Title	Summary International Reports, July 1994-June 1995
Citation	Memoirs of the Faculty of Engineering, Hokkaido University, 19(2), 225-377
Issue Date	1995
Doc URL	http://hdl.handle.net/2115/38062
Type	bulletin (other)
File Information	19(2)_227-378.pdf

Instructions for use

Appendix

Summary International Reports, July 1994-June 1995

July 1994-June 1995

The Design and Analysis of Submerged Floating Tunnels Subject to Waves and Earthquakes

Shunji KANIE, Yoichi MIZUTANI
Sapporo Branch, Taisei Corporation, Sapporo, Japan

Masashi SATO
Civil Engineering Research Institute, Hokkaido Development Bureau, Sapporo, Japan

You SAKAMOTO
Hokkaido Electric Power Company Inc., Sapporo, Japan

Yoshio KAKUTA
Hokkaido University, Sapporo, Japan

Submerged Floating Tunnels have not yet been developed for practical use, but they have different characteristics from conventional structures for strait crossings. The authors are studying the suitability of submerged floating tunnels in the seas around Japan, where significant wave and seismic action are unavoidable. This paper reports on some of the findings made so far in this research on submerged floating tunnels, focusing in particular on an example of analysis of wave and seismic action, which are critical forces in design. Proposals are also made for design procedures and analysis techniques.

Fatigue Design Procedure of Taut Mooring Line for Submerged Floating Tunnels

Naohiro MAEDA
Bridge Construction and Engineering Department, NKK, Yokohama, Japan

Masao MORIKAWA
Engineering Research Center, NKK, Tsu-City, Japan

Kuniteru ISHIKAWA
Ships and Offshore Engineering Department, NKK, Tsu-City, Japan

Yoshio KAKUTA
Hokkaido University, Sapporo, Japan

Submerged Floating Tunnels become attractive for crossing straits where the span exceeds the economical limits for a suspension bridge. Methods for designing the mooring lines of

submerged floating tunnels must be established. In particular, a method for evaluating fatigue strength is very important for the design stage. This paper presents a fatigue design method for the tension mooring lines of submerged floating tunnels. Fatigue strength analyses are performed for the mooring lines.

The Fifth International Conference on Marine and Offshore Industries and the Ice Technology September 13-16, 1994, Southampton, UK,

---

Ice control using a newly developed ice boom

H. SAEKI and F. HARA
Hokkaido University, Japan

S. KUNIMATSU
Second Harbour Construction Bureau, Ministry of Transport, Japan

K. ENOKI
Akita National College of Technology, Japan

M. MAWHINNEY
Tarmac Structural Repairs, UK

The authors conceived the use of an ice boom as a measure to prevent the ice floes from entering lagoons, and the authors have compared the controlling effect of the conventional ice boom with that of the new type ice boom and conducted experiments of controlling ice floes using a model at the second inlet of Saroma Lagoon. The authors report on the newly developed ice boom, which is an improved version of the new type ice boom and has a structure designed to prevent sea plants in lagoons from adhering to the ice boom and to repair the ice boom easily.

Pressure-area curve dependence on contact condition between ice sheet and structure

T. TAKEUCHI
Institute of Technology, Shimizu Corporation, Japan

H. SAEKI
Hokkaido University, Japan

C. ISHII
Akita University, Japan

M. MAWHINNEY

Tarmac Structural Repairs, UK

The relationship between indentation pressure and indentation area is examined through field ice indentation tests. The local ice pressures obtained here show intermittently sharp peaks and recessions, and do not satisfy the assumption that ice pressure in an independent ice failure zone follows the log-normal distribution used by Kry[1]. The nature of the contact between ice sheet and structure during indentation of structure into ice sheet is investigated statistically. It is shown that the indentation pressure is expressed a functionof contact ratio, indentation area and ice strength.

MODIFIED GREEN FUNCTION FOR WATER WAVE PROBLEM

Tsuneharu Orihashi and Yasunori Watanabe
Department of Civil Engineering, Hokkaido University, Japan

Ken-ichiro HAMANAKA
Department of Marine Sciences and Technology, Hokkaido Tokai University, Japan

For the problem of diffraction and radiation of water waves from an arbitrary shaped body John's Green function (1950) has been used by several authors. However this Jphn's Green function seems to have a ill behavior when the problem solved numerically through discretiza-

tion. In this paper we point out that this ill behavior is caused from the definition of delta function which is used by John, and propose a new Green function as a mokified Green function.

Conditions of Arch Formation by Ice Floes at Bridge Piers

Fumihiro Hara, Sei Kunimatsu and Hiroshi Saeki
Civil Engineering Dept., Hokkaido University, Japan

The authors have, since three years ago, been studying the conditions of arch formation due to the floes which cause ice jams at piers. The purposes of the present study are (1) to draw critical curves of arch formation, using flow velocity, the percentage of the floes covering water surface and the span of piers as variables, (2) to verify the effects due to cross-sectional shapes of the piers, and (3) to make use of the experimental results for designs and plans of pier construction on frozen rivers in future.

This paper reports on the results of the experiments to find how cross-sectional shapes of piers and shapes of floes influence the conditions of arch formation due to ice floes.

On Abrasion of Hydraulic Structures Cause by Movement of River Ice

Fumihiro Hara and Hiroshi Saeki
Department of Civil Engineering, Hokkaide University, Japan

This study clarified the present situation of damage to bridge piers in Hokkaide from abrasion due to ice movement, along with the mechanism of abrasion of various materials due to ice movement. In addition, based on these results, we describe a method to estimate the abrasion rate of concrete structures due to ice movement and confirm the appropriateness of the estimation method by comparing it with the results of field surveys.

The Strength of River Ice in the High Snow Accumulation Region of Hokkaido, Japan

Fumihiro Hara, Yashuhiro Okubo and Hiroshi Saeki
Department of Civil Engineering, Hokkaido University, Japan
Hazime YAMAGUCHI
Department of Civil Engineering, Hokkaigakuen University, Japan

The purpose of this study is to calculate the mean value of the unconfined compressive strength of the ice sheets through compression tests with specimens cut horizontally in the direction of the ice growth, and to estimate the strength of actual fresh water ice by comparing it with the results of compression tests conducted before with ice sheets in an artificial lake at the Katsurazawa Dam. The specimens were made out of ice sheets sampled from the Teshio River.

ICE LOAD ON WIDE STRUCTURE IN NON-SIMULTANEOUS FAILURE OF ICE SHEET BY SHOT NOISE MODEL

Takeuchi, TAKAHIRO
Research Engineer Shimizu Corporation, Japan
Saeki, HIROSHI
Professor Hokkaido University, Japan

A new method of generating local ice pressures is proposed through field ice-indentation tests. This method can statistically produce intermittent peaks of local ice pressures at independent ice failure zones of the ice/structure interface. It applies the shot noise model (WEISS, 1997) which is used to generate continuous time streamflows with sharp peaks and recessions. A spatial distribution of compressive strength of natural ice sheet is also considered, based on experimental data from ice sampled at Lake Saroma. The ice load calculation results as well as the contact ratio between ice sheet and structure are shown by combining the time histories of local ice pressures generated by the shot noise model for each independent ice failure zone.

Cold Storage and Transport System of Food Operated Only by Natural Energy

Toshihiko YAMASHITA and Hiroshi SAEKI
Department of Civil Engineering, Faculty of Engineering, Hokkaido University, Japan

Akihide IMAMURA
Cold Area Engineering Corporation, Japan

Hiroyuki NAKAGAWA
Hazama Corporation, Japan

The cold storage and transport system named "Solar J-Box" is suitable fore low-cost coldstorage and the transport of farm products in cold regions. This system is based on a new design concept which only used as a coolant and an electric fan, which is the only machine is motion, is powered by photovoltaic cells. Tis fan is used for circulating air for heat exchange. This system is energy saving and ecological, because it is operated only by natural energy. On the other hand, this system takes account of the transport system. Using a usual container with heat insulation as each unit, it is able to transport without transshipment of stocks. This paper describes the outline, field test results of the system and a questionnaire result of stored farm products.

Vertical Ice Forces on Pile Structures
Under Flooding Condition and Its Design Method

T. TERASHIMA and N. NAKAZAWA
Pacific Consultants, Japan

S. KIOKA, T. WATANABE and H. SAEKI
Hokkaido University, Japan

This presentation is titled Vertical Ice Forces on Pile Structures Under Flooding Condition and Its Design Method. In cold offshore regions, changes in water level can induce verticalforces on structures when sea ice cover interacts with the structures. A rise in water level generates an upward force on pile structures; likewise, a drop generates a downward force. These

forces are induced on pile structures due to changes in water level if the ice cover adheres to structures. In this presentation, I propose a method of calculation that estimated the vertical ice forces on pile structures due to changes in water level under flooding conditions.

THE THENTH INTERNA-
TIONAL SYMPOSIUM ON
OKHOTSK SEA AND SEA
ICE
February 5-8, 1995
MOMBETSU, HOKKAIDO,
JAPAN

Design Methods for Marina in Cold Regions

T. SASAJIMA and Y. MIZUNO
Hokkaido Development Bureau, Japan

T. TERASHIMA
Pacific Consultants, Japan

H. SAEKI
Hokkaido University, Japan

This paper presents the design methods for marina facilities in cold regions. Recently the marine recreation such as yachts and motorboats becomes popular in Japan. In Hokkaido, four public marinas are constructed in the coast of the Pacific Ocean and the Sea of Japan. This leads the marine activities more popular. But no marinas have been constructed in the coast of the Sea of Okhotsk ware sea ice cause many problems to the marina structures. On the other hand, a lot of marinas are constructed in the coast of Nothern Europe under the same climatic conditions as the Sea of Okhotsk, and marinas are used actively except the period when harbors are covered by sea ice. In this paper, the authors propose the design methods for marina facilities considering the ice influences on various structures.

Evaluation of Test Methods of Abrasion by Ice Movements on the Surface of Reinforces Concrete Structures

Fumihiro Hara, Masakuni Hanada, Shinichi Ito and Hiroshi Saeki
Department of Civil Engineering, Hokkaido University, Japan

The surface of reinforced concrete structures is subject to abrasion when they are constructed in rivers which freeze over in winter or in sea water where ice movement is active. Abrasion occurs due to the friction force between ice sheets and the structure caused by the ice force working on the structure. The exposure of reinforcing bars re resulting from a thin covering causes the loss of the stability of the structure because of rusting of the reinforcing bars and loses the yield strength of the structure itself.

Currently, a total seven abrasion test equipment have been developed in the world, including one developed by the authors. In this research, we look into the characteristics of each test equipment and evaluate its benefits and defects. Then we discuss the most rational abrasion test equipment in terms of reproducing abrasion by ice movement, each of tests and the similarity of abrasion mechanisms.

SAFETY FOR UTILIZATION OF ICE SHEET

Y. OKUBO and H. SAEKI
Hokkaido University, Japan

Y. ABE, M. ISHIKAWA and K. IZUMI
Hokkaido Tokai University, Japan

River, lakes and coastal area that freeze during winter are found in many part of the world. In Japan the Hokkaido area is especially affected by such freezing. Ice sheets are

frequently utilized for skating, fishing, parasailng and car and snowmobile racing. It is important to pay attention to safety in case of utilizing ice sheets. In this study we calculated bearing capacity of infinite ice plate that has a hole, and compare it with bearing capacity of infinite ice plate that has a hole, and we proposed the safe utilization methods of ice sheet.

THE THENTH INTERNA-
TIONAL SYMPOSIUM ON
OKHOTSK SEA AND SEA
ICE
February 5-8, 1995
MOMBETSU, HOKKAIDO,
JAPAN

THE STUDY ON ICE GOUGING

Y. MIZUNO, T. WAKAHAMA and K. IZUMI
Hokkaido Toukai University, Japan

S. KIOKA and H. SAEKI
Hokkaido University, Japan

Ice Gouging is phenomenon in which sea ice attached to the sea bottom in a shallow sea area scrapes the sea bottom while it is pushed by the offshore ice field to a shallow sea area. During its movement from offshore, the sea ice gouges the sea bottom, creating strong friction on reefy areas, and damaging sea urchins and sea weeds there. Conversely, the friction cleans up the breaker zone by eliminating sea weeks on the reef surface and directly exposes the surface.

In addition, off sandy beaches pressure by the sea ice itself kills shellfish and carries them to the shore, thus typifying the great influence on shellfish in shallow sea areas. Furthermore, sea ice possibly breaks intakes and pipes of hatchery facilities and damages fish reefs. Therefore, in order to create effective preventive measures against there problems, we believe that a dynamic model which represents ice gouging needs to be made to estimate the ice forces.

Kunimatsu et al. (1993) and Kioka et al. (1994) have been researching experimentally the effects of ice gouging and gave suggested equations to compute ice forces created by ice gouging. As we discuss later, in our research condition; the equations are strictly formulated, and they are verified by experiment.

VERTICAL ICE FORCE ACTING ON CIRCULAR-SECTION STRUCTURE

S. KIOKA and H. SAEKI
Hokkaido University, Japan

Y. TERASHIMA
Paciffic Consultant

When the ice cover adheres to a structure and change in water level occurs, vertical ice forces are exerted on the structure. and its forces shall be capable to pull out or damage against the structure.

Kerr (1975) calculated vertical ice forces caused by changes in water level, according to elastic plate theory. However, if the change in water level is great enough, either the ice cover will be fractured by the bending moment or adfreeze bond failure will occur. Although Kerr's method for calculating vertical ice forces is well derived, this method does not take both the vending failure into considerration. So, the method considered these failures have been proposed.

In this study, while we calculated its forces with varied or possible range of radius of structure, thickness of ice cover and Young's modules of ice against the past, we discussed its method. Also, considering the case of multi-legged structure, we discussed its effective values.

RUN-UP OF ICE FLOES ON IMPERMEABLE BEACH DUE TO TSUNAMI

Akira Katayama, Yoshimasa Takahashi, Akinori Hirano and Hiroshi Saeki
Hokkaido University, Japan

In the morning of March 4, 1952, an enormous tsunami, originated in the sea off the coast of Tokachi, japan, attacked the east coast of Hokkaido. As the result of it, towns and vil-

lages on the Pacific coast of Japan, especially those in Hokkaido and the Sanriku district suffered severe damage. When the tsunami attacked the coasts of Biwase and hamanaka bays which were located in the eastern part of Hokkaido, the both coasts were covered by ice floes drifted from the Okhotsk Sea. As the tsunami ran up the coast of Kiritappu peninsula which was located between Biwase and Hamanaka bays, with drifting ice floes, the damage of human lives and houses increased.

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 modules of ice and the velocity of ice floes due to the run-up of tsunami on flat beach should be clarified. In this paper, the authors experimented on the mechanism of ice floe movement due to solitary wave on impermeable flat beach.

