum at another forcing frequency which was approximately a half of the frequency of the Kelvin-Helmholtz instability immediately downstream of the separation edge. The reattachment length was independent of the forcing frequency if it was greater than approximately twice the Kelvin-Helmholtz frequency. For intermediate and high levels of the forcings, the reattachment length had a much complicated response. The modification of the rolling-up process of the shear layer was demonstrated by the power spectra of velocity fluctuations near the edge of the shear layer.

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The 2nd International Collo-  
quium on Bluff Body Aer-  
odynamics and Applications,  
Melbourne, Australia, 1992

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### **Aerodynamic Noise Generated by Two Circular Cylinders Arranged in Tandem**

O. MOCHIZUKI, M. KIYA, T. SUZUKI and K. KOMIYAMA  
Hokkaido University

The aerodynamic noise generated by two circular cylinders with different diameter ratio arranged in tandem has been investigated experimentally. In this study the diameter ratio  $d/D$  is smaller than or equal to 1, where  $d$  and  $D$  are the diameter of the upstream and downstream cylinders. Two major components were identified in the noise: one is the noise associated with vortex shedding from the cylinders (the vortexshedding noise) and the other is the interaction noise due to the vortices impinging on the downstream cylinder. The level of the vortex-shedding noise from the upstream cylinder changes periodically if it is plotted against the spacing  $L$ , between centers of the cylinders  $L$ , whereas its frequency increases asymptotically to the vortex-shedding frequency of the single cylinder in a uniform flow with increasing. The wavelength of the periodicity was found to be associated with the distance

between neighboring vortices shed from the upstream cylinder. On the other hand, the frequency of the vortex shedding noise from the downstream cylinder is reduced by the effect of the wake of the upstream cylinder. An interaction noise was found to exist; its frequency was determined by the distance  $L$  and the free-stream velocity in the same manner as that of a self-sustained oscillating flow.

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The 2nd International Colloquium on Bluff Body Aerodynamics and Applications, Melbourne, Australia, 1992

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### **Structure of Turbulent Leading-Edge Separation Bubble of a Blunt Circular Cylinder and Its Response to Sinusoidal Disturbances**

M. KIYA, O. MOCHIZUKI, Y. IDO and H. KOSAKU  
Hokkaido University

The leading-edge separation bubble of a blunt circular cylinder was forced by a sinusoidally oscillating jet issued from a thin slit along the separation edge. Reynolds number based on the main-flow velocity  $U_\infty$  and the diameter of the cylinder  $d$  was in a range of 4000-9500. The level of the forcing was defined at a position near the edge where the time-mean velocity attained a maximum value. The time-mean and r. m. s. velocities in the separation bubble were measured by a two-color four-beam Laser Doppler Velocimeter. A secondary separation zone was found in the separation bubble, and its length decreased with increasing Reynolds number. The reattachment length of the forced separation bubble decreased with decreasing forcing frequency in a range  $(2.5-8.5) U_\infty/d$ , probably attaining a minimum at a smaller forcing frequency.

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The 18th International Congress of Theoretical and Applied Mechanics, Haifa, Israel, 1992

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### **Active Control of a Turbulent Separated Flow Zone**

M. KIYA, O. MOCHIZUKI, M. SHIMIZU, Y. OGURA and Y. IDO  
Hokkaido University

Sinusoidal disturbances in two modes were introduced along the leading edge of a blunt circular cylinder aligned with the main-flow direction to study the corresponding response of the leading-edge separation zone at Reynolds number of the order  $10^5$ . One of the modes was the excitation by single-frequency sinusoidal disturbances, while the other was the excitation

by sinusoidal disturbances with two frequency components with various phase differences. The effectiveness of the excitation was represented by the time-mean reattachment length of the separation zone  $x_r$ , which was experimentally obtained in a fairly wide range of the governing parameters. The single-frequency excitation yielded a minimum of  $x_r$  at a frequency  $f_m$  which was approximately 1/30 of the frequency of Kelvin-Helmholtz instability near the separation edge  $f_{KH}$ , and approximately four times the frequency of shedding of large-scale vortices from the separation zone. The reattachment length attained a maximum (larger than the value of  $x_r$  for the unexcited flow) at an excitation frequency of approximately  $f_{KH}/2$ , and remained constant at excitation frequencies greater than approximately  $2f_{KH}$ . A particular combination of two frequencies  $f_m$  and  $f_m/2$  was found to have the most significant dependence of  $x_r$  on the phase difference between the two components.

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IUTAM-SYMPOSIUM  
Bluff-Body Wakes,  
Dynamics and Instabilities,  
Göttingen, Germany, 1992

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### **Flip-Flopping Flow Around Two Bluff Bodies in Tandem Arrangement**

M. KIYA, O. MOCHIZUKI, Y. IDO, T. SUZUKI and T. ARAI  
Hokkaido University

At sufficiently high Reynolds numbers, there exist two patterns or modes of flow around two circular cylinders of the same diameter  $d$  which are placed in tandem in a uniform flow of  $U_\infty$ . The purpose of this paper is to experimentally study statistical properties of the mode switching. A novel aspect of this study is judicious use of grid-generated turbulence to counteract possible effects on the mode switching of otherwise inherent disturbances inside and/or outside the wind tunnel. The experiment was performed in an open-return wind tunnel at Reynolds numbers  $Re$  (based on  $d$  and  $U_\infty$ ) of the order of  $10^4$ . Several bi-plane grids introduced free-stream turbulence with different intensities and scales. Pressure fluctuations at the near and front stagnation points of the upstream and downstream cylinders, respectively, served to differentiate the two modes. For the distance  $l$  at which the two modes occurred at the same probability, the interval of time during which each mode prevailed was found to be a random variable whose probability density distribution was a Gamma distribution. The average time interval of each mode was a rapidly-varying function of intensity of the free-stream turbulence, generally decreasing with increasing turbulence intensity. On the other hand, the integral length scale of the free-stream turbulence had only minor effects on the average time interval.

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The International Symposium on Simulation and Design of Applied Electromagnetic Systems, Sapporo, Japan, 1993

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### **Constitutive Equation of Magnetization for Magnetic Fluids**

Y. IDO and M. KIYA  
Hokkaido University

The behavior of magnetic fluids is considerably complex since the phenomena are generally concerned with the electromagnetic and flow fields. There are some basic equations for magnetic fluids, for example, by Shliomis, Shizawa and Tanahashi, and the authors. However, a complete set of basic equations for magnetic fluids has not been established yet. In particular, a treatment of magnetization is difficult in analyses of magnetic fluid flows. In this work, a constitutive equation of magnetization is discussed in detail. The constitutive equation of magnetization is determined by the thermodynamical method that is based on the Gibbs equation and the dissipation function. The constitutive equation obtained here includes Shliomis' relaxation equation of magnetization.

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SAE International Fuels and Lubricants Meeting and Exposition, San Francisco, California, U. S. A. October 19-22, 1992

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### **Description of Diesel Emissions by Individual Fuel Properties**

Noboru MIYAMOTO, Hideyuki OGAWA, Masahiko SHIBUYA and Tohru SUDA  
Hokkaido University

The effects of several fuel property variables on the emissions from a D.I. diesel engine were individually analyzed. The results showed that the smoke and dry soot increased with increased kinematic viscosity, shorter ignition lag, and higher aromatic content, especially at high equivalence ratios. Over the whole range of equivalence ratios, SOF depended on and increased with only ignition lag. The NO<sub>x</sub> improved slightly with increased kinematic viscosity, higher ignitability, and decreased aromatic content. The unburnt HC also improved with decreased kinematic viscosity and higher ignitability. The distribution shape of distillation curves had little influence on the emissions.

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SAE International Congress  
and Exposition, Detroit, Michigan, U. S. A. March 1-5,  
1993

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### **Time Series Analysis of Diesel Exhaust Gas Emissions under Transient Operation**

Noboru MIYAMOTO, Hideyuki OGAWA, Masahiko SHIBUYA, and Naohide FUWA  
Hokkaido University

Time series analysis of diesel exhaust gas emissions under transient operation was carried out using a uniquely developed gas sampling system to efficiently collect all exhaust gas throughout transient cycles. The effects of fuel properties and other engine operation parameters on the exhaust emissions under transient runs when fuel amounts abruptly increase were analyzed.

The results showed that THC increased abruptly to 2 or 6 times the final steady-state concentration immediately after the start of acceleration and then decreased to the steady-state values after 70~200 cycles. At acceleration,  $\text{NO}_x$  increased abruptly to about 80% of the final  $\text{NO}_x$  concentration, and then increased gradually to reach the final values after 60~500 cycles. The behaviors of THC and  $\text{NO}_x$  during transient operation can be described by exponential functions of the elapsed cycle numbers and the final emission concentrations. The concentrations of CO,  $\text{CO}_2$ ,  $\text{O}_2$ , and smoke changed abruptly to the steady-state values at the start of acceleration. The dominant factors affecting the gas emissions during transient operations are the deposition of fuel on the combustion chamber walls and the combustion rapidity.

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SAE International Congress  
& Exposition. Detroit, Michigan, Mar. 1-5, 1993

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### **Quantitative Measurements and Analysis of Ambient Gas Entrainment into Intermittent Gas Jets by Laser-Induced Fluorescence of Ambient Gas (LIFA)**

Akihiro KIDO, Hideyuki OGAWA and Noboru MIYAMOTO  
Hokkaido University

Mixture formation processes of intermittent gas jet were visualized and quantified with high accuracy by a developed LIF technique (LIFA). Mixture strength inside gas jets was quantified by the fluorescence of iodine in the ambient gas excited by the sheet light of a Nd:YAG laser. Two dimensional images of intermittent gas jets of various velocities were continuously recorded with VTR and quantified with high accuracy. The optimum conditions for measurements and accuracy with the LIFA technique were investigated. Accuracies better than 95% were obtained for the jet concentration. The experimental results show that consid-

erable amounts of ambient gas entrain just under the umbrella-like profile at the top of the Jet. The mean jet concentration decreased with decreased nozzle diameter ( $D$ ), and time elapsed after injection ( $\Delta t$ ). The mean jet concentration was approximately related to only one parameter, the ratio of the discharge Reynolds number and discharge velocity of the jet,  $ReD/(U_0\Delta t)$ .

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The 7th International Conference on Biomedical Engineering, Singapore, December 2-4, 1992

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**The structural Effects of the Posterior Elements on the Mechanical Properties of the Human Lumbar (L4-5) Functional Spinal Unit during Cyclic Loading**

Satoshi ASANO, Shigeru TADANO\*, Kiyoshi KANEDA  
Kuniyoshi ABUMI and Shinji UMEHARA  
Department of Orthopaedic Surgery, School of Medicine  
\* Department of Mechanical Engineering II  
Hokkaido University

Ten fresh human L4-5 functional spinal units (FSUs) were tested under the cyclic axial compression-tension tests and the torsion tests in order to investigate the structural effects of the posterior elements on the mechanical properties of L4-5 FSU. The stiffness of the FSU increased with the increase of displacement under every loading. This was same in the intact FSU and the FSU after removal of each posterior element respectively. After removing all the posterior elements, the stiffness of L4-5 FSU decreased significantly under every loading. The apophyseal joints had a significant effect on the compressive and torsional stiffness. The effect of the apophyseal joints on the torsional stiffness became greater according to the extent of displacement, while their effect on the compressive stiffness was constant. The posterior ligaments (supraspinous and interspinous ligaments) had a significant effect on the tensile stiffness.

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The 7th International Conference on Biomedical Engineering, Singapore, December 2-4, 1992

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### **Structure and Materials for a Synthetic Intervertebral Disc**

Shigeru TADANO, Hiromasa ISHIKAWA  
Satoshi ASANO\*, Kiyoshi KANEDA\* and Shinji UMEHARA\*  
Department of Mechanical Engineering II

\* Department of Orthopaedic Surgery, School of Medicine  
Hokkaido University

The objective of this study is to represent a new synthetic intervertebral disc for lumbar spine. The geometry and the structure of a synthetic disc were designed by the computer simulation of 3D-FEM, as the tensile-compressive and the torsional stiffnesses of the model agree with the static stiffnesses of cadaveric lumbar disc at L4/5. The proposed model consists of two plates of 3 mm in thickness and an intervenient disc of 8 mm, and is a semi-circular shape of 40 mm in radius. The disc part of the model has an inner ring of 10 mm in thickness and an outer skin layer of 1.25 mm. The plates which come into contact with bone is made by glass ceramics containing apatite and wollastonite. Material constants of the outer skin layer should be Young's modulus of 14.0 MPa and Poisson's ratio of 0.4. Therefore, silicone elastomer of medial grade is suitable as the material. On the other hand, material constants of the inner ring must be satisfied with Young's modulus of 1.0 MPa and Poisson's ratio of 0.1. As the material, foamed silicone elastomer with lower Poisson's ratio and lower Young's modulus is suitable for the synthetic disc.

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The 7th International Conference on Biomedical Engineering, Singapore, December 2-4, 1992

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### **The Effect of Annular Injury and Nucleotomy on the Mechanical Properties of the Human L4/5 Intervertebral Disc**

Shinji UMEHARA, Satoshi ASANO, Shigeru TADANO\*,  
Kuniyoshi ABUMI and Kiyoshi KANEDA  
Department of Orthopaedic Surgery, School of Medicine

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An intervertebral disc of the lumbar spine plays various roles, that is, bearing large load, deforming three-dimensional, and absorbing vibration, etc. Then, the failure of its function

leads to low back pain or neurological disorders. Several studies of the lumbar intervertebral disc were reported previously. Goel studied the effects of discectomy using multilevel spinal segment or one motion segment, and he stated that it is better to excise the least amount of nucleus. Brinckmann investigated the change of disc height, radial disc bulge, and intradiscal pressure after discectomy. In those studies, the spinal level of the specimens was varied, and the method of load application and estimation differed among authors. We carried out a study of the behavior of the intervertebral discs of human cadaveric spine, in order to estimate the mechanical properties of the discs and the effects of nucleotomy following annular injury. In this study, our investigation was limited to L4-5 motion segment, considering the flexibility and vulnerability of that spinal level.

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Conference on Spine+Science+Management, New Orleans, USA, 20-21, Dec. 1992

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### **A Biomechanical Evaluation of Spinal Segmental Instability**

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Department of Mechanical Engineering II, Hokkaido University

\* Department of Orthopaedic Surgery, School of Medicine  
Hokkaido University

The biomechanical definition of spinal instability has not been clarified sufficiently, because of great personal and level differences of intervertebral disc deformation. This work proposes a new method to judge spinal instability regardless of these differences. Since the geometry of human locomotoriums is thought to have a close relationship to their functions, we investigated the motion of human spine in terms of the relationship of the geometry and deformation of an intervertebral disc. Consequently, the lineal relationship between the geometry and the deformation ratio was obtained in the normal intervertebral discs. The degree of spinal instability could be evaluated statistically by calculating a residual value from the regression line of the normal intervertebral discs.

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The 7th International Conference on Biomedical Engineering, Singapore, December 2-4, 1992

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### **Mechanics of Bio-tribology for Artificial Joint**

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\*\* Department of Orthopedic Surgery,  
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To check the contact behavior of the ultra-high molecular weight polyethylene (UHMWPE) attached on the tibial surface of alumina ceramics in the artificial knee joint, a wear test is conducted using an UHMWPE disk and an alumina ceramic pin, and in addition, computer simulation based on the cyclic plasticity is performed, which gives a fairly good explanation for the complicated phenomena of wear of the UHMWPE disk.

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The Asia-Pacific Symposium on Advances in Engineering Plasticity and its Applications, Hong Kong, December 15-17, 1992

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### **Constitutive Equation Considering the Memorization of the Back Stress for Ratchetting Behavior**

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Hokkaido University, Sapporo, 060 Japan

One of the difficult problems in the study of the constitutive equation for cyclic plasticity is the prediction of ratchetting behavior which is induced by the superposition of a cyclic secondary load and a constant primary load in the biaxial case, or the mean stress in a uniaxial case. This paper shows the constitutive equation in which the memorization of the back stress is considered for ratchetting behavior, especially for biaxial ratchetting behavior. To verify the applicability of the constitutive equation to ratchetting behavior, a biaxial ratchetting test was carried out using type 304 stainless steel at room temperature. As a result, it is found that the simulation based on the constitutive equation has a good agreement with the test.

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The 3rd East Asian International Foundry Symposium,  
Pusan, Korea July 1-3, 1992

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**Fundamental study on erosive wear of  
Austempered Ductile Iron**

Kazumichi SHIMIZU, Toru NOGUCHI\*,  
Shigeru DOI\*\* and Mitsuru YANO\*\*

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Erosive wear of austempered ductile iron, which is noticed as a new cast material with high strength and toughness, was studied. Erosion test using a shot blast machine was performed with various impact angles and the results was compared with that of mild steel. Feature of surface damage was examined by SEM, metal flow in a surface was observed by an optical microscope, and the erosion mechanism and the effects of impact angle were discussed.

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A F S ( A m e r i c a n  
Foudrymen's Soc.) 97th Casting Congress Chicago, Illinois, U. S. A. April 24-27, 1993

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**Basic study on the erosive wear of  
Austempered Ductile Iron**

Kazumichi SHIMIZU, Toru NOGUCHI\*,  
and Shigeru DOI\*\*

Oita National College of Technology  
1666 Maki, Oita, 870-01 Japan

\* Faculty of Engineering, Hokkaido University

\*\* Faculty of Engineering, Oita University

Erosive wear tests were performed on austempered ductile iron and mild steel using a shot blast machine. Erosion damage was measured by the removed material volume at various impact angles between 10° and 90°. The eroded surface was observed by SEM, and the surface metal flow in the vertical section was also observed. The mechanism of erosive wear, the effect of the impact angle, and the difference in wear features in the two materials were discussed.

With both ADI and SS400, the eroded volume increases almost linearly with blasting time

after an initial stage. The amount of erosion in ADI about 1/5 of SS400, showing the superior erosion resistance of ADI.

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AFS (American Foundrymen's Soc.) 97th Casting Congress Chicago, Illinois, U. S. A. April 24-27, 1993

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**Cast-in Inserts of steel by Cast Iron  
Using Thermal Spraying**

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Tsukasa SATO and Masahiro SAKAI\*  
Faculty of Engineering, Hokkaido University,  
Sapporo, 060 Japan

\* Hokkaido Industrial Research Institute,  
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Thermal spraying with Ni based self-fluxing alloy was used in the cast-in inserts of mild steel and cast iron. Steel pipes and bars with various thicknesses and diameters sprayed on the surface were cast in flake graphite and spheroidal graphite cast irons. The experiments showed that bonding in cast-in inserts is sensitive to the volume ratio of the cast metal and inserts, pouring temperature, and other casting conditions; still thermal spraying greatly expands the region where successful bonding can be obtained. The strength of the bonding interface is comparable with that of the cast iron although diffusion zone is formed by the spray alloy elements. The sprayed alloy promotes diffusion bonding by remaining in liquid phase between solid inserts and cast iron, improving wettability and preventing oxide formation at the interface.

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International Conference on  
Martensitic Transformations  
Monterey, USA, July 20-24,  
1992

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**The Atomistic Processes of the Martensitic Transformation of  
Fine Iron Precipitates in Copper Alloys by Cold-Rolling**

Iwao ISHIDA  
Hokkaido University

The  $\gamma \rightarrow \alpha$  transformation of fine, coherent iron precipitates in single crystal copper alloy by cold-rolling has been investigated by the electron microscopy and the magnetic method.

Cold-rolled along the  $(101)_f$   $[010]_f$ , the transformed  $\alpha$ -iron particles had the Pitsch orientation relationship with the matrix and the shape expected from the Pitsch transformation mechanism, and the magnetic anisotropy expected from the coercive force also corresponded to the oblate spheroidal  $\alpha$ -iron particles expected from the Pitsch mechanism. Cold-rolled along the  $(101)_f$   $[101]_f$ , the  $\alpha$ -iron particles with the same orientation relationship and shape were also observed. Thus, it was concluded that the atomistic processes of the  $\gamma \rightarrow \alpha$  transformation of fine  $\gamma$ -iron particles are those proposed by Pitsch.

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The 6th International Conference on Ferrites Tokyo, Japan, Sept. 29-Oct. 2, 1992

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### **The Progress of Magnetic Recording Technology and Its Contribution to the Consumer Electronics**

Eiichi HIROTA\* and Koichi KUGIMIYA  
R & D Department, Matsushita Electric Industrial Co., Ltd.  
3-15 Yagumo Nakamichi, Moriguchi, Osaka, Japan

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Hokkaido University, Sapporo 060, Japan)

The progress of magnetic recording technology over these two decades since 1970, mainly about the VTR-technology, has been discussed along with the improvements of magnetic tapes and heads in which ferrite is the key material. Forecast is given for some of the future trend of the recording technology.

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Digests of International Magnetism Conference Stockholm Sweden, April, 13-16, 1993

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### **Giant Magnetic Moment Observed in the Cr/Co Multilayer Film**

Iwao ISHIDA  
Shiyuji YOSHIKAWA  
Kouichi HAMADA  
Toshimasa YOSHIE  
Akira OKADA  
Eiichi HIROTA  
Hokkaido University

A large saturation magnetization of 480 emu/g at 80 k was observed in a Cr/Co multilayer film. The magnetization curve of the multilayer film was composed of a small hysteresis loop

and a reversible magnetization curve whose magnetic susceptibility kept constant for increase of temperature. A giant magnetic moment is induced under the influence of Co layers in the Cr/Co multilayer film, and spin flopping is easily occurred in relatively low magnetic field.

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MODMM '93 The International Conference on Modern Design, Manufacturing and Measurement Beijing, China, May 6-8, 1993

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### **3D Measurement of Shape by a New Stereo Vision Algorithm**

Satoru IGARASHI, Katsuhisa SHIBUKAWA  
and Katsumasa SAITO  
Faculty of Engineering, Hokkaido University  
Sapporo, Japan

In the differential stereo vision system, depth information can be derived from brightness values of image without solving the exact correspondence problem (stereo matching) which requires complicated image processing in usual 3D measurement of shape using stereo image. However, this method has a weak point of narrow depth-range problem in measurement. In this study, a new method to solve this problem and to improve the accuracy of measurement is proposed and a new algorithm for the proposed method is developed. Through several examples of measurement, the effectiveness of the proposed method is confirmed, and the accuracy of measurement is discussed.

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The Fourth International Conference on Rapid Prototyping, Dayton, U. S. A., June 14-17, 1993

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### **Characterization of solidified resin created by Three Dimensional Photofabrication**

Hiroyuki NARAHARA, Katsumasa SAITO  
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Sapporo 060, Japan

The information on the relationship between irradiation conditions and solidified physical dimensions is important not only for short time fabrication but also for high accuracy models. Threshold energy is an important factor in determining solidified depth in the conventional

solidification theory. Determination of the threshold energy for solidification is a necessary experiment for the solidified shape estimation and shape accuracy improvement.

With several resins we estimate threshold energies for solidification, but our results show that the threshold energy is not constant under the exposure conditions even in the same resin, but input power and scanning speed has a non-linear relationship at the solidification level. We obtain the relationship experimentally between laser input power, scanning speed and threshold depth, and a modified solidification threshold is important for the estimation of the solidified shape.

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Power Conversion Conference-Yokohama, Japan, Apr. 19-21, 1993

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**Control Method for a Combined Active Filter System  
Employing a Current Source Converter and a High pass Filter**

Shoji FUKUDA and Takayoshi ENDOH  
Department of Electrical Engineering, Hokkaido University  
Sapporo, 060 Japan

This paper describes a control method with a combined filter system which senses load current, source current and line voltage to create the reference signals for an active filter. The transfer function of the active filter is identified and is used for the control system design. It is shown that the source current feedback is most effective to suppress the harmonic-enlarging effects due to parallel resonance and the harmonic current generated by source harmonic voltages. A small setup controlled by a DSP was built, and the validity of the method was demonstrated by the experimental results.

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IFIP World Computer Congress '92, Madrid, Spain, Oct., 1992

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**A Synthetic Media Architecture for an Object-Oriented Open Platform**

Y. TANAKA, A. NAGASAKI, M. AKAISHI and T. NOGUCHI  
Electrical Engineering Department  
Hokkaido University

Computers as meta-media should provide us with an open integrated environment for all kinds of our intellectual activities, and hence need a unified framework for (a) the modeling, (b) the presentation, (c) the synthesis, (d) the sharing, (e) the coordination of user interactions, (f) the circulation/publication, and (g) the management of multimedia documents, sys-

tem-provided functions, and application programs. The Intelligent Pad system we proposed in 1989 provided a unified framework for (a), (b), (c) and (g). It represents everything as a pad. The pasting of pads on another pad defines a new composite pad. This paper further extends it for (d), (e), (f), and (g), to propose it as an open integrated platform for the next-generation OISs.

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The 2nd Pacific Rim International Conference on Artificial Intelligence, Seoul, Korea, Sept., 1992

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### **Unifying Vocalog and Situation Semantics**

K. SAKAMOTO and Y. TANAKA  
Electrical Engineering Department  
Hokkaido University

We are aiming at building a natural language database system. Building such a system requires a programming language for system description, especially a language with deductive powers for inference, and furthermore, requires a semantic theory for expressing the meanings of natural language sentences. For system description, we use a logic programming language Vocalog (VOCA bularybased LOGic programming), which not only has deductive powers as other logic programming languages have, but also possesses the capability of vocabulary building similar to those of natural languages. Moreover, we adopted situation semantics as a basis of natural language semantics, which works quite efficiently to explain the context dependencies of natural languages. Therefore we are required to represent in Vocalog various situation semantic constructs, such as states of affairs, types, and restricted parameters. These constructs have their own structures. We attempt to represent these constructs in the framework of vocabulary building.

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The IASTED International  
Conference, Power Systems  
and Engineering, Vancouver,  
Canada, August 5-7, 1992

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**A Method for Hierarchical State Estimation Considering  
Zero-injection Nodes in Electric Power Systems**

K. NISHIYA\* and J. HASEGAWA

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\* Hokkaido Institute of Technology, Sapporo, Japan

New hierarchical techniques considering zero-injection nodes are developed for multi-area state estimation. For implementing effective control of power systems, we can utilize the basic coordination principles in hierarchical systems theory. The authors have already proposed hierarchical structures of state estimation in which the goal coordination method is applied. In this paper, a method for considering information of zero-injection nodes is incorporated in the above-mentioned hierarchical estimation. The effectiveness is confirmed by numerical examples and the extension to dynamic cases is also discussed.

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The 9th Conference on Elec-  
tric Power Supply Industry,  
Hong Kong, November 23-  
27, 1992

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**Load Frequency Control and Load Leveling  
Using Dispersed Energy Storage Systems**

H. KUBO, E. TANAKA, J. HASEGAWA and K. NISHIYA\*

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\* Hokkaido Institute of Technology, Sapporo, Japan

In this paper, an electric power system with dispersed energy storage systems is investigated as one promising form in the future. By installing the energy storage systems at the load bus, for example, secondly substations, this system is divided into a bulk power system and local subsystems. Based on this structure, we can expect that energy storage systems have multiple functions, such as load leveling, load frequency control, voltage stabilizing and reactive power control, and system stabilizing control. Among these functions, load frequency control and load leveling are described in detail. The performance of the control system is examined by the indicial responses and the frequency characteristics to load fluctuations. Further, the coordination of both functions is considered. As a result, the effectiveness of the system is confirmed.

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The 4th International Conference on Expert System Applications in Power Systems, Melbourne, Australia, January 4-8, 1993

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### **Thermal Power Station Maintenance Scheduling Based on Fuzzy Theory**

G. GIBSON, H. KITA, K. NISHIYA\* and J. HASEGAWA  
Department of Electrical Engineering, Hokkaido University, Japan

\* Hokkaido Institute of Technology, Sapporo, Japan

This paper presents a new method of maintenance scheduling which, based on Fuzzy theory, equalizes the supply reserve capacity rate while checking multi-year constraints. As most external factors pertaining to load and supply reserve capacity contain a degree of uncertainty, or fuzziness, Fuzzy membership functions are used. The Branch and Bound method is used for the optimization search. Load membership functions represent load at each time interval during the maintenance period and a new objective function is used so that the equalized reserve capacity is an averaged value containing the degree of uncertainty of load. For the future (multi) year constraint checks, integration between load and reserve capacity membership functions is carried out at each time interval resulting in an averaged reserve capacity level. This method is compared with a previously developed deterministic method to gauge its performance.

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International Power Engineering Conference, Singapore, March 18-19, 1993

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### **The Application of Fuzzy Theory to Generating Unit Scheduling Problems in Power Systems**

G. GIBSON, H. KITA, K. NISHIYA\* and J. HASEGAWA  
Department of Electrical Engineering, Hokkaido University, Japan

\* Hokkaido Institute of Technology, Sapporo, Japan

A new method for determining thermal power station generating unit maintenance scheduling has been developed based on Fuzzy theory. This method uses fuzzy membership functions to represent load and reserve capacity and the Branch and Bound method for optimization. In general, the membership functions are used to attain averaged reserve capacity values containing the degree of uncertainty of load and reserve capacity. The application of membership functions also provides constraint check flexibility. Simulations were run in tandem with a deterministically based method to assess the proposed method's performance. Comparisons are

made of the feasibility and number of solutions for both methods. In addition, reserve capacity levels for both methods are plotted together to show numerical differences in solution finding and to illustrate the flexibility of the proposed method.