STBILITY OF CONCRETE BLOCKS DUE TO ICE COLLISION

Y/TAKAHASHI, H/SAEKI
Hokkaido University, Japan

Y/YAMAGAMI
Alpha Suikho Consultant

In Okhotsk Sea coast of Hokkaido, the construction of aritificial rock reef which is used for the growth of konbu (a kind of seeweed) and sea urchin has been planned. The artificial rock reef consists of armor blocks of the artificial rock which are installed in offshore sido and filled stones which are placed behind armor blocks. The purpose of the structure is to make water depth shallow and konbu recieve easily sunshine. The authors investigate the stability of armor blocks due to the collision of ice in wave field through systematic experiments.

238

Numerical Study on the Energy Loss and the Wave Attenuation Over the Rippled Bed

Yasunori WATANABE and Hiroshi SAEKI
Hokkaido University, Japan

Ken-ichiro HAMANAKA
Hokkaido Tokai University, Japan

The kinematic energy loss of fluid over the rippled bad under the oscillatory flow, and the wave attenuation it causes, is investigated by numerical analysis. When surface waves propagate in shallow water regions, the flow field near the rough bottom become complex structures with separation and turbulence. We have succeeded in explaining numerically the flow field over the ripple for a relative high-Reynolds number. The energy loss of fluid over the ripple results in significant wave attenuation as a practical problem, especially for laboratory experiments. This problem is discussed by comparing numerically the reduction of wave height in the field and in a wave flume applying the Froude similitude.

Abrasion Mode of a Circular Cylindrical Concrete Structure Due to Sea Ice Movement

Yoshishige ITOH, Yoshihiro TANAKA and Alberto DELGADO
Taisei Corporation, Japan

Hiroshi Saeki
Hokkaido University, Japan

The estimation method for the abrasions of a cylindrical concrete structure due to sea ice movement proposed by Itoh et al. (1994) is extended to precisely predict the abrasion mode near the waterline of the concrete structure. The extended distinct element method (EDEM) by Meguro and Hakuno (1989) is applied to evaluate the ice contact pressure distribution on

the waterline assuming that the failure modes of the ice sheet be radial cracking and crushing. With a proper adjustment of the material parameters, realistic failure patterns and contact pressure histories can be obtained. We examine the adequacy of our extended estimation method through the field investigation of abrasion on concrete Swedish lighthouse. It is demonstrated that the abrasion mode of the circular cylindrical concrete structure would be mainly determined by the contact pressure distribution and the excursion of the broken pieces of the ice sheet near the waterline.

The Fifth (1885) International OFFSHORE AND POLAR ENGINEERING CONFERENCE
June 11-16, 1995
The Hague, The Netherlands

Mechanisms of Ice Gouging

Shinji Kioka and Hiroshi Saeki
Hokkaido University, Japan

Sea ice is carried to the coast of Hokkaido by wind and water currents every year. In low pressure systems or when there is much sea ice, it drifts out toward the Pacific Ocean. When sea ice moves in shallow water areas, the sandy subgrade on the sea bottom is gouged by the sea ice. This phenomenon is generally called "ice gouging". Substantial damage to sea food i. e. (shellfish) and to structures embedded in the seabed is reported every year. However, the mechanism and behavior of ice gouging is not known sufficiently enough for discussion. Therefore, we have conducted a suitable experiment to clarify this phenomenon and have suggested formulas to measure ice gouging.

Genuinely multi-dimensional scheme for shallow water equations

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

The grid independent upwinding algorithm for the numerical calculations of flows which was developed by Roe *et al.* was modified to apply to the shallow water flow equations. Some numerical tests by the unsteady two dimensional flows showed good ability of the model to catch the discontinuous phenomena such as Mach waves, the bores and the hydraulic jumps.

Neural Network Models Applied to Traffic Flow Problems

Takashi NAKATSUJI and Shuetsu SHIBUYA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Neural network models were applied to two traffic flow problems; the optimization of traffic signal timings and the description of macroscopic relationships between traffic flow variables. The first problem was separated into two processes, a training process and an optimization process. In the training process, two types of neural network model were used; a multilayer model and a Kohonen Feature Map model. The former model formed an input-output relationship between the timings and the objective function. Signal timings were adjusted so as to minimize the total weighted sum of delay time and stop frequencies. In the second problem, two-and three-dimensional relationships between traffic flow variables, such as density, mean speed, and flow rate, were described using both a multilayer model and a Kohonen Feature Map model.

Description of Macroscopic Relationships Among Traffic Flow Variables Using Neural Network Models

Takashi NAKATSUJI, Mitsuru TANAKA, Pourmoallem NASSER, and Toru HAGIWARA
Faculty of Engineering, Hokkaido University

Macroscopic relationships between traffic flow variables were described using some neural network models. First, a Kohonen Feature Map model was introduced to convert original observed data points into fewer, more uniformly distributed ones. This conversion improved regression precision and computational efficiency. Next, a multilayer neural network model was introduced to describe the two-dimensional relationships. The model was effective in describing the non-linear and discontinuous characteristics between traffic flow variables. It was unnecessary to specify the regression curves and the transition points in advance. Also, the multiple correlation coefficients resulting from the model were better than those resulting from a conventional non-linear equation.

Saturation flow rate at urban signalized intersections in winter

Takashi FUJIWARA, Takashi NAKATSUJI, Tohru HAGIWARA, Terutoshi KAKU
Department of Civil Engineering, Hokkaido University
Sapporo, JAPAN

The objective of this study is to clarify the degree to which slippery winter road conditions affect saturation flow rates at urban signalized intersections. In addition to usual traffic study and visual classification of road conditions, skid resistance values between tire and road surface were measured as an indicator of road slipperiness with a measuring device equipped vehicle. Skid resistance indicates friction resistance between a tire and the road surface, and is denoted by Skid Number. As a result, it was shown that the decrease of winter saturation flow rates was about 20 percent compared with the observed non-winter saturation flow rates and was at the most 30 percent compared with the basic saturation flow rate which is 2000pcpl-phg. PCE values for a heavy vehicle were estimated and heavy vehicle adjustment factors were computed using them.

STUDY OF LAW OF SIMILARITY OF VENTILATION CAUSED BY THERMAL CONVECTION IN SMALL ATRIUM MODELS, AND MEASUREMENTS OF TOTAL VENTILATION RATES

Masamichi ENAI and Noboru ARATANI
Dept of Architecture, Hokkaido University, Japan

Tomoaki MIYAJI
Nikken Sekkei Ltd., Japan

Tetsuhiro IKENAGA
Hokkaido Nikken Sekkei Ltd., Japan

ABSTRACT

Atriums in cold regions are cooled in the summer by the thermal convection. However, cooing effects are not estimated before construction, and it is very difficult to measure the actual ventilation rates in a full sized space. If the thermal factors in such a case could be simulated by a small model, this would be convenirnt. The appropriateness of such analyses to estimate the ventilation rates over the airflow patterns obtained using tracer gas techniques has not been confirmed.

This paper discusses tracer gas techniques for small model analyses as an applicable method for estimating ventilation rates. The law similarity, which can be used to simulate the thermal factors, has held well in such tests. Prior types of analyses by tracer gas techniques can be used to estimate the cooling effects if the atrium is being designed in a cold region.

Lessons Learned from the Three Large Damaging Earthquakes in Hokkaido, Northern Japan Occurred from 1993 to 1994

Hiroshi KAGAMI

Department of Architectural Engineering, Hokkaido University,

Sapporo 060 JAPAN

In Hokkaido district, northern most part of Japan, three large earthquakes hit and caused severe damages within two years of 1993 and 1994. In this paper the outline of these earthquakes is overviewed and lessons learned from these disasters are discussed considering their occurrence conditions. Based on the fact that these three earthquakes happened to occur at nighttime and attacked less populated areas, it is stressed that the lessons learned from these disasters should modify in order to adopt for the disaster mitigation problems in urbanized area.

Casualty Occurrence and Emergency Medical Response in the Two Major Earthquakes in 1993, in Hokkaido, Japan

Hitomi MURAKAMI

Department of Architectural Engineering, Hokkaido University,

Sapporo 060 JAPAN

In Hokkaido, the 1993 Kushiro earthquake caused 932 injuries mostly due to indoor damage of furniture and architectural elements. The 1993 southwest off Hokkaido earthquake accompanying very high tsunami resulted in 230 people killed and many injured. Medical facilities in both disaster regions suffered various damages to nonstructural elements, utilities, and equipment. In these two disasters, casualty distribution and causes, damage sustained at medical facilities, and emergency medical responses are investigated to elucidate ways to reduce such human casualty and better respond emergencies.

244

Change in Consumer's needs and Interruption of Lifelines
after the 1993 Kushiro-oki, Japan Earthquake

Chiaki WATANABE, Hiroshi KAGAMI
Department of Architectural Engineering, Hokkaido University, Sapporo 060 JAPAN

Haruo HAYASHI
Disaster Prevention Research Institute, Kyoto University, Uji 611 JAPAN

January 15, 1993 an earthquake hit Kushiro, thus resulting in severe damage of lifelines. Especially at Musa and Midorigaoka area, gas supply was suspended for a month, and citizens had to spend inconvenient days. We focus attention to the change in sales data with time before and after the earthquake, as citizens rushed to supermarkets and retail stores just after the earthquake.

Study on the Performance of an Up-flow Aerated Biofilter (UAB) in Municipal
Wastewater Treatments

Yoshimasa WATANABE, Satoshi OKABE
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Tomochika ARUTA
Maezawa Co. Ltd.. Saitama, Japan

Yuji HARATA
Niigatatekko Co. Ltd., Tokyo, Japan

A comprehensive wastewater treatment system that accomplishes oxidation of organic matter, nitrification, and denitrification was developed, and its characteristics and performance were investigated. A municipal wastewater was treated by an up-flow aerated biofilter (UAB), in which biofilms were developed on stainless meshes installed horizontally. This UAB exhibited a great potential ability of oxidation of organic matter, SS stabilization, and nitrification due to a unique aeration mechanism giving high DO concentrations with relatively low aeration rates. Another unique feature of the UAB was that attached biofilms on stainless

meshes physically filtered out and/or adsorbed suspended solids in the wastewater in addition to the biological oxidation of organic matter. A stable nitrification could be achieved at HRT=10 hours corresponding to a hydraulic loading of 86 L m^{-2} d^{-1} and at a ratio of aeration rate to wastewater flow rate (A/W) of 2, which is considerably low as compared to aeration rates of typical activated sludge systems. This UAB system also could handle relatively high hydraulic loading rates. The UAB used in this study still have enough space to install more stainless meshes so as to reduce hydraulic loading rates resulting in the reduction of HRT and aeration rate, which leads to improvement of the system performance as well as reduction of the running cost.

SIMULATION OF THE OPERATING CONDITIONS OF THE MUNICIPAL WASTEWATER TREATMENT PLANT AT LOW TEMPERATURES USING A MODEL THAT INCLUDES THE IAWPRC ACTIVATED SLUDGE MODEL

Naoyuki Funamizu and Tetsuo Takakuwa
Department of Sanitary and Environmental Engineering,
Hokkaido University, Sapporo, Japan

There are some advantages to using the sewage system to transport and melt snow in snowy regions. Since this would cause a drop in sewage temperature, adequate methods of operating treatment plants at low temperatures should be addressed. First, calibration of the IAWPRC activated sludge model was done using pilot plant data from a 10℃ experiment. Then, the temperature coefficients in the reaction rate equations were estimated using the data from operation at 5℃. Comparison of the simulation results with data gathered under other temperature conditions showed that the IAWPRC activated sludge model could be applied to low temperature conditions. A newly developed model of the full-scale plant was able to simulate not only the biological reaction in the aeration basin but also the performance of primary and final clarifiers, and sludge thickening and dewatering processes. The sludge and cake production rates, MLSS, and nitrification performance calculated by this model coincided with plant operation results at 12℃. Operation maps of the plant in Sapporo were drawn at presumed low temperatures, 4 and 8℃. They showed that if nitrifying bacteria were kept in the plant, an overload in the sludge treatment process would be unavoidable without augmenting the capacity of water or of the sludge-treatment system.

Study on Noise Reduction by T-profile barrier

Masaki HASEBE

Department of Sanitary and Environmental Engineering, Faculty of Engineering,
Hokkaido University, Sapporo 060 (Japan)

This paper presents an experimental study of the sound field emitted from a point source over a T-profile noise barrier. To clarify the noise reduction characteristics of a T-profile noise barrier, measurements were conducted indoors using a reduced-scale noise barrier and also outdoors using a full-scale noise barrier. The results obtained illustrate the advantages of T-profile noise barriers for noise reduction.

ESTIMATION OF REGION-BY-REGION SOURCE CONTRIBUTION RATIO TO THE ACID DEPOSITION IN JAPAN USING MODEL CALCULATIONS

Noritaka KATATANI*, Masanobu YOSHIKAWA*, Masahiro ICHIMURA**
Shin'ichi OKAMOTO*** and Naoto MURAO****

* Faculty of Engineering, Yamanashi University 4-3-11, Takeda, Kofu, 400, Japan
** Takano Corp., Japan
*** Tokyo University of Information Seiences, Japan
**** Faculty of Engineering, Hokkaido University, Japan

Abstract.

Some trial calculations were carried out in order to estimate region-by-region source contribution ratio to the acid deposition in Japan using a three-dimensional numerical model. The results are still on the preliminary stage, but following trends can be pointed out.

1) In winter, the oversea transport of pollutants from Asian continent contributes so much (more than 90% in maximum) especially in the region along Sea of Japan.

2) In the eastern part of Japan, the contribution of domestic emission is larger than foreign emission even in winter.

3) In summer, the effect of the oversea transport is much smaller except south-western part of Japan.

4) The estimated increase of SO_2 emission in P. R. China before 2000 may cause 5~25% increase of sulfates deposition in Japan compared to 1988.

A MODELING STUDY ON ACID DEPOSITION
IN EAST ASIA —— ESTIMATION OF
SOURCE-RECEPTOR RELATIONSHIP

Noritaka KATATANI[1], Naoto MURAO[2], Yoshiaki SASAKI[3],
Shin'ichi OKAMOTO[4] and Keizo KOBAYASHI[5]

1) Faculty of Engineering, Yamanashi University, Kofu, Japan
2) Faculty of Engineering, Hokkaido University, Sapporo, Japan
3) Fujitsu FACOM Information Processing Corp., Tokyo, Japan
4) Tokyo University of Information Sciences, Chiba, Japan
5) Japan Environmental Management Association for Industry, Tokyo, Japan

Abstract.

The numerical calculation and the statictical analysis were carried out in order to estimate the source-receptor relationships concerning the acid deposition in Japan. From these results, it can be judged that the precipitation acidity in Japan is affected by both oversea transport and domestic emissions of pollutants. The contribution of each source varies remarkably with the region and the season.

A SIMPLE CALCULATION METHOD FOR PARAMETERIZATION
OF TROPOSPHERIC CHEMISTRY

Satomi NAKAYAMA, Naoto MURAO, Kenji OGIWARA and Satio OHTA
Faculty of Engineering, Hokkaido University, Japan

Abstract ; In order to construct useful transport-chemistry model for large-scale variations of tropospheric trace species, accurate and low computational cost submodel for reaction is needed. Based on sensitivity analysis. Dunker developed a simple method for parameterization of atmospheric chemistry. We have investigated the possibility of applying the method to the equations of tropospheric photochemistry. Since the method was developed for urban air chemistry, some modifications were made. One-dimensional tropospheric model was used to test its accuracy and computational speed. The results indicated little loss of accuracy compared to detailed model simulations of chemistry with high time resolution. In addition, the computation time was reduced by about 2-order of magnitude.

ESTIMATION OF FUTURE ACID DEPOSITION IN EAST ASIA USING MODEL CALCULATIONS

Noritaka KATATANI[1], Masanobu YOSHIKAWA[1], Katsutoshi OKAZAKI[1],
Naoto MURAO[2], Sadamu YAMAGATA[2] and Sachio OHTA[2]

1 Faculty of Engineering, Yamanashi University, 4-3-11, Takada, Kofu, 400 Japan.
2 Faculty of Engineering, Hokkaido University, Sapporo, 060 Japan.

Abstract.

The authors have developed a three dimensional model in order to estimate those relation-
ships in East Asia, and some results of preliminary studies concerning the comptational
scheme, emission inventories, source-receptor relationships, etc. have been already reported.
In this paper, some trial calculations to estimate future acid deposition were conducted. The
future emission inventory was obtained by national reports and other results of socio-economi-
cal studies.

From the results, following points can be found.

1) The increase of SO_2 emission in P. R. China from 1987 through 2000 can cause 5~25%
   increase of sulfate deposition in Japan.

2) It is not easy to reduce sulfate deposition because approximately half of total SO_2 emis-
   sion in Japan is from volcanoes.

3) The increase of NO_x emission in these countries can cause more serious effects.

A MODELING STUDY ON ACID DEPOSITION IN EAST ASIA
— COMPARISON OF EULERIAN MODEL AND LAGRANGIAN MODEL —

Noritaka KATATANI[1], Naoto MURAO[2], Yoshiaki SASAKI[3],
Shin'ichi OKAMOTO[4] and Keizo KOBAYASHI[5]

1 Faculty of Engineering, Yamanashi University, 4-3-11, Takeda, Kofu, 400 Japan.
2 Faculty of Engineering, Hokkaido University, Sapporo, 060 Japan.
3 Fujitsu FACOM Information Processing Corp., Tokyo, 150 Japan.
4 Tokyo University of Information Sciences, Chiba, 265 Japan.
5 Japan Environmental Management Association for Industry, Tokyo, 110 Japan.

Abstract.

Model calculation is one of the useful methods to know such a source-receptor relationship. Many kinds of long-range transport model have been developed. The authors have developed a three-dimensional eulerian model in order to estimate those relationships in East Asia, and some results of preliminary studies concerning the computational scheme, emission inventories, source-receptor relationships, etc. have been already reported. In this paper, a comparison was carried out between above-mentioned eulerian model and a lagrangian model. The lagrangian model used in this study is based on the statistical trajectory model by Shannon (1981), and some modifications were made.

From the results, following points can be said.

1) The calculated values by both models were lying on the same level.

2) Some fractuations were found. The principal reason seemed to be the difference in deposition calculation.

Measurement of Gas Content and Prediction of Gas Emission from Longwall Panel

by Kotaro OHGA, Kiyoshi HIGUCHI
Hokkaido University, Sapporo, 060 JAPAN

Gota DEGUCHI
The Coal Mining Research Center, Tokyo, 101 JAPAN

The situation of Japanese coal mine is in the severe environment, because the policy on coal mining has changed. Nowadays we have only four coal mines in our country. To continue the production of coal, we have to reduce the cost of production. Therefore, the width of the longwall was attempted to expand more than 250m at Taiheiyo Coal Mine to reduce the cost. To get successful results by this mining method, the controlling and the prediction of gas emission from the longwall panel will be most important things.

In our laboratory, the special device for measurement of gas content of coal was developed and measurements of gas content of coal have been carried out by this device. The amount of gas emission from the longwall panel has been calculated by using the measured values of gas content by the special device. The measurement of amount of gas emission from the longwall panel has been carried out practically.

In this paper, the comparison of the predicted gas emission from the longwall panel by using numerical model with the observed results is described.

Water Jet Technology in the Japanese Coal Industry

Kotaro OHGA and Kiyoshi HIGUCHI
Hokkaido University, Sapporo 062 Japan

Due to the interst recently in methane as one of the gases causing the greenhouse effect, methane emission from coal mines will probably become the most serious problem for the Japanese coal industry in the near future. Various methods of methane drainage from coal

seam have been developed to reduce methane emission from the coal mines. In this paper, a method of methane drainage by using water jets system and the results of field tests are described.

Evaluation of methane Drainage from Mining Panel

K. OHGA and K. HIGUCHI
Hokkaido University, Sapporo, Japan

S. SHIMADA
University of Tokyo, Tokyo, Japan

G. DEGUCHI
The Coal Mining Research Center, Tokyo, JAPAN

In order to reduce the cost of coal production, mining by the longwall method, which is more than 250 m was attempted at the Taiheiyo Coal Mine. To get successful results by this mining method, the control and prediction of gas emission from the mining panel is most important. At the Taiheiyo Coal Mine, different methods of methane drainage from the mining panel have been carried out to reduce the methane concentration at the mining face.

To evaluate the effect of these drainage methods, different lengths of boreholes for methane drainage were drilled into the mining panel and the flow rate from each borehole was measured.

The results of data analysis showed that the conventional methane drainage method, which uses long-and middle-length boreholes, is very effective as a drainage method from disturbed coal seams, and the efficiency of methane drainage from undisturbed coal seams depends on the location of the borehole drilled in the coal seam.

Early Detection of Mine Fire in Underground by Using Smell Detectors

Kotaro OHGA and Kiyoshi HIGUCHI
Hokkaido University, Sapporo, 060 JAPAN

In our laboratory, a new detection system using smell detectors was developed to detect the spontaneous combustion of coal and the combustion of other materials used underground. Laboratory experiments were carried out on several kinds of coals, including South African coals, and machine oil, wood and rubber used in belt conveyers. The following results were obtained: 1) Spontaneous combustion of coal can be detected earlier by smell detectors than by conventional CO detection methods. 2) There were no differences in the results using different kinds of coal. 3) Combustion of other materials can also be detected earlier by this system than by conventional detectors for gas and smoke. 4) Use of this detection system enables one to discern the source of the combustion gases, whether it be coal, wood, oil or rubber.

Effect of Anionic Species on the Oxidative Dissolusion of Pyrite by Fe (III) Ions in Acid Solutions

Keiko SASAKI, Masami TSUNEKAWA
Department of Mineral Resources Development Engineering, Hokkaido University, Sapporo, Japan

Kiyoshi HASEBE
Graduate School of Environmental Earth Science, Hokkaido University, Sapporo, Japan

Hidetaka KONNO
Laboratory of Materials Chemistry, Hokkaido University, Sapporo, Japan

The reactivity of pyrite with Fe (III) ions in solutions of pH around 2 containing anionic species was evaluated by the determination of released Fe (II) ions, and by surface analysis of pyrite using X-ray photoelectron spectroscopy (XPS). The release of Fe (II) ions decreased with increasing concentration of total anionic species, and the suppression of pyrite dissolution was in the order chloride$<$sulfate$<<<$phosphate. The Fe (III) -CDTA and $[Fe (CN)_6]^{3-}$ complexes did not function as oxidants. For $[Fe (CN)_6]^{3-}$, the results were explained by a mechanism based on the molecular orbital theory, since the complex is inert and a low-spin

type. For the others, the order of suppression was found to be in parallel with the order of potential as oxidant, the standard redox-potential, E^0. The experimental results and the calculated E^0 indicate that E^0 for SO_4^{2-}/pyrite-S may be around 0.3 V. This means that E^0 is an important measure to estimate the ligand effect.

Influence of Extracellular Phospholipids on Bacterial Leaching of Chalcopyrite by *Thiobacillus ferrooxidans*

Naoki Hiroyoshi, Masami Tsunekawa and Tsuyoshi Hirajima
Deperment of Mineral Resources deveropment Enginnering,
Hokkaido University, Sapporo, Japan

Phosphalipids like phosphatidylglycerol and phosphatidylethanolamine are detected in cultures of *Thiobacillus ferrooxidans* and *Thiobacillus thiooxidans* as extracellular substances. In this study, the effects of the phospholipids on bacterial leaching of chalcopyrite by *Thiobacillus ferrooxidans* were investigated. Phosphatidylglycerol depressed the main reactions of the indirect leaching mechanism (the ferrous oxidation by *Thobacillus ferrooxidans* and chalcopyrite oxidation by ferric ions), and the amount of extracted copper in bacterial leaching decreased with increasing the addition. The addition of phosphatidylethanolamine had little influence on the main reactions of the indirect leaching mechanism and the copper extraction in bacterial leaching.

254

A Flexible Expert System to Assist Climate Control in a Deep Coal Mine by Using Heat Exchangers and Regulators

Yuusaku TOMINAGA, Takayosi IWAMOTO, Masaji KATO and Takeshi TANAKA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

A flexible expert system with algorithm to estimate climate condition in a network was developed to suggest working time of heat exchangers and branches to be set a regulator for reasonable use of natural ventilation pressure. The main results in this study are as follows; 1) An air temperature transfer diagram of a specified branch, a coal face and an advancing face, can be derived from the macroscopic characteristic. Control possibility range of air temperature of the specified branch can be shown as a parameter in the air temperature transfer diagram with the airflow rates in the two branches with regulator as coordinates. 2) To make operating cost of a main fan less, it is profitable that airflow in a branch with a regulator is the same direction as natural ventilation pressure. 3) A branch relation table between a branch with a regulator and natural ventilation pressure in a network is available to select a branch for setting a regulator in a network placed heat exchangers. 4) It is shown that a flexible expert system with proceeding computer simulation of mine ventilation is an effective tool to assist working schedule of heat exchangers and selection of a branch to be set a regulator.

An Integrated System to Control Airflow Rate Distribution in a Complicated Ventilation Network

Yuusaku TOMINAGA, Tsuyoshi KATOH and Shinya ONO
Faculty of Engineering, Hokkaido University, Sapporo 060, Japan

In order to monitor/control airflow rate distribution in a complicated ventilation network installed many regulators, an integrated system composed of expert system, exerting programs for simulation to get macroscopic characteristics and drawing diagram, monitoring system and so on is introduced in this study. The main results of this study are as follows; 1) Combinations of two branches to monitor aerodynamic resistance change in a branch p in a network can be selected by comparing factor's value in a branch relation table. 2) Dot pattern diagram shows airflow rate relation between an active branch and a passive branch. Three relations such as a) a straight line, b) a monotonous curve and c) extremums are displayed in

different patterns for all the sets between an active branch and a passive branch at a time. 3) The ranges of airflow rate in coal faces by changing aerodynamic resistance of any one branch placed a regulator are shown in the Pareto diagram using values in the branch relation table. 4) Ventilation transfer diagram with two parameter, one shows airflow rate in a coal face and the other shows energy provided by main fans to overcome aerodynamic resistance in a network, is utilized to decide countermeasures for decreasing energy consumption in the network on increasing of airflow rate in the specified branch.

An Application of Geostatistical Method to Estimation of Some Variables Distributed in a Geothermal Reservoir

Masaji KATO, Takeshi TANAKA and Yuusaku TOMINAGA

Faculty of Engineering, Hokkaido University, Sapporo, Japan

The distributions of both the initial temperature and the peak intensity of diffracted X-ray of pyrophyllite in the Matsukawa geothermal reservoir, where is located in Northeast Japan, were estimated by using geostatistical method, the kriging. These are important to comprehend a hydrothermal convection system in a geothermal reservoir. As a result, it was shown that the high temperature zone extends in the direction of SW deeply and there is frequent occurrence of pyrophyllite along intrusive rocks. Moreover, according to the mutual relationship between the initial temperature and the peak intensity of diffracted X-ray of pyrophyllite, it can be inferred that the temperature in this reservoir has decreased a few decades degrees C since pyrophyllite was deposited.

256

New Diagram Showing Potential of Geothermal Wells Drilled in a Geothermal Area

Takeshi TANAKA

Faculty of Engineering, Hokkaido University, Sapporo, Japan

It is difficult to clarify the potential of some geothermal wells drilled in the geothermal surveyed area.

New diagram can be drawn as a quadrangle diagram as follows.

Maximum temperature of geothermal well (T)

X-axis: $T = T_m$

T_m : Maximum temperature of the well (℃)

Index containing temperature decline (DI)

X'-axis: $DI = \left[1 - \dfrac{\Delta T}{T + \Delta T}\right] \times 100$

ΔT : Temperature decline (℃), $\Delta T = T_f - T_l$

T_f : Formation temperature of alteration minerals (℃)

T_l : Measured temperature of the well (℃)

Activity index (AI)

Y-axis: $AI = \left[1 - \dfrac{T_b - T_m}{T_b - T_g}\right] \times 100$

T_b : Boiling temperature of water at the depth (℃)

T_g : Imaginary temperature by average geothermal gradient (3℃/100m) at the depth (℃)

Heat flow (HF)

Y'-axis: $HF = k\dfrac{\Delta \theta}{\Delta z}$

k : Thermal conductivity ($\times 10^{-3}$w/m ℃)

$\dfrac{\Delta \theta}{\Delta z}$: Geothermal gradient (℃/m)

Applying this diagram to three main geothermal areas in Japan, Iburi area in Hokkaido district, Hachimantai-east area in Tohoku district and Kurino-Tearai area in Kyusyu district, it was proved to be effective.

Axisymmetric, Helical and Multipler Forcing of the Round Jet

Masaru KIYA, Yoshikazu OGURA and Yasushi IDO
Department of Mechanical Engineering, Hokkaido University

Three-dimensional discrete-vortex simulations were made of active forcing of a circular jet by periodic disturbances with axisymmetric, helical and multiple modes. The jet issuing from a straight nozzle was constructed by the combination of distributed source and vortex panels. The axisymmetric disturbance was produced by a sinusoidal oscillation of the axisymmetric of the source, while the helical disturbance was produced by a circumferential distribution of source strength oscillating sinusoidally with time. The multiple forcing was made by combinations of helical disturbances. The axisymmetric foring produced highly coherent vortex rings and high level of velocity fluctuations. The combination of clockwise and counterclockwise helical disturbances of the some frequency and the same circumferential wavenumber produced elliptical and square cross section of the jet depending on the wavenumber.