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The 10th International Conference on GAS DISCHARGE AND THEIR APPLICATIONS, 13-18 September 1992, Swansea, Wales, UK

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### **Process of Decomposing NO<sub>2</sub> by Glow Discharge**

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In this article, spatial and time variations of optical emission from N<sub>2</sub>, N<sub>2</sub><sup>+</sup> and NO in NO<sub>2</sub> DC glow discharge are applied to investigate the process of decomposing molecules of NO<sub>2</sub> by using a computer-aided single photon counting system. Moreover, time variation of the total pressure in NO<sub>2</sub> glow discharge as a parameter of electrical current is measured. We report some results of these measurements.

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The 10th International Conference on GAS DISCHARGE AND THEIR APPLICATIONS, 13-18 September 1992, Swansea, Wales, UK

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### **Ionization and Attachment Coefficients in NO<sub>2</sub> and NO<sub>2</sub>/He Mixtures**

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The present article describes, for the first time, the ionization, attachment and effective ionization coefficients of electrons for NO<sub>2</sub> and NO<sub>2</sub>/He gas mixtures measured by the steady-state Townsend method for gas pressures between 1 and 10 Torr. These values are compared

with those for  $N_2$ ,  $O_2$  and  $SF_6$  and discussed.

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The 10th International Conference on GAS DISCHARGE AND THEIR APPLICATIONS, 13-18 September 1992, Swansea, Wales, UK

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**Spectroscopic and Image Intensified Investigations of  
RF Plasma in  $H_2$  and  $CH_4$  Mixtures**

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\*\* Department of Electrical Engineering, Hokkaido University, Sapporo, Japan

In this article, we show the experimental arrangements developed in detail and briefly report preliminary measurements of the optical emission diagnostics by using the DC plasma in nitrogen in order to confirm a new system. We will present results of a diagnostics according to the processing for amorphous carbon deposition in  $H_2$  and  $CH_4$  mixture orally.

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The 10th International Conference on GAS DISCHARGE AND THEIR APPLICATIONS, 13-18 September 1992, Swansea, Wales, UK

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**Analysis of the Electron Swarm Parameters by using  
Fourier Transforms of the Boltzmann Equation**

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In this paper a new method to calculate the electron swarm parameters directly by employing a Fourier transformed Boltzmann equation is represented and the swarm parameters includ-

ing higher order parameters are derived from the dispersion relation of the eigenvalue problem of the equation. The results are compared with those obtained by the conventional methods.

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The 10th International Conference on GAS DISCHARGE AND THEIR APPLICATIONS, 13-18 September 1992, Swansea, Wales, UK

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**Computer Simulation study of correspondence  
Between Experimental and Theoretical  
Electron Drift Velocities in SF<sub>6</sub> GAS**

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Muroran Institute of Technology, Muroran, Japan

\*\* Department of Electrical Engineering, Hokkaido University, Sapporo, Japan

The purpose of this work is to clarify the relation between the theoretical and experimental electron drift velocities in SF<sub>6</sub> gas quantitatively. The behaviour of electrons in swarm in Schlumbohm's and Frommhold's experiments are simulated exactly using a Monte Carlo technique, then the obtained drift velocities are compared with the theoretical electron drift velocities  $V_d$ ,  $W_v$ ,  $W_r$  and  $W_m$  deduced from the same cross sections. Moreover, correspondence between the theoretical drift velocities and the drift velocities obtained by simulation of those two real experiments is discussed.

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10th International Conference on GAS DISCHARGE AND THEIR APPLICATIONS, 13-18 September 1992, Swansea, Wales, UK

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**Continuity Equation study of  
Development of RF Electron Swarms in Gases**

M. Nakamura, Y. Sakai and H. Tagashira

Department of Electrical Engineering, Hokkaido University, Sapporo 060 Japan

The purpose of this work is to develop a simulation model for which the calculation can be

performed on an engineering work station in a few hours. Also, it appears that there has been no investigation of the accuracy of fluid models. Therefore, the validity of the model is investigated through comparison with the results of a Monte Carlo simulation. This is the second purpose. The simulation model is applied to an RF plasma in Ar.

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NATO Advanced Research  
Workshop on NON-THER-  
MAL PLASMA TECH-  
NIQUES FOR POLLUTION  
CONTROL, September 21-  
25, 1992, Cambridge, Eng-  
land, UK

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### **Decomposition of NO<sub>2</sub> by Glow Discharge Plasma**

Y. SAKAI and H. TAGASHIRA

Department of Electrical Engineering, Hokkaido University, Sapporo 060 Japan

In the present study, we measured the decomposition rate of NO<sub>2</sub> air pollutant molecules, in a uniform glow discharge and the electron impact ionization coefficient and attachment coefficient in NO<sub>2</sub> gas of pressures between 1 and 7 Torr. In this experiment Harrison type parallel plate electrodes were used. The decomposition process of NO<sub>2</sub> is discussed.

The measurement of the electron impact ionization and attachment coefficients in NO<sub>2</sub> gas in a  $E/p_0$  range between 70 and 380 V/cm/Torr showed that the ionization coefficient in NO<sub>2</sub> gas was smaller than values in N<sub>2</sub> and O<sub>2</sub> gases for  $E/p_0$  below 200 V/cm/Torr and that the attachment coefficient was smaller than values of SF<sub>6</sub> while it was larger than values of O<sub>2</sub>. The limiting  $E/p_0$  in NO<sub>2</sub> gas was given to be 95 V/cm/Torr.

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The 45th Annual Baseous  
Electronics Conference, 27-30  
October 1992, Boston, Mas-  
sachusetts, US

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### **Monte Carlo Modeling of RF Non-equilibrium Plasma in Monosilane**

H. TAGASHIRA, A. YOKOZAWA and K. KITAMORI

Department of Electrical Engineering, Hokkaido University, Sapporo, Japan

An rf non-equilibrium plasma between parallel plates in monosilane has been simulated by a Monte Carlo technique. The electric field is determined self-consistently with the densities of electrons and ions. The frequency of the total radical generation is obtained. This frequency is distributed to various radical species. Then, the diffusion equation representing the

reaction and transport of radicals is solve considering the reaction of the radicals at the surface of the deposited amorphous silicon. For the deposition of the film, a simple Monte Carlo model is employed. All the simulations, i. e. for the charged species, for the radicals and for the film growth are integrated by feedback simulations. It is found that some radical density distributions are affected considerably by the feedback simulations, demonstrating the importance of the integration.

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The 45th Annual Gaseous  
Electronics Conference, 27-30  
October 1992, Boston, Mas-  
sachusetts, US

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### **Electron Thermalization Processes In After Glow Plasma**

Y. SAKAI, S. SAWADA and H. TAGASHIRA

Department of Electrical Engineering, Hokkaido University, Sapporo, Japan

Thermalization processes of electrons in after-glow plasma of rare gases and Penning gas mixtures has been analyzed using the time and energy dependent collision frequencies. The following collision processes were considered, i. e. elastic and excitation collisions and recombination for electrons, and generation of electrons from metastable atoms by Penning effect, ionization collision between two metastable atoms and stepwise ionization. The decay rate of the electron concentration in Xe gas was given to agree well with experimental values. During the thermalization the electron energy distribution showed peculiar structures. The thermalization process was discussed comparing with experimental data.

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THE 5TH ASIAN CONFERENCE ON ELECTRICAL DISCHARGE, 25th-27th November 1992, Ngee Ann Polytechnic, Singapore

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**Studies on Water Capacitor  
For Pulsed Power Generation**

Y. NAKAO, H. ITOH, Y. SAKAI\* and H. TAGASHIRA\*  
Department of Electrical and Electric Engineering,  
Muroran Institute of Technology, Muroran, Japan

\* Department of Electrical Engineering, Hokkaido University, Sapporo, Japan

Recent progress of pulse power technology is very remarkable. As a dielectric material of a capacitor used in pulse power generators for pulse forming and pulse compression, dielectric liquid, especially water which has a high relative dielectric permittivity  $\epsilon_r$ , a high resistivity  $\rho$  and a large breakdown strength  $E_b$ , has been widely noticed. In this paper, fundamental studies on breakdown characteristics of pure water and water/ethylene glycol mixture are presented. Further a design and a trial manufacture of a coaxial-cylindrical water capacitor, and experiments on a pulse forming line by using it are carried out.

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THE 5TH ASIAN CONFERENCE ON ELECTRICAL DISCHARGE, 25th-27th November 1992 Ngee Ann Polytechnic Singapore

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**Breakdown strength Measurement of Vapor-Mist Dielectrics  
—SV90 and FX3300 in Air—**

Y. SAKAI, T. OKADA, Y. Kaneko and H. TAGASHIRA  
Department of Electrical Engineering, Hokkaido University, Sapporo 060 Japan

The AC and DC breakdown voltage ( $V_{s,AC}$  and  $V_{s,DC}$ ) of vapor-mist, SV90 ( $C_7F_{16}O_4$ ) and FX3300 ( $C_8F_{18}$ ), in 100-760 Torr air has been measured for sphere-sphere electrodes with a diameter of 5 mm. The results showed that  $V_s$  increased with increasing the vapor pressure and that, as the concentration of SV90 and FX3300 vapor increased to about  $10^{17} \text{ cm}^{-3}$ ,  $V_s$  was about 2 times larger than that in air. The effect of one vapor molecule on the raise in  $V_s$  was almost the same in both vapors. The increment of  $V_s$  in FX3300-mist was found to be brought considerably by the large size mists more than  $1 \mu\text{m}$ .

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International Workshop on  
Electronbeam Assisted  
Processes, 13, 14 January  
1993, Nagoya, JAPAN

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### **Decaying Process of Xe After-Glow Plasma**

Y. SAKAI and S. SAWADA

Department of Electrical Engineering, Hokkaido University, Sapporo 060 Japan

Decaying behavior of the concentration, mean energy, energy distribution and collision frequencies of electrons in Xe after-glow plasma were analyzed numerically.

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The Second Japan-Hungary  
Joint Seminar on Applied  
Electromagnetics in Material  
and Computational Technol-  
ogy, Sapporo, Japan, Sept.  
16-18, 1992

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### **Eddy Current Analysis of a Circular Plate Rotating in Dipole Magnetic Field**

M. TSUCHIMOTO and K. MIYA\*

Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Kita 13, Nishi 8, Kita-ku, Sapporo 060, Japan

\* Nuclear Engineering Research Laboratory, Faculty of Engineering,  
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Eddy current of a circular plate rotating in dipole magnetic field is analyzed numerically by using the current vector potential method (T-method). When the eddy current is assumed constant through the thickness of the plate, the analysis is reduced to a scalar problem. Relations between applied field on the plate and velocity term are mentioned, and total joule loss and torque of the plate are compared with analytical solutions and numerical solutions of other computational codes. The peak of the torque depends on a rotating cycle and it is discussed from the numerical results.

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The Second Japan-Hungary  
Joint Seminar on Applied  
Electromagnetics in Material  
and Computational Technol-  
ogy, Sapporo, Japan, Sept.  
16-18, 1992

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### **Experimental and Computational Evaluation of Corona Devices**

T. MORINAGA, H. IGARASHI and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Japan

This paper presents experimental and computational evaluation of corona devices which are widely used in xerographic processes. The devices form space charge fields governed by the Poisson equation and the equation of current continuity. The equation of current continuity is solved by the method of characteristics (MOC), in which the charge density is calculated from the values of the electric field on characteristic lines. On the other hand, the boundary element method (BEM) is used to solve the Poisson equation because, in general, space charge problems include open boundaries. The above mentioned solution procedure is carried out by turns until a self-consistent solution is obtained. The current-voltage characteristics of the corona devices are calculated by the above method and the numerical results are compared with experimental data.

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The Second Japan-Hungary  
Joint Seminar on Applied  
Electromagnetics in Material  
and Computational Technol-  
ogy, Sapporo, Japan, Sept.  
16-18, 1992

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### **A Coupling Analysis of Two-dimensional MPD Thruster Using FDM and FEM**

H. ITOH, H. IGARASHI and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Japan

This paper describes a quasi-steady two-dimensional analysis of an MPD (magnetoplasmadynamic) thruster. The fluid equations and magnetic field equation are numerically solved by an iterative method to obtain self-consistent numerical solutions. The finite difference and finite element methods are employed to solve the fluid equations and magnetic field equation, respectively.

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The Second Japan-Hungary  
Joint Seminar on Applied  
Electromagnetics in Material  
and Computational Technol-  
ogy, Sapporo, Japan, Sept.  
16-18, 1992

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### **Differential Form Diagram of Electrodynamics Containing Hertzian Tensor Potential**

H. KAWAGUCHI and T. HONMA

Department of Electrical Engineering, Faculty of Engineering, Hokkaido University  
Kita 13, Nishi 8, Kita-ku, Sapporo, 060 Japan

Hertz introduced so-called Hertzian vector to analyze electromagnetic fields, because four-potential derived from Hertzian tensor potential satisfies Lorentz condition automatically. After that, the concept of Hertzian vector has been extended. For example, Righi introduced "magnetic Hertzian vector", Laporte and Uhlenbeck introduced "Hertzian tensor" and so on.

In this paper, Helmholtz's theorem in four dimensional space is derived from the Poincaré lemma. Then, it is shown using the above theorem that four-potential can be resolved into two partial fields, the one derived from Hertzian tensor potential and the other from a gauge function. Furthermore, as an example, Hertzian tensor potential produced by the moving charged particle is introduced. Finally, the differential form diagram of electromagnetics containing the Hertzian tensor potential is shown.

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The Second Japan-Hungary  
Joint Seminar on Applied  
Electromagnetics in Material  
and Computational Technol-  
ogy, Sapporo, Japan, Sept.  
16-18, 1992

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### **On Numerical Instabilities in Equilibrium Shape Determination of Electromagnetic Levitation Melting of Metals**

O. IWATA, H. IGARASHI, H. KAWAGUCHI and T. HONMA

Department of Electrical Engineering, Faculty of Engineering, Hokkaido University,  
Kita 13, Nishi 8, Kita-ku, Sapporo 060, Japan

This paper describes a numerical analysis of the levitated liquid metals in an axisymmetric alternating electromagnetic field. The equilibrium shape of the liquid metal is determined by minimizing the functional which consists of the magnetic, gravitational and surface tension

energies. In this report, numerical instabilities in the numerical determination of the equilibrium shape are considered.

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The Second Japan-Hungary  
Joint Seminar on Applied  
Electromagnetics in Material  
and Computational Technol-  
ogy, Sapporo, Japan, Sept.  
16-18, 1992

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### **On a Precise Calculation of Electron Trajectory in Halbach Wiggler**

H. TAKAHASHI, H. KAWAGUCHI and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering  
Hokkaido University, Kita 13, Nishi 8, Kita-ku, Sapporo, 060 Japan

In this paper, a simulation method using a transfer matrix for Free Electron Lasers (FEL) system with the Halbach wiggler is presented. When electron motion is relativistic, it is necessary to calculate electron trajectory precisely because the velocity of an electron may exceed light velocity by numerical error.

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ISEM-Sapporo, The Interna-  
tional Symposium of Simula-  
tion and Design of Applied  
Electromagnetic Systems,  
Sapporo, Japan, January 26-  
30, 1993

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### **Crack Recognition near a Rivet Hole with Sheet Eddy Current**

A. FUKAYA, M. TSUCHIMOTO and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Kita 13, Nishi 8, Kita-ku, Sapporo 060, Japan

The crack recognition on the edge of a rivet hole is analyzed numerically by using the current vector potential method (T-method). When the eddy current is assumed to be constant through a thickness of a plate, the analysis is reduced to a scalar problem. Vertical component of induced field on a thin plate is evaluated for the magnet optic eddy current imager. A vague image of a crack is improved by cancellation of signals of the rivet hole in the numerical analysis.

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ISEM-Sapporo, The International Symposium of Simulation and Design of Applied Electromagnetic Systems, Sapporo, Japan, January 26-30, 1993

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### **Effects of a Grain Boundary on Levitation Force of a High $T_c$ Superconductor**

H. TAKEUCHI, M. TSUCHIMOTO and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Kita 13, Nishi 8, Kita-ku, Sapporo 060, Japan

Levitation force of a high  $T_c$  superconductor (HTSC) is evaluated numerically by using a model with a grain boundary. Effects of the grain boundary on the levitation force are discussed from a view point of equivalent critical current density. It is shown that existence of grain boundaries is one of reasons of the difference between the measured critical current density and the equivalent critical current density.

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ISEM-Sapporo, The International Symposium of Simulation and Design of Applied Electromagnetic Systems, Sapporo, Japan, January 26-30, 1993

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### **A Complementary Variational Analysis of Waveguides**

H. IGARASHI and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Japan

The cutoff frequencies of a rectangular waveguide are analyzed using the finite element method based on the complementary variational principle. The present method is shown to provide the lower bounds of the cutoff frequencies of the waveguide whereas the conventional FEM based on the Rayleigh quotient gives the upper bounds.

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ISEM-Sapporo, The International Symposium of Simulation and Design of Applied Electromagnetic Systems, Sapporo, Japan, January 26-30, 1993

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### **A BEM Analysis of Space Charge Field in a Corotron**

T. MORINAGA, H. IGARASHI and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Japan

This paper describes an analysis of space charge fields in the corotron which is used to electrify a photoconductor in electrophotographical processes. The space charge fields in the device are analyzed by the combination of the boundary element method (BEM) with the method of characteristics. In particular, the non-uniform voltage applied on the wires is shown to give nearly uniform current profiles on a metallic plate in the device.

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ISEM-Sapporo, The International Symposium of Simulation and Design of Applied Electromagnetic Systems, Sapporo, Japan, January 26-30, 1993

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### **A Finite Difference Analysis of the Two Dimensional MPD Thruster**

H. ITOH, I. FUNAKI\*, H. IGARASHI, K. TOKI\*, T. HONMA and K. KURIKI\*  
Department of Electrical Eng., Faculty of Eng., Hokkaido University, Japan  
\* Institute of Space and Astronautical Science, Japan

This paper describes a quasi-steady two-dimensional analysis of an MPD (magnetoplasma-dynamic) thruster. The fluid equations and magnetic field equation are numerically solved by an iterative method to obtain self-consistent solutions. The finite difference method is employed to solve the fluid and magnetic field equations. The resultant current-thrust characteristics are shown to agree well with experimental results.

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ISEM-Sapporo, The International Symposium of Simulation and Design of Applied Electromagnetic Systems, Sapporo, Japan, January 26-30, 1993

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### **Estimation of the Critical Mass in Levitation Melting Process**

O. IWATA, H. KAWAGUCHI and T. HONMA

Department of Electrical Engineering, Faculty of Engineering, Hokkaido University  
Kita 13, Nishi 8, Kita-ku, Sapporo 060 Japan

In this paper, an estimation method of the critical mass, which can be levitated, in the electromagnetic levitation melting process, is considered. In this process, the surface tension plays a important role for determination of the metal shape. From this point of view, the estimation method of the temperature and the temperature dependence of the surface tension are discussed.

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ISEM-Sapporo, The International Symposium of Simulation and Design of Applied Electromagnetic Systems, Sapporo, Japan, January 26-30, 1993

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### **Simulation of Free-electron Lasers Systems Using Symplectic Integrator**

H. TAKAHASHI, H. KAWAGUCHI and T. HONMA

Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Kita 13, Nishi 8, Kita-ku, Sapporo 060 Japan

In this paper, a symplectic integrator for a simulation of the Free Electron Lasers (FEL) is presented. Firstly it is indicated that, for the FEL with a planer wiggler, one can implement the symplectic integrator very easily. And then, combining the integrator with radiation fields calculation, the FEL starting-up simulation is done.

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TEAM Workshop on Compu-  
tation of Applied Electro-  
magnetics in Materials,  
Sapporo, Japan, January 30,  
1993

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### **An Analysis of Electromagnetic Fields in Waveguide Loaded Cavity**

H. IGARASHI, Y. SUGAWARA and T. HONMA

Department of Electrical Eng., Faculty of Eng., Hokkaido University, Japan

The electromagnetic fields and resonant frequencies in closed cavity resonators have been analyzed by various numerical methods. However, there are few methods by which waveguide loaded cavities are effectively analyzed. Kroll *et al.* reported a useful numerical method for computing the external  $Q$  and resonant frequency of them. Their method is based on the Slater method in which, inserting the terminating short in the waveguide region and varying the distance of the terminating short from the end of the waveguide, the above quantities are obtained by solving the eigenvalue problem. This paper describes a different approach for analysis of electromagnetic fields in a cavity coupling to an external waveguide.

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International Magnetics Con-  
ference (INTERMAG),  
Stockholm, Sweden, April  
13-16, 1993

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### **Numerical Analyses of Levitation Force and Flux Creep on High $T_c$ Superconductor**

M. TSUCHIMOTO, T. KOJIMA, H. TAKEUCHI and T. HONMA

Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Kita 13, Nishi 8, Kita-ku, Sapporo 060, Japan

Levitation force between a permanent magnet and a high  $T_c$  superconductor is examined by using two numerical methods. The levitation force to vertical direction is calculated by using the critical state model. Stiffness of restoring force to horizontal direction is calculated by using a frozed-in field model. Numerical solutions agree well with experimental results. Dynamic properties of the levitation force are also analyzed by combining the two methods.

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International Magnetism Conference (INTERMAG),  
Stockholm, Sweden, April  
13-16, 1993

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### **An Analysis of Eddy Current Testing with Sheet Current**

M. TSUCHIMOTO, A. FUKAYA and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Kita 13, Nishi 8, Kita-ku, Sapporo 060, Japan

Eddy current problem to recognize a crack on the edge of a rivet hole is analyzed numerically by using the current vector potential method. Vertical field is induced by the disturbance of the sheet eddy current on a thin plate. The vertical field is evaluated for a visualization technique with magneto optics. A vague image of a crack is improved by cancellation of signals of the rivet hole in the numerical analysis.

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International Magnetism Conference (INTERMAG),  
Stockholm, Sweden, April  
13-16, 1993

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### **Experimental Estimation of Electromagnetic force on Nonmagnetic and Ferromagnetic Thin plates**

M. TSUCHIMOTO, M. HASHIMOTO\*, A. YAMASHITA<sup>+</sup> and K. MIYA<sup>++</sup>  
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<sup>+</sup> Railway Technical Research Institute, Hiei-kudankita-biru,  
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<sup>++</sup> Nuclear Engineering Research Laboratory, Faculty of Engineering,  
University of Tokyo, 2-22, Shirakata-shirane, Tokai, Ibaraki 319-11, Japan

Mechanical vibrations are investigated experimentally to evaluate electromagnetic force on nonmagnetic and ferromagnetic thin plates. In addition to Lorentz force caused by eddy current in conductive material, drag force caused by magnetization also works to the ferromagnetic materials. The electromagnetic forces are evaluated from the peak deflection of cantilevered acrylic beam with test pieces. The Lorentz force and the drag force are discussed from several experimental results.

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International Magnetism Conference (INTERMAG),  
Stockholm, Sweden, April  
13-16, 1993

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**Estimation of Metal Temperature  
in Electromagnetic Levitation Melting Process**

H. KAWAGUCHI, O. IWATA and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering, Hokkaido University  
Kita 13, Nishi 8, Kitaku, Sapporo 060 Japan

In this paper, an estimation method of metal temperature in the electromagnetic levitation melting process is considered. In this process, the surface tension plays an important role for determination of the metal shape. From this point of view, the estimation method of the temperature and the temperature dependence of the surface tension are discussed.

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Third Polish-Japanese Joint  
Seminar on Modelling and  
Control of Electromagnetic  
Phenomena, Kazimierz,  
Poland, April 19-21, 1993

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**On a Double Fibre Bundle Structure of the Liénard-Wiechert Superpotentials**

H. KAWAGUCHI and T. HONMA  
Department of Electrical Eng., Faculty of Eng., Hokkaido University  
Kita 13, Nishi 8, Kita-ku, Sapporo 060 Japan

There exist superpotentials for the Liénard-Wiechert potentials (the Liénard-Wiechert superpotentials). And also, there are many similarities between the Liénard-Wiechert potentials and the superpotentials. In this paper, noticing the similarities, the geometrical structure of the Liénard-Wiechert superpotentials is considered. From the consideration, the double fibre bundle structure of the electromagnetic fields is found.

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The Fifth Japan-China Symposium on Boundary Element Methods, Sapporo, Japan, June 1-4, 1993

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### **An Iterative Boundary Element Analysis of a Corona Device**

H. IGARASHI, T. MORINAGA and T. HONMA  
Department of Electrical Eng., Faculty of Eng.,  
Hokkaido University, Japan

This paper deals with an iterative boundary element analysis of a corona device used for electrifying a photoconductor drum and papers in electrophotographical processes. The ion flow field in a corona device is assumed to be governed by the Poisson equation and the equation of current continuity. In this paper, the combination of the boundary element method with the method of characteristics (MOC) gives a self-consistent solution to the above equations. Moreover, the voltage induced by the ion flow on a moving photoconductor is determined iteratively.

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The Fifth Japan-China Symposium on Boundary Element Methods, Sapporo, Japan, June 1-4, 1993

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### **A Boundary Element Analysis of Potential Fields Using Fundamental Solutions Obtained by the Image Method**

K. SASAKI, H. IGARASHI and T. HONMA  
Department of Electrical Eng., Faculty of Eng., Hokkaido University, Japan

In boundary element analysis, the fundamental solution is usually used while the classical field analysis based on the integral equation employs the Green function completely satisfying the boundary conditions. On the other hand, when the boundary condition has a symmetry in space, we can often analytically obtain the fundamental solution satisfying the symmetry condition by use of the image method. The use of this solution may allow us to effectively reduce the computational model for the boundary element analysis because we do not need to discretize a part of the boundary of the domain.

In this paper, we apply two fundamental solutions derived by the image method to boundary element methods, that is, we consider a fundamental solution whose sources are (A) a line charge between infinitely wide, parallel conducting plates, and (B) a line charge outside a circular conductor.

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The Fifth Japan-China Symposium on Boundary Element Methods, Sapporo, Japan, June 1-4, 1993

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### **On the Fundamental Solution to a Helically Symmetric MHD equilibrium Problem**

M. YOSHIDA, H. IGARASHI and T. HONMA

Department of Electrical Eng., Faculty of Eng., Hokkaido University, Japan

For the numerical analysis of the MHD stability of fusion plasmas, in general, we must obtain the free boundary MHD equilibrium governed by the Laplace equation. The MHD equilibria in the stellarators can be approximated as being helically symmetric. This approximation permits us to analyze the equilibrium and stability in two dimension. Since the equilibria must be calculated for a number of different plasma geometries, the boundary element method seems to be suitable for the analysis of them.

In this paper, We derive the fundamental solution of the Laplacian described in the helical coordinates and show that it can be expressed in both an integral form and infinite series of the modified Bessel functions. We then analyze the MHD equilibria in the stellarators by the boundary element method with the fundamental solution.

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The Fifth Japan-China Symposium on Boundary Element Methods, Sapporo, Japan, June 1-4, 1993

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### **An Analysis of the Axisymmetric Ion Engine Using Boundary Element Method**

T. HONMA, Y. OKUBO, A. FUKAYA and H. IGARASHI

Department of Electrical Eng., Faculty of Eng., Hokkaido University, Japan

In this paper, the trajectory of ions in the nozzle of an axisymmetric ion engine is analyzed using the boundary element method. In order to obtain the ion trajectories, we iteratively solve the Poisson equation and the equation of motion. Since the boundary element method gives accurate electric field at arbitrary points in the nozzle, it seems suitable for the trajectory analysis. The shape of the plasma surface emitting the ions is determined so that the normalized perveance per hole coincides with a given value. The present method provides the dependence of the ion beam divergence angle, which characterizes the performance of the ion engine, on the normalized perveance.

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The Fifth IEEE Biennial  
Conference on Electromag-  
netic Field Computation  
(CEFC), Claremont, U. S. A.,  
August 3-5, 1993

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**A Boundary Element Analysis of Space Charge Fields  
in a Corona Device**

H. IGARASHI, S. SAKAI\*, T. NAKAMURA\*, T. MORINAGA and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Japan

\* Consumer Products Lab., Mitsubishi Electric Co., Japan

This paper describes a boundary element analysis of space charge fields in a corona device which are used to electrify a photoconductor drum and papers in electrophotographical processes. The space charge fields are governed by the Poisson equation and the equation of current continuity. In this paper, the combination of the boundary element method with the method of characteristics (MOC) provides a self-consistent solution to the above equations. Moreover, the charge density on the discharge wire, which controls the current emitted from the wire, is determined from Peek's empirical law in order to obtain the current-voltage characteristics of the corona device. The numerical results are shown to agree well with the experimental results.

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The Fifth IEEE Biennial  
Conference on Electromag-  
netic Field Computation  
(CEFC), Claremont, U. S. A.,  
August 3-5, 1993

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**An Integral Equation Analysis of Coupled Cavities  
for a Linear Accelerator**

H. TAKAHASHI, H. IGARASHI and T. HONMA  
Department of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Japan

This paper deals with computational analysis of electromagnetic fields in resonant cavities with axisymmetry in a radio frequency linear accelerator. In particular, the dependence of the modes on the distance between the cavities is investigated by using the hybrid boundary element method.

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International Union of Radio  
Science (URSI) Interna-  
tional Symposium on Electro-  
magnetic Theory Sydney,  
Australia, Aug. 17-20, 199

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**Time-Dependent Formulation of Scalar Potential Field  
with Lorentz Gauge Condition for Lossive Field**

N. YOSHIDA

Dept. of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

In the analysis of electromagnetic fields, the vector potential has important roles especially when sources exist. But for the analysis using the vector potentials, the consideration of the gauge condition becomes indispensable. I have already proposed the treatment for the Coulomb's gauge condition. In this paper, the unified formulation is presented by using the Lorentz gauge condition relating both electric and magnetic scalar potentials for lossive field.

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Institute of Electronics,  
Information and Communica-  
tion Engineering Interna-  
tional Symposium on Anten-  
nas and Propagation Sappor-  
o, Japan, Sept. 22-25, 1992

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**Formulation of Electromagnetic Fields in Spatial Network  
by Vector Potential with Lorentz Gauge Condition**

N. YOSHIDA

Dept. of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

In the analysis of electromagnetic fields and Schrödinger equation for quantum effects, the vector potential has important roles especially when sources or external magnetic fields exist. But for the analysis using the vector potentials, the consideration of the gauge condition becomes indispensable. In this paper, the unified formulation is presented by using the Lorentz gauge condition relating both electric and magnetic scalar potentials for lossive field.

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URSI International Symposium on Electromagnetic Theory, Sydney, Australia  
17-20, August 1992.

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**Time Domain Analysis of Yagi-Uda Antennas in Three-Dimensional Space Using the TD-FD Method**

T. KASHIWA, S. TANAKA and I. FUKAI  
Department of Electrical Engineering,  
Hokkaido University, Sapporo, 060, Japan

In this paper, time domain analysis of the Yagi-Uda antenna is carried out in three dimensional space using the time-domain finite-difference method. The transient field patterns were calculated for pulse inputs. The simulation shows how the waves both radiate and propagate. The physical meaning of the system can thus be easily understood. The recent advent of computers such as workstation enable us to graphically animate the simulation.

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International Symposium on Antennas and Propagation, Sapporo, Japan Sept. 22-25, 1992.

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**Full wave analysis of tapered microstrip lines using the conformal grids FD-TD method**

T. KASHIWA, M. SASAKI and I. FUKAI  
Department of Electrical Engineering,  
Hokkaido University, Sapporo, 060, Japan

In this paper, three dimensional full wave analysis of tapered microstrip lines is carried out in the time domain. The method is the conformal grids ED-TD method. Computed results are compared with experimental ones and those obtained by the finite element method. The results agree well. As a result, it is shown that the propagation characteristics are very different from those obtained through two dimensional modeling.

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International Symposium on  
Simulation and Design of  
Applied Electromagnetic Sys-  
tems Sapporo, Japan, Jan.  
26-30, 1993

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**Unified Formulation for Vector and Scalar Potential Fields  
for Lorentz Gauge Condition by using Equivalent Circuits**

N. YOSHIDA

Dept. of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

In the formulation of electromagnetic fields by the spatial network, the equivalent circuits has important roles to present the relation between each components of variables. Especially for the spatial network for the vector potentials, the consideration of the Lorentz gauge condition demands the unified equivalent circuits for the formulation relating both vector and scalar potentials.

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IEEE Antennas and Propaga-  
tion Society International  
Symposium and URSI Radio  
Science Meeting Ann Arbor,  
Michigan U. S. A., June 28-  
July 2, 1993

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**Adaptation of Spatial Network for Vector Potential  
to Electromagnetic Fields with Medium Conditions**

N. YOSHIDA

Dept. of Electrical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

In the analysis of electromagnetic fields, the vector potential has important roles. But for realizing general purpose analyses by the vector potentials, the treatment of the medium and boundary conditions should be simple. In this paper, the treatment by lumped circuit elements at each node can be performed in the spatial network for the vector potentials as same in that for electromagnetic variables.

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IEEE Antennas and Propagation Society International Symposium, University of Michigan, Ann Arbor, MI, USA June 28-July 2, 1993

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**Analysis of Microstrip Antennas on a Curved Surface Using the Conformal Grids FD-TD method**

T. KASHIWA, T. ONISHI\* and I. FUKAI

Department of Electrical Engineering, Hokkaido University, Sapporo, 060 Japan

\* Toyo Communication Equipment Co., LTD., Kanagawa, 253-01 Japan

In this paper, microstrip antennas mounted on a curved surface are analyzed using the curvilinear FD-TD method. In this analysis, the cylindrical surface is given exclusive consideration, as construction of a physical models for comparison is simple. The calculated results were compared with experimental results, and the degree of agreement appears to confirm the validity of the method and the predictions. The results for MSA on a curved surfaces are compared with planar MSA. As a result, it is shown that the input impedance and directivity differ from those for the flat case.

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URI Radio Science Meeting,  
University of Michigan, Ann Arbor, MI, USA June 28-July 2, 1993

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**Time Dependent Wave Envelope Finite Difference analysis of dielectric slabs**

T. KASHIWA and I. FUKAI

Department of Electrical Engineering,  
Hokkaido University, Sapporo, 060 Japan

In this paper, the time dependent wave envelope finite difference approach is proposed to analyze the dielectric slabs. The required amount of discretization in the  $z$  direction becomes significantly small compared with that necessary in the usual FD-TD approach which uses a direct discretization scheme. In this approach, there is no need to know the precise propagation constants and coupling constants of the component in advance, unlike in the coupled mode method. The method can be used when the reflection is small. Consequently, the method can be applied to the analysis of, for example, the weakly coupled optical directional coupler.

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The 5th International Conference on Shallow Impurities in Semiconductors: "Physics and Control of Impurities", Kobe, Japan, August 5-8, 1992

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**Partial Ferromagnetic Order in p-type (In, Mn) As Diluted  
Magnetic III-V Semiconductors**

H. OHNO

Department of Electrical Engineering, Hokkaido University,  
Sapporo 060, Japan

H. MUNEKATA, T. PENNEY, S. von MOLNÁR, and L. L. CHANG  
IBM Research Division, T. J. Watson Research Center, P. O. Box  
218, Yorktown Heights, N. Y. 10598, U. S. A.

The interaction between the conduction holes and the Mn 3d spins in a p-type (In, Mn) As, a new diluted magnetic semiconductor based on a III-V semiconductor, is manifested in the formation of partial ferromagnetic order (asperomagnetism) below 7.5 K. The formation of partial ferromagnetic order reveals itself in the hysteresis of Hall resistivity and resistivity below the critical temperature of 7.5 K as well as in the magnetic field dependence of the magnetization in the same temperature range. The coexistence of remanent magnetization and unsaturated spins in partial ferromagnetic order, the large negative magnetoresistance, and the rapid increase in the zero field resistivity at low temperatures can be explained by the formation of large bound magnetic polarons.

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Seventh International Conference on Molecular Beam Epitaxy, August 24-28, 1992, Schwabich Gmund, Germany

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**In situ Auger electron spectroscopy of carbon transient behavior on GaAs surfaces exposed to trimethylgallium**

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Surface species and its transient behavior on GaAs surfaces exposed to trimethylgallium (TMGa) have been observed directly by in situ Auger electron spectroscopy under the condition where the self-limiting growth of GaAs takes place by chemical beam epitaxy (CBE). After exposure to TMGa, the initial carbon (C) intensity related to alkyls originating from TMGa exponentially decreases with a large time constant (105 s, at 490°C), eventually reaching a steady state. The dynamic transient of surface reconstruction during this desorption process of the alkyls was observed by reflection high-energy electron diffraction. A modified atomic layer epitaxy growth showed that self-limiting growth occurs on the steady state surface.

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1992 International Conference  
on Solid State Devices and  
Materials (SSDM'93), Tsu-  
kuba, Japan, August 26-28,  
1992

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**Deep Level Characterization of Submillimeter-Wave GaAs Schottky  
Diodes Produced by a Novel In-Situ Electrochemical Process**

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Various preparation methods used for fabrication of submillimeter-wave Pt/GaAs Schottky diodes are compared with respect to deep levels present in the diode surface region. In the samples prepared by the standard electron-beam evaporation process, three process-induced deep levels were detected with the concentrations in the range of  $10^{13}$ - $10^{14}$  cm<sup>-3</sup>. On the other hand, these levels were very much reduced in the diodes produced by a new in-situ electrochemical technique. This appears to be related to the reported very low noise property of the latter diodes.

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1992 International Conference  
on Solid State Devices and  
Materials (SSDM'93), Tsu-  
kuba, Japan, August 26-28,  
1992

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**Control of GaAs Schottky Barrier Height  
by Ultrathin MBE Si Interface Control Layer**

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Interface Quantum Electronics Hokkaido University,

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An attempt is made to control the Schottky barrier height (SBH) of the Al/GaAs Schottky barrier by inserting ultrathin MBE Si interface control layer (Si ICL). Theoretical calculation of SBH is presented based on a new model. Experiments has shown that the SBH can be

varied precisely over a wide range of about 400 meV by the use of the pseudomorphic Si ICL with suitable As doping. When the Si ICL is relaxed, control becomes more difficult due to competition between the dipole resulting from ionized dopant atoms and the ionized interface states at the Si ICL-GaAs interface.

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1992 International Conference  
on Solid State Devices and  
Materials (SSDM'93), Tsu-  
kuba, Japan, August 26-28,  
1992

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**A Novel Contactless and Nondestructive Measurement Method  
of Surface Recombination Velocity on Silicon Surfaces  
by Photoluminescence**

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T. SAWADA and H. HASEGAWA  
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The surface recombination velocity,  $S$ , is usually taken to be a characteristic constant of the surface. However, we have recently shown that  $S$  is strongly dependent on the incident light intensity.

This paper presents a novel photoluminescence (PL)-based measurement method of  $S$ . By this method, the value of  $S$  under device operation conditions can be determined in a contactless and non-destructive fashion together with the energy distribution of the density ( $N_{ss}$ ) of the surface states causing recombination. The measurement principle and method of the new technique are presented as well as its application to bare and passivated Si surfaces.

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1992 International Conference  
on Solid State Devices and  
Materials (SSDM'93), Tsu-  
kuba, Japan, August 26-28,  
1992

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### **In-Situ Characterization of Compound Semiconductor Surfaces by Novel Photoluminescence Surface State Spectroscopy**

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The recently proposed novel photoluminescence surface state spectroscopy (PLS<sup>3</sup>) technique is applied for in-situ characterization of variously processed surfaces of GaAs, InP and InGaAs. Chemical etching, anodization, MBE growth and passivation give rise to U-shaped surface state density distributions with characteristic charge neutrality energy levels,  $E_{HO}$ , being consistent with the disorder induced gap state model. As or P escape by annealing leads to formation of discrete levels. The effectiveness of a ultrathin MBE Si interface control layer for InGaAs MIS structures is also confirmed.

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Galium Arsenide and Related  
Compounds 1992, Karuisawa,  
Japan, Sept. 28-Oct. 2, 1992

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### **Investigation of valence band offset modification at GaAs-AlAs and InGaAs-InAlAs heterointerfaces induced by Si interlayer**

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Hokkaido University, Sapporo 060, Japan

The apparent band offset changes caused by insertion of Si interlayers are studied by XPS and found to be large for GaAs-AlAs and much smaller for  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As-In}_{0.52}\text{Al}_{0.48}\text{As}$ . A detailed computer simulation based on the delta-doped interface model shows that the observed  $E_V$  changes are not real ones due to interface dipole as reported previously, but only apparent ones resulting from modification of XPS signals caused by the sharp band bending at surface due to the Fermi level ( $E_F$ ) pinning and the delta-doping of Si.

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Galium Arsenide and Related  
Compounds 1992, Karuisawa,  
Japan, Sept. 28-Oct. 2, 1992

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### **Atomic Layer Epitaxy Growth of GaAs/InAs Superlattice Structures**

S. GOTO, J. ISHIZAKI, T. FUKUI and H. HASEGAWA  
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Interface Quantum Electronics, Hokkaido University,  
Sapporo, 060 Japan

GaAs and InAs are grown successfully, for the first time, by atomic layer epitaxy (ALE) at the same growth temperature using TEGa, TMIIn and AsH<sub>3</sub>. Both GaAs and InAs growth rates saturated to 1ML/cycle with respect to the supply pressure of TEGa and TMIIn. But clear saturation was not seen with respect to injection pulse duration, revealing instead the existence of an initial rapid reaction region and a subsequent slow reaction region. This result was explained by a new alkyl-desorption rate limited growth model. GaAs/InAs superlattice structures are also grown on InP substrates. Clear superlattice satellite peaks are obtained.

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Galium Arsenide and Related  
Compounds 1992, Karuisawa,  
Japan, Sept. 28-Oct. 2, 1992

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### **In-Situ Photoluminescence Characterization of Growth Interrupted Interfaces of MBE GaAs**

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The recently proposed photoluminescence surface state spectroscopy (PLS<sup>s</sup>) technique was successfully applied for the first time for growth interrupted interfaces of MBE GaAs. By using a sample structure having a thin AlGaAs cap layer, recombination at the sample surface becomes negligible and in-situ contactless optical determination of the interface state density at growth interrupted interfaces becomes possible. The result indicates that the previously observed carrier depletion/accumulation anomaly around the interface is caused not by incorporation or redistribution of shallow impurities, not by formation of discrete deep levels, but by appearance of continuous U-shaped states at growth interrupted interfaces.

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3rd International Conference  
on Solid State and Integrated  
Circuit Technology (ICSIT'  
92), Beijing, China, Oct. 18-  
24, 1992

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**In-Situ Characterization and Control of  
Compound Semiconductor Surfaces and Interfaces  
for Completely UHV-Based Nanostructure Fabrication**

H. HASEGAWA, T. SAWADA, T. SAITOH, S. KODAMA,  
M. AKAZAWA and H. FUJIKURA  
Research Center for Interface Quantum Electronics and  
Department of Electrical Engineering  
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Novel UHV-based in-situ characterization and control techniques of compound semiconductor surfaces and interfaces for a completely UHV-based future fabrication/characterization system for semiconductor nanostructures are presented and discussed. For characterization, a novel photoluminescence based surface state spectroscopy technique is presented and, for interface control, use of ultrathin MBE Si interface control layer (ICL) is discussed.

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International Conference on  
Science and Technology of  
Electron Devices, Kruger  
National Park, Republic of  
South Africa, Nov. 16-18,  
1992

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**In-Situ Characterization and Control of  
GaAs and InGaAs Surfaces and Interfaces  
for Completely UHV-Based Nanostructure Fabrication**

H. HASEGAWA, T. SAITOH, M. AKAZAWA  
H. FUJIKURA and T. SAWADA  
Research Center for Interface Quantum Electronics and  
Department of Electrical Engineering  
Hokkaido University, Sapporo, 060 Japan

There exist increasing interests in semiconductor nanostructures for scaled down devices as well as for future quantum devices and integrated circuits. In nanostructures, surfaces and interface play far more important roles than in the present-day devices. However, except for a few nearly ideal hetero-interfaces, surfaces or interfaces of compound semiconductors gener-

ally possess high density of gap states, resulting in the so-called Fermi level pinning.

This paper presents novel UHV-based in-situ characterization and control techniques of GaAs and InGaAs surfaces and interfaces. The experiment was done in a UHV-based system consisting of MBE, CVD, XPS, metal-deposition, gas exposure and PL chambers all connected by a UHV transfer chamber.

The new technique used for in-situ surface characterization is the photoluminescence surface state spectroscopy (PLS<sup>3</sup>) technique. It consists of a detailed measurement of the band-edge PL efficiency (defined as the PL intensity divided by excitation intensity) vs. excitation intensity, followed by a rigorous computer analysis to determine the surface state density ( $N_{ss}$ ) distribution. The principle relies on the remarkable sensitivity of the photo-induced unpinning behavior of the surface Fermi level on the  $N_{ss}$  distribution. This technique allows for the first time a contactless and nondestructive assessment of virgin and processed "free" surfaces. The results obtained on epitaxial, regrown, wet and dry etched, metal-deposited and passivated surfaces of GaAs and InGaAs are presented and discussed.

An in-situ control of interfaces utilizes an ultrathin MBE Si interface control layer (Si ICL). The technique was applied successfully to remove of Fermi level pinning at insulator semiconductor interfaces and to control of Schottky barrier heights at metal-semiconductor interfaces. Preparation and properties of interfaces having Si ICL, their in-situ characterization by PLS<sup>3</sup> technique and their applications to fabrications of quantum wire structures are presented and discussed together with the underlying mechanism of interface control.

The novel techniques can be utilized in a future completely UHV-based fabrication system of nanostructures where all the necessary processing and characterization steps are done in-situ in a UHV-based system without exposing the sample surface to air at any time.

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International Conference on  
Science and Technology of  
Electron Devices, Kruger  
National Park, Republic of  
South Africa, Nov. 16-18,  
1992

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### **Technology Developments of AlGaAs Transistors, Sensors and ICs operate up to 500°C**

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In this paper first the the relevant reliability problems of ohmic and Scottky contacts to GaAs and of total surface encapsulation by  $Si_3N_4$  are discussed. Various diffusion barrier concepts such as those based on  $LaB_6$  are used to achieve high temperature stability. Then, the high temperature performance of MESFETs, HEMTs, HBTs and the bipolar mode field effect transistor (BRFET) are described as high temperature devices. A number of sensors are presented which measure pressure, temperature, position and other useful parameters at

temperatures up to 500°C. All these developments are possible with AlGaAs since its wide energy gap gives only relatively small leakage currents at elevated temperatures.

There is a growing need for intelligent sensors and smart actors working at these high temperatures well beyond the usual temperature allowance for the normal semiconductor devices. Here, devices must also be designed differently.

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Conference on Advanced  
Heterostructure Transistors,  
Keauhou, Kona, Hawaii,  
Nov. 29-Dec. 4

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### **Control of Compound Semiconductor Interfaces by Si Interface Control Layer and Its Applications**

H. HASEGAWA, M. AKAZAWA, S. KODAMA, K. KOYANAGI,  
S. SUZUKI, Y. G. XIE and T. SAWADA  
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In advanced heterostructure transistors, electronic properties of the surfaces and interface play dominant roles. It is even more so, as the device dimensions are reduced into nanometer range either towards ultimate scaling of present-day devices or towards exploitation of quantum effects. The purpose of this paper is to report on the efforts to control the compound semiconductor interfaces by using of a ultrathin MBE Si interface control layer (Si ICL)[1]. Main topics are listed below :

(1) Unpinning of Fermi level on InGaAs surface by Si ICL and its applications: A recently reported side-gating in GaAs quantum wires is most probably due to surface states, indicating importance of passivation also in quantum regime. In the present study, a Si ICL is inserted between InGaAs and SiO<sub>2</sub> to achieve better surface passivation. Its preparation consists of MBE growth of InGaAs, MBE growth of Si ICL on InGaAs, partial oxidation of Si ICL and deposition of photo-CVD SiO<sub>2</sub> layer using ArF excimer laser. Crucial factors to minimize the interface state density are maintenance of pseudomorphic lattice matching between Si ICL and InGaAs, and minimization of subcutaneous oxidation of InGaAs by photo-excited oxygen radicals, particularly, selective oxidation of Ga. An attempt of a monolayer level control of the interface profile by an improved process was made. A complete unpinning was realized by the optimized structure and processing conditions. This technique has been successfully applied to InGaAs MISFETs and InGaAs quantum wire structures.

(2) Control of GaAs Schottky barrier heights by Si ICL: Based on the DIGS model for Schottky barrier formation [2], attempts were made to control the Schottky barrier heights (SBH) by Al/Si ICL/GaAs structures. If Si ICL is pseudomorphic and the Si ICL/GaAs interface is free from pinning, SBH should be controlled over a wide range by high-level doping. Indeed, an overall variation of SBH of about 400 meV was achieved with excellent diode behavior and reproducibility. Above the critical layer thickness of Si (10 Å), the behavior can

be explained by a theory taking account of interface states at Si ICL/GaAs interface.

(3) Control of band line-ups by Si ICL: Attempts were made to control the band line-ups at GaAs/AlAs and InGaAs/InAlAs interfaces by Si ICL. The samples were prepared by MBE, and the valence band discontinuity was determined by XPS. Remarkable apparent change of band discontinuity was obtained in agreement with Sorba et al [3]. However, anomalies were found in XPS signals which can be explained not by the intrinsic dipole shift mechanism [3] but by a new delta doped interface model involving no intrinsic change in band line-up. The new model is based on sharp band-bending due to surface Fermi level pinning and high Si doping. Possibilities of band line-up controlled by doped Si ICLs are then discussed.

[1] H. Hasegawa et al, Jpn. J. Appl. Phys., Vol. 27 (1988), L2265.

[2] H. Hasegawa and H. Ohno, J. Vac. Sci. Technol. B4 (1986), 1130.

[3] L. Sorba et al, Phys. Rev. 43, 2450.

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Second International Symposium on "New Phenomena in Mesoscopic Structures",  
Kauai, Hawaii, Dec. 7-11,  
1992

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**In-Situ Characterization of Fabrication Processes for  
Compound Semiconductor Nanostructures Based on  
Photoluminescence Surface State Spectroscopy**

H. HASEGAWA, T. SAITOH, S. TOHDOH, H. FUJIKURA and T. SAWADA

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In nanostructures used for mesoscopic electronics, surfaces and interface play far more important roles than in the presentday devices. The processing steps for nanostructure fabrication are generally applied to surfaces, and they produce electronically active surface or interface states, reflecting surface reconstruction or surface damages of varying characters and degrees. Capture and emission of electrons by such process induced surface or interface states interfere with wave-motions of electrons. The far reaching depletion layer due to surface or interface Fermi level pinning tends to push electrons out from closely spaced nanostructures. Side-gating takes place in GaAs quantum wires due to surface states. However, there exists no method to assess processed "free" surfaces quantitatively.

The purpose of this paper is to present a new photoluminescence (PL) surface state spectroscopy technique which allows, for the first time, in-situ, non-destructive and contactless measurements of surface state distributions on the processed free surfaces. The method has been applied to various processing steps for fabrication of GaAs, InP, AlGaAs and InGaAs nanostructures, including crystal growth and regrowth, wet and dry etching, thermal annealing, chemical surface treatments, electron and ion beam exposure, oxidation and insulator and metal deposition.

The new method consists of a detailed measurement of excitation intensity dependence of the band-edge PL efficiency and a subsequent rigorous computer analysis. The basic principle and data analysis procedure have been presented elsewhere [1]. Photoluminescence is widely used for assessment of surfaces and quantum structures. However, PL intensity analysis has been only qualitative due to lack of proper theoretical understanding. In the new technique, a rigorous PL theory is used which indicates that the previous analyses assuming a constant surface recombination velocity,  $S$ , are incorrect, and that the dependence of  $S$  on the excitation intensity indeed provides quantitative information on the properties of surface states causing surface recombination.

For measurements, a fully computer controlled PL efficiency measurement system was used. The PL chamber is connected to MBE growth, photo-CVD insulator deposition, chemical treatment, metal deposition and XPS analysis chambers by a UHV transfer chamber.

The measured surface state density distributions on freshly grown, regrown, wet and dry etched, oxidized and insulator deposited surfaces of GaAs, InP, AlGaAs and InGaAs, are generally U-shaped with characteristic charge neutral minima,  $E_{HO}$ , below and above which states are donor-type and acceptor-type, respectively. The magnitudes of the density are, however, strongly dependent on the details of processing. Carrier profile anomaly associated with regrowth is attributed to formation of such U-shaped state continuum. Ion irradiation causes strong Fermi level pinning at  $E_{HO}$ . The result is consistent with the DIGS (disorder-induced gap state) model concerning the Fermi level pinning phenomena [2]. Thermal annealing of bare surfaces produces stoichiometry related discrete levels. The implications of the present method on possible surface effects in the assessments of quantum structures by photoluminescence are also discussed.

[1] T. Saitoh, H. Iwadate and H. Hasegawa, *Jpn. J. Appl. Phys.*, 30 (1991), 3750

[2] H. Hasegawa and H. Ohno, *J. Vac. Sci. Technol.*, B4 (1986), 1130.

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The International Symposium on Nonlinear Phenomena in Electromagnetic Fields (ISEM), Sapporo, Japan, Jan. 26-30, 1993

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**Towards Microelectronics in Quantum Regime (Invited)**  
**—Key Issues and Roles of Simulation—**

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The current status and future trends of research toward construction of novel microelectronics in the quantum regime are reviewed. Attempts are made to identify the key research issues and future roles of simulation for success of such research efforts.

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The Second Japan-Korea Joint Symposium Quantized Electronic Structures of Semiconductors, Jeonju, Korea, February 11, 1993

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**Diluted Magnetic III-V Semiconductor, (In, Mn) As, and Its Heterostructures**

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A new diluted magnetic semiconductor based on a III-V compound, (In, Mn) As, is described. Epitaxial films of p-type (In, Mn) As exhibited partial ferromagnetic order at low temperatures. The coexistence of remanent magnetization and unsaturated spins in partial ferromagnetic order, and the large negative magnetoresistance can be explained by the formation of large bound magnetic polarons. Formation of such order in the (In, Mn) As heterojunction system is also reported.

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The Royal Society, Discussion Meeting on Semiconductor Growth, Surfaces and Interfaces, London, March 3-4, 1993

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### **In-Situ Characterization and Control of Compound Semiconductor Interfaces**

H. HASEGAWA

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Formation of semiconductor interfaces for nano-structure devices requires an entirely UHV-based integrated fabrication/characterization system to achieve atomic-scale perfection. This paper discusses recently developed characterization and control techniques for use in such a system. The process characterization technique is based on photoluminescence and determines the surface state density distribution on processed "free" surfaces of semiconductors. The interface control technique utilizes an ultrathin MBE Si interface control layer and has been applied to insulator-semiconductor, metal-semiconductor and semiconductor-semiconductor interfaces.

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5th International Conference on Indium Phosphide and Related Materials (IPRM'93), Paris, France, April 19-22, 1993

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### **Control of Structure and Properties of Compound Semiconductor Interfaces by Si Interface Control Layer (Invited)**

H. HASEGAWA, S. KODAMA, K. KOYANAGI and M. AKAZAWA  
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In the semiconductor nanostructures used either for ultimate scale-down of the present-day devices or for fabrication of quantum devices, roles played by surfaces and interfaces becomes greater than in the present-day devices both in favorable and unfavorable directions. Potential differences at surfaces and interfaces are utilized in many of the sophisticated advanced devices. On the other hand, surface and interface states in the energy gap cause many unwanted effects including the so-called Fermi level pinning phenomenon.

The purpose of the present paper is to review the current status of our recent attempts to

control the structure and properties of compound semiconductor interfaces by ultrathin Si interface control layer (Si ICL). Control of insulator semiconductor (I-S), metal-semiconductor (M-S) and semiconductor-semiconductor (S-S) interfaces are discussed.

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5th International Conference  
on Indium Phosphide and  
Related Materials (IPRM'  
93), Paris, France, April 19-  
22, 1993

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**Properties of InP Grown by Migration-Enhanced Epitaxy  
Using Polycrystalline InP as Phosphorus Source**

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$\text{In}_x\text{Ga}_{1-x}\text{As}$  lattice-matched or pseudomorphic to InP, is an attractive electronic and optoelectronic material. It is therefore, desirable and uneful, if InGaAs and InP can be grown in the same standard MBE system. However, such is known to be difficult due to the high vapor pressure of red phosphorus. Recently, we have shown that poly-crystalline InP is a useful phosphorus source (1-3) for such a purpose, and particularly suitable for migration-enhanced epitaxy (MEE) mode (4).

The purpose of this paper is to present and discuss the crystal-line quality and electrical properties of InP grown by the MEE mode. Electrical properties which are strongly dependent on growth temperature, are explained in terms of the "impurity conduction" through the residual stoichiometry-related donor defects.

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SOTAPOCS XVIII,  
Honolulu, Hawaii, May 18,  
1993

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**Control of Compound Semiconductor Interfaces  
by Si Interface Control Layer and Its Applications**

H. HASEGAWA, S. KODAMA, K. KOYANAGI and M. AKAZAWA  
Research Center for Interface Quantum Electronics  
and Department of Electrical Engineering  
Hokkaido University, Sapporo, 060, Japan

Understanding and control of semiconductor interfaces are of prime importance in nano-

structure devices. This paper discusses the recently developed interface control techniques for compound semiconductors. It utilizes an ultrathin MBE Si interface control layer and has been applied to insulator-semiconductor, metal-semiconductor and semiconductor-semiconductor interfaces. The entire processing is done in an entirely UHV-based integrated fabrication/characterization system to achieve atomic-scale perfection. The details of processing, properties of interfaces and possible applications are discussed.