Forced Separation Bubble : Separated Shear Layer Interacting with Solid Surface

Masaru KIYA, Masayuki SHIMIZU, Osamu MOCHIZUKI and Yasushi IDO
Department of Mechanical Engineering, Hokkaido University

Separated shear layer emanating from the square-cut leading edge of a blunt circular cylinder was forced by single-frequency sinusoidal disturbances. The shear layer reattaches on the surface to form the separation bubble. The separation bubble was almost eliminated in a range of forcing frequency at sufficiently high levels of forcing. Flow visualization and survey of time-mean and fluctuating velocities revealed how the shear-layer vortices were modified by the forcing.

258

Aerodyncamic Sound Generated by Wake-Body Interaction

Osamu MOCHIZUKI, Masaru KIYA and Takashi ARAI
Department of Mechnaical Engineering, Hokkaido University

Aerodynamic sound generated from the flow around two circular cylinders of different diameters in staggered arrangement was investigated experimentally. The diameter of the upstream cylinder was 0.4 times smaller than that that of the downstream cylinder. Magnitude of sound generated by the vortex shedding from the upstream cylinder attained maxima and minima at particular longitudinal spacings between the cylinders. The distance between two successive maxima was approximately 4 diameters of the upstream cylinder. This distance was explained by assuming a self-excited flow sustained by a feedback loop.

Determination of a Complete Set of Basic Equations of Magnetic Fluids

Yasushi IDO and Masaru KIYA
Department of Mechanical Engineering, Hokkaido University

A complete set of basic equations was determined by the thermodynamical method based on the free energy and the dissipation function. The balance equations were derived from the conservation laws. Constitutive equations of conducting magnetic fluids were obtained using the principle of material frame indiference and the thermodynamical method. The quasi-conservative parts of the constitutive equations were determined by thermodynamical equations while the dissipative parts were derived by the principle of maximal dissipation rate. The electric displacement and the magnetic flux density were treated as variables of electromagnetic field. A new constitutive equation of magnetization is proposed. This new constitutive equation includes terms related to the unsteady effect of the magnetic field and the rotation of suspended ferromagnetic particles.

Aerodynamic Sound Generated by Wake-Body Interaction

Osamu MOCHIZUKI, Masaru KIYA and Takashi ARAI
Department of Mechanical Engineering, Hokkaido University

Aerodynamic sound generated by the flow past two circular cylinders in various arrangements was studied experimentally as a typical sound caused by the wake-body interaction. The diameter of the upstream cyliner was 0.4 times smaller than that of the downstream cylinder. The sound was presented as a function of the longitudinal spacing L and the lateral spacing S between the cylinders. Most important finding of this study is that the magnitude of sound generated by vortices periodically shed from the upstream cylinder attains several maxima (and minima) at longitudinal spacings with the interval of approximately 4 diameters of the upstream cylinder. This interval was explainedon the assumption that the flow between the cylinders is the self-excited flow maintained by the feedback loop. The shear-layer oscillation sound is generated by the two cylinders in staggered arrangement for the smaller longitudinal spacings than the critical spacing.

Bimodal active forcing of a turbulent separation bubble

Masaru KIYA
Department of Mechanical Engineering

The leading-edge separation bubble of a blunt circular cylinder is forced by a two-frequency sinusoidal disturbance at Reynolds number of 6.9×10^4. The disturbance is produced by a woofer inside the cylinder and introduced uniformly through a thin slot along the leading edge. The disturbance is defined on the basis of the sinusoidal velocity fluctuation measured near the leading edge. In most cases, one of the frequencies is the frequency, say F, at which the single-frequency forcing yields a minimum reattahment length of the separation bubble, while the other frequency is chosen as $2F$, $3F$, $4F$, $F/2$. Other combinations of the frequencies are also studied. The phase between two components ϕ ranges from 0 to 2π, while their r. m. s. amplitudes are chosen to be the same, ranging from 1% to 10% of the main-flow velocity U_∞. The reattachment length is found to depend most strongly on the phase for the combination of F and $2F$, attaining a maximum at phase $\phi = \pi$ and a minimum at phase $\phi = 0$

for the forcing amplitude of (0.01-0.02) U_∞. This is caused by the enhanced merging of vortices produced in the separated shear layer by the $2F$ component at phase $\phi = 0$ and the shredding of the vortices at phase $\phi = \pi$. If the forcing amplitude is increased to $0.10 U_\infty$, the reattachment lengh becomes independent of the phase. For the other combinations of the frequencies, the reattachment length insignificantly depends on the phase in the present range of the amplitude.

Three-Dimensional Numerical Analysis of Circular Jet by Vortex Method

Yasushi IDO, Masaru KIYA, Shunsuke OHTA and Yoshikazu OGURA
Department of Mechanical Engineering, Hokkaido University

A round jet issuing from a circular nozzle was simulated by three-dimensional vortex blob method. An upper limit was set for the vorticity of vortex blobs and the vortex structures were fairly independent of this condition.

Aerodyncamic Sound Generated by Two Parallel Circular Cylinders in Various Arrangements

Osamu MOCHIZUKI, Masaru KIYA and Takashi ARAI
Department of Mechanical Engineering, Hokkaido University

Aerodynamic sound generated by the flow past two circular cylinders in various arrangements was studied experimentally as a typical sound caused by the wake-body interaction. The diameter of the upstream cylinder was 0.4 times smaller then that of the downstream cylinder. The sound was presented as a function of the longitudinal spacing L and the lateral spacing S between the cylinders. The magnitude of the vortex-shedding sound from the upstream cylinder was found to change periodically with L. This change was observed even at a large S $(=1.75D)$, being interpreted in terms of the feedback mechanism. The shear-layer oscillation sound with higher frequency than that of the vortex-shedding sound appeared if $L \leqq L_c$ and $S \geqq S_c$, where L_c and S_c are the critical spacings.

Wavelet Transform of Turbulent-Wake Velocity Fluctuations

Masaru KIYA, Hitoshi ISHIKAWA and Osamu MOCHIZUKI
Department of Mechanical Engineering, Hokkaido University

Time histories of longitudinal velocity fluctuations in the intermediate- and far-wake
regions of the turbulent wake of a two-dimensional circular cylinder were analyzed by the
wavelet transform employing antisymmetric, Mexican-hat and Morlet wavelets. Contours of
the wavelet transform in the (a,b) space, where a is the scale and b implies the temporal
location of the wavelet, were basically similar for the three wavelets if the a- and b-axes were
appropriately translated. This was particularly true for the Mexican-hat wavelet and the real
part of the Morlet wavelet both of which are symmetric with respect to the location b. The
morlet wavelet was found to yield most detailed multiscale structure of the velocity fluctuations
among the three wavelets.

TRANSIENT PHENOMENA IN A SUSPENDED LIQUID DROPLET UNDER REDUCED GRAVITY AND HOT ENVIRONMENTS

Hiroshi TANIGUCHI, Kazuhiko KUDO, Tatsuru TANAKA and Tsuyoshi TOTANI
Department of Mechanical Engineering, Hokkaido University, Sapporo, Japan

Wen-jei YANG
Department of Mechanical Engineering & Applied Mechanics
University of Michigan, Ann Arbor, MI, U. S. A.

Transient profiles of velocity and temperature are numerically obtained within a droplet of
different liquid fuels which is suspended by a rod with a temperature of 300K and is exposed to
an environment with a temperature of 700K. The Marangoni number range is from 2.7×10^4 to
1.7×10^5. The diameters of the support rod and the droplet are 0.35 and 1.2mm respectively.
From the analysis, following results are obtained: Surface temperature of the droplet is almost
constant. Under the present conditions, the temperature rise within a droplet is appreciably
accelerated by the existence of the Marangoni convection.

ANALYSIS ON RADIATIVE CHARACTERISTICS
OF HIGH-TEMPERATURE NONGRAY-GAS JET

Kazuhiko KUDO, Hiroshi TANIGUCHI, Akiyoshi KURODA,
Maromu OTAKA, and Tetsuhiro USHIJIMA
Department of Mechanical Engineering, Hokkaido University, Sapporo, Japan

Masakazu OBATA
Research Institute, Ishikawajima-Harima Heavy Industries, Tokyo, Japan

Combined radiative-convective-heat transfar is analyzed in a two-dimensional co-axial jet of nongray gas. The Monte Carlo method is used for the radiative heat transfar calculation. To obtain the spectral absorption coefficient of CO_2 and H_2O, the Elsasser narrow-band model in conjunction with the correlation parameters in Edward's exponential wide-band model is used. From these studies, the profiles of the jet temperature and radiative heat flux to the surroundings and the spectrum of the heat flux are calculated, and following results are obtained. Gray gas analysis using Planck mean absorption coefficient gives higher jet temperature adjacent to the nozzle region and gives lower jet temperature in the down-flow region compared with nongray gas analysis. When the jet initial velocity is increased, the radiative cooling effect becomes relatively small compared to the enthalpy transport, and both the jet temperature and the radiative heat flux to the surroundings are increased.

Significant NO_x Reductions with Direct Water Injection
into the Sub-Chamber of an IDI Diesel Engine

Noboru MIYAMOTO, Hideyuki OGAWA, Jianxin WANG
Department of Mechanical Engineering, Hokkaido University
and Hiroshi OHASHI
Yanmar Diesel Co. Ltd.

The effect of direct water injection into the combustion chamber on NO_x reduction in an IDI diesel engine was investigated. The temperature distribution in the swirl chamber was analyzed quntitatively with high speed photography and the two color method.
Direct water injection into the swirl chamber prior to fuel injection reduced NO_x emission

significantly over a wide output range without sacrifice of BSFC. Other emissions were almost unchanged or slightly decreased with water injection. The flame temperature especially at the center of the swirl chamber, where the highest gas temperature was observed, was significantly reduced with water injection although the apparent mean gas temperature in the cylinder and the rate of heat release remained almost constant. It was found that this made it possible to reduce NO_x without sacrifice of BSFC.

Utilization of 10 Seconds Microgravity Environment for the Measurement of Coal Dust Flame Propagation Speed

Kenichi Ito, Osamu Fujita, Takaharu Tagashira
Department of Mechanical Engineering, Hokkaido University, Sapporo, 060, Japan
and
Jun'ichi Sato
Isikawajima-Harima Heavy Industries Co., Ltd.
1-15, Toyosu 3-Chome Tokyo, 135 Japan

Flame propagation of coal dust in a microhravity environment was observed. Ten seconds microgravity environment which is available at Japan Microgravity Center (JAMIC), Hokkaido, Japan, was used to attain a spatially homogeneous and quiescent distribution of pulverized coal.

Ignition was carried out using a Nichrome wire under various oxygen concentrations and flame spread was recorded by a high speed camera. As a result of the experiments, clear images of the flame propagation in coal dust were obtained and the propagation speed was measured from the images. Detailed comparison of the flame front structures for different oxygen concentrations have been carried out to discuss the effect of oxygen concentration on the flame propagation speed.

264

Carbon Particles Agglomeration in Diffusion Flames under Microgravity

Hiroyuki ITO, Osamu FUJITA and Kenichi ITO
Department of Mechanical Engineering, Hokkaido University,
Sapporo, 060, Japan

To investigate the agglomeration of soot particles formed in microgravity diffusion flames, microgravity combustion experiments were carried out using a drop shaft with a relatively long microgravity duration of 10 seconds located in Hokkaido, Japan. In this study, it was found out that large numbers of finer soot particles generated in the microgravity diffusion flames agglomerated to form larger carbon particles. The average diameter of these particles was about 200~500 times larger than those formed under normal gravity.

To investigate the conditions defining soot agglomeration and growth, the fuel velocity, the fuel flow rate and the oxygen concentration of surrounding air were varied in the experiments. These results suggest that the carbon particles generation was strongly influenced by conditions in soot generation zone, such as the oxygen concentration, the temperature profiles, and the residence time of the generated particles.

Agglomeration of Soot Particles in Diffusion Flames under Microgravity

Hiroyuki ITO, Osamu FUJITA and Kenichi ITO
Department of Mechanical Engineering, Hokkaido University,
Sapporo, 060, Japan

Experiments have been conducted to investigate the behavior of soot particles in diffusion flames under microgravity conditions using 490-m drop shaft (10-s microgravity duration) in Hokkaido, Japan. The oxygen concentration of surroundings, the butane gas flow rate, and the burner diameter are varied as experimental parameters. The generated soot particles are sampled under microgravity and observed using TEM. The flame with a residual convection and or forced convection are also observed to examine the influence of flow field on soot particle generation under microgravity. From these results, it is found that a number of large luminous spots appear in diffusion flames under microgravity. From the observation of TEM images, the luminous spots are the result of the agglomerating soot particles and growth of their diameters to a discernible level. The diameter of the agglomerated particles measure about 0.1mm, 200 to 500 times as large as those generated under normal gravity.

Visualization of Formaldehyde Distribution above Platinum Plate Catalyst by Using LIF Method

Woo KANG, Osamu FUJITA, and Kenichi ITO
Department of Mechanical Engineering, Hokkaido University,
Sapporo, 060, Japan

Visualization has been attempted to measure formaldehyde formation during catalytic combustion of methanol/air mixtures. The visualization of formaldehyde distribution above a platinum plate in methanol premixed gas flows was carried out by a LIF (Laser Induced Fluorescence) method. Formaldehyde has fluorescence spectra in the 340.6-493.3nm range when it is excited by the third harmonic wavelength of Nd: YAG laser (355nm). In our study, formaldehyde was excited by a pulse laser shot and the fluorescence at wavelength of 412.2nm was selected for investigation. By this laser technique, the time resolved instantaneous distribution of formaldehyde on the platinum plate was successfully observed. The results show that the distribution of formaldehyde fluorescence is affected by gas velocity, catalyst temperature and especially excess air ratio. The results correspond well with the results of other studies performed by conventional flow-reactor experiments and it confirms that this method is useful for analyzing the mechanism of catalytic combustion.

Japan's Research on Ignition and Flame Spread of Solid Material

Kenichi ITO and Osamu FUJITA
Department of Mechanical Engineering, Hokkaido University,
Sapporo, 060, Japan

Solid material combustion under microgravity, such as ignition and flame spread, is relatively new research field in Japan. As the other reports in this workshop describe, the main part of microgravity combustion research in Japan is droplet combustion as well as gas phase combustion.

Since the JAMIC, the Japan Microgravity Center, (which gives 10 seconds microgravity time) opened in 1992, microgravity combustion research is robust, and many drop tests relat-

ing to solid combustion, (including paper combustion, cotton strings combustion and metal combustion with Aluminum or Magnesium) have been performed. These tests proved that the 10 seconds of microgravity time at JAMIC is useful even for solid combustion area. In this paper, some experimental and numerical works relating to solid combustion performed before JAMIC opened will be reviewed as well as some experimental results obtained at JAMIC.

The Formaldehyde and Methyl Nitrite Levels in a Garage at the Cold Start-up of a Methanol Fueled Vehicle.