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The 1993 Electric Materials  
Conference, Santa Barbara,  
CA, June 23-25, 1993

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### **In-Situ Characterization of Compound Semiconductor Surfaces, Interfaces and Quantum Structures by Photoluminescence Surface State Spectroscopy**

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Department of Electrical Engineering, Hokkaido University  
North-13, West-8, Sapporo 060, Japan

There exist increasing interests in a UHV-based total system for growth, fabrication and characterization of semiconductor nanostructures. However, there exists at present no established way to characterize the electronic quality of the surfaces and interfaces used for fabrications of nanostructures without breaking vacuum.

The purpose of this paper is to present and discuss a novel photoluminescence (PL) surface state spectroscopy which allows *in-situ* characterization of compound semiconductor surfaces, interfaces and quantum structures. Unlike previous PL measurements which were only qualitative, the new technique allows for the first time quantitative, contactless and non destructive assessments.

The new technique consists of a detailed measurement of the quantum efficiency of the band edge or quantum structure photoluminescence as a function of the excitation intensity followed by a rigorous computer analysis to determine the surface/interface density distributions. The principle relies on the remarkable sensitivity of the photo-induced unpinning behavior of the surface/interface Fermi level on the state distributions. In spite of its multi-parameter nature, the measurement can be calibrated easily by providing a standard sample for the standard C-V analysis.

The experiments were done on processed surfaces, regrown epitaxial interfaces and quantum wells of GaAs and AlGaAs using a UHV-based system where an *in-situ* PL chamber was connected via UHV transfer tunnel to MBE, CVD, metal-deposition, EB, FIB and XPS chambers. The MBE GaAs surface was found to have a high density of surface states which were removed by an AlGaAs cap layer. MBE growth interruption of various modes in the growth chamber and all stoichiometry preserving processings led to formation of particular type of U-shaped distributions with a characteristic charge neutrality level.

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The 21st International Conference on the Physics of Semiconductors August 10-14 1992 Beijing, China

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**Atomic Structure and Mass transport of Ag and In on Vicinal Si(111) Surfaces**

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Atomic structure and mass transport of Ag and In on  $0^\circ\sim 6^\circ$ -off vicinal Si(111) surfaces were investigated by LEED and SAM. The In overlayer on the vicinal surfaces formed a single  $4\times 1$  domain. The mass transport on the vicinal surfaces showed high anisotropy. the diffusion on the intermediate layer is strongly enhanced parallel to the step edge for Ag adatoms, while it is remarkably suppressed perpendicular to the step edge for In adatoms.

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Second Pacific Rim International Conference on Artificial Intelligence, Seoul, September 15-18, 1992

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**Noncopying Term Rewriting and Modularity of Termination**

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Department of Information Engineering, Hokkaido University, Japan

It is known that termination is *not* a “modular” property of term rewriting systems: the disjoint union of terminating term rewriting systems need not be terminating. In this paper, we show that termination *is* a modular property of “noncopying” term rewriting systems, which are a kind of graph rewriting systems: let  $\Rightarrow_R$  be the noncopying rewrite relation defined by the set  $R$  of rewrite rules; then  $\Rightarrow_{R_0\cup R_1}$  is terminating whenever  $\Rightarrow_{R_0}$  and  $\Rightarrow_{R_1}$  are terminating. Actually, we can relax the disjointness condition and allow  $R_0$  and  $R_1$  to share constructors while preserving our major result.

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Second Pacific Rim International Conference on Artificial Intelligence, Seoul, September 15-18, 1992

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### **Diagnosis of Fuzzy Logic Circuits Based on Constraint Propagation**

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A diagnostic reasoning system is given symptoms of malfunctions of a system and determines which components could possibly be responsible. In this paper, a diagnostic reasoning method for fuzzy logic circuits is proposed. We show that structures, behaviors and observations of the circuits can be represented by a set of equations and inequations. In addition, we show how diagnoses can be computed based on a set of inference rules. In order to improve efficiency, the method uses a local constraint propagation as an inference procedure. Unfortunately, it can miss some diagnoses for certain fuzzy circuits. To overcome this problem, an algorithm called extreme search is proposed. Our method is implemented in the diagnostic reasoning system *DiaLog-III*.

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International Workshop on New Models for Software Architecture '92: Reflection and Meta-Level Architecture, Tokyo, November 4-7, 1992

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### **An Algebraic Specification and an Object-Oriented Implementation of a Reflective Language**

M. KURIHARA and A. OHUCHI

Department of Information Engineering, Hokkaido University, Japan

We present an algebraic specification and an object-oriented implementation of a reflective, functional programming language called Brown. The emphasis is put on how we can specify the language abstractly (in the sense of the abstract data type theory) in equational logic, and how it is implemented in a straightforward, object-oriented way, thanks to the abstract setting.

The major part of the specification consists of a set of equations (axioms) based on a denotational semantics which models environment, continuation and metacontinuation. Basically, all the equations are presented in this paper. The specification is abstract, first order and executable by term rewriting. A straightforward implementation in Common Lisp Object

System (CLOS) is described. We believe that our specification technique will help make reflective languages easier to be understood, implemented, extended and reasoned about.

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The 20th International Symposium on Acoustical Imaging Nanjing, China September 12-14, 1992

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### **Transmission of Holographic Imaging Data of Micro-and Acoustic Waves by Communication Satellite**

Yoshinao AOKI, Ryuichi MITSUHASHI, Shin TANAHASHI and Yuji SAKAMOTO  
Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

In this paper we propose a technique for transmitting 3-D images using hologram data in the long wavelength region and an experiment of hologram data transmission was carried out utilizing a Japanese communication satellite (JCSAT-2), where frequencies used in communication are 12 and 14 GHz and communication speed is 64 Kbit/sec. A VSAT antenna of 1.8 m is used for transmitting and receiving hologram data. Image reconstruction was achieved numerically after receiving the hologram data returned from the communication satellite, where hologram data was collected using X-band microwaves by a multi-frequency method. Data conversion, transmission protocol of hologram data and display technique of reconstructed 3-D image are discussed. Degradation of the reconstructed 3-D image according to the condition of the transmission lines, for example weather condition, is investigated and techniques to improve the transmitted 3-D images in micro and acoustic wave region are discussed.

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1992 International Symposium on Antennas and Propagation Sapporo, Japan September 22-25, 1992

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### **Car-Borne Imaging Radar System**

Yuji SAKAMOTO and Yoshinao AOKI  
Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

Under bad driving conditions such as heavy rain, heavy snowfall, and fog, drivers can not adequately see the road, often resulting in traffic accidents. A car-borne imaging radar can provide an all-weather driving system. It is well known, that there is little attenuation for micro-wave transmission in snow, rain, or fog. While conventional imaging radars are both

short-pulse and real-aperture, it is difficult to reconstruct images of targeted objects over a short range. Holographic radars, however, have good resolution in such a situation. In this paper, we propose a technique for a front-looking radar which is based on holographic-radar principle. The proposed technique consists of a car-borne imaging radar using micro-waves.

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1992 International Symposium on Antennas and Propagation Sapporo, Japan September 22-25, 1992

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### **Remote Sensing Satellite Image Data Restoration Processing Without MTF**

Liu Hui, Yuji SAKAMOTO and Yoshinao AOKI  
Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

We developed an image restoration method for remote sensing satellite image data without MTF. This method is useful for American TM and French SPOT remote sensing resource satellite image processing, and additionally we were able to receive improved images or super-resolution images as well. Characteristics of remote sensing blurred images are discussed, including the limited blurring set (LBS). We discuss limited blurring set analysis (LBSA). From image-self blurring properties we estimate image restoration. Finally we discuss and show remote sensing satellite image processing results. In addition the method would be useful for digital processing of weather satellite images, sea satellite images, resource satellite images (including Japanese ERS-1, Earth Resource satellite-1), remote sensing resample images, etc.

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1992 International Symposium on Antennas and Propagation Sapporo, Japan September 22-25, 1992

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### **A Method of Automatic Image Reconstruction For Snow Search Radar**

Ryuichi MITSUHASHI and Yoshinao AOKI  
Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

Snow Search Radar System (SSRS) is a three-dimensional (3-D) imaging radar system for searching of objects under accumulated snow using multi-frequency microwave holography. Multi-frequency holography can provide good resolution on the order of one or two wave-

lengths in both directions. In order to reconstruct an image from collected SSRS's data, it is necessary to know the relative permittivity of accumulated snow. The assumed relative permittivity at X-band microwave of dry snow depends on the accurate measurement of its density. In this paper we propose a method of automatic estimation of the relative permittivity of snow utilizing certain characteristics of multi-frequency holography itself. We are able to obtaine satisfactory results concerning image reconstruction of the SSRS's data.

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The Fifth Sino—Japanese  
International Conference on  
Computer Applications Chin-  
huangtao, China September  
27-29, 1992

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**A Neural Network Classification/Recognition of Scripts  
Unaffected by Shift in Position and Change in Size**

Chen LING, Chen XUEDE, Zeng BEIKAI, Zheng ZHONG and Yoshinao AOKI\*  
College of Computer, Shenyang Polytechnic University,  
Shenyang 110021, China

\* Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

This paper has proposed a neural network model for classifying or recognizing scripts (such as handwritten characters, numerals, Chinese characters), stated its preprocessing techniques, neural network architecture, working algorithm, learning algorithm, and given experiment results for the handwritten numeral recognition and the handwritten Chinese character classification. The experiments on the handwritten numeral recognition and the handwritten Chinese character classification have been done. The satisfactory results have been obtained, and shown that the ways proposed by us are efficient.

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The Fifth Sino-Japanese  
International Conference on  
Computer Applications Chin-  
huangtao, China September  
27-29, 1992

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### **Uncertain Geometry for Model-Based Sensor Fusion**

Toshio KAWASHIMA and Yoshinao AOKI  
Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

In this paper, we deal with model-based object recognition by uncertain geometric observations using uncertain object models. The first step to the problem is to decompose the recognition process into a hierarchy of Bayes' estimation subproblems depending on sensor uncertainties and model uncertainties. The second is to preserve the consistency under model uncertainties; information loss can be avoided by adding dummy variables and constraints to geometrical descriptions. The fusion algorithm is implemented on a vision system for tracking a moving object.

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The Fifth Sino-Japanese  
International Conference on  
Computer Applications Chin-  
huangtao, China September  
27-29, 1992

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### **A Two-Dimensional Histogram of Pixel Value and the Magnitude of Gradient**

Akio OTSUKA, Yuji SAKAMOTO and Yoshinao AOKI  
Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

Recently X-Ray CT (Computed Tomography) and MRI (Magnetic Resonance Imaging) are being put to medical use. A doctor recognizes 3-D (three-dimensional) images of organs using sets of 2-D tomograms. This judgement is difficult and depends on his ability and experience. We usually use a histogram of gray-scale level to classify CT data. This is suitable for clustering a tissue having a high CT value, such as a bone. But it does not work well when we try to recognize a body having an intermediate value, such as a soft tissue, because a pixel which represents multiple tissues also has an intermediate value. We do not distinguish a "mixed" pixel from a "pure" one by only one value. In this paper, we describe the magnitude of gradient. A mixed pixel has a higher magnitude than a pure one. We propose a 2-D histogram of pixel value and the gradient magnitude. CT data is distributed distinctively on

the histogram. This graph can be used to separate a mingled pixel from a single one.

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The Fifth Sino—Japanese  
International Conference on  
Computer Applications Chin-  
huangtao, China September  
27-29, 1992

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**Gesture Description in a Dictionary for  
Intelligent Communication of Sign Language Images**

Jun XU, Yoshinao AOKI and Zheng ZHONG\*  
Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

\* College of Computer, Shenyang Polytechnic University,  
Shenyang 110021, China

Sign language is a typical example of human communication using gestures. In this paper we propose a way to describe the gestures in a dictionary for intelligent communication of sign language images. The basic component of the gesture dictionary in the intelligent transmission system was developed. This dictionary can be applied to translating Japanese into sign language; it displays an actor who speaks the given Japanese sentences by gestures of sign language words and finger alphabets.

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The Fifth Sino—Japanese  
International Conference on  
Computer Applications Chin-  
huangtao, China September  
27-29, 1992

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**An Intelligent System of Chinese Inputting and Word Processing**

Chen LING, Chen XUEDE, Zeng BEIKAI, Zheng ZHONG and Yoshinao AOKI\*  
College of Computer, Shenyang Polytechnic University,  
Shenyang 110021, China

\* Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

An intelligent system, called PyCharSys, of Chinese Inputting and Word Processing is presented. The system can automatically convert a Chinese Pinyin text without any spaces between syllables into a Chinese Character text segmented into words. The central theme of this paper is a description of a neural network selection of Chinese homophones. A special

model of neural networks for selecting Chinese homophones is given, which computes in the logic derived from the basic backpropagation. Several important issues, such as the knowledge representation in natural languages, the organization and management of great number of neural networks with the same model, and the training of neural networks, are discussed. A new term "ANN Base" (Artificial Neural Network Base) is proposed, which will be necessary to organize and manage the knowledge represented in form of Neural Networks very well.

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The Second International  
Symposium on Measurement  
and Control in Robotics,  
Tsukuba, Japan November  
15-19, 1992

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### **Sensor Fusion System for Model-Based Object Tracking**

Toshio KAWASHIMA, Takeshi NAGASAKI and Yoshinao AOKI  
Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

In this paper, a model-based multi-sensor tracking system for a moving articulated object is reported. The system consists of a hierarchy of part-trackers, communicating state information each other, and local feature sensors supervised by the part-trackers. Each part-tracker tracks a rigid part of an object supervising a group of local feature sensors. Partial estimations are sent to other part-trackers and integrated under geometric constraints between rigid subparts. After the integration is completed, the result is transferred backward to backward to each subpart to maintain consistencies between subparts. The shape and articulation of an object are described as equations of the state parameters between parts; in the equations, articulation is represented as dummy parameters and dummy constraints. The fusion method is implemented on a parallel vision system and experimental results are presented for simulated data and actual images.

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IAPR Workshop on Machine  
Vision Applications Tokyo,  
Japan December 7-9, 1992

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**Development of a System for Producing Stereo Ground Models  
by Optical Lithography**

Yoshinao AOKI, Shin TANAHASHI, Osamu KINOSHITA and Hideaki NAKAMURA\*

Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

\* Hokkaido Chizu Co. Ltd, Asahikawa, Japan

This paper presents a method of controlling ultraviolet rays by utilizing mask patterns for producing stereo ground models. The LCD display system was developed as a substitute for a mask pattern sheet. Usually an ultraviolet laser and raster scanning are used when producing stereo models by optical lithography. However, this method has some drawbacks such as lengthy procedures when producing large objects and the high cost of optical lithography machinery. We can produce objects more speedily by using a mask pattern sheet and a low cost lamp can be used in the place of a UV laser.

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IAPR Workshop on Machine  
Vision Applications Tokyo,  
Japan December 7-9, 1992

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**Generating Hierarchical Aspect Graph Using Silhouettes of Curved Objects**

Satoru MORITA, Toshio KAWASHIMA and Yoshinao AOKI

Department of Information Engineering, Hokkaido University,  
Sapporo 060, Japan

This paper introduces a new approach for computing a hierarchical aspect graph of curved objects. One of the problem of the aspect graph is that the aspect graph is sometimes so complex that much time is required to identify the posture of an object in accordance with its complexity. We introduce the concepts of the hierarchical description to aspect graph. A viewpoint space are divided into 2 or 3 regions at the top level, and each region is partitioned into more detailed regions in the lower level. In particular, characteristic deformations occur in the neighbourhood of a cusp point as the viewpoint moves. We analyze the division types of the viewpoint space in multiresolution to generate aspect graph from a limited number of viewpoints. Moreover the aspect graph is automatically generated using the algorithm of the minimization criteria. This approach has been implemented and several examples are presented.

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1992 International Symposium on Antennas and Propagation (ISAP 1992), September 22-25, 1992, Sapporo, Japan

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**Performance of an adaptive array antenna  
with a systolic array processor**

Manabu OHMIYA, Tatsuya KAWABATA, Yasutaka OGAWA and Kiyohiko ITOH  
Department of Electronic Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

The multipath signal suppression performance of an adaptive array (SAP-AA) using a systolic array processor (SAP) is analyzed by a computer simulation. With an SAP, a parallel pipeline process can be realized by regularly placing SAP cells with identical functions and structures so that the throughput in the data processing can be improved. Also, the SAP is suitable for VLSI design and enables miniaturization, weight reduction and mass production of the processing equipment. This paper describes the SAP-AA which realizes the least squares (LS) algorithm based on the QR decomposition of the input data matrix by the Givens transformation. Further, the transient response and the steady-state performance are investigated when an SAP-AA is used for multipath signal suppression. From the above discussion, it is concluded that the SAP-AA is effective for unwanted signal suppression in a multipath signal environment.

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1992 International Symposium on Antennas and Propagation (ISAP 1992), September 22-25, 1992, Sapporo, Japan

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**Theoretical Consideration on Parallel-Plate  
Waveguide Modes of a Slot Antenna with a Reflector**

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Hokkaido University, Sapporo 060, Japan

A slot antenna which has a reflector is widely used as an element of antenna arrays. However, parallel-plate waveguide modes are excited by the slot and propagate between a conductor on which the slot is cut and the reflector. The higher parallel-plate waveguide modes affect the radiation characteristics of the slot, such as the degradation of the radiation efficiency and input impedance. An aim of this paper is to make a mechanism of the excita-

tion of the parallel-plate waveguide modes clear theoretically. Moreover, this paper presents and discusses numerical results obtained by the Galerkin's method in spectral domain.

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1992 International Symposium on Antennas and Propagation (ISAP 1992), September 22-25, 1992, Sapporo, Japan

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### **A Consideration on the Thin Planar Antenna Analysis with Wire-Gird Model**

Nozomu ISHII, Kiyohiko ITOH  
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Hokkaido University, Sapporo 060, Japan

The card-sized receiver has indeed just the right geometry for the personal communication, because we can carry this type of the receiver anywhere. The development and researches of the antenna for the card-sized receiver are urgently required. We analyze the antenna using the method of moment for its the wire-grid model, and we evaluate the performance of the antenna focusing the validity of the radius and the grid division of the wire-gird model. As the results, we show that the wire-grid model is very sensitive for the radii of the wires of the grid and the grid geometry.

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1992 International Symposium on Antennas and Propagation (ISAP 1992), September 22-25, 1992, Sapporo, Japan

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### **A Continuous Measurement System of $G/T$ for Satellite Broadcasting Receivers**

Yuliman PURWANTO, Yasutaka OGAWA, Kiyohiko ITOH  
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Hokkaido University, Sapporo 060, Japan

Rain and snow directly affect the performance of receiving antennas. The performance of satellite broadcasting receivers is determined by a parameter  $G/T$  ( $G$ =antenna gain,  $T$ =equivalent noise temperature at the output port (K)), which is commonly called the *figure of merit*. Since the weather condition always changes, it is important to obtain the  $G/T$  values continuously to examine the effect of the weather to the satellite broadcasting receivers.

Moreover, the study needs to investigate the performance of various types of antennas simultaneously. Therefore, a continuous measurement system of the  $G/T$  values for several satellite broadcasting receivers for a long period is absolutely needed. The conventional method of  $G/T$  measurement cannot perform a continuous measurement because the antenna noise can not be measured continuously. To solve the noise measurement problem, we propose a *noise estimation* method. Using this method, a continuous measurement of  $G/T$  can be performed, and we can measure more than one receiving system almost simultaneously so that a comparison of the figure of merit for various types of antennas can be performed. No special site is needed to perform the measurement.

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1992 International Symposium on Antennas and Propagation (ISAP 1992). September 22-25, 1992, Sapporo, Japan.

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### **A Time-Domain Superresolution Technique for Scattering Measurements**

Hiroyoshi YAMADA, Yasutaka OGAWA and Kiyohiko ITOH  
Department of Electronic Engineering,  
Faculty of Engineering, Hokkaido University,  
Sapporo 060, Japan

For understanding scattering phenomena, it is important to detect scattering centers. In network analyzer measurements, the resolving scattering centers from frequency-domain data has been realized by the Fourier transform. However, its resolution is limited by the frequency bandwidth. In this paper, we apply a superresolution technique to detect the scattering centers. Especially, applicability of the method to the back scattering measurement of a conductive sphere is described. Furthermore, simulation results show that data calibration utilizing time-domain gating can improve a signal-to-noise ratio, and that the method is available for few snapshot data. The resolution capability of the technique is also verified with experiments.

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1992 International Symposium on Antennas and Propagation (ISAP 1992), September 22-25, 1992, Sapporo, Japan

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### **A Superresolution Technique for Antenna Pattern Measurements**

Yasutaka OGAWA, Teruaki NAKAJIMA, Hiroyoshi YAMADA, and Kiyohiko ITOH  
Department of Electronic Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

In measurements of a radiation pattern for a large aperture antenna, a measurement system must be constructed outdoors to achieve a far-field range. In this case, reflected signals from the ground and other objects often impinge on the antenna, and the measured data are disturbed by them. Time-domain superresolution techniques have been developed to resolve the reflected signals, and to eliminate them for narrowband antennas. In this paper, we propose a new time-domain superresolution method which employs the MUSIC (Multiple Signal Classification) algorithm accompanied with the fast Fourier transform and the gating technique. The new method can resolve closely located signals using fewer snapshots than the conventional superresolution technique. The new technique is useful for antenna pattern measurements because it saves the measurement time.

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Proc. of 10th International Sympo. High Energy Spin Physics, Nagoya Japan, November 9-14, 1992

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### **Detection of Optically Pumped Spin-Polarized Electrons by STM**

Kazuhisa SUEOKA, Kōichi MUKASA, Kazunobu HAYAKAWA\*  
Faculty of Engineering, Hokkaido University  
Sapporo 060 Japan

\* Catalysis Research Center, Hokkaido University

A preliminary experiment of the spin-polarized scanning tunneling microscope (SP-STM) with optically pumped GaAs was performed. With a thin GaAs sample and a ferromagnetic Ni tip, tunneling current variation was observed, having its origin the fact that the excited carriers in the GaAs and the Ni electron states were spin-polarized. The tunneling current depends upon both spin-polarizations. This experimental result suggests that a GaAs tip illuminated by circularly polarized light is useful for imaging surface spin polarization of mag-

netic materials in high lateral resolution.

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INTERMAG '93 Stockholm,  
Sweden April 13-16, 1993

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**Observation of Spin Polarized Photo-Induced Tunneling  
Electron in Scanning Tunneling Microscope With GaAs and Ni**

Kōichi MUKASA, Kazuhisa SUEOKA, Kazunobu HAYAKAWA\*  
Faculty of Engineering, Hokkaido University  
Sapporo 060 Japan

\* Catalysis Research Center, Hokkaido University

Scanning Tunneling Microscope (STM) is the powerful tool for surface property investigations of several materials and has much potential possibility. Recently its application for observing surface magnetism with the atomic scale has attracted the attention and a few attempts to see the spins on surface were reported. Here we demonstrate the perturbation of spin polarized tunneling current by external circularly polarized light by means of STM in air with Ni tip and thin GaAs that is epitaxially grown on AlGaAs by MBE. If we use GaAs as a sample and Ni as a tip and negative bias is applied to the tip, spin polarized tunneling electrons in Ni tunnel into GaAs and its tunneling probability depends on the concentration of the electrons in the conduction band excited by external circularly polarized light. Excited electron itself has a tunneling probability into spin polarized empty state of the Ni. Then the resultant current is perturbed by the pumping light

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The Second Japan-Hungary  
Joint Seminar on Applied  
Electromagnetics in Mate-  
rials and Computational  
Technology, Sapporo, Japan,  
Sept. 16-18, 1992

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**Numerical Analysis of Curved Optical Waveguides by the  
Finite-Element Method**

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Hachioji, Tokyo 192, Japan

\*\* Department of Electronic Engineering, Hokkaido University,  
Sapporo 060, Japan

A numerical approach based on the finite-element method is described for the analysis of

curved optical waveguides. Both TE-like and TM-like modes are systematically formulated. Numerical examples on the propagation characteristics of curved rib waveguides are given. Our results for curved rib waveguides with rectangular cross section agree well with the results of the method of lines. We also demonstrate the application of this approach by analyzing curved rib waveguides with trapezoidal cross section.

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1992 International Symposium on Antennas and Propagation, Sapporo, Japan, Sept. 22-25, 1992

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**Analysis of Discontinuities in a Multilayer Waveguide by  
Combination of Finite-Element and Boundary-Element Methods**

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Technology, Kitami 060, Japan

\*\* Department of Electronic Engineering, Hokkaido University,  
Sapporo 060, Japan

A numerical approach based on a combination of the finite-element and boundary-element methods is described for the analysis of discontinuities in a slab waveguide with any number of layers. Here all the eigenmodes in a slab waveguide are taken into account. To show the validity and usefulness of this approach, computed results are given for the coupling between a five-layer laser and a four-layer passive waveguide monolithically integrated.

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The 7th INTERNATIONAL  
SYMPOSIUM ON NOVEL  
AROMATIC COMPOUNDS.  
Victoria, British Columbia,  
CANADA July 19-24, 1992

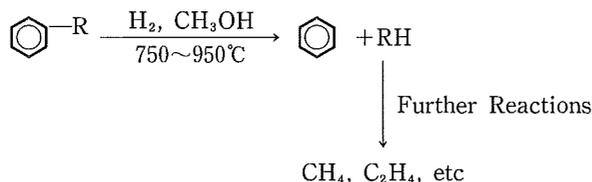
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**Non-Catalytic thermal hydrodealkylation of  
alkylbenzenes with hydrogen in the presence  
of methanol under normal pressure**

Norihiko YONEDA, Toshiyuki SATOH,  
Hironori ITOH, Masataka MAKABE, and the late Kimiji OUCHI  
Department of Applied Chemistry, Faculty of Engineering,  
Hokkaido University, Sapporo 060 Japan

Thermal hydrodealkylation of alkylbenzenes was successfully carried out in hydrogen atmo-

sphere in the presence of methanol at 750–950°C to afford benzene in good yields; this had a remarkably lower formation of condensed products, carbon deposit and tarry materials compared with these of the reactions without methanol.



Nascent hydrogen generated in situ by the pyrolysis of methanol may play an important role for the hydrodealkylation of alkylbenzenes effectively.

Application of this hydrodealkylation procedure has led to a useful process for simplifying the composition of coal liquid, which contained complicated various aromatic compounds including alkylbenzenes.

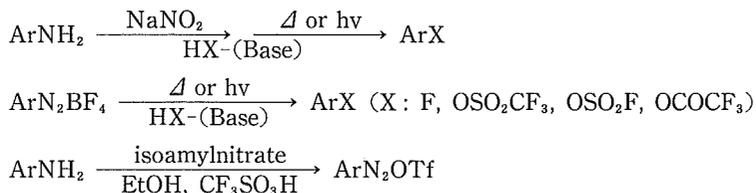
The 10th European Symposium on Fluorine Chemistry.  
Padua, Italy. September 20–25, 1992

**Diazonation and dediazonation of aminoarenes in fluorine-containing strong acids: A facile preparation of arenes having fluorine-containing functional groups**

Norihiko YONEDA and Tsuyoshi FUKUHARA  
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Hokkaido University, Sapporo, 060 Japan

Aromatic (including heterocyclic) compounds having fluorine-containing functional groups (ArX: X=F, OSO<sub>2</sub>CF<sub>3</sub>, OSO<sub>2</sub>F, OCOCF<sub>3</sub>) have been prepared in good yields by the diazonation of the corresponding aminoarenes (ArNH<sub>2</sub>) and the thermal or photochemical decomposition in situ in fluorine-containing strong acids (HX) with or without bases, or dediazonation of arenediazonium tetrafluoroborate salts (ArN<sub>2</sub>BF<sub>4</sub>) in HX-(Base).

Novel arenediazonium triflates (ArN<sub>2</sub>OTf) have been prepared in good yields by non-aqueous state diazotization of ArNH<sub>2</sub> in EtOH with isoamyl nitrate in CF<sub>3</sub>SO<sub>3</sub>H. Decomposition of ArN<sub>2</sub>OTf will be also described to afford the corresponding ArOSO<sub>2</sub>CF<sub>3</sub>.



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The 204th ACS National Meeting, International Symposium of Cellulose Polymorphs Washington D.C. USA Aug. 23-28, 1992

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### **Irreversible Change from Cellulose I $\alpha$ to I $\beta$ Families**

Jisuke HAYASHI, Nanae ARAI, and Keizou MICHIHATA  
Faculty of Engineering, Hokkaido University

It was found that Na-cellulose I and cellulose III prepared from cellulose I $\alpha$  of valonia etc. and I $\beta$  of plants were different each other on their  $^{13}\text{C}$  NMR spectra. And they were regenerated into their original structure, I $\alpha$  and I $\beta$ . Na-cell I $\alpha$  irreversibly changed into Na-cell I $\beta$  just like from cellulose I $\alpha$  to I $\beta$ . The cause of the irreversibility should be due to a characteristic structure of an individual chain that is common within each family. Because of that I $\alpha$  and I $\beta$  both have parallel chain structure, the characteristic structure should be chain conformations.