Tazuko MORIKAWA and Kenichi ITO
Department of Mechanical Engineering, Hokkaido University,
Sapporo, 060, Japan

The use of methanol fuels in heavy duty diesel type engines is environmentally attractive because of their low nitrogen oxides (NO_x) and reactive organic gases (ROG) emissions. However, there still remains the problem that a lot of unburnt methanol and formaldehyde (HCHO) is emitted at the cold start-up of the vehicle. HCHO has pungent odor and possibility of carcinogenic agent. Althogh the amount is small, methyl nitrite (MN) has also been identified in exhaust emissions of methanol vehicles. Methyl nitrite is toxic and has been confirmed to cause genetic mutation in Salmonella typhimurium. Under high concentration of methanol and low temperature, like that of start-up conditions, more MN forms by reacts with the co-exhaust emission of nitrogen dioxide (NO_2).

In this study, during the cold start-up of a methanol fueled truck, HCHO is measured by a second order derivative spectrophotometer. Also, MN is measured by gas chromatgraph equipped with an ECD or a FID. The HCHO concentration level inside a closed garage at starting of the methanol vehicle are also evaluated by computer simulation. The possibility of MN formation when exhaust gases are diluting in the garage is evaluated.

Finite Element Simulation in the Progression of Idiopathic Scoliosis

Shigeru TADANO, Kazuaki SAKAI, Masahiro KANAYAMA*,

Takayoshi UKAI, Kiyoshi KANEDA*

Department of Mechanical Engineering II, Hokkaido University

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

Scoliosis is defined as an appreciable lateral deviation in the normally straight vertical line of the spine. Idiopathic scoliosis is deformity which develops during a period of rapid growth and reduces after skeletal maturity. In this paper, in order to simulate the progression of idiopathic scoliosis, a strucutral model of thoracolumbar spine was constructed by the three dimensional finite element method. The normal skeletal spine model consists of elastic solid elements which represent the vertebrae and intervertebral discs of the thoracolumbar region T1–L5, the sacrum, rib pairs, sternum, costal cartilages and joint capsules. A vertebral body has the substructures of cortical and cancellous bone, and an intervertebral disc has the substructures of annulus fibrosus and nucleus pulposus. Total element number of the model is 2002. The geometry of the model incorporated the data of many anatomical features. Material constants were selected from the reference data in many published papers. Growth deformations of the spine were calculated using the three dimensional finite element analysis of ANSYS, with applying growth force at a local side in cortical bone of a thoracic vertebral body. As a result, this model could simulated the modulation of growth in the osseous tissues, as well as a single thoracic scoliosis curvature convex toward the lateral direction with axial rotation, as seen in typical scoliosis deformities.

Distribution of Compressive Elastic Modulus in the Degenerated Intervertebral Disc

Shinji UMEHARA*, Shigeru TADANO, Kazuaki KATAGIRI,

Takayoshi UKAI, Kiyoshi KANEDA*

Depatment of Mechanical Engineering II, Hokkaido University

*Department of Orthopaedic Surgery, School of Medicine Hokkaido University

The lumber intervertebral disc is susceptible to degeneration, injuries and diseases. However, mechanical behaviors and material constants of the disc with degeneration have been poorly understood. This study clarifies the distribution of compressive elastic modulus on the axial plane in the intervertebral disc, and are evaluated the differences of the distribution between normal and degenerated discs. The compressive elastic modulus could be estimated by indentation test. To evaluate the distribution between normal and degenerated discs, the specimens of two normal cadaveric lumbar discs and two degenerated discs were tested. The degree of degeneration of the specimens was confirmed macroscopically using Galante's classification and radiographically by Kellgren's grading. The distribution of elastic modulus in normal discs was symmetric on the axial plane. The portion of the nucleus pulposus and the posterolateral portion of the annulus fibrosus showed lower elastic modulus. The values of elastic modulus in the anterior portion of the annulus fibrosus were highest. While, the destribution in degenerated disc was asymmetric and irregular. The values of elastic modulus of the nucleus pulposus and the annulus fibrosus were much higher than those of normal discs. The distribution of elastic modulus in normal intervertebral discs is thought to be inherent and would relate to the pathophysiology of disc herniation. The alteration of mechanical property in degenerated disc could be clearly detected by this method.

The Load Sharing of Posterior Elements in Human Lumbar Spine

Satoshi ASANO, Kiyoshi KANEDA, Kuniyoshi ABUMI, Shinji UMEHARA,

Itaru ODA, Shigeru TADANO*

Department of Orthopaedic Surgery, School of Medicine, Hokkaido University

*Department of Mechanical Engineering II, Hokkaido University

Twenty fresh cadaveric L4-5 functional spinal units (FSU) were tested under various types of loading to investigate the role of each posterior element in sustaining the external loads. All muscles surrounding the FSU specimens were removed, whereas care was taken to preserve all skeletal structure and ligamentous components intact. Every specimen showed relatively mild disc degeneration. The FSU specimens were loaded in compression-tension test, torsion test, anterior-posterior flexion test and anterior-posterior shear test. In every stage of the sequential resection of posterior elements, the specimens were tested in the same loading conditions. The maximum displacements were ± 1.5 mm both in the compression-tension test and in the anterior-posterior shear test. The maximum angle were ± 5 degrees in the torsion test, 9 degrees in anterior flexion test and 3 degrees in the posteriou flexion test. The loading rates were 0.3 mm/sec. in the compression-tension test and in the shear test, and 1 degree/sec. in torsion test and in the flexion test. The ratios of load sharing of all posterior elements to intact FSU were 29-33% in compression, 26-27% in tension, 43-51% in torsion, 33-40% in anterior flexion, 45-49% in posterior flexion, 60-63% in anterior shear and 30-45% in posterior shear. The apophyseal joints had a significant effect in sustaining the external load. The largest ratio of the apophyseal joints to intact FSU was 54-56% in the anterior shear test.

Three-Dimensional Morphologic Curve of the Scoliotic Spine

Masahiro KANAYAMA*, Shigeru TADANO, Kiyoshi KANEDA*,

Takayoshi UKAI, Kuniyoshi ABUMI*

Department of Mechanical Engineering II, Hokkaido University

*Department of Orthopaedic Surgery, School of Medicine Hokkaido University

Because scoliosis is a spinal deformity that is defined as a pathological frontal curvature accompanied with a loss of the physiological sagittal curvature and a vertebral axial rotation, it must be understood as a three-dimensional deformity. This study presents a morphologic curve to describe the three-dimensional configuration of the scoliotic spine from two plain radiographs on the frontal and the sagittal planes. To formulate the spatial curve, the coordinate system on the spine is defined as a origin of axes at the mid-point between two upper corners of S1, and the X, Y and Z axes vertical to the frontal, sagittal and transverse planes, respectively. From two planar curves approximating the X–Z and Y–Z coordinate values of the centers of the vertebral bodies, the spatial curve could be formulated mathematically. The Cobb angle is widely used for clinical evaluation of the scoliosis deformity, and it could be calculated three-dimensionally as the maximum value of an angle between two tangent vectors of this morphologic curve. Every configuration of 45 patients with the scoliotic spines was extremely well approximated by the spatial curve. The three-dimensional Cobb angle calculated from the morphologic curve was significantly larger than the frontal Cobb angle. The three-dimensional Cobb angle, which contains a sagittal curvature as well as a frontal curvature, indicates three-dimensional magnitude of the spinal curvature in scoliosis. Therefore, this morphologic curve can be used for three-dimensional evaluation of the spinal configuration in scoliosis.

Structual Growth Analysis to Simulate Scoliotic Spine

Shigeru TADANO, Takayoshi UKAI, Kazuaki SAKAI, Masahiro KANAYAMA[*]

Department of Mechanical Engineering II, Hokkaido University

[*]Department of Orthopaedic Surgery, School of Medicine, Hokkaido University

Scoliosis is defined as an appreciable lateral deviation with axial rotation in the normally straight vertical line of the spine. Idiopathic scoliosis is a deformity which develops during a period of rapid growth and reduces after skeletal maturity. The definite cause of it, however, is unknown yet. As a biomechanical approach to scoliosis, this paper presents a finite element skeletal structure model of the whole human spine, and its use in computer simulation to examine the hypothesis that asymmetric local growth in a vertebral body might initiate scoliosis deformities of the spinal column. The normal skeletal spine model was constructed with three dimensional isoparametric solid elements. Bony growth deformation induced by growth force was defined as permanent deformation, and was simulated by introducing the constitutive laws of incremental stress-plastic strain which permits the volume change. The normal growth deformation was calculated by applying uniform growth force at an axial direction in cortical bone of each vertebral body. The iterated calculation was carried out with updated growth force in a vertebra at each step. In order to simulate the configuration of scoliotic spine with thoracic single curve, the effects of asymmetric distribution of growth force in a local region, the stress-growth interactions, and the end constraints were investigated on the deformation of the spine. The model was loaded in stepwise with the asymmetric local growth force in thoracic vertebra of T8 and the uniform growth force in the other vertebrae. The modulation of growth in the osseous tissues, as well as a single thoracic scoliosis curvature convex toward the lateral direction with axial rotation could be simulated well.

272

Effect of Disc Degeneration on the Distribution of Compressive Elastic Modulus in a Lumber Intervertebral Disc

Shinji UMEHARA*, Shigeru TADANO, Kiyoshi KANEDA*

Department of Mechanical Engineering II, Hokkaido University

*Department of Orthopaedic Surgery, School of medicine Hokkaido University

The effect of disc degeneration on the mechanical behaviors of a lumbar intervertebral disc has been poorly understood. This study is to measure the three-dimensional distribution of axial compressive elastic modulus in a lumbar disc, and to clarify the difference of the distribution between normal and degenerated discs. In this work, to estimate the three-dimensional distribution of elastic modulus, three sheet speciments of 5mm thickness were sliced from the upper, the middle, and the lower portion in a frozen cadaveric lumbar disc. Two normal and two degenerated discs were tested to clarify the effect of disc degeneration on the distribution of elastic modulus. The distribution of elastic modulus in normal disc was symmetric on each lateral plane. The elastic modulus of nucleus pulposus, of course, was lower than that of annulus fibrosus, but was almost the same of the posterolateral portion in annulus fibrosus. The elastic modulus at the anterior annulus fibrosus were the highest in a disc. The distribution pattern of elastic modulus in annulus fibrosus was independent of vertical direction in a disc. While the elastic modulus of nucleus pulposus on the middle plane were relatively higher value. In comparison with normal discs, degenerated discs showed the asymmetric and irregular distribution of elastic modulus. The elastic modulus of nucleus pulposus and annulus fibrosus was much higher than those of normal discs. The results will lead to more understanding of the process of disc degeneration.

Three-Dimensional Stress Analysis in Femur Before and After Total Hip Replacement

Shigeru TADANO, Takayoshi UKAI, Takahiro SASAKI

Depatment of Mechanical Engineering II, Hokkaido University

Artificial hip joint replacement is an effective treatment for serious forms of osteoarthritis and for disabling effects, for example, rheumatoid arthritis etc. Although a vast amount of biomechanics research has been devoted to developing a prosthetic device, the precise mecha-

nism of loosening at the bone-stem interface has not been entirely solved. In this work, to confirm the load tranfer between bone and stem following total hip replacement with a non-cemented artificial hip joint of the Harris type, three-dimensional finite element analysis of the femur and hip was carried out before and after total hip replacement. A modeling method was also represented for the complicated three-dimensional geometry of the femur and pelvic bone. Young's modulus of each element located three-dimensionally at the osseous tissue in the femur could be estimated from the distribution of mineral content obtained from an X-ray photo-graph. Therefore, the effect of the three-dimensional shapes of an artificial joint on the fixa-tion between bone and stem was confirmed from the stress distribution in the interface. From this analysis, the following results were obtained: 1) Higher stress occurs in the postero-cen-ter region of diaphysis in both the normal femur and the femur after total hip replacement. 2) In the femur after total hip replacement, great stress concentration occurrs in the neck of stem. 3) In the femur after total hip replacement, stress shielding occurrs in the posterior region of diaphysis. 4) In the femur after total hip replacement, steep gradient of stress occurrs in the bone-stem interface.

Computer Simulation of Idiopathic Scoliosis Initiated by Asymmetric Growth Force in a Vertebral Body

Shigeru TADANO, Masahiro KANAYAMA*, Takayoshi UKAI
Department of Mechanical Engineering II, Hokkaido University

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

As a biomechanical approach to scoliosis, this paper presents a computer simulation method to examine the hypothesis that asymmetric local growth in a vertebral body might initiate scoliosis deformities of the spinal column. The normal skeletal spine model was con-structed with three dimensional isoparametric solid elements, which consists of the vertebrae and the intervertebral discs of the thoraco-lumbar region, the sacrum, the rib pairs, the ster-num and costal cartilages, and the joint capsules. The model geometry incorporated the data of many anatomical features. Bony growth deformation induced by growth force was defined as permanent deformation, and was simulated by introducing the constitutive laws of in-cremental stress-plastic strain which permits the volume change. The nomal growth defoma-tion was calculated by applying uniform growth force at an axial direction in cortical bone of each vertebral body. The iterated calculation was carried out with updated growth force in one vertebra at each step, using the FEA package. In order to simulate the configuration of scoliotic spine with thoracic single curve, the effects of asymmetric distribution of growth force in a local region, the stress-growth interactions, and the end constraints were investigated on the deformation of the spine. As a result, when the axial asymmetric growth force was applied to the lateral region from the left to posterior in T8 vertebral body, this model could simulated a single scoliosis curvature convex toward the lateral direction with axial rotation, as seen in typical scoliosis deformities.

Free Vibration of Rotating Disk–Blade Coupled Systems

T. TOMIOKA, Y. KOBAYASHI and G. YAMADA
Depatment of Mechanical Engineering II,
Hokkaido University, Sapporo, Japan

The free vibration of rotating disk–blade coupled system is investigated by Ritz method. Centrifugal effects due to rotation are taken into account for both of the disk and blades. The boundary conditions and the continuity conditions between the disk and blades are satisfied by means of artificial springs introduced at their joints, and the orthogonal polynomials generated by using the Gram–Schmidt process are employed as admissible functions for both of the disk and blades. By this approach, the mass matrix derived from the kinetic energies becomes diagonal and this makes the numerical manipulation easy and stable. Frequency parameters for various rotating speeds are obtained to investigate the vibration of the disk–blade coupled system, and the modes of vibration are classified into several groups. The frequency parameters obtained by the present method are compared with those by the finite element method (FEM).

Prediction of Fatigue Failure of 60Sn–40Pb Solder Using Constitutive Equation for Cyclic Viscoplasticity

H. ISHIKAWA[*] and K. SASAKI[*]
[*]Department of Mechanical Engineering II,
Hokkaido University, Sapporo, 060 Japan

In this paper, the authors proposed the constitutive equation for cyclic viscoplasticity in which a viscoplastic potential function, the modified Prager–incorporated. In order to verify the applicability of the proposed constitutive equation to the deformation of Pb-Sn solder alloys, a series of basic experiments, such as pure tensile tests, creep tests and cyclic tension-compression loading tests with constant strain amplitudes under constant strain rates were performed using 60Sn–40Pb solder alloys both at 20°C and 75°C. Moreover, the proposed constitutive equation was used to predict fatigue failure of the solder alloy. As a result, it was clear that the proposed constitutive equation was applicable to explain the viscous deformation

of the solder alloy, and that fatigue failure of the solder alloy could be predicted using the plastic strain energy density calculated by the simulation based on the proposed constitutive equation.

Recent Advances in Research on Melting Heat Transfer Problems

Shoichiro FUKUSAKO and Masahiko YAMADA
Department of Mechanical Engineering, Hokkaido University, Sapporo 060, Japan

Recent advances in the understanding of melting heat transfer is reviewed mainly in context of its application to latent heat-of fusion thermal energy storage. The emphasis in the paper is on the fundamental, physical phenomena observed during melting of phase change material as well as snow layer and liquid ice bed. The important role played by buoyancy-driven fluid flow is discussed and problem areas for further research are identified.

Rapid Heat Transfer Manipulation of Fine Powder by Use of a Fluidized Bed

Shoichiro FUKUSAKO, Masahiko YAMADA, Akihiko HORIBE, and Tamaki OHMICHI
Department of Mechanical Engineering, Hokkaido University, Sapporo 060, Japan

Experiments were performed to investigate the rapid heat transfer manipulation of the powder by use of a fluidized bed. Fine glass beads were injected into the test section as the testing powder. Injection rate and diameter of the powder, flow rate and temperature of the main flow, and diameter of the bed particles were adopted as the parameters. The effects of these parameters on the heat transfer characteristics of both the fluidized bed and of the powder in the current system were extensively determined.

Continuous Production Characteristics of
Liquid Ice by Use of Fluidized Bed

Shoichiro FUKUSAKO, Masahiko YMADA, Akihiko HORIBE,
and Kazuya HATAKEYAMA
Department of Mechanical Engineering, N13-W8, Sapporo 060 Japan

Hiromichi KAWABE
Senshu University, Hokkaido College, Bibai 079-01, Japan

This paper presents an experimental study dealing with the continuous production characteristics of liquid ice by use of a fluidized bed. Ethylene-glycol aqueous solution was cooled by a vertical circular cylinder immersed in a primary air-liquid two phase fluidized bed. Experiments were carried out for a variety of conditions of initial concentration of solution, cooled-wall temperature, and airflow rate for fluidization in order to determine the production performances of the liquid ice. It was observed that a frozen layer which formed along the vertical circular cylinder might be separated from the cooled surface owing to the fluidization motion to be the liquid ice. An operation range for continuous production of liquid ice was identified.

Melting Characteristics of Liquid Ice
in a Rectangular Vessel Heated From Above

Myoung Hawng KIM
Department of Marine Engineering, Korea Maritime University, Pusan, Korea

Shoichiro FUKUSAKO and Masahiko YAMADA
Department of Mechanical Engineering, Hokkaido University, Sapporo, Japan

Melting characteristics of unrestrained liquid ice in a rectangular vessel with top heated wall were investigated experimentally. The liquid ice, a mixture of fine ice particles and ethylene-glycol aqueous solution, was adopted as a testing material. During the melting process the liquid ice was drawn by buoyancy to the top heated wall of the rectangular vessel where close-contact melting occurred. The melting behavior and melting rate of the liquid ice as well as local/mean heat-transfer coefficient at the heated top wall were observed and measured under a variety of conditions of heat flux and various initial concentration of the aqueous binary solution. The heat transfer of the heated top wall was found to be markedly promoted by the close-contact melting. Photographic evidence demonstrated that channel segregates owing to plumes containing solute-rich liquid issuing from isolated chimneys within the liquid ice layer took place.

Solidofication Characteristics of Supercooled High-Temperature Melt

Shoichiro FUKUSAKO, Masahiko YAMADA, and Akihiko HORIBE
Department of Mechanical Engineering, Hokkaido University, Sapporo, Japan

Experiments were performed to determine the effect of various parameters on the solidification characteristics of supercooled high-temperature melt. Potassium thiocyanate was adopted as a sample material. The sample was dried and kept over the melting point for more than 1 hour, then both the observation of the solidification characteristics and the measurement of temperature distribution were carried out under constant cooling velocity. The experimental results show that both the initial temperature of melt and the cooling velocity exert the considerable effects on both the supercooling characteristics and the properties of solidified layer of the sample material.

Heat Transfer Characteristics of an Insulation with Function of Removing Moisture

Hiroaki KAWAI and Osamu OKAGAKI
Department of Mechanical Engineering, Hokkaido Institute of Technology, Sapporo, Japan

Shoichiro FUKUSAKO
Department of Mechanical Engineering, Hokkaido University, Sapporo, Japan

Experiments have been performed to investigate the effect of air-flow rate in the clearance between the insulation and the cooling plate on the temperature distribution, moisture accumulation and heat flux. The glass wool, whose density is 16 kg/m^3, was adopted as a testing material. The clearance thickness was 20 mm, and the mean velocity of inlet-air ranged from 0.2 to 1.0 m/s. Temperature and relative humidity of the air for the heating side of the glass-wool were 25℃ and 60%, respectively. The cooling plate temperature was varied from −5 to 15℃. Relative humidity of the flowing air in the clearance was 70%. As a result of the present investigation, it was observed that an increase in both the mean air velocity and the cooling plate temperature caused the decrease in the moisture accumulation within the glass-wool. The performance of the insulation was seen not to be affected markedly by the moisture accumulation in the range of the experiment. The inlet-air temperature was found to have a considerable influence on the heat transfer through the glass wool and became quite important for evaluating performance of the insulation.

278

Forced Convection Heat Transfer Characteristics
of Three Cylinders Formed Across

Akihiko HORIBE, Shoichiro FUKUSAKO and Masahiko YAMADA
Department of Mechanical Engineering, Hokkaido University, Sapporo, Japan

Hiromichi KAWABE
Senshu University, Hokkaido College, Bibai, Japan

An experimental study has been performed to investigate the heat-transfer characteristics around three circular cylinders situated across each other in a forced flow. Considering the surface-pressure distributions, the effects of distance among the cylinders and its axial varia-tion on the heat-transfer characteristics of the second cylinder were extensively determined. The experiments were carried out under the condition both with the thermal boundary layer from other cylinders and without it.

It was found that the distance among the cylinders might exert a significant effect on the heat-transfer coefficient along both the rear side and the front side of the second cylinder owing to the surface-pressure distribution. The results revealed that the maximum mean heat transfer around the second cylinder might be in axial distance from the cylinder center $y^+=0$ to 1.0 ($y^+=y/d$, y: axial distance from center, d: diameter of test cylinder), and its value is about 1.3 to 1.4 times as large as that of the single cylinder.

Heat and Mass Transfer in a Plate-Type
Reformer Tube for Fuel Cell Reformer

Yutaka USAMI
Energy and Environment R & D Center, The Tokyo Electric Power Company, Inc.
Yokohama 230, Japan

Shoichiro FUKUSAKO and Masahiko YAMADA
Department of Mechanical Engineering, Hokkaido University, Sapporo, Japan

Heat and mass transfer characteristics in a plate-type reformer tube have been clarified by both experimental data and one-dimensional analysis. Reaction heat was approximately 80% of gross heat absorption, and the overall heat transfer coefficient in the packed bed was five times as large as that of non-chemical reaction. The major reaction was performed at the upper portion of the tube along the plate-fin heat exchanger. It was also found that the proc-ess gas inlet temperature was the key parameter in reforming reaction enhancement.

SPECTROMETER FOR HIGH-SPATIAL RESOLUTION

Naoshi BABA, Kouki HOZUMI

Department of Applied Physics, Faculty of Engineering,
Hokkaido University, Sapporo 060 JAPAN

Susumu KUWAMURA

Institute of Physical and Chemical Research (RIKEN), Wako 351-01 JAPAN

Abstract

Observational results of speckle spectroscopy for high-spatial resolution are presented. A
speckle spectrometer in real-time mode is proposed. A specklegram and its dispersed speckle
image is simultaneously detected. By referring to a specklegram, a real-time shift-and-add
operation is conducted. Several optical simulation experiments are conducted toward real-
time speckle spectroscopy. Experimental results confirm the effectiveness of the proposed
spectroscopic system.

Solar Imaging by Blind Deconvolution of Segments from Multiple frames

Noriaki MIURA, Naoshi BABA

Hokkaido University, Department of Applied Physics, Sapporo, Japan

Fumiaki TSUMURAYA

The Graduate University for Advance Studies, Department of Astronomy,
Mitaka, Japan

Takashi SAKURAI

National Astronomical Observatory, Solar Physics Division, Mitaka, Japan

A blind deconvolution method is applied to restoration of atmospherically degraded solar
images. The method consists of an iterative deconvolution algorithm that uses several partial
images segmented from multiple frames. It is shown that the algorithm decreases a specified
error-metric, allows a unique solution and reduces contamination originally existing in solar
images observed with a limited field-of-view. Results of computer simulations and restoration
of observed solar images are presented.

Interactions of Paramagnetic Metal ions with Gellan Gum Studied by ESR and NMR methods

T. HIRAOKI, S. KAWAHARA and A. TSUTSUMI

Department of Applied Physics, Hokkaido University, Sapporo 060, Japan

The characterization of the gellan–paramagnetic metal ion complex has been investigated by ESR and NMR. The carboxyl carbon of the D-glucuronate unit in ^{13}C-NMR spectra of gellan is selectively broadened with the addition of Mn (II) in the sol state, due to the paramagnetic interaction between the carbon and the Mn (II) ion. Further addition of Mn (II) makes only the resonances of the D-glucuronate unit broadened, showing the binding of Mn (II) to the carboxyl groups. Water proton relaxation indicate that water molecules are as well coordinated to the Gellan-Mn (II) ion complex. ESR measurements of Mn (II) ion gives the dissociation constant of $\sim 10^{-3} M$ and the number of the binding site of about 0.5 per the repeated unit in both sol and gel states. The latter indicates that a Mn (II) ion binds two D-glucuronate units of gellan.

Deuterium NMR Studies of Benzene-d_6 in poly (L-leucine) Gel

T. HIRAOKI, S. KITAZAWA, and A. TSUTSUMI

Department of Applied Physics, Hokkaido University, Sapporo 060, Japan

The gel-sol transition in the benzene solution of α-helical poly (L-leucine) (PLL) was investigated by deuterium NMR. The relaxation times indicate the presence of the slow motional states and/or the exchange process of benzene in the system, and that dynamics of benzene molecules remarkably changes in the gel-sol transition temperature of 50℃. Furthermore, the ordered molecular aggregate in the temperature of 50 to 70℃ is found in the higher concentrations more than 2%w/w. The molecular dynamics parameters of benzene obtained were remarkably different between each state. The relaxation times provide information about the solution structure and the benzene dynamics.

Effects of Zn Doping on Structural Phase Transitions in $La_{1.875}Ba_{0.125}CuO_4$

Yoshitoshi OKAJIMA, Sunao HASHIMOTO and Kazuhiko YAMAYA

Department of Nuclear Engineering, Hokkaido University, Sapporo 060, Japan.

The transition temperature to the low-temperature tetragonal structure T_{d2} has been investigated for $La_{1.875}Ba_{0.125}Cu_{1-y}Zn_yO_4$. It has been revealed that T_{d2} is almost constant at least up to Zn content of $y=0.06$. The low-temperature tetragonal structure is neither enhanced nor suppressed by a small amount of Zn doping for the Cu site. This is in contrast to the structural transition at higher temperature, which is enhanced by the Zn doping.

Tailoring of neutron pulse shapes from a coupled liquid-hydrogen moderator for pulsed spallation neutron sources

Y. KIYANAGI[a], J. M. CARPENTER[b], N. KOSUGI[a], H. IWASA[a], F. HIRAGA[a] and N. WATANABE[c]

[a]Department of Nuclear Engineering, Hokkaido University, Sapporo, 060 Japan
[b]Argonne National Laboratory, Argonne, Illinois 60439, USA
[c]National Laboratory for High Energy Physics, 1-1 Oho, Tsukuba-shi, Ibaraki, 305 Japan

In this paper we introduce an idea for improving the broader pulse width and the long-time tail of cold neutrons from a coupled composite moderator system, by decoupling the premoderator from the reflector. We confirmed experimentally that the pulse width from a decoupled system, a 5cm thick liquid-hydrogen moderator with 3cm thick lighe-water premoderator decoupled from a graphite reflector, can be reduced considerably almost at no cost of the peak height and the decay time of the pulse can also be improved significantly, when compared to those from a coupled composite moderator of the same material and dimensions. The present results are compared to those obtained with an alternative method by heterogeneously poisoning the reflector.

Comparison of coupled liquid hydrogen and solid methane moderators for pulsed neutron sources

Y. KIYANAGI[a], S. SATOH[a], H. IWASA[a], F. HIRAGA[a] and N. WATANABE[b]

[a]Department of Nuclear Engineering, Hokkaido University, Sapporo 060, Japan
[b]National Laboratory for High Energy Physics, Tsukuba 305, Japan

A coupled liquid-hydrogen moderator with a premoderator can provide a much higher cold neutron beam intensity than a traditional decoupled moderator. A premoderator is being considered also for the solid methane moderator system, mainly aimed at reducing the radiation damage of methane. We have studied experimentally the neutronics of two different cryogenic moderators of liquid hydrogen and solid methane with variable premoderator thickness. The optimal premoderator thicknesses were found for 2 and 5cm thick cryogenic moderators. Optimal premoderator thickness is thinner for solid methane moderators than for liquid hydrogen moderators, due to the larger hydrogen number density. The pulse characteristics of cold neutrons from these moderators were also measured. It was found that a coupled solid methane moderator with premoderator cannot exceed a coupled liquid-hydrogen moderator with premoderator in cold neutron intensity. If solid methane is utilized, the thickness of both premoderator and solid methane moderator must be small.

Backscattering moderators for pulsed spallation neutron soures

Y. KIYANAGI[a], M. NAKAJIMA[a], F. HIRAGA[a], H. IWASA[a] and N. WATANABE[b]

[a]Department of Nuclear Engineering, Hokkaido University, Sapporo, 060 Japan
[b]National Laboratory for High Energy Physics, 1-1 Oho, Tsukuba-shi, Ibaraki, 305 Japan

The effect of the moderator position relative to the neutron generating target on the neutron intensity were studied experimentally for various poisoned and unpoisoned moderators. For all types of moderators a backscattering geometry is superior to a normal-extraction geometry. At a backscattering position, poisoned moderators give higher intensity than unpoisoned thin moderators, while at a normal-extraction position the latter is better than the former except for a very thin moderator.