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The 8th International Cellulose Conference Lund, Sweden, June 21-24, 1993

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### **Synthesis and Characterization of Bacterial Cellulose Composite (BCC)**

K. TAJIMA, M. FUJIWARA, M. TAKAI and J. HAYASHI  
Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

We succeed in preparing an incorporated BC (BC composite) with water-soluble polymer, such as carboxymethyl cellulose (CMC) or methyl cellulose (MC) by adding water-soluble polymer into the standard medium of *Acetobacter xylinum* (*A. xylinum*). The contents of WSP were 10-20 Wt% in BC composite (MC) and 40-45 Wt% in BC composite (CMC). Young's modulus of BC composites was about 1-3 times that of normal BC (30-40 GPa). And BC composites were almost degraded in soil for 28 days as well as normal BC.

This preparation method will be applied to synthesis a new type of BC having both high biodegradability and other functions.

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The 8th International Cellucon Conference Lund, Sweden, June 21-24, 1993

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**Cellulose production by *Acetobacter xylinum*  
in the presence of cellulase**

T. NAKAMURA, K. TAJIMA, M. FUJIWARA, M. TAKAI and J. HAYASHI  
Faculty of Engineering, Hokkaido University

The cellulose productivity by *Acetobacter xylinum*, cellulose producing bacteria, is enhanced by a small amount of heat-denatured cellulase. The cellulase consists of many components. The heat-denatured cellulase components showed a little enhancement of cellulose productivity compared with the standard culture. In the native state, the  $\beta$ -glucosidase fraction is the most effective component for cellulose production. Enhancement of cellulose production by the cellulase is mainly caused by  $\beta$ -glucosidase component.

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The 8th International Cellucon Conference, Lund, Sweden, June 21-24, 1993

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**Structural Change of Cellulose Polymorphs by Milling**

Kikuya KIMURA, Yu-ichi SHIMIZU and Jisuke HAYASHI  
Tomakomai Technical College and  
Faculty of Engineering, Hokkaido University

Cellulose I, II, III<sub>I</sub> and III<sub>II</sub>, all went to an amorphous state via IV by milling. For the transformation to IV heat was not always necessary and molecular motions under the relaxed intermolecular hydrogen bonds was necessary. The stabilization of the polymorphs was discussed from the decrystallization rate. Amorphous ramies milled for 80 and 100 min were recrystallized into I and II, respectively. And the cause of the irreversible change from I to II was discussed.

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The 12th International Symposium on the Reactivity of Solids, Madrid, Spain, Sep. 24-30, 1992

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**Preparation and reactivity of acicular  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> from synthetic diaspore,  $\beta$ -Al<sub>2</sub>O<sub>3</sub> · H<sub>2</sub>O**

Takeshi TSUCHIDA

Department of Applied Chemistry, Faculty of Engineering,  
Hokkaido University, Sapporo, 060 Japan

The acicular  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> (width < 4  $\mu$ m, length < 20  $\mu$ m) obtained by the thermal decomposition of synthetic diaspore at 530, 600 and 1300°C was characterized by means of XRD, SEM, FTIR, <sup>27</sup>Al MASNMR, XPS, nitrogen adsorption-desorption isotherm and BET surface area. The high adsorptive activity of  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> obtained at 530°C is attributable to its larger specific surface area (66.2 m<sup>2</sup>/g) and lower crystallinity. The dehydration kinetics of diaspore to  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> obeyed Avrami-Erofeev equation and gave activation energy of 52.4 kcal/mol.

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The 4th International Conference on Bulk Materials Storage, Handling and Transportation, Wollongong, Australia, July 6-8, 1992

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**Segregation by Multi-point Feeding of Binary Solids Mixture onto Two-dimensional Heap**

Kunio SHINOHARA and Jun SAITOH

Department of Chemical Process Engineering,  
Hokkaido University, Sapporo, Japan.

In storing particle mixture of different size and density in a heap, segregation phenomenon is inevitable to produce non-uniform spread of constituents over and inside the heap.

To know the effects of multi-point feeding and the heap descending, the segregation patterns were experimentally investigated under various operational conditions in two dimension.

In case of a static heap, the fraction increases inside the heap along the surface with higher initial mixing ratio and lower feed rate. While, in case of the descending heap, the fraction gets large with higher descending velocity. These trends become conspicuous with larger size difference and particle density.

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The 183rd Meeting of  
Electrochemical Society,  
Honolulu, Hawaii, U. S. A.  
May, 16-21, 1993

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### Shape formation of electrodeposited gold bumps

Kazuo KONDO, Toyohide MIYAZAKI\* and Youichi TAMURA\*\*

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An experimental study of shape formation of electrodeposited gold bumps is described. The bumps has been electrodeposited in cathode cavities formed by photoresist and observed by SEM. With decrease in cathode diameters formed by photoresist, photolithographic diameters, the lower and flat regions or dent depths on bump centers decrease, and elliptical hemisphere bump shapes formed. With increase in Reynold's number, the expansions in bump circumferences disappear and elliptical hemisphere bump shapes formed. The larger raises at upper flow stream formed for the Reynold's number of 44.5 and 88.9. With increase in arsenic additive amount in electrolyte, the expansions in bump circumferences and dents or lower regions on bump centers disappear and form elliptical hemisphere bumps. These effects on bump shapes, i. e. photolithographic diameter, electrolyte flow and amount of additive in electrolyte are discussed based on the current distributions in photolithographed cathodes at the initial bump formation stages.

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The 6th U. S. A.-Japan-China  
Trilateral Symposium on  
Catalysis, Beijing, China,  
June 7-11, 1993

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### Catalytic Decomposition and Selective Catalytic Reduction of Nitrogen Dioxide over Various Metal Oxides

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Department of Chemical Process Engineering,  
Hokkaido University, Sapporo 060 (Japan)

The relationship between the specific rates of the catalytic decomposition of  $\text{NO}_2$  over 18 metal oxides and the enthalpy changes ( $-\Delta H$ ) for the formation of metal oxides ( $\text{MeO}_{x-1} + 1/2\text{O}_2 \rightarrow \text{MeO}_x$ ) shows a V-shaped curve with a minimum at  $-\Delta H$  around 700 kJ/mol. The decomposition and the reduction of  $\text{NO}_2$  with  $\text{C}_3\text{H}_6$  in the presence of  $\text{O}_2$  (selective reduction) proceeded through the redox mechanism over the catalysts such as  $\text{Co}_3\text{O}_4$ ,  $\text{SnO}_2$ ,  $\text{ZnO}$  (Group

I) in descending branch of the V-shaped curve. Over the catalysts such as  $\text{Al}_2\text{O}_3$ ,  $\text{ZrO}_2$ ,  $\text{MgO}$  (Group II) in the ascending branch of the V-shaped curve, the reactions proceeded through the adsorption type mechanism and  $\text{C}_3\text{H}_6$  reacted with  $\text{NO}_2$  in preference of  $\text{O}_2$ . It was concluded, therefore, that Group II metal oxides operated by the adsorption type mechanism were more suitable than Group I metal oxides for the selective reduction of  $\text{NO}_2$  with  $\text{C}_3\text{H}_6$  in the presence of  $\text{O}_2$ .

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The XIVth IUPAC Symposium on Photochemistry, K. U. Leuven, Belgium, 1992

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**New One-Step General Syntheses of Furoquinones and Indolequinones by New [2+3] Photoaddition of 2-Hydroxy- or 2-Amino-1, 4-quinones with Alkenes**

Hiroshi SUGINOME and Kazuhiro KOBAYASHI  
Faculty of Engineering, Hokkaido University, Sapporo 060, Japan

We report a novel one-step formation of 2, 3-dihydronaphtho[2, 3-*b*]furan-4, 9-diones as well as 2, 3-dihydro-1*H*-benz[*f*]indole-4, 9-diones based on a new type of regioselective [2+3] photoadditions of 2-hydroxy or 2-amino-1, 4-naphthoquinone with alkenes in fair to high yields. Dihydrofuroquinones thus obtained, can readily be transformed into naphtho[2, 3-*b*]furan-4, 9-diones. The [2+3] adducts derived from aminonaphthoquinone with 2-methoxypropene and vinyl acetate spontaneously gave 1*H*-benz[*f*]indole-4, 9-diones in good yields.

The photoaddition was applied to a two-step synthesis of maturinone and a one-step synthesis of a kinamycin skeleton.

The reaction pathways of the photoaddition involving fused hydroquinones as the intermediates are discussed.

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The Six International Symposium on Organic Free Radicals, Noordwijkerhout, The Netherlands, 1992

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**Synthesis of Some Natural Products involving The Selective Fragmentation of Alkoxy Radicals as The Key Step.**

Hiroshi SUGINOME  
Faculty of Engineering, Hokkaido University, Sapporo 060, Japan

The utility of selective radical fragmentation in synthesis is demonstrated by presenting

some selected examples of our own syntheses of a variety of molecules, including natural products, using the fragmentation of alkoxy radicals generated by photolysis of the corresponding hypiodites at room temperature, as the key step. The classes of molecules which we have synthesized include 18 and 19-norsteroids, steroidal lactones, benzohomotropones, 18-functionalized steroids, lignans, medium-sized lactones, macrolides, phthalides, naphthalide lignans, monocyclic lactones, macrocyclic ketones, furoquinolones, furocoumarins, furochromones, 2, 3-dihydronaphtho[1, 2-*b*]furan-4, 5-diones, and sesquiterpenes.

These selected examples of the synthesis may indicate that fragmentation of the alkoxy radicals takes place in a very specific manner and has become an integral part of strategies in organic synthesis.

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The 183rd Meeting of The  
Electrochemical Society,  
Honolulu, May 16-21, 1993

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**Regioselective Synthesis of  $\beta$ ,  $\gamma$ -Unsaturated Acids by Electrochemical Carboxylation of Allylic Halides Using a Reactive-metal Anode**

Masao TOKUDA, Yoshitaka KATOH, Takashi KABUKI, and Hiroshi SUGINOME  
Department of Chemical Process Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

Electrochemical carboxylation of allylic halides in the presence of atmospheric carbon dioxide using a reactive-metal anode gave a mixture of two regioisomeric  $\beta$ ,  $\gamma$ -unsaturated acids in high yields. Similar carboxylation of substituted propargylic halides gave a mixture of  $\beta$ ,  $\gamma$ -acetylenic acid and allenic acid. The purpose of this study was to clarify the regioselectivity in these carboxylations and to control their regioselectivities. It was found that the electrochemical carboxylation of crotyl, prenyl, and geranyl halides took place exclusively at a less highly substituted carbon of allylic groups to give a single regioisomer of  $\beta$ ,  $\gamma$ -unsaturated acids, which was inaccessible by conventional carboxylation using organometallic compounds. Similar electrochemical carboxylation of propargylic halides carrying terminal acetylenic group gave exclusively the corresponding allenic acids.

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The 183rd Meeting of The  
Electrochemical Society,  
Honolulu, May 16-21, 1993

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**Carbon-Carbon Bond Formations by Electrochemical Reaction of  
Allylic Halides Using a Reactive-metal Anode**

Masao TOKUDA

Department of Chemical Process Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

Efficient carbon-carbon bond formations were achieved by electrochemical reduction of allylic halides in the presence of appropriate substrates using a reactive-metal anode such as copper, cadmium, or magnesium. Thus, the electrochemical allylation of aldehydes or ketones and carboxylic acid derivatives by the use of a reactive-metal anode gave the corresponding homoallyl alcohols and  $\beta$ ,  $\gamma$ -unsaturated ketones in high yields. Electrochemical carboxylation of substituted allylic halides in the presence of atmospheric carbon dioxide by the use of a magnesium anode gave exclusively one of two possible  $\beta$ ,  $\gamma$ -unsaturated acids, which was not attained by conventional carboxylation using organometallic compounds. New preparation of a reactive zinc metal by electrolysis and its use for a facile isoprenylation of aldehydes and ketones were also reported. The synthesis of some pheromones, ipsdienol and ipsenol, was conveniently achieved by this isoprenylation method.

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The 34th IUPAC International Symposium on Macromolecules. Prague Czechoslovak, July 12-17, 1992

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**An ESR study of Poly(phenylacetylene) Polymerized  
by Rh Complex as a Catalyst of Stereoregular Polymerization**

M. TABATA, K. YOKOTA, W. YANG and Y. NOZAKI

Faculty of Engineering, Department of Chemical Process Engineering,  
Hokkaido University Sapporo, 060 Japan

The polymerization of phenylacetylene was successfully performed by Rh complex,  $[\text{Rh}(\text{norbornadiene})\text{Cl}]_2$  in the presence of solvent, like alcohol or triethylamine. It was found that the complex was functioned as a new and highly stereoregular polymerization catalyst of acetylenes which gave rise a cis-transoid polymer in high yield at room temperature. The resulting polyacetylenes were characterized by using IR, resonance Raman, and ESR methods. The ESR spectrum observed at 330 K was carefully analyzed by the aide of the theoretical molecular orbital calculation and computer simulation.

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Int. Symp. on Chem. and  
Phys. of Molecular Based  
Magnetic Materials. Tokyo  
Japan, Oct. 25-30, 1992

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**Polymer Spin Glass Generated from Poly(phenylacetylene)s Polymerized  
by Rh complex as a Catalyst of Stereoregular Polymerization**

M. TABATA, K. YOKOTA, W. YANG and Y. NOZAKI  
Faculty of Engineering, Department of Chemical Process Engineering,  
Hokkaido University Sapporo 060 Japan

It was demonstrated that the phenylacetylene (PPA) monomer was stereoregularly polymerized by the Rh complex,  $[\text{Rh}(\text{norbornadiene})\text{Cl}]_2$  where cis-transoid polymer was formed in quite high yield at room temperature when the alcohol or triethylamine was used as the polymerization solvent. The resulting PPA polymers were carefully characterized by IR, resonance Raman, NMR and ESR method. It was investigated whether or not the PPA polymer shows the magnetic behavior as the spin glass by the super conductive quantum interference detector, SQUID

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The 4th Int. Symp. on  
Photopolymer Science and  
Technology, Tokyo JAPAN.  
May 21-23, 1993

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**Structure and Magnetic Properties of Soluble Poly(phenylacetylene)  
Polymerized by Ionizing Radiation and Rh  
Catalyst of Aromatic Acetylene**

M. TABATA, Y. NOZAKI and K. YOKOTA  
Faculty of Engineering, Department of Chemical Process Engineering,  
Hokkaido University Sapporo 060 Japan

It was demonstrated that the polymerization of phenylacetylene (PPA) was performed by  $\gamma$ -ray irradiation and catalyst with Rh complex as stereoregular polymerization catalyst for acetylene. The former method was found to give rise a trans form PPA polymers as the major product. On the other hand, the later method gave rise a cis-transoid PPA polymer in a quite high yield when alcohol or triethylamine was used as the polymerization solvent. The physicochemical properties of the both polymers were compared carefully using IR resonance, NMR, and ESR methods.

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The 8th NRCT, NUS,  
DOST-JSPS Joint Seminar  
on Biotechnology, Bangkok,  
Thailand, October 29-31,  
1992

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**Cloning and nucleotide sequence of an alginate lyase  
gene from *Pseudomonas* sp. OS-ALG-9 and its expression  
in *Escherichia coli***

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The genomic DNA of *Pseudomonas* sp. OS-ALG-9 was extracted, partially digested with *Sau* 3I, fractionated by sucrose gradient (0-40%) centrifugation, and 20~40 kb DNA was ligated to cosmid vector pHC79 digested with *Bam* HI. It was packaged into phage *in vitro*, and transduced to *Escherichia coli* LE392 to construct a gene library of *Pseudomonas* sp.

Alginate degrading activity was screened in 3,100 transductants, and 10 clones showed clear zones. The recombinant DNA was extracted from one of positive clones, pAL28, and a DNA fragment of alginate lyase gene was minimized by successive subclonings to *E. coli* HB101 via pUC18 by following restriction enzyme treatments: pAL5 (8 kb with *Kpn* I); pAL10 (4 kb with *Bgl* II); pAL20 2.3 kb with *Hpa* I). The alginate lyase gene was further minimized to 1.4 kb by exonuclease treatment.

The nucleotide sequence determination was carried out by using pAL20 with the dideoxy chain termination method, 1991 bp of nucleotide sequence was determined, and an open reading frame composing of 1,365 bp was found. It can encode a protein composing of 455 amino acids (molecular weight of 46,361), which coincides with that of previously purified alginate lyase of *Pseudomonas* sp. OS-ALG-9 (46,000), whose *N* terminal sequence (20 amino acids) corresponds to that at 41st to 60th amino acid estimated from the open reading frame.

The expression of alginate lyase in *E. coli* harboring pAL205 was induced 15-fold by isopropyl- $\beta$ -D-thio-galactoside, which was 100-fold higher than that of *Pseudomonas* sp.

*Pseudomonas* sp. produced the enzyme intra- and extracellularly equally. In *E. coli* 80% of the activity was intracellularly produced, but by the addition of glycine 65% was found in the culture broth.

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International Conference on  
Fractals and Disordered Sys-  
tems, Hamburg, Germany,  
July 27-31, 1992

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**Dynamics of random fractals :  
large-scale simulations**

Tsuneyoshi NAKAYAMA  
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Sapporo 060, Japan

This paper presents the results of large-scale simulations on the dynamics of random fractal structures, in particular the simulated results on the vibrational density of states, characteristics of fracton wavefunctions, and the confirmation of the single-length scaling postulate (SLSF) for the dynamic correlation function. The results on the density of states (DOSs) for large-scale percolating antiferromagnets are also presented as well as the scaling argument on this.

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The 7th International Confer-  
ence on Phonon Scattering in  
Condensed Matter, Ithaca,  
U. S. A., Aug. 3-7, 1992

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**Dynamic Structure Factor and Its Single-Length Scaling  
for Random Fractal Structures**

T. NAKAYAMA and K. YAKUBO  
Department of Applied Physics, Hokkaido University,  
Sapporo 060, Japan

We present our numerical results on the dynamic structure factor for large-scale site-percolating networks (site numbers from 93,382 to 110,793), and confirm its scaling properties. It is shown that the dynamic structure factor  $S(q; \omega)$  can be scaled by a single-length scale  $\Lambda(\omega)$  with the scaling function  $h(q\Lambda(\omega))$ . This indicates that three characteristic lengths, i. e., a wavelength  $\lambda(\omega)$ , elastic scattering length  $l_{\text{scat}}(\omega)$  and localization length  $l_{\text{loc}}(\omega)$ , have the same frequency dependence. Our results are interpreted in terms of the scaling theory recently proposed by Alexander, Courtens and Vacher [1].

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Sino-Japan Symposium on  
Engineering Optics, Beijing,  
China, Oct. 25-28, 1992

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**Real-time Hough transform using  
direct-binary-search computer-generated-hologram**

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Hough transform is one of useful means for detection of element shapes such as straight line or circle from a noisy image. Some figures can be recognized in an image by detecting such element shapes. Therefore, it may be a very promising tool in digital image processing. Though Hough transform has been investigated into precise and efficient algorithms, it requires quite much computation and its high speed or real-time processing is not yet accomplished by a digital computer.

We discuss in this paper on optical implementation of Hough transform using a two dimensional array of direct-binary-search computer-generated-holograms. Each hologram reconstructs the image corresponding to the space-variant point spread function of Hough transform. A high contrast Hough-transformed image is produced because of those excellent performances of the holograms.

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International Conference on  
Diffusion in Materials,  
Kyoto, Japan, Sept. 1992

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**Photoinduced Diffusion of Ag in Chalcogenide Glasses**

K. TANAKA and H. SANJOH

Department of Applied Physics,

Faculty of Engineering, Hokkaido University

Anomalously fast diffusion of metals into chalcogenide glassy semiconductors in bilayer

structures consisting of Ag/As(Ge)–S(Se) exposed to light illumination has been studied extensively, nonetheless the mechanism is not elucidated. We are developing the pulsed light experiment, the results of which show that the diffusion of Ag<sup>+</sup> ions is triggered and mediated by photons and photoexcited holes.

After introducing the photoinduced diffusion phenomenon, we will talk about the details of the pulsed diffusion and photoconduction experiments, which are performed under similar illuminating conditions. The results show that the Ag diffusion is initiated within 0.1  $\mu$ s after pulsed illumination, and that the response times of the diffusion and the photoconduction are nearly the same in various samples.

Taking previous results and the present time-resolved data into account, we will demonstrate that the phenomenon is a kind of photoelectronic ion diffusion reactions. That is, the first step is the photoexcitation of holes in chalcogenide glassy semiconductors. Then, hole flow into Ag layer occurs, and the flow induces the Ag<sup>+</sup> counterflow, which appears as the anomalously fast diffusion.

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Sino-Japan Symposium on  
Engineering Optics, Beijing,  
China, Oct. 25-28, 1992

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### **High Resolution Imaging With Large Telescope**

Naoshi BABA

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and

National Astronomical Observatory, Mitaka 181, Japan

Several problems to attain high angular resolution with a large telescope are discussed. The common strategy to construct a large telescope is described. The typical methods for high-angular resolution imaging from the ground are reviewed. The importance of optical interferometry is stressed for very high resolution imaging.

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Sino-Japan Symposium on  
Engineering Optics, Beijing,  
China, Oct. 25-28, 1992

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### **Stellar Spectroscopy with Diffraction-Limited Resolution of Large Telescope**

S. KUWAMURA<sup>1</sup>, N. BABA<sup>1</sup>, N. MIURA<sup>1</sup> and K. MURATA<sup>2</sup>

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<sup>2</sup> Department of Applied Electronics, Hokkaido Institute of Technology,  
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Shift-and-add (SAA) technique is employed to reconstruct spectra of stellar objects with the diffraction-limited spatial resolution of telescope from atmospherically degraded dispersed specklegrams taken by dedicated camera system. Two spatially separated spectra of the binary star ADS16836 are reconstructed in wideband and low dispersion mode. From the narrow band and medium dispersion data, the absorption and the emission H $\beta$  lines are reconstructed in diffraction-limited spectra of  $\epsilon$  Her and P Cyg respectively.

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Sino-Japan Symposium on  
Engineering Optics, Beijing,  
China, Oct. 25-28, 1992

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### **Image Reconstruction Using Parallel Blind Deconvolution Method And its Application to speckle Data of Binary stars**

Noriaki MIURA, Naoshi BABA,  
Hokkaido University, Department of Applied Physics,  
Faculty of Engineering, Sapporo 060, Japan.  
Syuzo ISOBE and Motokazu NOGUCHI  
National Astronomical Observatory, Mitaka, Tokyo 181, Japan.

An algorithm based on parallel scheme of the iterative blind deconvolution method is presented. The algorithm enables stellar object reconstruction using several speckle frames without reference star data. Images reconstructed by using the algorithm satisfy both a non-negativity constraint and convolution relation in all the frames used. The results of computer simulation showed good performance of the algorithm. Observational data of binary stars were processed and high resolution images were clearly reconstructed.

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The 3rd Asian Conference on  
Solid State Ionics, Varanasi,  
India, Nov. 9-3, 1992

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### **Photo-Electro Ionic Motion in Chalcogenide Glasses (Invited)**

Keiji TANAKA

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Sapporo, 060 Japan

It is known that in chalcogenide glasses  $\text{Ag}^+$  ionic diffusion is enhanced substantially by light illumination. The phenomenon referred to as "photodoping" or "photo-dissolution". Despite extensive studies, however, its mechanism has not been elucidated. To understand the mechanism, we have performed two novel experiments.

The first is to examine the photodoping efficiency in Ag/As-S and Ag/Ge-S samples subjected to hydrostatic compression. With increasing pressure, the photodoping becomes efficient, and then quenched at higher pressures, which are 8 GPa in Ag/As-S and 4 GPa in Ag/Ge-S.

The second is to investigate the photodoping dynamics excited by nanosecond pulsed light. The most important result obtained in this study is that the photodoping occurs within  $0.1 \mu\text{s}$  after pulse excitation.

These results suggest that the  $\text{Ag}^+$  motion occurs as a counterflow to the photoexcited-hole motion in Ag-chalcogenide glasses, which are known to be ion-hole mixed conductors.

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The 1992 International Sym-  
posium on Antennas and  
Propagation, Sapporo,  
Japan, Sept. 22-25, 1992

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### **Propagation of Electromagnetic Waves in Ice Derived**

#### **From Its Dielectric Properties**

#### **1. Wave Velocity and Birefringence**

Shuji FUJITA and Shinji MAE

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Kita-13 Nishi-8, Kita-ku Sapporo 060, Japan

Based on the measured dielectric properties of ice, the propagation velocity and birefringence of electromagnetic waves in ice at MHz and GHz frequencies are discussed. The velocity of electromagnetic waves in solid ice is around  $169 \text{ m}/\mu\text{sec}$  and it decreases with increasing temperature at a rate of  $0.023 \text{ m}/\mu\text{sec}$  per  $1^\circ\text{C}$ . Dielectric anisotropy of ice single crystal indicates that wave velocity can be varied within  $1 \text{ m}/\mu\text{sec}$  depending on the angle between electric field vector and crystal orientations of ice. Dielectric anisotropy also indicates that the polari-

zation state of the electromagnetic waves are determined by the dielectric permittivity tensor in the polycrystalline ice.

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The 1992 International Symposium on Antennas and Propagation, Sapporo, Japan, Sept. 22-25, 1992

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## **Propagation of Electromagnetic waves in Ice Derived from Its Dielectric Properties**

### **2. Attenuation**

Shuji FUJITA and Shinji MAE

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Kita-13 Nishi-8 Kita-ku Sapporo 060, Japan

Based on the measured dielectric properties of ice, attenuation of electromagnetic waves in ice at MHz and GHz frequencies is discussed. The relative complex dielectric permittivity of acid-doped ice shows that attenuation is significantly influenced by the concentration of hydrogen ions or the pH value in ice. The penetration depth of the microwave from J-ERS1SAR and E-ERSI SAR are estimated as a function of pH value.

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The Second International Conference and Exhibition on Computer Applications to Materials and Molecular Science and Engineering, Yokohama, Japan, Sept. 22-25, 1992

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### **A molecular dynamics study on structural stability of clathrate hydrate crystals**

J. TABATA<sup>a</sup>, K. KAWAMURA<sup>b</sup>, +A. GOTO<sup>a</sup>, T. HONDOH<sup>c</sup> and S. MAE

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We have carried out molecular dynamics simulations on Ar-hydrates to examine the stability of the Stackelberg's structure II formed by very small guest molecules. Considerable changes in relaxations of the host lattices were observed in accordance with varying site occupancies of cages. Stability of the structure is discussed in terms of this relaxation. It was also found that Ar atoms in the large cages were located at various positions apart from the

centers of the cages or moved around the centers. These results are compared with recent experimental data on this structure.

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The Fourth International  
Workshop on Ice Drilling  
Technology, Tokyo, Japan,  
April 20-23, 1993

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### **Drilling fluid for Dome F Project in Antarctica**

Shuji FUJITA<sup>1)</sup>, Tomomi YAMADA<sup>2)</sup>, Renji NARUSE<sup>2)</sup>, Shinji MAE<sup>1)</sup>,  
Nobuhiko Azuma<sup>3)</sup> and Yoshiyuki FUJII<sup>4)</sup>

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- <sup>4)</sup> National Institute of Polar Research, 1-9-10 Kaga, Itabashi-ku, Tokyo 173, Japan

At Dome F, one of the summits of the East Antarctic Ice Sheet, a very deep ice-coring operation is to be carried out by the Japanese Antarctic Research Expedition from 1995. Since it will take two years to complete the coring up to about 3000 m depth, the borehole should be filled with proper drilling fluid to prevent the borehole closure during the operation. This paper is a report on our investigations for searching for the proper drilling fluid which can be used in the very cold environment at Dome F. Although the investigations are still in progress, three kinds of fluid were chosen as the drilling fluid candidates. They are; 1) n-butyl acetate, 2) "IP-solvent" with densifier and 3) Silicone Oil. Their properties were investigated and compared in terms of density and viscosity, which are the essential requirements to the drilling fluid. As the result, it was showed that n-butyl acetate and IP-solvent with densifier can be used as the drilling fluid. However, the use of n-butyl acetate is impossible without sufficient ventilation at the coring site and any actions to get rid of its vapor. When the use of IP-solvent with densifier is considered, the choice of proper densifier is also the problem which still remains.

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The Fourth International  
Workshop on Ice Drilling  
Technology, Tokyo, Japan,  
April 20-23, 1993

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### **The Storage Conditions of Ice Core Samples To Keep The Ice Core Quality**

Tsutomu UCHIDA<sup>1)</sup>, Takeo HONDOH<sup>2)</sup> and Shinji MAE<sup>3)</sup>

<sup>1)</sup> Government Industrial Department Laboratory, Hokkaido ; Sapporo 065, Japan

<sup>2)</sup> Low Temperature Science Institute, Hokkaido University ; Sapporo 060, Japan

<sup>3)</sup> Faculty of Engineering, Hokkaido University ; Sapporo 060, Japan

Both high temperature and long time conditions damage the deep ice core samples during their transportation and storage. This lowering of ice core quality was explained by the dissociation of air hydrate crystals included in the ice core samples. Once air hydrate crystal dissociated and changed to air bubble, the ice core sample was fractured and became brittle. The maximum temperature and time interval conditions to keep air hydrate crystals in the ice core samples away from the dissociation were discussed.