Rerefied Gas Flows Induced by Wall Temperature Gradients in A Container

Kenichiro SUGIYAMA, Manabu MIYATA, Ryoji ISHIGURO
and Takeaki ENOTO
Department of Nuclear Engineering, Hokkaido University

There is a possibility that flow (thermal creep flow) induced by the distribution (gradient) of wall temperature can occur in reduced pressure containers. Simulation of this type of flow is important in material technology, such as chemical vapor deposition or in the design of thermal devices effectively utilizing this phenomenon.

The objective of the present study is to clarify the possibility of modeling this type of flow by the direct simulation Monte Carlo method. As a result, it is demonstrated that thermal creep flows with around magnitudes of 10^{-2} of the most probable velocity at system temperature are well simulated by using this method.

SPECTRUM ANALYSIS OF AN ELECTROMAGNETIC FIELD GENERATED BY LINAC ELECTRON BEAMS

Hiroyasu ITOH, Shusuke NISIYAMA, Satoshi TOMIOKA, Takeaki ENOTO
Department of Nuclear Engineering, Hokkaido University, Sapporo, Japan

A spectrum of an electromagnetic field obtained by electron beams is important to analyze structures of micro-pulses. However to measure the shape of the transient electric field, radiated from micro-pulses of electron linear accelerator, is difficult because of the limitations of frequency bandwidth of detector systems. The spectrum can be also obtained by measuring a spatial field distribution of a standing wave, instead of the time variation obtained using a expensive ocilloscope. This distribution of the standing wave is generated in a cylindrical waveguide terminated by a conductive plate which is placed perpendicular to the electron beams. The measured spatial distribution is transformed into the wavenumber spectrum using the Fourier transform. The numerical results obtained using the finite-difference time-domain method are compared with results obtained by measurements in a frequency domain.

Numerical Simulation on Unsteady Flow Induced in Rarefied Gas Container by the Monte Carlo Method

Ken-ichiro SUGIYAMA, Hiroyuki SAKURAI, Takeaki ENOTO
and Ryoji ISHIGURO
Department of Nuclear Engineering, Hokkaido University

The present study analyzes physical fields in a two-dimensional container having a Knudsen number of 0.1, in order to clarify the behavior of unsteady physical fields in reduced pressure systems using the direct simulation Monte Carlo method.

It is found that when the temperatures of a pair of wall surfaces facing each other suddenly change to specified values, the induced flow periodically changes the direction with showing a kind of organized motion of moloecules. The finally disappears, resulting in the heat conduction field with a temperature jump on the wall surfaces. It is also confirmed that when a temperature change of the side walls normal to a pair of walls above-mentioned, which makes a large temperature gradient, is suddenly applied, the thermal creep flow finally appears and subsequently is sustained.

Nonequilibrium Plasma Generator-Effects of Oxygen Dissocia-tion/Recombination and Condensed Metal Oxide On Light Metal Combustion Plasma.-

Shun OIKAWA, Takeaki ENOTO
Department of Nuclear Engineering, Hokkaido University
N-13, W-8, Sapporo, 060 JAPAN

B. C. Abel LIN, John T. LINEBERRY, and Y. C. L. Susan WU
1940 Elk River Dam Road UTSI Research Park, Tullahoma, USA

Abstract

A nozzle performance of the Nonequilibrium Plasma Generator has been numerically evaluated. Effects of the condensed metal oxide have also been investigated. Numerical results are as follows. 1) Oxygen recombination in the nozzle is slow compared with the resident time of the gas for various oxygen mass fractions. Therefore, there will be less diatomec

oxygen that prevents the plasma from nonequilibrium ionization due to large inelastic collision cross section of the molecule; 2) oxygen dissociation and recombination reactions are virually frozen with the combustion chamber conditions; 3) the particle size of the metal oxides has a significant influence on the nonequilibrium plasma properties; 4) when the particle diameter is 50 μm or larger the gas energy is transferred to the particle.

Physical Properity and Dropping Form Effects on Vapor Explosion

Ken-ichiro SUGIYAMA, Yoshifumi SUZUKI, Takahiro NAKAYAMA
and Michio ISHIKAWA

Department of Nuclear Engineering, Hokkaido University

The effects of dynamic viscosity and surface tension of melts were experimentally examined to clarify the sensitivity of melts to the disturbances triggering off vapor explosion. Experiments were conducted by dropping molten tin or/and zinc into water in two dropping forms. It was observed that molten tin, which has a relatively small dynamic viscosity and surface tension, always resulted in metal-water interaction in both dropping forms, and zinc melt, which has a relatively large dynamic viscosity and surface tensiton, didn't cause metal-water interaction in both dropping forms. The molten tins dropped in a slender cylinddrical shape, produces metal-water interaction more moderate that dropped in a lumped-shape. It was also confirmed that when molten zinc and tin were dropped simultaneously to expose molten zinc to the disturbance produced by tin-water interaction, zinc showed a trace of metal-water interaction. These results indicate that the occurrence of vapor explosion is closely related to the physical property and the dropping form of the melt.

286

Radiolytic Studies of Ruthenium Oxo-Acetato Dinuclear Complexes in Acetonitrile

Akira KISHIMOTO, Takashi SUMIYOSHI, Kenta TAKAHASHI,
Tatsuma FUKUMOTO, Taira IMAMURA and Yoichi SASAKI

Hokkaido University, Sapporo, Japan

Pulse radiolysis of the ruthenium (III, III) oxo-acetato dinuclear pyridine complex, [Ru$_2$ (μ-o) (μ-CH$_3$COO)$_2$ (py)$_6$] (PF$_6$)$_2$ (abbr. Ru$_2$(33)), in acetonitrile was studied. Electron-pulse irradiation of the argon, air, or dioxygen saturated acetonitrile solutions caused one-electron reduction of the central metals of Ru$_2$(33) to form Ru$_2$(32) in a few micro seconds at room temperature. In the solutions containing dioxygen, Ru$_2$(33) was competitively reduced by the acetonitrile-radical anion, CH$_3$CN$^{\cdot-}$ and the superoxide ion, O$_2^-$. Ru$_2$(32) produced was reoxidized by the peroxyl radical, $\cdot$O$_2$CH$_2$CN to regenerate Ru$_2$(33) in 100-300 μs after the irradiation. The reaction mechanism is discussed in comparison with the ruthenium (III, III, III) trinuclear complex system reported previously.

A GENERAL ANALYSIS OF WIRELINE-TYPE MONITOR FOR RELATIVISTIC ELECTRON BEAMS

Teruko SAWAMURA, Hatsuo YAMAZAKI, Akira HOMMA, Juzo OHKUMA*,
Shuichi OKUDA*, Kunihiko TSUMORI*, Tamotsu YAMAMOTO*,
Shouji SUEMINE* and Toichi OKADA*

Hokkaido University, Sapporo, Japan

*The Institute of Scientific and Industrial Reserch, Osaka University,
Osaka, Japan

The output signal waveform of the wireline-type beam monitor with an arbitrary terminated, caused by a relativistic electron beam is studied theoretically. The pickup is set on the inside wall of a metal cylinder, with one end arbitrarily connected to the wall and the other end led to the output. The response of the beam monitor and its energy dependence are derived. The limiting case of extremely short wireline is analyzed and the response of a capacitive monitor and an inductive monitor are obtained for an open-ended and a short-circuit ended wireline. The experimental results and the calculation are compared and discussed.

Cold Fusion Experiments by Sparking Discharges in Water

Takaaki MATSUMOTO
Department of Nuclear Engineering, Hokkaido University,
Sapporo 060, Japan.

Cold fusion experiments associated with microsparks were performed by discharges in ordinary water mixed with 1.5 Mol/l potassium carbonate. A high current density of DC was employed with thin wire electrodes (0.5-0.2 mmΦ). Palladium, nickel, titanium, iron, cadmium and tungsten were used for the electrodes. When the voltage increased above about 40 V, many microsparks appeared on the surface of the electrode and simultaneously extraordinary phenomena were observed. The following was examined:

- a. A microtelescope-VTR system recorded microsparks which sometimes have a ring structure and exploded.
- b. The I/V curve showed a strong nonlinearity associated with the microsparks.
- c. Extraordinary radiations were measured with a CsI scintillation detector.
- d. Extraordinary traces recorded on nuclear emulsions showed tiny ball-lightning phenomena.
- e. Microscopic ring-like products which were caught on an electrode showed the magnetization and decayed to a regular hexagonal plate.
- f. Extraordinary traces suggesting the production of the prototype of micro-bacteria were found on nuclear emulsions.
- g. Explanations would be given by the Nattoh model[1].

Reference

(1) T. Matsumoto: "Mechanisms of Cold Fusion: Comprehensive Explanations by the Nattoh Model." Submitted to Fusion Technology, March (1993).

Corrosion of Iron and Migration of Corrosion Products in Compacted Bentonite

Tamotsu KOZAKI, Yuji IMAMURA, Seichi SATO and Hiroshi OHASHI
Department of Nuclear Engineering, Hokkaido University, Sapporo, Japan

Jitsuya TAKADA
Research Reactor Institute, Kyoto University, Kumatori-cho, Sennan-gun, Osaka, Japan

For safety assessment of the geological disposal of the high level radioactive waste, it is necessary to study corrosion of the overpack materials and migration of the corrosion products in the compacted bentonite. In the present study, average corrosion rates of iron foil and apparent diffusion coefficients of the corrosion products were determined using a neutron-activated iron foil. The average corrosion rates were on the order of 10^{-6} m/y, while apparent diffusion coefficients were in the range from 10^{-12} to 10^{-14} m²/s. No tendency to decrease in the corrosion rate with increasing corrosion time was observed. This suggests that the iron foil corrodes under reducing condition. Asymmetric concentration profiles of iron corrosion products were obtained in some experiments. It can be considered that either cathodic or anodic reaction would dominantly occur on one side of the iron foil surfaces and that each reaction would change the pH in pore water of bentonite specimens adjacent to the iron foil surfaces.

Thermodynamic Properties of Water in Compacted Bentonite under External Pressure-free Conditions

Yuji TORIKAI, Seichi SATO and Hiroshi OHASHI
Department of Nuclear Engineering, Hokkaido University, Sapporo, Japan

In an attempt to determine the thermodynamic properties of water in bentonite, the vapor pressure of water in compacted bentonite was measured as a function of water content and temperature, under external pressure-free condition. The relative partial molar Gibbs free energy $\Delta \overline{G}_{H_2O}$, enthalpy $\Delta \overline{H}_{H_2O}$ and entropy $\Delta \overline{S}_{H_2O}$ of the water in bentonite were determined at

temperature of 298.15K. The interlayer distance of montmorillonite in bentonite was also measured by X-ray diffraction.

It is probable that one fourth of the total water included in the bentonite at water content of 20.3 wt% and dry density of 1.76×10^3 kg/m³ is free water; the water is not regarded as dilute electrolytic solution, but the solution with higher ionic strength. Another one fourth of the water in the bentonite at the water content is bound water; the partial molar entropy of the bound water referred to pure water is from a half to whole of solidification entropy of pure water. The remainder is regarded as intermediately bound water.

XVIII International Sympo-
sium on the Scientific Basis
for Nuclear Waste Manage-
ment, Kyoto, Japan, October
23-27, 1994

Influence of Humic Acid on Sorption of Neptunium (V) onto Soil

Yosiaki SAKAMOTO, Seiya NAGAO, Toshihiko OHNUKI, Muneaki SENOO
Department of Environmental Safety Research, Japan Atomic Enetgy
Research Institute, Tokai-mura, Naka-gun, Ibaraki-ken, Japan

Akikazu OHASHI, Seichi SATO, Hiroshi OHASHI
Department of Nuclear Engineering, Hokkaido University, Sapporo, Japan

The pH dependence of the stability constant of Np(V)-humate and the sorption of Np(V) onto soil were studied to clarify the influence of dissolved organic carbon on the migration behavior of Np(V) in soil layer. The stability constant of Np(V)-humate was expressed by $\log \beta_1 = (0.35 \pm 0.03)\text{pH} + 0.04 \pm 0.01$ in the pH region from 5.3 to 8.7, and the intrinsic stability constant by $\log \beta^*_1 = 3.66 \pm 0.05$.

The sorption of Np(V) increased with pH up to pH 7, and tended to reach maximum, about 95%, at pH 9 in the absence of humic acid. In the presence of humic acid more than 140 mg/l, the sorption of Np(V) was lower than that without humic acid above pH 7, while any influence of humic acid on the sorption of Np(V) onto soil was not observed below pH 7. The sorption behavior of Np(V) onto soil was explained by reversible of NpO_2^+ and sorption of $NpO_2CO_3^-$ and/or NpO_2OH. Further, the influence of the size distribution of Np(V) on the sorption onto soil was examined and discussed.

Excess Heat Evolution and Analysis of Elements for Solid State Electrolyte in Deuterium Atmosphere During Applied Electric Field

Tadahiko MIZUNO, Tadashi AKIMOTO, Kazuhisa AZUMI,
Masatoshi KITAICHI, and Kazuya KUROKAWA

Hokkaido Univ., kitaku, north 13 west 8, Sapporo 060 Japan

Michio ENYO

Hakodate National College of Technology, Tokuracho 14-1, Hakodate 042 Japan

The alleged Cold Fusion reaction still has not confirmed because of lack of data. It is very important to obtain precision relationships quantitatively between each reaction product that may cause from the reaction. We understand that the most desirable parameter to analysis the reaction mechanism is to obtain simultaneously all the quantities such as heat evolution, neutron emission, tritium generation, and so on. However, unfortunately, this is very difficult due to difficulties to reproduce and control the phenomena. Even if it has been possible, usually the amounts of reaction products are very low and sometimes nearly or under the detection limit; it is difficult to calibrate quantitatively. Therefore, it is suitable to analyze the elements in the sample before and after the experiment. A proton conductor, the solid state electrolyte, made from oxide of strontium, cerium, niobium and yttrium can be charged in a hot D_2 gas atmosphere to produce excess heat. Anomalous heat evolution was observed for 12 in 80 cases of the samples charged by alternating current for 5 to 45 Volts at temperatures ranging from 400 to 700°C. Several kinds of alkali metals, Ca, Mg, Bismuth, lantanides and Aluminum were locally segregated and distributed around the melted and swelled parts of the samples that generated an excess heat.

MONTE CARLO CALCULATIONS OF DOSE EQUIVALENTS FOR HIGH ENERGY ELECTRONS USING THE MIRD-5 HUMAN PHANTOM.

Sadashi SAWAMURA, Tomoharu FUJIWARA, Miho KATAGIRI,
Masatoshi KITAICHI, Ichiro NOJIRI*, and Osamu NARITA*

Department of Atomic Science and Nuclear Engineering, Faculty of
Engineering, Hokkaido University, Sapporo, 060, Japan.

*Power Reactor and Nuclear Fuel Development Corporation,
Tokai-mura, Ibaraki-ken, 319-11, Japan.