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The Fourth International  
Workshop on Ice Drilling  
Technology, Tokyo, Japan,  
April 20-23, 1993

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### **The Influence of The Formation of Air Hydrate Crystal on The Brittle Ice Core Samples**

Tsutomu UCHIDA<sup>1)</sup>, Takeo Hondoh<sup>2)</sup>, Shinji MAE<sup>3)</sup>,

Volodya Ya. LIPENKOV<sup>4)</sup> and Paul DUVAL<sup>5)</sup>

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<sup>5)</sup> Laboratoire de Glaciologie et Geophysique de l'Environnement ; 38402 St Martin d'Heres Cedex, France

The brittle ice core samples are obtained from the middle depth region of ice sheet, which is called the brittle zone or the fracture zone. The microscopic observations of air hydrate crystals in the ice core samples revealed that the bottom of the brittle zone was the depth where most of air bubble transformed to air hydrate crystals. Air bubbles containing high pressure gas were considered to make the ice core samples brittle. On the other hand, the formation of air hydrate crystal stabilized the ice core samples.

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International Conference on  
Martensitic Transformations,  
Monterey, U. S. A., July 20-  
24, 1992

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### **Theoretical Investigation of the Bainitic Transformation in Copper Based Alloys**

K. MARUKAWA

Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

The atomic mechanism of the bainitic transformation in Cu alloy has been studied theoretically with the intention to solve the apparent dual nature of this transformation, i. e., features of shear transformation and diffusional phase decomposition. The results are as follows. (1) Bainitic precipitates in this alloy can be taken as coherent precipitates, so that their growth can be described in terms of the motion of transformation dislocations. (2) The dislocation motion is coupled with the solute re-distribution through the concentration fluctuation. It is to be noted that the lattice shearing and the solute diffusion are compatible with each other in the course of the bainitic reaction. (3) Transformation by lattice shearing takes place even at a temperature above the equilibrium temperature  $T_0$  of the two phases, if it is coupled with the solute re-distribution.

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International Conference on  
Martensitic Transformations,  
Monterey, U. S. A., July 20-  
24, 1992

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### **Anisotropic Growth of Bainite Plate in Cu-Zn-Al Alloys**

K. TAKEZAWA, S. SATO\* and K. MARUKAWA  
Faculty of Engineering, Hokkaido University,  
Sapporo 060, Japan

\* Professor Emeritus, Hokkaido University,  
Sapporo 060, Japan

Bainite plates in Cu-Zn-Al alloys have the form of a long hinge. Since this particular form is thought to be originated from the growth anisotropy of plate, an attempt has been made to measure the growth rate separately in two directions on the habit plane, parallel and perpendicular to the direction of transformation shear. The results show that the growth rate in the parallel direction is about three times higher than that in the perpendicular direction. An activation energy of growth, 117 kJ/mol, is obtained from the temperature dependence of

the growth rate, which is nearly the same as that of the atomic diffusion in the matrix crystal. The present results suggest that the bainite lattice is formed by the atomic shear mechanism in a similar manner to the martensitic transformation and also that the growth process is controlled by the diffusion of solute atoms.

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Asian Crystallographic Association Inaugural Conference,  
Singapore, Nov. 13-16, 1992

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### **Experimental Test of the Statistical Dynamical Theory of Diffraction**

Toshihiko TAKAMA and Takashi KIHARA  
Department of Applied Physics, Faculty of Engineering, Hokkaido  
University, Sapporo 060, Japan.

The influences of crystal imperfection on diffraction have been studied by measuring integrated intensities on the Laue case as a function of X-ray wavelength. SiO<sub>2</sub> precipitate micro defects were introduced in Czochralski-grown silicon wafers by heating at 1223 K for five different periods varying from 25 to 145 hr. The measurements revealed that the increases of both the integrated intensity and the Pendellösung beat spacing were accompanied by a decrease of the beat amplitude with increasing heating period.

The original statistical dynamical theory did not describe the data. A new model assuming that correlation length of wave-field amplitude is independent of wavelength and varies with crystal perfection and reflection plane, was proposed. The application of the model led to an excellent agreement for the data.

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The 12th Meeting of the  
International Collaboration  
on Advanced Neutron  
Sources, Abindon, UK, 24-28  
May, 1993

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### **Some Optimization Studies on Flux-Trap Moderators for Increasing The SlowNeutron Beam Intensity**

Y. KIYANAGI, N. WATANABE\* and M. NAKAJIMA  
Department of Nuclear Engineering, Faculty of Engineering,  
Hokkaido Univ., Sapporo 060

\* National Laboratory for High Energy Physics, 1-1 Oho,  
Tsukuba-shi, Ibaraki, 305

A flux trap geometry has various possibilities to increase the slow-neutron intensity,

compared with the traditional wing geometry. We compared the slow-neutron intensities from various flux-trap moderators (extended, overlap and backscattering) by computer simulations and mock-up experiments. The results show that those moderators are useful for enhancing the intensity. A gain factor of more than 1.5 is obtainable. It was found that backscattering moderators give a higher intensity with a narrower pulse width, compared to normal extraction.

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The 12th Meeting of the  
International Collaboration  
on Advanced Neutron  
Sources, Abindon, UK, 24-28  
May, 1993

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### **Studies of Decoupled Composite Moderators of Liquid Hydrogen and Zirconium Hydride**

Y. KIYANAGI<sup>a</sup>, J. M. Carpenter<sup>b</sup>, N. WATANABE<sup>c</sup>,  
H. IWASA<sup>a</sup> and M. NAKAJIMA<sup>a</sup>

<sup>a</sup> Department of Nuclear Engineering, Hokkaido University, Sapporo, Japan.

<sup>b</sup> Argonne National Laboratory, Argonne, Illinois and Visiting Scientist,  
National Laboratory for High Energy Physics, Tsukuba, Japan.

<sup>c</sup> National Laboratory for High Energy Physics, Tsukuba, Japan.

We report the results of a series of measurements of the intensities and pulse shapes of decoupled composite 2 cm-thick liquid Hydrogen moderators, with various thickness of cold Zirconium hydride backing.

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The 12th Meeting of the  
International Collaboration  
on Advanced Neutron  
Sources, Abindon, UK, 24-28  
May, 1993

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### **Premoderator Studies for a Coupled Liquid-Hydrogen Moderator**

Y. KIYANAGI, N. WATANABE\*, H. IWASA and Y. NAKAYAMA  
Department of Nuclear Engineering, Faculty of Engineering,  
Hokkaido Univ., Sapporo 060

\* National Laboratory for High Energy Physics, 1-1 Oho,  
Tsukuba-shi, Ibaraki, 305

A coupled liquid-hydrogen moderator with a premoderator is one of the most promising

candidates for a cold neutron source at an intense pulsed spallation neutron source. The choice of the premoderator material is especially important since the neutronic performance strongly depends on the material. Premoderators of polyethylene, water and zirconium hydride have been studied experimentally. The cold neutron intensity from a moderator system with a  $ZrH_2$  premoderator is unexpectedly low: about 75% of that from a reference coupled liquid-hydrogen moderator with a polyethylene premoderator. However, the pulse widths (FWHM) are narrower than those from the reference moderator, and the peak intensities are almost unchanged. We also discuss the function of the premoderator.

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The 12th Meeting of the  
International Collaboration  
on Advanced Neutron  
Sources, Abindon, UK, 24-28  
May, 1993

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### **Tailoring Intensities and Pulse Shapes in Coupled Moderator-Reflector Systems**

J. M. Carpenter<sup>a</sup>, Y. KIYANAGI<sup>b</sup>, N. WATANABE<sup>c</sup>  
H. IWASA<sup>b</sup> and M. NAKAJIMA<sup>b</sup>

<sup>a</sup> Argonne National Laboratory, Argonne, Illinois and Visiting Scientist,  
National Laboratory for High Energy Physics, Tsukuba, Japan.

<sup>b</sup> Department of Nuclear Engineering, Hokkaido University, Sapporo, Japan.

<sup>c</sup> National Laboratory for High Energy Physics, Tsukuba, Japan.

In this paper we introduce an idea for controlling the trading off of intensity and pulse width in coupled moderator-reflector systems by heterogeneously positioning the reflector, with particular application for cold moderators. We describe measurements which illustrate the effect, performed at the Hokkaido Linac neutron source. The principle may be useful for varying on-line the performance of coupled moderator-reflector systems.

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The 12th Meeting of the  
International Collaboration  
on Advanced Neutron  
Sources, Abindon, UK, 24-28  
May, 1993

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### **Comparison of the Slow-Neutron Intensity-0.8 GeV vs 3 GeV Protons-**

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\*\* Department of Physics, Faculty of Science,  
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The choice of the proton energy for an intense pulsed spallation neutron source is one of the most important topics in recent years. A high proton energy, but with a modest beam current, is more acceptable from an accelerator point of view. We calculated the slow-neutron intensities from a reference target-moderator-reflector assembly for various proton energies over the range 0.8-3 GeV. The result shows that the slow-neutron intensity per unit proton beam power with 3-GeV protons is about 80% of the 0.8-GeV case. A higher proton energy is also well acceptable from a neutronic point of view.

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The 9th International Confer-  
ence on MHD Electrical  
Power Generation, Beijing,  
China, Oct. 12-16, 1992

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### **Turbulence Suppression and Effective Generalized Ohm's Law for Partially Ionized Plasmas with Temperature Gradients**

Shun-ichi OIKAWA<sup>+</sup>, Naoyuki KAYUKAWA\*, Hiroshi SUGIYAMA<sup>+</sup>,  
Yoshiaki AOKI\* and Takeaki ENOTO<sup>+</sup>

<sup>+</sup> Department of Nuclear Engineering,

\* Advanced MHD Research Institute, Hokkaido University,  
Sapporo 060, Japan.

A closed analytical turbulence model for the generalized Ohm's law in partially ionized plasmas with the spatial gradient of the electrical conductivity is formulated. This model does not require any *a priori* relations between the electrical quantities and fluctuating motion of the working fluid, other than relations between the mean and the fluctuating motion of fluids. The present model suggests that when there is a spatial gradient of the electrical conductivity on a

plane perpendicular to the magnetic field, fluctuating motions of partially ionized plasmas are anisotropically suppressed even on that perpendicular plane due to the anisotropic Lorentz force exerted on the plasma, which results in the emergence of a steady flow along  $\Delta\sigma$ . Although the time-averaged conductivity at any point of the plasma increases with increasing temperature fluctuations because of the nonlinear dependence of the conductivity on temperature, the "effective" conductivity decreases. The Reynolds' stress tensor in the presence of a magnetic field based on the Prandtl's mixing length hypothesis in the presence of a magnetic field were derived.

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Int. Symp. on Simulation  
and Design of Applied Elec-  
tromagnetic Systems (ISEM-  
Sapporo) Sapporo, Jan. 26-  
30, 1993

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**Turbulence damping in a weakly ionized plasma  
with a temperature gradient**

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Yoshiaki AOKI<sup>†</sup> and Takeaki ENOTO\*

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<sup>‡</sup> Advanced MHD Research Institute, Hokkaido University,  
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A theoretical model was developed to explain the damping of the motion of a turbulent fluid lump in partially ionized magnetohydrodynamic (MHD) plasma flows with the spatial gradient of the electrical conductivity. The model was based upon the Prandtl's mixing length theory. The Lagrangian equation of motion for the lump was solved for the damped fluctuating velocity. The solution of a turbulent eddy velocity was averaged over its lifetime, and successively averaged in the fluctuation velocity space. Such procedures resulted in a steady mass flow along the spatial gradient of the electrical conductivity in the presence of the magnetic field due to anisotropic turbulence suppression. The approximated magnitude of the steady mass flow directed from the electrode wall to the core region was then evaluated. Simple expressions for the damped Reynolds' stress and its damping coefficient tensor have also been presented.

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Int. Symp. on Simulation  
and Design of Applied Elec-  
tromagnetics Systems  
(ISEM-Sapporo) Sapporo,  
Jan. 26-30, 1993

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**Removing spurious solutions in boundary elemental method for multimedia problems using virtual boundary dividing method**

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\* Faculty of Engineering, Hokkaido University.  
Kita 13, Nishi 8, Kita-ku, Sapporo, 060, Japan

In the analysis of multi-media problems by the boundary element method (BEM), we have found that spurious solutions superimpose onto the true solutions. To remove the spurious solutions, we propose a new method named the "Virtual Boundary Dividing Method". The virtual boundary dividing method is one of the region or boundary selecting methods for multi-media problems. It obeys Huygens' principle as long as optical paths don't cross another medium. We show the validity of the virtual boundary dividing method for removing of spurious modes.

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The International Sympos-  
ium on Simulation and  
Design of Applied Electro-  
magnetic Systems Sapporo,  
Japan, Jan. 26-30, 1993

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**Numerical analysis of ultra high-speed shuttering characteristics using finite-difference time-domain method**

Makoto KAGATA<sup>a</sup>, Brian D. Landberg<sup>a</sup>, Satoshi TOMIOKA<sup>a</sup>,  
Takeaki ENOTO<sup>a</sup> and Ichiro FUKAI<sup>b</sup>

<sup>a</sup> Dept. of Nuclear Engineering,

<sup>b</sup> Dept. of Electrical Engineering, Faculty of Engineering,  
Hokkaido University.

In the study on laser driven fusion, the most important problem is to obtain highresolution images of the plasma implosion process. It is thus necessary to use a high-speed framing camera system. This paper presents a numerical analysis of ultra high-speed shuttering characteristics using the FD-TD method. These analytical results show good agreement with experimental results, and using this method, we determine the cause of leakage of shuttering fields from one of the divided electrodes to the other. Thus, it is clear that the FD-TD method is valid and useful for analysis of shuttering characteristics of high-speed camera systems.

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Int. Symp. on Simulation  
and Design of Applied Elec-  
tromagnetic Systems (ISEM-  
Sapporo) Sapporo, Jan, 26-  
30

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### **High speed shuttering characteristics of proximity focused image intensifiers**

Brian LANDBERG<sup>+</sup>, Makoto KAGATA<sup>+</sup>, Satoshi TOMIOKA<sup>+</sup>,  
Takeaki ENOTO<sup>+</sup>, and Ichiro FUKAI<sup>\*</sup>

<sup>+</sup> Department of Nuclear Engineering

<sup>\*</sup> Department of Electrical Engineering

Faculty of Engineering,

Hokkaido University Sapporo 060, Japan.

In view of the increasing importance of recording and measuring the processes of instantaneous reactions such as laser fusion, the precision of existing shuttering technology is no longer sufficient. In this paper, a system including a proximity focused image intensifier and an external transparent electrode is proposed. Using this apparatus, a shuttering rate of 100 ps-order is realized and a comparison of the new design with that of the photoelectric plate-based shuttering system is included. The inclusion of the transparent electrode externally effectively eliminated the "iris-effect" (uneven propagation of the shuttering pulse) as well as shadows cast upon the image intensifier, found in previous experiments. Also, methods of mathematical analysis, such as FD-TD, are used to successfully simulate the shuttering process.

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US-Japan Seminar on Elec-  
tronic Structure and Fer-  
miology of High- $T_c$  Super-  
conductors Sendai, Japan,  
July 27-29, 1992

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### **Ion Channeling in the Oxide Superconductors**

Kazuhiko YAMAYA

Department of Nuclear Engineering

Hokkaido University, Sapporo 060, Japan

Lattice anomalies appeared near the superconducting transition temperature  $T_c$  of  $YBa_2Cu_3O_7$  have been investigated using an ion channeling method. The results are summarized as follows; (1) the anomalous lattice vibrations for Cu and O atoms begins at temperature of about 40 K above  $T_c$  and (2) at  $T_c$ , the lattice-vibration amplitudes for all atoms increase. These results imply that the lattice anomaly near  $T_c$  are induced by the changes in the lattice vibration for Cu and O atoms appeared in the normal state.

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Maple Summer Workshop  
and Symposium, University  
of Michigan, Ann Arbor,  
June 28-30, 1993

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### **Introductory Quantum Mechanics Using Maple V**

Yutaka ABE

Quantum Instrumentation Laboratory,  
Hokkaido University, Sapporo, 060 Japan

This article discusses a set of Maple programs developed to reinforce understanding of basic concepts presented in an introductory quantum mechanics course. It was designed so that the solutions of the problems were analytically tractable as well as numerically obtainable. We note that there exist various approaches to a simple quantum mechanical problem. For example, for the problem of bound-state with a one-dimensional potential, the transfer matrix method, the Laplace transform method, and the Feynmann path integral method can equally be applied. We believe that this type of program is extremely useful for igniting the student's interest and widening his or her viewpoint.

Several examples, such as the solutions of the one-dimensional potential problems and the solution of the one-dimensional Schroedinger wave equation, are discussed in order to indicate how constructive reinforcement is established.

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Twelfth International Vacuum Congress (IVC-12) and  
Eighth International Conference on Solid Surface  
(ICSS-8) Hague, Netherlands,  
Oct. 12-16, 1992

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### **Application of Flash Desorption Spectroscopy for Pressure Measurement**

Yuko HIROHATA, Satoshi FUJIMOTO, Tomoaki HINO,  
Toshiro YAMASHINA, Toshio KIKUCHI and Nobuharu OHSAKO  
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Sapporo, 060 Japan

Flash desorption spectroscopy (FDS) technique was applied to measure the pressure in the range of extremely high vacuum (XHV). After the adsorption of hydrogen gas on a clean tungsten filament at room temperature in the chamber made by aluminum alloy, the pressure rise during the flash of filament was measured by an ionization gauge of extractor type (EG).

The pressure rise was observed to be linearly proportional to the adsorption time, in the

pressure range from  $10^{-9}$  to  $10^{-8}$  Pa. The adsorption rate, being proportional to the pressure of the chamber, then, was determined. For lower pressure range, the adsorption rate was observed to be approximately proportional to the pressure of the chamber, even in the range of  $10^{-10}$  Pa.

Since the linearity between the adsorption rate and pressure may be able to be extrapolated to the lower pressure range of  $10^{-11}$  Pa, the present FDS technique can be regarded as an useful for the pressure measurement of the XHV regime.

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Twelfth International Vacuum Congress (IVC-12) and Eighth International Conference on Solid Surface (ICSS-8) Hague, Netherlands. Oct. 12-16, 1992

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### **Collisional Effect of Sputtering Particle on Morphology of Molybdenum Film**

Tomoaki HINO, Yasushi MAKABE, Yuko HIROHATA  
and Toshiro YAMASHINA

Department of Nuclear Engineering, Hokkaido University  
Sapporo, 060 Japan

The morphology of sputtered film largely depends on the deposition condition such as substrate temperature and the working gas pressure. In the present study, for Mo films prepared with different deposition condition in a magnetron sputtering apparatus, the structures were examined in terms of surface morphology, effective surface area and crystallization. In addition, the spatial distribution of excited species of Mo in the plasma was measured by a technique of optical emission spectroscopy.

As the increase of Ar gas pressure, the film roughness was enhanced, in addition to the deterioration of crystallization. It was observed that emission of excited molybdenum rapidly dropped around the substrate when the pressure was high. It thus, is presumed that the incident angle of Mo particle on the substrate became isotropic at high pressure, because of the collision with Ar atom.

It was concluded that the enhancement of the film roughness was due to the collision of sputtered Mo atom with residual Ar atom.

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Twelfth International Vacuum Congress (IVC-12) and Eighth International Conference on Solid Surface (ICSS-8) Hague, Netherlands, Oct. 12-16, 1992

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### **Limit of Pressure Measurement by Spinning Rotor Gauge**

Eisuke UEDA, Yuko HIROHATA, Tomoaki HINO  
and Toshiro YAMASHINA  
Department of Nuclear Engineering, Hokkaido University  
Sapporo, 060 Japan

The individual pressure of spinning rotor gauge,  $P_{ind}$ , was correlated with Pressure,  $P_{IG}$ , measured by ionization gauge. The linearity between them has been observed to residual drag called as offset pressure,  $P_{OFS}$ , so far. In the present study, for the entire region with reactively dominant residual drag, the offset value was determined for the standard deviation of  $[P_{IG} - (P_{ind} - P_{OFS})]$  to be minimized. The linearity was extended to the pressure range of  $10^{-6}$  Pa by using the obtained offset pressure.

It was also shown by a simple analysis that the standard deviation of the indicative pressure was proportional to  $SI^{-2.5}$ . Here,  $SI$  is the sampling interval. Even at the range of  $10^{-6}$  Pa, we observed this relation.

Since the value of the offset pressure depends on the change of volume and mass density of a sphere rotor made of stainless steel, the effect of the temperature rise in the rotor on the offset pressure was analytically examined.

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The Fifth International Topical Meeting on Reactor Thermal Hydraulics, Salt Lake City, UT, USA, September 21-24, 1992

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### **An Experimental Study on Combined Convection Heat Transfer of Liquid Sodium in Upward Crossflows Through a Bank of Tubes**

K. SUGIYAMA, R. ISHIGURO, A. SHIRATO and H. SATO  
Department of Nuclear Engineering, Hokkaido University,  
Sapporo 060, Japan

In order to clarify the heat transfer characteristics in combined convection of liquid Na for the shell side in a helical coil heat exchanger, we conducted an experiment using liquid Na for a system having three rows of rods at  $P/d=2.0$ . The measurement covered a range of

$Gr^*/Re^2=39$  to 418 at  $Re=2000$  and a range of  $Gr^*/Re^2=4.4$  to 45.7 at  $Re=6000$ . The measured values and analytical values which were obtained by using a method previously reported show a good agreement both for local and mean values at an accuracy appropriate for practical use.

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US Eng. Foundation Conf.  
on Condensation & Con-  
denser Design at St. Aug-  
stine, Florida, March 7-12,  
1993

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### **A Numerical Simulation on Metal Condensation**

K. SUGIYAMA, R. ISHIGURO and H. YOSHIDA  
Hokkaido University, Sapporo, Japan

Analysis on condensation of alkali metals has to be based on the molecular kinetic theory, since the discontinuity of physical quantities at the vapor-liquid interface does not permit ordinary treatment as continuum model. The direct simulation Monte Carlo method has recently been applied to problems of rarefied gases with the development of high-speed computers with large memory. We apply this method to the problem of metal condensation using the parallel plate system.

The numerical results are found to be an excellent agreement with the experimental result of potassium condensation, and the numerical analysis based on the moment method, when the condensation coefficient and evaporation coefficient are set as unity. It is also confirmed that a slight shift of evaporation and condensation coefficients from unity changes the numerical result so that it disagrees with the experimental data.

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ITEC-93, First International  
Thermal Energy Congress,  
Marrakesh, Morocco, June  
6-10, 1993

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### **A Study on Temperature Fluctuations of Thermal Media**

K. SUGIYAMA, R. ISHIGURO, Y. KOJIMA  
Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

Temperature fluctuations of thermal media cause thermal stresses in structure materials in contact with the media. As a result the materials sometimes result in a situation of thermal fatigue. We discuss first in this report the similarity conditions of temperature fluctuations

between different thermal media. Secondly, we perform an analysis of temperature fluctuations by means of numerical calculations.

Temperature fluctuations in a structure material are very much affected by their thermal properties and the thermal boundary conditions in which it is situated as well as the temperature fluctuation of the media. As a first step, however, to get fundamental characteristics in the flow field, only the temperature fluctuation of thermal media is discussed in this report.

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The 2nd ASME/JSME International Conference on Nuclear Engineering, San Francisco, U. S. A., March, 21-24, 1993

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**Stability Analysis of BWR  
Using The Bifurcation Theory**

M. TSUJI and M. NARITA

Department of Nuclear Engineering, Hokkaido University, Sapporo, Japan

K. NISHIO

Kyoto University, Kyoto, Japan

Y. OGAWA

Department of Industrial Engineering, Hokkaido Institute of Technology, Sapporo, Japan

M. MORI

Tokyo Electric Power Company, Tokyo, Japan

A new approach using the bifurcation theory was applied to the analysis of BWR instability phenomena accompanied with an in-phase power oscillation. In this approach, the dependencies of the equilibrium states on the parameters that have a large influence on the stability are investigated topologically over a wide range of phase space. The stability information can be derived from the analysis of the bifurcation phenomena on the equilibrium states.

The main results of the stability analysis can be summarized as follows; (1) The loss of linear stability takes place at a lower reactor power as the coolant flow rate decreases, and this instability occurs at the Hopf bifurcation point. (2) The channel hydrodynamics heavily play a significant role in the stability. (3) The periodic state bifurcating at the Hopf bifurcation point is orbitally unstable and a limit cycle attractor does not exist in the vicinity of the bifurcation point.

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The 3rd International Conference on Cold Fusion in Nagoya, Japan, Oct. 21-25, 1992

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**Cold Fusion Reaction Products and  
Behaviour of Deuterium  
Absorption in Pd Electrode**

Tadahiko MIZUNO, Tadashi AKIMOTO and Kazuhisa AZUMI  
Dept. Nuclear Eng., Fac. Eng. Hokkaido Univ., Michio ENYO  
Catalysis Research Center, Hokkaido Univ.

Excess heat generation from Pd electrode during cathodic polarization in  $D_2O-LiOD$  solution was investigated as a function of D/Pd loading ratio. The excess heat was observed when a Pd sample was filled with deuterium to  $D/Pd \approx 0.90$  by cathodic charging. The excess heat ( $H_{ex}$ ) increased with D/Pd in an exponential manner; the  $H_{ex}$  was of the order of magnitude of  $0.1 \text{ watt/cm}^2$  at  $D/Pd \approx 1.0$ .

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The 4th International Conference on Hydraulic Engineering Software (HYDROSOFT 92), Valencia, Spain, July 21-24, 1992

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**Numerical Analysis of Incompressible Fluids  
with Uneven or Moving Boundaries**

Y. MIZUTA  
Department of Engineering Science,  
Faculty of Engineering Hokkaido University,  
Sapporo 060, Japan

This paper shows a general and natural method in numerical analysis of incompressible fluids in channels or rivers which uses deformable cells and integral-type laws of conservation, similar to the finite-volume method or the ALE method. The method includes a unified treatment of boundary conditions such as free surface and density interface. The outline and the usage of a computer program coded on this method are shown, together with the numerical results of free surface waves and density interface waves.

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The 4th International Conference on Computational Engineering Science, Hong Kong, December 17-22, 1992

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**General Treatment of Boundaries by a Deformable-Cell Method  
in Numerical Analysis of Incompressible Fluids**

Y. MIZUTA

Department of Engineering Science,  
Faculty of Engineering, Hokkaido University,  
Sapporo 060, Japan

Though numerical analysis of incompressible fluids with free surface or density interface has been considered difficult to treat, methods using a grid which is deformable according to the uneven or moving boundaries lighten the burdens in the course of formulating, coding and debugging. In the present work, the equations for numerical analysis are derived from the integral-type laws of conservation. Especially, the law of conservation of volume on boundary called "boundary equation" here is used to treat various boundaries generally, such as wall, free surface, density interface and so on. Together with these movable boundaries, immovable "open boundary" is also incorporated into the general treatment of boundaries.

Numerical results on the free surface waves or density interface waves under the effect of uneven topography are shown. Furthermore, the behavior of the free surface of a magnetic fluid under changing magnetic fields is simulated.

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The 7th International Conference on Phonon Scattering in Condensed Matter, Ithaca, U. S. A., 1992

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**Measurements of Phonon Elastic Scattering Rates  
By Phonon Imaging and Monte Carlo Simulation (Invited)**

S. TAMURA, J. A. SHIELDS\*, M. T. RAMSBEY\*  
and J. P. WOLFE\*

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Sapporo 060, Japan

\* Department of Physics and Materials Research Laboratory,  
University of Illinois at Urbana-Champaign, Urbana, IL 61801, U. S. A.

Theoretical predictions of phonon scattering rates from mass defects in crystals have long preceded actual measurements. Experimentally, the use of phonon imaging with frequency selective detectors, combined with slotted samples to isolate scattered and ballistic flux, yields

a measure of the ratio of scattered to ballistic phonons. To extract the scattering rate we have conducted a series of Monte Carlo simulations for varying elastic scattering strengths and compared to the data. For a high purity Si crystal, the extracted scattering rate agrees closely with the theoretical predictions for naturally occurring isotopes. For a GaAs crystal, the scattering of LA phonons is consistent with isotope scattering but the TA-phonon scattering is much stronger. This mode-selective scattering will be attributed to extrinsic defects such as EL2.

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The 7th International Conference on Phonon Scattering in Condensed Matter, Ithaca, U. S. A., 1992

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### **Thermal Conductivity in Low-Dimensional Nonlinear Lattices**

Norihiko NISHIGUCHI, Naoki TAKAHASHI, Yoshito KAWADA  
and Tetsuro SAKUMA

Department of Engineering Science, Hokkaido University,  
Sapporo 060, Japan

We investigate the validity of Fourier's law in low-dimensional nonlinear lattices, i. e. 1-D diatomic Toda lattice, Fibonacci one, and 2-D Toda lattice with uniform mass distribution, by means of molecular dynamics. Paying special attention to nonlinear temperature profiles which have been overlooked so far, we derive the temperature dependence of the thermal conductivity. The resultant thermal conductivity is found to be proportional to the inverse of local temperature both for one- and two-dimensional lattices. We also confirm Fourier's law excluding the non-diffusive energy flow from the total energy current.

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The 7th International Conference on Phonon Scattering in Condensed Matter, Ithaca, U. S. A., 1992

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### **Phonon Transmission and Localization in Random Superlattices**

Norihiko NISHIGUCHI and Shin-ichiro TAMURA

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Sapporo 060, Japan

The observation of phonon propagation and scattering in randomly-layered media will provide important information on phonon localization in one dimension. We study theoretically the localization and related transmission fluctuations of phonons in random superlattices.

Analyzing the backscattering of phonons due to the mass-density fluctuations renormalized by including all of the forward scattering processes, we derive the analytic expressions for the average phonon transmission rate, the localization length and the transmission fluctuations. Both the average transmission rates and the transmission fluctuations are the functions of the system length divided by the mean free path, implying that the transmission fluctuations depend universally on the average transmission rate. We compare the analytic results with the numerical calculations based on transfer matrix method.

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The 7th International Conference on Phonon Scattering in Condensed Matter, Ithaca, U. S. A., 1992

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### **Design of a Superlattice Based Phonon Optics Device**

S. MIZUNO and S. TAMURA

Department of Engineering Science, Hokkaido University,  
Sapporo 060, Japan

Phonon optics devices such as frequency-selective phonon filters and reflectors based on thin-film superlattice structures were suggested by Narayanamurti several years ago. Here, we propose a new type of phonon optics device. The system we consider has a double barrier structure for phonons consisting of a bulk material sandwiched by periodic superlattices. We have derived the analytical expressions for the phonon transmission rate and the resonance condition in this system. The results indicate that the phonons in frequency gaps of the superlattices are transmitted through the whole system without attenuation, when the frequency of incident phonons coincides with that of discrete levels; these levels are induced by the sandwiched bulk material and located in a wide frequency gap. The sharp resonant transmission originating from these levels is used to design a phonon resonator for the detection or generation of monochromatic high-frequency phonons.

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The 13th International Symposium on Nonlinear Acoustics, Bergen, Norway, 28 June-2 July 1993

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**Nonlinear Propagation of Plane Waves Emitted  
by the Variation of Temperature on a Wall**

Yoshinori INOUE and Yutaka UNEURA  
Department of Engineering Science, Faculty of Engineering  
Hokkaido University, Sapporo 060, Japan

The weakly nonlinear propagation of the waves is studied, which are generated in a half-space filled with a perfect gas when the wall temperature varies sinusoidally only during a half cycle. The field may be divided into two regions, a thermal boundary layer adjacent to the wall and an outer wave region. Suppose a parameter  $\varepsilon \equiv \delta_T/\lambda$  is sufficiently small compared with unity and  $\alpha \equiv \Delta T/\varepsilon T_0 = O(1)$ . The weak flow in  $O(\varepsilon^2)$  is then induced at the outer edge of the thin layer and thereby an acoustic wave is radiated to the outer wave region. The nonlinear behaviour in the far field is exactly investigated using the Burgers equation. If  $1 \ll \alpha \ll \varepsilon^{-1}$ , the acoustic Reynolds number may be so large that two shock waves can be formed. In such a case the wave profile develops into an N wave with a tail. In the far field, the tail diminishes and so the wave is reduced to an ordinary N wave.

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The 122nd Electrochemical Society Meeting, Toronto, Ontario, Canada, October 11-16, 1992

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**Oxide Films Formed on Aluminum  
by Duplex Thermal/Anodic Oxidation Processes.  
—Effect of Pretreatment—**

Chiko IKEGAMI, Hideaki TAKAHASHI and Masahiro SEO  
Faculty of Engineering, Hokkaido University,  
Sapporo 060, Japan

Formation of anodic oxide films on aluminum with electropolishing,  $H_3PO_4/CrO_3$ - and NaOH-immersion treatment, followed by thermal oxidation at 823 K has been investigated by electrochemical measurements and electron microscopy.

It was found that thermal oxidation of  $H_3PO_4/CrO_3$ -treated specimens was slower than other specimens, and that the terminal thickness of thermal oxide films was ca. 30 nm, independent of the kind of pretreatment.

The anodic oxide films formed on all the 3 hr heated specimens showed a crystalline one

layer structure, the thickness of which was proportional to the anode potential with  $0.77 \text{ nm V}^{-1}$  as the proportionality constant. The anodic oxide films on electropolished and  $\text{H}_3\text{PO}_4/\text{CrO}_3$ -treated specimens included appreciable amounts of voids and cracks. The apparent dielectric constant of the anodic oxide films was observed to be 10-34, depending on the anode potential. This is discussed in terms of the penetration of electrolyte into voids in the oxide after anodizing.

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The 183rd Electrochemical  
Society Meeting, Honolulu,  
Hawaii, U. S. A., May 16-21,  
1993

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### **Breakdown on Anodic Oxide Films on Aluminum by Cathodic Polarization**

Hideaki TAKAHASHI, Kazutoshi FUJIWARA, and Masahiro SEO  
Faculty of Engineering, Hokkaido University,  
Sapporo 060, Japan

Aluminum electrode covered with porous-and barrier-type anodic oxide films was polarized to negative potentials in a neutral borate solution to examine the breakdown of the oxide films by cathodic polarization.

During cathodic polarization, a number of pits were formed and an appreciable amounts of dissolved  $\text{Al}^{3+}$  ions were observed. The number of pits and the amount of dissolved  $\text{Al}^{3+}$  ions increased considerably with decreasing film thickness by chemical dissolution of oxide.

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The 18rd Electrochemical  
Society Meeting, Honolulu,  
Hawaii, U. S. A., May 16-21,  
1993

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### **Electroluminescence From p-Type Silicon During Anodic Oxidation and Breakdown of The Anodic Oxide Films**

M. SEO, K. FUSHIMI, H. TAKAHASHI and K. AOTSUKA  
Department of Engineering Science, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

Electroluminescence (EL) from p-type Si was observed during anodic oxidation under a galvanostatic condition in ethylene glycol solution of  $\text{KNO}_3$ . The EL spectra consist of two peaks at 370 nm and 670 nm. The addition of KCl to the solution enhanced the EL peak intensities, particularly, at 670 nm. The EL intensities of 370 nm and 670 nm, however, decreased

rapidly at the breakdown of anodic oxide films, responding to the change in electrode potential of Si. Discussions were made on the relation between breakdown of anodic oxide films and EL.

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The 12th ISRS International  
Symposium on the Reactivity  
of Solids, Madrid, Spain,  
September, 1992

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**Effect of Preparation Temperature and  
Grinding Time of  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub> on its  
Reactivity for MgFe<sub>2</sub>O<sub>4</sub> Formation**

Ryusaburo FURUICHI, Syuuichi NAKANO,  
Shiro SHIMADA and Tadao ISHII  
Faculty of Engineering, Hokkaido University  
Kita-KU Sapporo 060 Japan

$\alpha$ -Fe<sub>2</sub>O<sub>3</sub>(500) and  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>(1200) were prepared at 500°C and 1200°C and ground for  $t_m = 0$ -300 min. The BET area ( $S_{BET}$ ), median diameter ( $D_m$ ), and crystallite size ( $D_c$ ) of  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>(500) were unchanged with  $t_m$ , but  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>(1200) showed increasing  $S_{BET}$  and decreasing  $D_m$  and  $D_c$ . MgFe<sub>2</sub>O<sub>4</sub> formed through surface reaction followed by the process obeying Jander's law. Grinding increased the fractional surface reaction. Jander's rate was constant for  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>(500) and increased with  $t_m$  for  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>(1200).

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Tenth International Confer-  
ence on Vacuum Ultraviolet  
Radiation Physics, Paris,  
July 27-31, 1992

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**Predominant Decay Channel for Superexcited  
Organic Molecules**

Hitoshi KOIZUMI  
Faculty of Engineering, Hokkaido  
University, Sapporo 060, Japan

Photoabsorption and photoionization cross sections of organic molecules are systematically compared for elucidating relation between super-excitation and ionization. The cross sections examined are of alkenes, alkanes, alcohols, and ethers in the energy range of about 2 eV above the first ionization potential. Although the photoabsorption cross sections are much different one another, the photoionization cross sections are similar in each molecular group.

This result indicates that ions are formed only through direct photoionization and most of superexcited molecules dissociate to neutral fragments. Ionization efficiency curves are calculated under the assumption of no autoionization, and they well reproduce the observed ionization curves which mainly depend on energy difference between the first and second ionization potentials.

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The Japan-Russia Joint  
Meeting on Quantum Effects  
in Chemical Reaction—Low  
Temperature Chemistry,  
Nagoya, Japan, Nov. 29-  
Dec. 3, 1992

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**H-Abstraction Reaction in Solid Acetonitrile :  
An MO Approach**

Hiroshi YOSHIDA, Hiroto TACHIKAWA and Nobuyuki HOKARI  
Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

The H-atom abstraction by  $\text{CH}_3$  radical from acetonitrile at low temperature has attracted the interest of chemists because the atom tunneling in reaction was experimentally shown for the first time by ESR for this reaction. We studied this reaction based on ab initio MO calculations in order to deepen the understanding of the role of the atomic tunneling in the chemical reaction. The dependence of rate constant on temperature, especially almost zero-activation energy at low temperatures, as well as a large kinetic isotope effect between H and D atom reproduced by the theoretical calculations indicates that the ESR observations are understood in terms of the tunneling through the potential surface of the reaction.

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The International Symposium  
on Simulation and Design of  
Applied Electromagnetic Sys-  
tems. ISEM-Sapporo,  
Sapporo, Japan, Jan., 26-30,  
1993

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**Improvement of the Boundary Element Solution  
on the Corner Problem in Compound Materials**

Tsuyoshi TAKEDA and Toshihiko KUWAHARA\*  
Faculty of Engineering, Hokkaido University  
Sapporo, 060, Japan

\* Dept. of Electrical Engineering, Hakodate Technical College

The paper describes one of the method which improves the accuracy of boundary element solution without increasing the number of boundary elements. The problem shown here is an electrostatic field in compound dielectric materials having corners where the field becomes singular. An indicator for reforming the pattern of boundary mesh without making new other element, is proposed. Some numerical examples about the field near the corner are given to show, and the effectiveness of reforming the mesh is proved.

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The International Sympo-  
sium on Simulation and  
Design of Applied Electro-  
magnetic Systems, ISEM-  
Sapporo, Sapporo, Japan,  
Jan., 26-30, 1993

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**Preprocessor for the 3D Boundary Element Method  
based on the Constructive Solid Geometry**

Masakuni NISHINO and Tsuyoshi TAKEDA  
Faculty of Engineering, Hokkaido University  
Sapporo, 060, Japan

The preprocessor which generates boundary element meshes is proposed based on the constructive solid geometry. The method can perform the logical operation between the primitives having different nature of materials by introducing a new operation ADD besides fundamental ones such as AND, OR and SUBTRACT. When the ADD operation with a primitive is performed on the another primitive having different nature of material, the boundary mesh of the former one is left in the latter one. Then, the unique boundary mesh is made on the complex structure of materials.

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The International Symposium  
on Simulation and Design of  
Applied Electromagnetic Sys-  
tems, ISEM-Sapporo,  
Sapporo, Japan, Jan., 26-30,  
1993

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**A Mesh Refinement for Boundary Element Method  
using an Error Estimating Index**

Masash NAKAHIRA and Tsuyoshi TAKEDA  
Faculty of Engineering, Hokkaido University  
Sapporo, 060, Japan

The paper describes a mesh refinement for boundary element solution using an error estimating index. The index is defined as the difference between two field values at the specified point on the boundary. The one is the interpolation by the shape function on the boundary element. The another one is obtained by the integral scheme on whole boundary. The accuracy of the analysis depends on the layout of boundary elements. The proposed error estimating index can designate the elements to be subdivided or moved for the mesh refinement and the reformation of layout.

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Congres International sur  
Analyse en Distance, Rennes,  
France, Jun. 22-26, 1992

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**A Graphical Representation of Nonsymmetric Dissimilarities**

Yoshiharu SATO  
Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

Most of the graphical representations based of the dissimilarity data, typically multidimensional scaling, are implicitly assumed the Euclidean structure in a configuration space. However, if the observed dissimilarities are inherently nonsymmetric, this assumption is not suitable. Then, in this paper, we employ a Minkowski metric function which is allowed to be nonsymmetric reproducing the nonsymmetric dissimilarities, namely, we construct a configuration of objects in a Minkowski space. In order to get a general concrete metric function in 2 or 3 dimensional Minkowski space, we introduce a class of ovals or ovaloids that are used as the indicatrix which is a generalized concept of Euclidean unit hypersphere.

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Proceedings of the 2nd International Conference on Fuzzy Logic and Neural Networks, Japan, Jul. 17-22, 1992

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### **A Clustering Method For The Fuzzy Observations**

Mika SATO and Yoshiharu SATO  
Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

In a clustering problem in which the attributes of the objects are given by the linguistic variables, the ordinary fuzzy k-means method is not available when the value of the attribute is observed by a fuzzy grade. Here, we propose the modified fuzzy k-means clustering method for such data.

We define a new dissimilarity between two objects and a procedure which determines a centroid of a cluster based on the fuzzy set operations. These play an essential role of the clustering process and its criterion.

To investigate the performance of the presented method, we show some results of numerical examinations.

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The 2nd Meeting of Japanese-French Scientific Seminar—Data Science and its Applications—, Montpellier, France, Aug. 31-Sep. 2, 1992

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### **A Derivation of the Algebraic Curve for Two-dimensional Data Using the Least-squares Distance**

Masahiro MIZUTA  
Faculty of Engineering, Hokkaido University  
Sapporo 060, Japan

We present a new method for fitting algebraic curve to two dimensional data using the least-squares distance between data points and the curve.

Fitting smooth curves is one of the most important themes on pattern recognition and data analysis. Simple Regression Analysis or Multivariate Regression Analysis is in use for a data set consisting of observations on some variables which can be treated one of them as response variable and the others as explanatory variables. However, these analyses do not work well for a data set whose variables can not be distinguished between response and explanatory.

A fitting straight line can be obtained using Principal Component Analysis for this kind of data. We extend Principal Component Analysis to curve fitting with the algebraic curve that has the least-squares distance from data. Numerical examples of the proposed method are shown.

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1st International Conference  
on Biomedecal Engineering  
5th International Symposium  
on Biomedical & Rehabilita-  
tion Engineering Changhai,  
China Sept. 24-26, 1992

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### **Study on the improvement of lubrication properties for the artificial joint.**

Ikuya NISHIMURA, Keiichi IKUBO and Toshio YUHTA  
Division of Biomedical Engineering, Hokkaido University  
N13, W8, Kita-ku, Sapporo 060, Japan

The current materials used for the artificial joint are metal (SUS) or ceramics and ultra-high molecular weight polyethylene (UHMWPE). The loosening or rereplacement of the artificial joint are caused by the wear particles of the frictional surfaces. Those are formed by the friction between these materials. To prevent the wearing down of the frictional surface of the artificial joint is very important for the long-term clinical use. Therefore, we have designed micro surface structure at the frictional surfaces to make the lubrication condition stable and to reduce the wear particle formations.

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SEVENTH INTERNA-  
TIONAL CONFERENCE  
ON BIOMEDECAL ENGI-  
NEERING Singapore Decem-  
ber 2-4, 1992

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### **A Basic Study of the Hydraulic Characteristics of Micro Mechanisms.**

Dong-Wook KIM, Toshiyuki SHIMOOKA,  
Yoshinori MITAMURA and Toshio YUHTA  
Department of Biomedical Engineering Faculty of Engineering,  
Hokkaido University North 13. West 8. Sapporo Japan

A micro pressure transmission system using fluid was examined. This system has the possibility of power transmission in optional directions. The hydraulic characteristics were studied by using the capillary tube system and of the micro cylinder that consist of a rod and a

micro capillary tube. A new hydraulic micro actuator using magnetic fluid and an external magnetic field was also investigated.

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SEVENTH INTERNATIONAL CONFERENCE ON BIOMEDEICAL ENGINEERING Singapore December 2-4, 1992

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**A Study of the Hydrodynamics for Developing a New Bileaflet Prosthetic Heart Valve.**

Toshio YUHTA, Yukiaki KIKUTA and Yoshinori MITAMURA  
Department of Biomedical Engineering, Hokkaido University  
North 13 West 8 Kitaku Sapporo Hokkaido Japan 005

Parametric studies were conducted to determine design optimums for a new, bileaflet, centrally opening, prosthetic heart valve. Valve related complications have been attributed to hemodynamic disturbance caused by improper valve designs. Consequently, hydrodynamics is very important in valve development. To determine the optimum shape two design parameters, axis position rate ranging between 65% and 85% and leaflet curvature from 0% to 13% were used. Energy loss and closure volume were observed in mock circulation system to compare valve fluid dynamics. Results to hydrodynamic studies suggested an optimum axis position rate of 70% and a 9% leaflet curvature.

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American Society for Artificial Internal Organs  
39th Annual Meeting New Orleans, America April 29, 30 & May 1, 1993

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**Surface Modification of the Frictional Surfaces of Artificial Joint**

Ikuya NISHIMURA, Keiichi IKUBO and Toshio YUHTA  
University of Hokkaido

To overcome the wear problems associated with the artificial joint materials, new surface structure with regular patterning were designed and fabricated. The lubrication properties were studied to evaluate the wear of the frictional surfaces.

The surface structure was the dents pattern having a diameter of 0.3 mm with the pitch of 0.4 mm and 3  $\mu$ m depth. The pattern was fabricated on the stainless steel (SUS) surface by

photo chemical etching technique. The time-dependent changes of friction force between patterned SUS and smooth ultrahigh molecular weight polyethylene were measured, and the surface morphological changes were observed.

The smooth surface without patterning showed rapid increase in the friction force for up to one hour, then reached to the maximum value of 10 gf. However the friction force was maintained about 3 gf by the patterned surface. After experiments, many wear particles were observed on the patterned surface. These results demonstrated that the lubrication properties could be improved by patterning of the frictional surfaces. The surface patterning have a good effect on preventing the wear of the frictional surface. The life of the artificial joint could be extended by the patterning on the frictional surfaces.

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American Society for  
Artificial Internal Organs  
39th Annual Meeting New  
Orleans, America April 29,  
30 & May, 1, 1993

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### **Study of the Cell Contacting with Material and Affected by Physical Stimulations**

Toshiyuki SHIMOOKA, Kohji YAMADA, Ikuya NISHIMURA,  
Shun MURABAYASHI and Toshio YUHTA  
University of Hokkaido

For the purpose of controlling the functions of cells in the limited area without drugs, effects of physical stimulations on the surface of implanted materials were investigated. In this paper effects of the patterning of the surface and magnetic field are presented.

Aluminum stripes were patterned on the glass by photo-chemical fabrication. The width of the patterns was 40  $\mu\text{m}$  and thickness was 3-10  $\mu\text{m}$ . Then  $\text{Al}_2\text{O}_3$  was coated over the patterns. L929 Cells in EAGLE's MEM with 10% FBS at 37°C, in 5%  $\text{CO}_2$  were cultured with the patterned material for 96h, fixed and observed by SEM. Most of the cells had spindle shape and were lined along the stripes. On the patterns which had the triangular cross section, it was observed the cells were lined on the peaks of the patterns.

To study the effects of static magnetic field, a neodymium magnet (diameter of 15 mm) was placed under a culture dish (diameter of 35 mm) and L Cells were cultured. The magnetic flux density was 0.3 T (maximum) inside of the dish. The cultured cells were observed by the phase-contrast microscope. It is generally said static magnetic field has no effects on the cultured cells, but the cells were attracted to the magnetic field in our experiments. The density of the cells in the magnet's area was apparently higher than the density without magnetic field. The total number of the cells in the dish had no significant difference.

We are planning to study the effects of electric field by micro-patterned electrodes. These physical stimulations or these interactions are expected to be useful to influence the function of the cells.

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The 39th Annual Meeting of  
American Society for  
Artificial Internal Organs,  
New Orleans, U. S. A., April  
29-May 1, 1993

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**Application of pulsed magnetic fields  
for cellular immunomodulations**

Shun MURABAYASHI, Kouhei FUKAYA, Hiroshi MIYAZAKI,  
Toshio YUHTA, Tsuneo TAKAHASHI\* and Sadami SEKIGUCHI\*

\* Dept. of Biomedical Engineering, \* Hokkaido Red Cross

To evaluate if the pulsed magnetic field (PMF) can be applicable for the extracorporeal cellular immunomodulations, the effects of PMF on the activation process of macrophages and monocytes were studied.

Murine peritoneal macrophages prepared by thioglycollate stimulation were incubated in the presence of INF- $\gamma$  with or without LPS and exposed to the PMF of 4.4 mT with the frequency of 50 Hz and the duty of 50% which was generated by a Helmholtz coil. At the end of incubations, the activation of macrophages were evaluated by the measurements of glucose consumptions. Compared with the control samples which were shielded from the PMF, the degree of glucose consumption was enhanced as much as 30% by the exposure to PMF when they were incubated with both INF and LPS. No PMF effect was observed when they were stimulated by INF or LPS alone. It was found that the PMF affected the INF activation process and enhanced the susceptibility to the LPS.

The PMF also enhanced human monocytes activation, and demonstrated augmented and prompt Ca ion influx into the cells. These evidences suggest that the PMF could be one of the useful methods for cellular immunomodulations.

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The 39th Annual Meeting of  
American Society for  
Artificial Internal Organs,  
New Orleans, U. S. A., April  
29-May 1, 1993

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**Blood compatibility of plasmapheresis devices**

Shun MURABAYASHI  
Dept. of Biomedical Engineering

Due to the blood-material interactions during plasmapheresis, various hematological and immunological changes are known to occur, which include cellular changes in population, function and secretions, and humoral changes such as activations, adsorptions and denaturations.

These individual changes interact in ways that may impact on the hematological and immunological state of the patient. The degree and nature of the impact depends on the blood-material interactions. Regarding to the blood compatibility in plasmapheresis, we may think that if the blood-material induce less impacts, it would be more blood compatible. However, such impacts might induce beneficial effects for certain group of patients. We should not overlook such beneficial effects of so called "blood incompatible interactions". This concept is quite different from other type of artificial organs. Why the plasmapheresis is different? Because the plasmapheresis is not a replacement device, it is the therapeutic device, and used for the treatment of various diseases and many of them are immunologically mediated diseases. Therefore, the immunological impacts induced by the blood-material interactions might be beneficial for certain group of patients. Whether the impact will induce adverse effects or beneficial effect may depend on the patient's disease type and disease state. Therefore, the blood compatibility issue of plasmapheresis should be discussed not only from adverse point of view but also from possible beneficial effects point of view.

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The 39th Annual Meeting of  
American Society for  
Artificial Internal Organs,  
New Orleans, U. S. A., April  
29-May 1, 1993

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**Preliminary evaluation of substrate size effect  
on the cellular immunomodulations**

Hiroshi MIYAZAKI, Shun MURABAYASHI, Toshio YUHTA,  
and Kazunori ONOÉ\*

Dept. of Biomedical Engineering,

\* Institute of Immunological Science

It is well known that the adsorption behavior of lymphocytes on fiber materials is related to the fiber size. In our previous study, murine lymphocytes cultured on various sizes of fibers showed different IL-2 activity, and ultra-fine fibers of 1.5  $\mu\text{m}$  showed the highest value. Based upon these results, to evaluate the applicability of ultra-fine fibers on the extracorporeal immunomodulation, Con A was immobilized on the surface of fibers of different sizes. Murine lymphocytes were cultured on these fibers, and the effect of fiber size was evaluated in terms of IL-2 production.

The Con A immobilized fibers could stimulate as high as 70-80% of the maximal value induced by Con A. Statistical differences in IL-2 production were not observed among the fibers, although the contact area of the lymphocytes with the fiber became smaller as the fiber decreased in size, suggesting fiber size effect on lymphocytes functions. Therefore, ultra-fine fibers might be useful substrate for immobilizing biological response modifiers.

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The 4th International Symposium on Artificial Heart & Assist Devices, Tokyo, Japan, August 7-8, 1992

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### **Endurance of a Motor-Driven Assist Pump**

Eiji OKAMOTO, Kiyoshi TOMODA, Katsuyuki YAMAMOTO,  
Yoshinori MITAMURA\* and Tomohisa MIKAMI\*

Division of Biomedical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo, Japan

\* School of Engineering, Hokkaido Tokai University, Sapporo, Japan

We have developed a totally implantable assist pump system consisting of a motor-driven assist pump and a transcutaneous energy transmission system. The motor-driven assist pump (volume: 350 ml) consists of a brushless dc motor driving a ball-screw and a magnetic coupling mechanism between a blood pump and an actuator. The pump stroke is controlled by a PID-follow up controller on an one chip microcomputer.

Endurance of the pump has been tested in vitro. The motor-driven assist pump has been pumping water against an afterload of 100 mmHg with a drive rate of 75 bpm. Pump outflow, motor input power, and surface temperature on the actuator have been continuously monitored. Pump outflow of 4.9 l/min. has been obtained with an efficiency of 18% (pump output/motor input). No mechanical and electrical problems have been observed and the pump performance has not changed for 31 days.

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The 3rd Congress of Asian Federation of Societies for Ultrasound in Medicine and Biology, Seoul, Korea, August 30-September 3, 1992

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### **Measurement of Arterial Elasticity Using Intravascular Ultrasonic Imaging Technique**

Katsuyuki YAMAMOTO, Toshiyuki AMANO,  
Masahiro SHIKUTANI and Eiji OKAMOTO

Division of Biomedical Engineering, Hokkaido University, Sapporo, Japan

The intravascular ultrasonic imaging has potentialities of a new technique for obtaining elastic properties of the artery. Since the elastic properties are reflected in a pulsatile motion of the artery, the arterial elasticity can be measured as the pulsatile change of a luminal cross section in response to the pulsation in blood pressure. Based on this principle, we have developed a prototype system which enables us to measure the arterial elasticity using an intravas-

cular ultrasound probe. Inserting the probe and the manometer into the aorta of dogs through the femoral artery, we measured the luminal area of the aorta  $S$ , its pulsatile change  $\Delta S$ , and the pulse pressure  $\Delta P$ . From these parameters, the pressure-strain elastic modulus  $E_p$  was calculated by the equation;  $E_p = \Delta P / (\Delta D / D) = 2\Delta P / (\Delta S / S)$ , where  $D$  is the diameter of the aorta. The gradual increase of  $E_p$  ( $0.5$  to  $2.5 \times 10^6$  dyne/cm<sup>2</sup>) with increasing distance from the heart was confirmed in the in vivo experiments.

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The 20th International Symposium on Acoustical Imaging, Nanjing, China, September 12-14, 1992

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### **An Intravascular Ultrasonic Imaging Technique for Measurement of Elastic Properties of the Artery**

Katsuyuki YAMAMOTO, Masahiro SHIKUTANI,  
Toshiyuki AMANO and Eiji OKAMOTO

Division of Biomedical Engineering, Hokkaido University, Sapporo, Japan

We have developed a prototype system which enables us to measure the arterial elasticity using an intravascular ultrasonic imaging technique. The system is designed to detect the pulsation of the artery with simultaneous measurement of blood pressure. It consists of an intravascular probe of 2.7-mm diameter, a pulser and receiver unit, an A/D converter, a catheter-tip manometer for blood pressure measurement, and a personal computer. A 15-MHz PZT element is placed at the tip of the probe and connected to a mechanically rotating flexible shaft. Echo signals from the receiver are transferred to the computer and used for constructing the cross-sectional images of the artery. A contour detection algorithm has also been developed to obtain the luminal cross section.

The performance of the system was evaluated by measuring the elasticity in the aorta of dogs. The results show that the intravascular ultrasonic imaging technique combined with blood pressure measurement is promising not only for the morphological studies but also for characterizing the elastic properties of the artery.

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The 2nd Korea-Japan Joint  
Conference on Totally Im-  
plantable Artificial Heart  
and its Hemocompatibility,  
Osaka, Japan, September 28-  
29, 1992

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### **An Implantable Motor-Driven Assist Pump System**

Yoshinori MITAMURA, Eiji OKAMOTO\* and Katsuyuki YAMAMOTO\*  
School of Engineering, Hokkaido Tokai University, Sapporo Japan

\* Division of Biomedical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo, Japan

We have been developing a totally implantable assist pump system consisting of a motor-driven assist pump and a transcutaneous energy and information transmission system. The motor-driven assist pump consists of a brushless dc motor driving a miniature ball-screw, a pusher-plate type blood pump, a compliance chamber. The blood pump and the pump actuator are magnetically coupled. During a diastole a vacuum pressure less than  $-25$  mmHg is applied to the blood pump. Stroke of the blood pump is controlled by a PID-follow up controller on an 8-bits 1-chip microcomputer.

In vitro tests show that the assist pump system has adequate hemodynamics performance (pump outflow of 4.5 l/min. against a mean afterload of 100 mmHg with motor input power of 5.0 W), high actuator efficiency (20%), and long-term durability (over 38 days).

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The 13th Nihon University  
International Symposium  
Research and Development  
of Artificial Heart: Its Con-  
tribution to Human Welfare,  
Tokyo, Japan, March 10-11,  
1993

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### **A High Performance Controller for a Totally Implantable Assist Pump System**

Eiji OKAMOTO, Kiyoshi TOMODA, Katsuyuki YAMAMOTO,  
Yoshinori MITAMURA\* and Tomohisa MIKAMI\*

Division of Biomedical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo Japan

\* School of Engineering, Hokkaido Tokai University, Sapporo, Japan

We are developing a high-performance controller and a bi-directional optical telemetry system for a next stage totally implantable motor-driven assist pump system. The high perfor-

mance controller consists of a 16-bits and an 8-bits 1-chip microcomputer, and a power amplifier. The assist pump is mainly controlled by the 16-bits 1-chip microcomputer. The 8-bits 1-chip microcomputer is responsible for time management for pump systole and diastole, measurement of pump stroke and motor velocity, and output of PWM signal. The bi-directional optical telemetry system consists of two pairs of an infrared LED and a silicon PIN photo-diode, and two pairs of a digital modulator and a digital demodulator. The optical telemetry system offers transcutaneous communication between the high performance controller inside body and a host computer outside the body.

This new control system contributes toward controlling the totally implantable assist pump system so as to maintain a patient in good physiological condition.

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The 39th Annual Meeting of  
American Society for  
Artificial Internal Organs,  
New Orleans, USA, April  
29-May 1, 1993

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### **A Novel Totally Implantable Motor-Driven Assist Pump System**

Yoshinori MITAMURA, Eiji OKAMOTO\*, Katsuyuki YAMAMOTO\*,  
Kiyoshi TOMODA\* and Tomohisa MIKAMI

School of Engineering, Hokkaido Tokai University, Sapporo, Japan

\* Division of Biomedical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo, Japan

To meet a strong demand for a totally implantable assist pump system, we have developed a novel assist pump system.

The assist pump consists of a brushless d. c. motor driving a miniature ball-screw, a blood pump (65 ml), a compliance chamber, and a controller. The blood pump and the actuator are magnetically coupled during a diastole. A vacuum pressure of  $-25$  mmHg is applied to the pump. The pump volume is 350 ml. Stroke of the blood pump is controlled by a PID-follow up controller on an 8-bits one chip microcomputer.

Pump outflow of 5.4 l/min. was obtained with an efficiency of 21%. Pumping continued up to 87 days. A power of 24.5 W was transcutaneously transmitted into the body with a temperature rise of 0.2 C in vivo experiments. Two-channel transcutaneous optical information transmission was achieved.

The developed assist pump system has adequate pump performance and reliability for long-term use.

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The International Symposium on Simulation and Design of Applied Electromagnetic Systems, Sapporo, Japan, Jan. 26-30, 1992.

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**Evaluation of Ion-current Exposure on Animal Bodies  
Using Boundary Element Method**

Masaji YAMASHITA, Koichi SHIMIZU\* and Goro MATSUMOTO  
Hokkaido Institute of Technology, Sapporo 006, Japan

\* Division of Biomedical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

For the safety assessment of DC power transmission lines, a technique has been developed to evaluate the ion-current exposure on animal bodies. This technique is based on the boundary element method. The space charge terms were processed under an assumption of a lumped source of ion-current. Calculation errors were examined and found to be small enough for our applications. Using this technique, the ion-current exposure was evaluated with a human bodies. The field distributions along the body surface were obtained. Their dependence on the ion density and the insulating conditions was clarified.

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The 12th International Symposium on Biotelemetry, Ancona, Italy, Aug. 31-Sep. 5, 1992.

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**Development of Simultaneous Tele-stimulation  
and Telemetry System for Brain Research**

Masaji YAMASHITA, Koichi SHIMIZU\* and Goro MATSUMOTO  
Hokkaido Institute of Technology, Sapporo 006, Japan

\* Division of Biomedical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

A tele-stimulation and telemetry system was developed for the EEG analysis of a rabbit. It enables us to stimulate the brain and to measure the neural responses at the same time without restraining the subject. This system is used to study the EEG of the epilepsy of a rabbit. To induce an epileptic fit, a rabbit is stimulated from a remote place without visual and auditory cues. A flash of invisible infrared light is illuminated on the rabbit, and photo diode circuit gives the electric stimulation on the hippocampus neurons of the rabbit. Two channels of EEG signals are transmitted from the rabbit to a remote place using radio FM waves. Two channels are differentiated by the difference in modulation frequency, or 78 MHz

and 89 MHz. The system is small and light enough to be equipped on a rabbit's head. The feasibility of this technique was verified by detecting EEG signals before and after epileptic fits. This system should be useful to detect the neural responses when stimulating other nucleus, such as suprachiasmatic nucleus for rhythmic control.

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1992 International Symposium on Antennas and Propagation, Sapporo, Japan, Sep. 22-25, 1992.

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**Suppression of Diffuse Scattering  
for Imaging Through Dense Random Media**

Koichi SHIMIZU, Masataka KITAMA, Tatsuya NAKAI  
and Katsuyuki YAMAMOTO

Division of Biomedical Engineering, Faculty of Engineering,  
Hokkaido University, Sapporo, 060 Japan

For the imaging through dense random media, we have studied the light propagation in the diffuse medium such as biological tissues. In a computer simulation, the behavior of light in the medium was analyzed. Based on the results of the analysis, a technique was proposed to suppress the diffuse scattering. In experiments, the effectiveness of the technique was verified, and its applicability to biological tissue was confirmed.

This technique seems to have promising potential to visualize the internal structure of animal body using light. It may be able to contribute to the realization of an optical CT.

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Second International Symposium on Functionally Gradient Materials, San Francisco, USA, Nov. 2-4, 1992

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**Functionally Gradient Material of the System Ni-AIN  
by Pressureless Sintering**

Koji ATARASHIYA, Yusuke ISHIDA and Tadao NAGAI  
Metals Research Institute, Faculty of Engineering  
Hokkaido University, Sapporo 060, Japan  
Masahiro UDA  
Nisshin Steel Co. Ltd., Ichikawa 272, Japan

A FGM-block of the system Ni-AIN was prepared by powder metallurgy. A compositionally gradient mixture of a coarse nickel powder and an ultrafine aluminum particle

was pressed (200 MPa) in a steel die followed by two-step heating (600 K and 1000 K) in flowing nitrogen. In this process, the ultrafine aluminum particle reacted with nitrogen into aluminum nitride, but, the nickel powder did not react with nitrogen. Thus, the Ni-AIN FGM block was completely accomplished. The FGM block prepared by this method was characterized by some properties.

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Second International Forum  
on Structural Ceramics Join-  
ing, San Francisco, USA,  
Nov. 3-4, 1992

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### **Joining of AIN Plate and Composite of the System Al-AIN Using Ultrafine Al Particle**

Koji ATARASHIYA  
Metals Research Institute, Faculty of Engineering  
Hokkaido University, Sapporo 060, Japan

A commercial Al powder 5-12  $\mu\text{m}$  in diameter and ultrafine Al-AIN particle 0.2  $\mu\text{m}$  in diameter were used. Compositionally changed (25, 50 or 75 wt% Al respectively) mixtures of the commercial powder and the ultrafine particle were pressed (200 MPa) in a steel die. These green compact were put on AIN plates followed by heating (873 K) in flowing nitrogen. Then, the joinings were completely accomplished. Chemical analysis of the material in the vicinity of the interlayer, carried out by means of EPMA, indicated that Al metal layer was formed along the interlayer.

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International Conference on  
Advanced Composites—Fab-  
rication, Processing, Prop-  
erties, Performance, Design  
and Applications—Wollon-  
gong, Australia, Feb. 15-19,  
1993

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### **Nano-Structured FGM of the System AlN-Ni**

Koji ATARASHIYA  
Metals Research Institute, Faculty of Engineering  
Hokkaido University, Sapporo 060, Japan  
Masahiro UDA  
Nisshin Steel Co. Ltd., Ichikawa 272, Japan

A nano-structured FGM block of the system AlN-Ni was prepared by the method of powder metallurgy. A compositionally gradient mixture of an ultrafine nickel particle and an ultrafine aluminum-aluminum nitride particle was pressed (200 MPa) in a steel die, followed by two-step sintering (873 K and 1273 K) in flowing nitrogen under null pressure. The techniques of an ultra-fine particle mixing and sintering without crystal-grain growth were invented. The structure and the compositional distributions of the FGM block were examined by SEM and EDX. The physical properties of the FGM block such as density, thermal expansion coefficient and micro hardness were measured.

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Coal Structure '92; Second  
Int. Symp. on Structure,  
Properties and Reactivity of  
Coal, Krakow, Poland, Sep-  
tember 21-23, 1992

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### **ESR and IR Studies of Electron Acceptor Doped-Coals and Model Compounds**

Yuzo SANADA, Haruo KUMAGAI and Masahide SASAKI\*  
Metals Research Institute, Faculty of engineering,  
Hokkaido University,  
N-13 W-18, Kita-ku, Sapporo, 060 Japan

\* Government Industrial Development Laboratory, Hokkaido,  
2-17, Tsukisamu-Higashi, Toyohira-ku, Sapporo, 062 Japan

With respect to coal chemistry, noncovalent bond interactions like hydrogen bonds and

aromatic  $\pi$ - $\pi$  interactions have to be clarified, because associations such as noncovalent bonding in the molecular structure of coal have greatly shown to influence the physical and chemical behaviors.

Charge transfer complexes of polyaromatic hydrocarbons and coal as host molecules are formed easily with tetracyanoquinodimethane and iodine as electron acceptors. They are characterized by means of electron spin resonance and infrared spectroscopic methods together with nuclear magnetic resonance method.

The method proposed is favorable not only exploring the substantial nature of pure aromatic hydrocarbons but also characterizing and monitoring of chemical reactions such as coalification and carbonization of coal.

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Gordon Research Conference  
on the Science of Hydrocarbon  
Resources, Hawaii, U. S.  
A. November 8-13, 1992

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**Structural Correlation of Organic Sulphur Compounds as Compared  
Between Extraction Oils and Hydrogenation Oils Derived from Coals  
by Means of HPLC-GC-LV MS**

Susumu YOKOYAMA, Akikazu OHTANI, Mitsuyoshi MURAJI,  
Mohamed M. Y. BAKR, Masaki SATOH and Yuzo SANADA  
Faculty of Engineering, Hokkaido University,  
Kitaku kita 13 Jyo Nishi 8 Choume, Sapporo, 060 Japan

In order to elucidate the bonding types of organic sulphur compounds in macromolecular coal structures, high sulphur content coal of Illinois No. 6 (C: 80.7, S: 2.5 wt. %) and Miike coal (C: 84.5, S: 1.1 wt. %) from Japan were subjected to study concerning the chemical structure of sulphur containing compounds in extraction oils soluble to n-hexane and hydrogenation oil derived from pyridine insoluble residue by hydrogenation reaction by means of capillary column GC and GC-MS analyses.

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Second Joint Saudi-Japanese  
Workshop on Recent Devel-  
opments in Selected Petro-  
leum Refining and Petro-  
chemical Processes, Dhahran,  
Saudi Arabia, December 12-  
13, 1992

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### **Characterization and Coking Behaviour of Heavy Oil and Polyaromatic Hydrocarbons**

Yuzo SANADA

Metals Research Institute, Faculty of engineering,  
Hokkaido University,  
N-13 W-18, Kita-ku, Sapporo, 060 Japan

This paper deals with charge transfer and hydrogen transfer in heavy aromatic hydrocarbons. Several significant articles have been referred to and discussed, covering the following items: (1) electron donor ability, (2) hydrogen donor ability of aromatic hydrocarbons, and (3) interaction of aromatic hydrocarbons with various catalysts.

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The 4th Japan-China Sympo-  
sium on Coal and C<sub>1</sub> Chemis-  
try Osaka, Japan, May 25-  
28, 1993

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### **Estimation of Physical Properties of Hydrocarbons in a Coal-Derived Liquid by a Group Contribution Method**

Masaki SATOU, Susumu YOKOYAMA and Yuzo SANADA

Metals Research Institute, Faculty of Engineering, Hokkaido University,  
Sapporo 060, Japan

A simple method of calculating the physical properties (boiling point, density and refractive index) of hydrocarbons in a coal derived liquid was developed using contribution of component groups to the property. Now, group analyses were performed by gas chromatography/mass spectroscopy (GC/MS) or a combination of <sup>1</sup>H-, <sup>13</sup>C- nuclear magnetic resonance (NMR) spectroscopies and elemental analysis. The component groups adopted in this study are aromatic rings, naphthenic rings, aromatic conjunction carbons and aromatic inner carbons. The contributions of each component group to physical property were determined by regression analysis. The values obtained corresponded well, with the increments per component group, to the physical property of normal paraffin with the same total number of carbons. Thus, the calculated properties of hydrocarbon compound classes in a coal derived liquid

showed good agreement with those observed.

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The 4th Japan-China Symposium on Coal and C<sub>1</sub> Chemistry Osaka, Japan, May 25-28, 1993

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### **EPR Power Saturation Behaviour of Electron Acceptor Doped Coal**

Haruo KUMAGAI<sup>1)</sup>, Masahide SASAKI<sup>2)</sup>, Kazuo NAKAMURA<sup>3)</sup>,  
Takaki OHKUBO<sup>1)</sup> and Yuzo SANADA<sup>1)</sup>

<sup>1)</sup> Metals Research Institute, Faculty of Engineering,  
Hokkaido University, Sapporo 060, Japan

<sup>2)</sup> Government Research Development Laboratory,  
Hokkaido, Sapporo 062, Japan

<sup>3)</sup> Fundamental Research Laboratories,  
Osaka Gas Co., Ltd., Osaka 554, Japan

The electron paramagnetic resonance (ERP) power saturation behaviour of both original and iodine doped coal has been monitored to investigate the  $\pi$ - $\pi$  interaction in coal. Changes in the EPR power saturation behaviour with iodine doping depend on the rank of coal. The contribution of  $\pi$ - $\pi$  interaction for formation of macromolecular structure in higher rank coal is larger than that of low rank coal. The EPR power saturation technique is useful to investigate the type and population of noncovalent interaction in coal.

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The 21st Biennial Conference  
on Carbon, June 13-18, 1993  
State University of New  
York at Buffalo, USA

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### **Characterization and Carbonization of Air-blown Pitches**

J. H. CHOI, H. KUMAGAI, M. SATOU, S. YOKOYAMA  
and Y. SANADA

Faculty of Engineering, Hokkaido University,  
Sapporo 060, Japan

The chemical property and the carbonization behaviour of the air blown coal tar and petroleum pitches were investigated with comparing the nitrogen blown ones. Petroleum and coal tar pitches seemed to have different reaction mechanism in air blowing reaction. Pro-

vided that both air and nitrogen the blown pitches showed the same toluene insoluble content level, air blown ones showed higher molecular mobility than nitrogen blown ones and exhibited lower carbonization yields.

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The 21st Biennial Conference  
on Carbon, June 13-18, 1993  
State University of New  
York at Buffalo, USA

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### **Kinetics of Carbonization in Air-blowing Process**

J. H. CHOI, H. KUMAGAI, T. CHIBA and Y. SANADA  
Faculty of Engineering, Hokkaido University,  
Sapporo 060, Japan

The kinetics of toluene insoluble (TI) formation from petroleum and coal tar pitches were studied under air or nitrogen blowing system. The rates of TI formation in air blowing could be explained with an assumption that the pitch would be composed with less-reactive and reactive components. Air blowing reaction of pitches would be less temperature-sensitive than nitrogen blowing one since the reactivity of pitch was promoted by oxygen in air.

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The 9th International Confer-  
ence on MHD Electrical  
Power Generation, Beijing,  
China, Oct. 12-16, 1992

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### **Effective Ohm's Law for a Spatiotemporally Fluctuating Combustion Plasma and its Effects on the Performance of the Faraday MHD Channel**

Naoyuki KAYUKAWA\*, Shun-ichi OIKAWA<sup>+</sup>, Yoshiaki AOKI\* and Shigeo YATSU\*

\* Advanced MHD Research Institute, Hokkaido University,  
N-13 W-8, Sapporo 060, Japan.

<sup>+</sup> Department of Nuclear Engineering, Hokkaido University,  
N-13 W-8, Sapporo 060, Japan.

Effects of the temporal fluctuation and spatially one dimensional inhomogeneity of a combustion magnetohydrodynamic plasma on the local and output characteristics of an infinitely segmented Faraday-type MHD generator were evaluated with numerically simulated turbulence of both the temperature and the velocity. An averaged Ohm's law was presented in terms of ensemble averages of the current density, the electric field, and the correlations between the electric field and the plasma conductivity. The Rosa's G-factor was extended to include the

effect of the temporal plasma fluctuation.

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The 9th International Conference on MHD Electrical Power Generation, Beijing, China, Oct. 12-16, 1992

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**Turbulence Suppression and Effective Generalized Ohm's Law for Partially Ionized Plasmas with Temperature Gradients**

Shun-ichi OIKAWA<sup>+</sup>, Naoyuki KAYUKAWA<sup>\*</sup>, Hiroshi SUGIYAMA<sup>+</sup>,  
Yoshiaki AOKI<sup>\*</sup> and Takeaki ENOTO<sup>+</sup>

<sup>+</sup> Department of Nuclear Engineering,

<sup>\*</sup> Advanced MHD Research Institute, Hokkaido University,  
Sapporo 060, Japan

A closed analytical turbulence model for the generalized Ohm's law in partially ionized plasmas with the spatial gradient of the electrical conductivity is formulated. This model does not require any a priori relations between the electrical quantities and fluctuating motion of the working fluid, other than relations between the mean and the fluctuating motion of fluids. The present model suggests that when there is a spatial gradient of the electrical conductivity on a plane perpendicular to the magnetic field, fluctuating motions of partially ionized plasmas are anisotropically suppressed even on that perpendicular plane due to the anisotropic Lorentz force exerted on the plasma, which results in the emergence of a steady flow along  $\nabla\sigma$ . Although the time-averaged conductivity at any point of the plasma increases with increasing temperature fluctuations because of the nonlinear dependence of the conductivity on temperature, the "effective" conductivity decreases. The Reynolds' stress tensor in the presence of a magnetic field based on the Prandtl's mixing length hypothesis in the presence of a magnetic field were derived.

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The 9th International Conference on MHD Electrical Power Generation, Beijing, China, Oct. 12-16, 1992

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### **Maximum Power Design of a Coupled MHD Generator and Magnet Coil System for 1300 MWth Coal Combustion MHD Generator**

Ryo NISHIMURA, Yoshiaki AOKI, Shigeo YATSU and Naoyuki KAYUKAWA  
Advanced MHD Research Institute, Faculty of Engineering, Hokkaido University,  
N-13 W-8, Sapporo 060, Japan.

This paper describes the effect of the cross-sectional distribution of the magnetic field upon the reduction of the MHD channel length. Employing a coal-combustion plasma with semi-perfect gaseous characteristics, the generator output performance of various magnet coil shapes was evaluated by the quasi 1-D gasdynamic model. The cross sectional shape optimization of an MHD generator channel including magnet coil was carried out for a 1300 MWth supersonic constant velocity Faraday-type MHD generator with a squared inlet cross section. It was shown that the channel length can be shortened by 34% by the optimization of the coil shape in comparison with the case of the crescent shape coil producing a uniform magnetic field, where the enthalpy extraction was effectively kept unchanged.

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Int. Symp. on Simulation and Design of Applied Electromagnetic Systems (ISEM-Sapporo) Sapporo, Jan. 26-30, 1993

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### **Electrofluidynamical Correlations of Seeded Combustion Plasma in a Faraday-type Magnetohydrodynamic Channel**

Naoyuki KAYUKAWA\*, Shun-ichi OIKAWA<sup>+</sup>, Yoshiaki AOKI\* and Shigeo YATSU

\* Advanced MHD Research Institute, Hokkaido University,  
N-13 W-8, Sapporo 060, Japan.

<sup>+</sup> Department of Nuclear Engineering, Hokkaido University,  
N-13 W-8, Sapporo 060, Japan.

Effects of the temporal fluctuation in an anisotropic combustion plasma on both the instantaneous and mean electrical behavior of the Faraday-type MHD channel were studied. The 2D MHD electrical equations were solved over the cross section of the channel with simulated turbulent data of each the velocity and the temperature. It was clarified that the correlation of the conductivity and the velocity fluctuation and that of the conductivity and the transverse electric field are positive and amount to several percents of the corresponding mean core

values. We showed that the mean output performance is enhanced by the turbulence, although the current and the electric field correlation results in the local electrode potential drops.

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Int. Symp. on Simulation  
and Design of Applied Elec-  
tromagnetic Systems (ISEM-  
Sapporo) Sapporo, Jan. 26-  
30, 1993

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**Turbulence damping in a weakly ionized plasma  
with a temperature gradient**

Shun-ichi OIKAWA\*, Naoyuki KAYUKAWA<sup>†</sup>, Yoshiaki AOKI<sup>†</sup> and Takeaki ENOTO\*

\* Department of Nuclear Engineering, Hokkaido University,  
N-13 W-8, Sapporo 060, Japan.

<sup>†</sup> Advanced MHD Research Institute, Hokkaido University,  
N-13 W-8, Sapporo 060, Japan.

A theoretical model was developed to explain the damping of the motion of a turbulent fluid lump in partially ionized magnetohydrodynamic (MHD) plasma flows with the spatial gradient of the electrical conductivity. The model was based upon the Prandtl's mixing length theory. The Lagrangian equation of motion for the lump was solved for the damped fluctuating velocity. The solution of a turbulent eddy velocity was averaged over its lifetime, and successively averaged in the fluctuation velocity space. Such procedures resulted in a steady mass flow along the spatial gradient of the electrical conductivity in the presence of the magnetic field due to anisotropic turbulence suppression. The approximated magnitude of the steady mass flow directed from the electrode wall to the core region was then evaluated.

Simple expressions for the damped Reynolds' stress and its damping coefficient tensor have also been presented.

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Int. Symp. on Simulation  
and Design of Applied Elec-  
tromagnetic Systems (ISEM-  
Sapporo) Sapporo, Jan. 26-  
30, 1993

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**Plasma Chaos under Oscillatory External Magnetic Field  
and Its Application to Controlling Internal Flux**

Shigeo YATSU\*, Atsushi IOBE\*, Masaru IWAMATSU, Yoshiaki AOKI\*,  
Tatsuo KASAHARA, Yutaka ABE<sup>+</sup> and Naoyuki KAYUKAWA\*

\* Advanced MHD Research Institute, Hokkaido University,  
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<sup>+</sup> Department of Nuclear Engineering, Hokkaido University,  
N-13 W-8, Sapporo 060, Japan.

The radial oscillation of a pinched plasma under an oscillating external magnetic field is analyzed numerically. The external magnetic field consists of a slowly varying bias field and a periodically oscillating field component. On the assumption that the plasma is confined in a thin annulus and plasma conductivity is finite, the nonlinear oscillatory behavior of plasma and the internal trapped magnetic flux are solved numerically. Results represent that the nonlinear radial oscillation excited by an oscillating external field have several kinds of oscillatory mode, and in addition to some quasiperiodic oscillations a chaotic oscillation is recognized as a stable mode. A power spectral density decreases in proportion to the inverse of frequency in the wide range. This tendency suggests our chaos may be "1/f chaos". The simulation about a theta pinch plasma using equations including the connection between a plasma current and an external circuit current gives a new result showing that when a small amplitude oscillatory field component is superimposed upon a normal crowbar decay magnetic field, the trapped flux inside of the plasma has originally. From our simulation's results, a feasible way to control the trapped flux inside of the initial plasma FRC formation is obtained.

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Int. Symp. on Simulation  
and Design of Applied Elec-  
tromagnetic Systems (ISEM-  
Sapporo) Sapporo, Jan. 26-  
30, 1993

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**Numerical studies on the shape optimization of a coupled 1300 MWth coal  
combustion MHD channel and magnet coil system**

Ryo NISHIMURA, Yoshiaki AOKI, Shun-ichi OIKAWA

Shigeo YATSU and Naoyuki KAYUKAWA,

Advanced MHD Research Institute, Faculty of Engineering, Hokkaido University,  
N-13 W-8, Sapporo 060, Japan.

This paper discusses the effect of the cross-sectional shape of the magnet coil upon the reduction of the MHD channel length. Employing a coal-combustion plasma with semiperfect gaseous characteristics, the generator output performance of various magnet coil shapes is evaluated by the quasi 1-D gasdynamic model. The shape optimization of a magnet coil cross section is carried out for a 1300 MWth supersonic Faraday-type MHD generator. It is shown that the channel length can be shortened more than 30% by the optimization of the coil shape in comparison with the case of the crescent shaped coil producing a uniform magnetic field, where the enthalpy extraction is effectively kept unchanged. Also, it is estimated that the capital cost for a stand alone commercial MHD plant can be decreased more than 6% by this coil shape optimization.

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The 31st Symposium on  
Engineering Aspects of  
magnetohydrodynamics  
(SEAM 31) Whitefish, June  
29, 1993

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**Coupled Optimization of the Channel and Magnet Coil Configuration  
for a 200 MWe Coal-fired MHD Generator**

Ryo NISHIMURA, Yoshiaki AOKI and Naoyuki KAYUKAWA

Advanced MHD Research Institute, Faculty of Engineering, Hokkaido University,  
N-13 W-8, Sapporo 060, Japan.

This paper discusses the effect of the cross-sectional shape of the magnet coil upon the reduction of the MHD channel length. The optimization for the cross-sectional shape of a magnet coil including an MHD channel is carried out for a 200 MWe coal fired supersonic Faraday-type MHD generator. It is shown that the channel and the coil length can be shortened more than 30% by the optimization of the coil shape in comparison with the case of the

crescent shaped coil producing a uniform magnetic field, where the enthalpy extraction is effectively kept unchanged. Also, it is estimated that the capital cost for a stand alone commercial MHD/steam combined plant can be decreased more than 6% by this coil shape optimization.

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China-Japan Joint International Conference on Graphics Education, Wuxi, China, March 31-April 3, 1993

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### **Attempts to Reform Graphics Education Systems in Hokkaido Districts Reflecting Recent Institutional Issues**

S. INO<sup>1</sup>, A. SUGINOME<sup>2</sup>, S. IWAI<sup>3</sup>, M. MITANI<sup>3</sup>,  
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<sup>1</sup> Laboratory of Information and Graphic Science,  
Faculty of Engineering, Hokkaido University, Japan

<sup>2</sup> Muroran Institute of Technology, Japan

<sup>3</sup> Hokkaido University of Education, Japan

<sup>4</sup> Kitami Institute of Technology, Japan

<sup>5</sup> Hokkaido Institute of Technology, Japan

Herein first to be outlined is the actualities of graphics education in universities with science/engineering faculties in Hokkaido, as one having undergone largely heteronomous changes in form and content.

Second, we introduce the current state of computer graphics education in Hokkaido, citing examples in Hokkaido University and Kitami Institute of Technology, where the above implied new subjects of Graphics Exercise and Computer Graphics Exercise have lately been instituted to help widen the established scope of graphics education.

Lastly, we suggest some idea about how we should reform the content of traditional graphics education in the near future when the total of its units is possibly reduced to somewhere between the present number and half that, c. g. from four to two in Hokkaido University and other relatively large institutes.

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China-Japan Joint International Conference on Graphics Education, Wuxi, China, March 31-April 3, 1993

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**Hypercard Stacks  
for Descriptive Geometry Education**

Hiroshi HAYASAKA  
Faculty of Engineering, Hokkaido University, Japan

Teaching aids for descriptive geometry have been developed. Teaching aids which are so called HyperCard stacks can use pictures, characters and even sound. HyperCard is the name of world-wide well-known software package for the Macintosh computer, originating in the U. S. A.. Stacks, a kind of software made by HyperCard, have been applied to descriptive geometry education at Hokkaido University in Japan. Due to unique features of HyperCard functions, we can make educational stacks more easily and effectively than ever. Developed stacks are mainly related to two or three dimensional presentation of various lines, plains and solid bodies which are in the textbook. These stacks runs in the computer and pictures on the CRT are projected to the screen by using a special film for a over head projector. This trial teaching method seems to give a better understanding of descriptive geometry for students compared with conventional blackboard and chalk education method. Students of the general education course are now obtaining information directly form a large computer screen projected with a special overhead projector system.

In this paper, HyperCard stacks for descriptive geometry education by the author are introduced briefly.

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JSME-ASME International Conference on Power Engineering-93, Tokyo, Japan, September 12-16, 1993

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**Numerical Analysis of Radiative Heat Transfer in a  
Boiler Furnace with Arbitrary Geometry**

Hiroshi HAYASAKA  
Hokkaido University, Japan  
Norihide MATSUMURA  
Shikoku Electric Company, Japan

Radiative Heat Ray Method (the RHR Method for short) which has been developed by one of authors is one of the effective methods to solve a radiative heat transfer problem in a

boiler furnace. Until recently, the RHR Method has only been applied to simple furnace geometry problems. Although an actual boiler furnace in a thermal power plant has a complicated shape with such as division walls. To solve a complicated shape furnace problem, a special numerical analysis technique is developed by the authors. As a results, the RHR Method is able to solve a radiative heat transfer problem in a complicated shape furnace with several division walls. In this paper, the effect of division walls on radiative heat transfer is discussed. This special furnace with several division walls will be used to reduced emissions such as  $\text{NO}_x$ ,  $\text{CO}_2$  and etc. in the near future.