Abstract

For radiation protection from high energy electrons such as those from Linac, absorbed doses and dose equivalents in human organs were calculated by using the EGS4 monte carlo simulation code and MIRD-5 mathematical human phantom. Effective dose equivalents were also calculated for AP and PA geometrical irradiation conditions in the incident energy range of 0.1 to 200 MeV. The conversion factors from the incident particle fluence to the tissue dose equivalents as well as to the effective dose equivalents were obtained for electrons and compared with those for photons and neutrons. The H_{1cm} in ICRU sphere was also simulated.

A Study on Cubic Nonlinear Optical Elements Efficiently Responding to Femtosecond Pulses

Mikio Yamashita and Ryuji Morita
Faculty of Engineering, Hokkaido University Sapporo, Japan

Femtosecond pulse propagation and compression are investigated experimentally and theoretically for a new nonlinear fiber cored by an organic crystal. An ultrafast, nonlinear refractive index $n_{2,DAN}$ of the organic fiber of a few mm length is measured to be 1.7×10^4 times as large as that of a fused-silica fiber. Furthermore, using the organic fiber 39 fs pulses from a colliding-pulse mode-locked dye laser are efficiently compressed to 22 fs without any amplification. In addition, from an observation of a red-shift in the output pulse spectrum from the organic fiber it is found that a response time of the $n_{2,DAN}(t)$ is several ten

femtoseconds. Finally, a computer analysis reveals that degradation of pulse compression efficiency due to the nonlinear delayed response can be compensated for by a frequency-dependent phase adjuster of up to third-order dispersion.

The 14th International Conference on Numerical Methods in Fluid Dynamics, Bangalore, India, July 11-15, 1994

Concepts on Boundary Conditions in Numerical Fluid Dynamics

Y. MIZUTA

Department of Engineering Science, Faculty of Engineering,
Hokkaido University, Sapporo 060, Japan

Boundary conditions are essential in some problems in numerical fluid dynamics—fluids with free surface or density interface, fluids around a moving or oscillating body (bodies), open boundary, and so on. For successful numerical experiment of these problems, some useful concepts with physical significance are discussed: law of conservation of volume (LCV), surface force, volume force, extended pressure, pressure equation, boundary equation, corner equation, set of equations, interface condition and open boundary. They are embodied on numerical experiments of a magnetic fluid with a free surface under an alternating magnetic field and a solitary wave travelling on a density interface in a two-layered fluid with an open boundary. It was shown that these examples owe the above considerations on boundary conditions, and the boundary equation is the basis for their general treatment.

Efforts on Generalization in Computational Fluid Dynamics

Y. MIZUTA
Department of Engineering Science, Faculty of Engineering,
Hokkaido University, Sapporo 060, Japan

In spite of the recent remarkable development supported by highly efficient computers in computational fluid dynamics in several fields of science and technology, its effectiveness is still limited within a part of existing fluids. The scheme faithful to physical principles with less mathematical techniques will lead to successful numerical analysis of fluids even under complex conditions—according to this opinion, the present research starts with integral-type laws of conservation, and adopts physically reasonable boundary conditions. In addition, the efforts on generalizing the formulated equations and the computer program are important. The reliability of the formulation and the program must be increased if the parts depending on individual problems are minimized and they are used for different problems. Some devices in this direction were reported in the lecture.

Numerical Experiment of Surface and Interface Waves in a Two-Layered Fluid on a Slope

Y. MIZUTA
Department of Engineering Science, Faculty of Engineering,
Hokkaido University, Sapporo 060, Japan

A procedure for straightforward vertical analysis of two-layered fluid on a slope is shown which can resolve the free surface and the density interface clearly by using the cells deformable in accordance with such movable boundaries. Those boundaries are treated generally together with others by "boundary equation". Tiny cells around the tip of the layers are treated carefully to cope with high waves. Reflection and collapse of an interfacial solitary wave on a slope were analyzed numerically.

294

Electronic Structures of Potassium–Oxygen–Graphite Ternary Intercalation Compounds

Shin'ichi HIGAI

Institute of Materials Science, University of Tsukuba, Tsukuba 305, Japan

Seiji MIZUNO

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

Kenji NAKAO

Institute of Materials Science, University of Tsukuba, Tsukuba 305, Japan

The electronic structures of potassium–oxygen–graphite ternary intercalation compounds
are theoretically studied. We construct several simple structural models for stage-1 and stage-
2 compounds based on experimental results, and carry out the selfconsistent band-structure
calculation. For all models, we show that the oxygen 2p–band with small dispersion intersects
the Fermi level. We also estimate the amount of charge transfers among constituent atoms,
and show that 4s charges of potassium are perfectly transferred to oxygen and carbon. Our
results show that the present GICs are donor types.

ELECTRONIC STATES OF GRAPHITIC HETEROCOMPOUNDS OF CARBON, BORON AND NITROGEN

Mitsutaka FUJITA

Institute of Materials Science, University of Tsukuba, Tsukuba 305, Japan

Seiji MIZUNO

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

Kenji NAKAO

Institute of Materials Science, University of Tsukuba, Tsukuba 305, Japan

The electronic structures of the graphitic heteromaterials B/C, C/N and B/C/N including
BC_3 and BC_2N are studied theoretically by performing the band calculations based on a local-
density-functional formalism with use of self-consistent numerical-basis-set linear combination

of atomic-orbitals method. We show the electronic band structures and give the estimations of the amount of charge transfers among individual atoms. In these heteromaterials, large charge transfers occur from boron to carbon and nitrogen, and from carbon to nitrogen suggesting the ionic properties. Further we exhibit the character of orbitals for various arrangements of heteroatoms at the top of valence bands and at the bottom of conduction band, which should correspond to the images of STM measurements.

International Symposium
Ultrafast and Ultra-Parallel
Optoelectronics, July 12,
1994, Tokyo, Japan

Polarimeters with Different Carrier Frequencies for Measuring Spatiotemporal Birefringent Parameters

Yoshihiro OHTSUKA and Kazuhiko OKA

Faculty of Engineering, Hokkaido University, Sapporo, Japan

Three types of optical interferometric polarimeters have been exploited to make mapping of spatiotemporal physical parameters for a birefringent sample. The first and second ones generate temporal and spatial carrier frequencies, respectively, and the third is the one in that the first and second are combined to generate spatiotemporal carrier frequencies. All the polarimeters incorporate a reference beam consisting of orthogonal linearly polarized two components to generate the respective carrier frequencies. The resultant interference fringe pattern gives a photocurrent characterized by any one of three kinds of carrier frequencies. A spatiotemporal change in state of polarization for an elliptically polarized signal wave can offer the significant parameters to determine the spatiotemporal birefringent parameters to be mapped at any instant of time. It is demonstrated that the spatiotemporal stress distributions for an epoxy sample plate as well as the spatiotemporal refractive index variations for an anti-ferroelectric liquid crystal cell are successfully mapped.

Mapping of Spatiotemporal Birefringent Parameters in an Anti-Ferroelectric Liquid Crystal Cell by Novel Optical Heterodyne Polarimetry

Kazuhiko OKA and Yoshihiro OHTSUKA

Faculty of Engineering, Hokkaido University, Sapporo, Japan

Mapping of the time-sequential two-dimensional birefringent parameters in an anti-ferroelectric liquid crystal cell is presented. The optical heterodyne polarimeter developed allows us to map a spatiotemporal change in birefringent parameters at every 100 μs.

Spatiotemporal Strain Distribution Mapping Using Novel Optical Heterodyne Polarimeter

Kazuhiko OKA, Tomoko YAMAGUCHI and Yoshihiro OHTSUKA

Faculty of Engineering, Hokkaido University, Sapporo, Japan

A novel method for mapping spatiotemporal strain distributions in a photoelastic sample is described. In an optical heterodyne polarimeter developed, a circularly polarized beam of light is transmitted by a photoelastic sample which is being loaded with time, and then photomixed with a local oscillator beam with linearly polarized two-frequency components. The photocurrent generated in a MOS TV camera possesses the two orthogonal filed components of the signal beam transmitted by the sample, from which the spatiotemporal orthogonal principal strains induced in the sample can be determined. No use of mechainically movable components for polarization alignment allows us to follow a rapid change in the strain distribution. The major advantage of this method is that the orthogonal in-plane principal strains and the out-of-plane strain can be determined independently. The spatial and temporal resolutions in the maps are 0.18 mm and 2.9 ms, respectively.

Fiber-optic interferometric hydropressure sensor immune from temperature disturbances

S. TANAKA, M. SATOH, and Y. OHTSUKA
Department of Engineering Science, Faculty of Engineering,
Hokkaido University, Sapporo, Japan

A length of PANDA fiber is cut at its midpoint and spliced again so that birefringent axes can be arranged interchangeably. At the spliced location it is folded to make a double fiber-coiled sensor to achieve immunity from temperature disturbances. The sensor sensitivity obtained is 1.9 deg/hPa.

Generation of streaming and rarefaction of the gas in the far field of the weakly nonlinear plane waves

Takeru YANO and Yoshinori INOUE
Department of Engineering Science, Hokkaido University, Sapporo, Japan

The propagation of weakly nonlinear plane waves emitted from a harmonically oscillating plate into an ideal gas of semi-infinite extent is considered under the condition that the energy dissipation is negligibly small everywhere except for discontinuous shock fronts. Recently, the authors have numerically shown that, in the case of strongly nonlinear waves, contrary to the result of the conventional weakly nonlinear theory, streaming due to shocks occurs in the direction of wave propagation and thereby the gas near the source is rarefied as time proceeds [Y. Inoue and T. Yano, J. Acoust. Soc. Am. 94, 1632-1642 (1993)]. In the present paper, the evolution of the weakly nonlinear waves including shocks is determined up to O (M^2), where M is the acoustic Mach number $(M \ll 1)$. In this order of approximation, the wave profile develops into an asymmetrical sawtooth-like one in the far field and weak streaming is excited in the region beyond the shock formation distance. For $M \leq 0.2$, the results quantitatively agree with those in the previous work. Furthermore, by taking into account of both the production of entropy and the generation of reflected wave at each shock front, the physical mechanism is clarified for the rarefaction of the gas in O (M^3).

Application of Norbury Rule to Thermal Conductivity in Intermetallic Compounds

Yoshihiro TERADA, Tetsuo MOHRI and Tomoo SUZUKI

Division of Mat. Sci. Eng., Hokkaido Univ., Sapporo 060, JAPAN

Thermal conductivity λ is examined for B2-type aluminides and titanides, and $L1_2$-type nickel based compounds, by using laser-flash method. The thermal conductivity is changed in the following order; $\lambda(\text{NiAl}) > \lambda(\text{CoAl}) > \lambda(\text{FeAl})$ for B2-type aluminides, $\lambda(\text{NiTi}) < \lambda(\text{CoTi}) < \lambda(\text{FeTi})$ for B2-type titanides, and $\lambda(\text{Ni}_3\text{Al}) > \lambda(\text{Ni}_3\text{Si})$, and $\lambda(\text{Ni}_3\text{Ga}) > \lambda(\text{Ni}_3\text{Ge})$ for $L1_2$-type nickel based compounds. According to Norbury rule originally proposed for the concentration dependence of electrical resistivity, the increasing rate is greater in the solid solution, where the position of solute elements is more remote in horizontal distance from a host metal in the periodic table. It is found that this rule holds for the thermal conductivity measured for the intermetallic compounds with the combination of a series of guest constituents and a fixed host constituent both in the B2 and $L1_2$ intermetallic compounds.

MORPHOLOGY AND MICROSTRUCTURE OF ELECTRODEPOSITED ZINC-NICKEL BINARY ALLOYS-1 CRYSTAL GROWTH MECHANISM WITH ZINC CONTENT

Kazuo KONDO, Mitsunori YOKOYAMA, and Kunio SHINOHARA

Department of Materials Science, Faculty of Engineering, University of
Hokkaido Nishi-8, Kita-13 Sapporo 060 Japan

Zinc-nickel electrodeposit have widely been adopted for surface treatment of automobile body steel sheets for high corrosion resistance. This paper describes the morphology and microstructure of electrodeposited zinc-iron binary alloys. With zinc content decrease, morphology changes from hexagonal plate to hexagonal columnar crystal. The hexagonal columnar crystal consists of lateral growth of η-phases hexagonal plate along $(00.1)\eta$ of hexagonal columnar crystal. The γ-phases granular particles precipitate within this η-phases hexagonal plate. This zinc content morphological change have been explained by this lateral growth and γ-phases particles.

MORPHOLOGY AND MICROSTRUCTURE OF ELECTRODEPOSITED ZINC-NICKEL BINARY ALLOYS-2 CRYSTAL GROWTH MECHANISM WITH CURRENT PULSE

Kazuo KONDO, Mitsunori YOKOYAMA and Kunio SHINOHARA

Department of Materials Science, Faculty of Engineering University of
Hokkaido Nishi-8, Kita-13 Sapporo 060 Japan

Zinc-nickel electrodeposit have widely been adopted for surface treatment of automobile body steel sheet for high corrosion resistance. This paper describes the morphology and microstructure of pulsed electrodeposited zinc-iron binary alloys. With increase in pulse current-current off time, morphologies change from hexagonal columnar crystals to pyramidal shaped crystals with two independent c-axes and to pyramidal shape crystals with granular crystals on $(10.0)\eta$ of hexagonal columnar crystals. Macro steps of hexagonal plates thick in the direction of c-axis form on hexagonal columnar crystals of pyramidal shape. These macro steps can be explained by macro step formation mechanism proposed by F. C. Frank, if the γ-particles are regarded as absorbed impurity atoms Further increase in pulse current-current off time produces larger amount of γ-particles which can no more be absorbed in hexagonal columnar crystals and form granular crystals on $(10.0)\eta$ of hexagonal columnar crystals.

Growth of YVO_4 Single Crystals by the Floating Zone Method

Mikio HIGUCHI, Kazuhito HATTA, Junichi TAKAHASHI and Kohei KODAIRA

Graduate School of Engineering, Hokkaido University, Sapporo 060, Japan

Yttrium orthovanadate (YVO_4) is a promising material for both polarizer and laser host. The evaporation of some vanadium oxides has been troublesome for the melt growth of YVO_4 single crystals. In this study, the floating zone method was employed to grow YVO_4 single crystals in an oxygen stream, which suppressed the evaporation of vanadium oxides. The optimum growth condition was as follows: growth rate was 10 mm/h; rotation rate was 10 rpm and 50 rpm for the feed rod and the seed crystal, respectively; growth direction was the c-axis. The as-grown YVO_4 single crystal was transparent and nearly colorless, and no absorption was observed in the transmission spectrum in the wavelength region from 340

(absorption edge) to 2000 nm.   The interference figure proved that the YVO_4 single crystal had little stress birefringence.   The dislocation density was estimated to be about $2 \times 10^5/cm^2$ from the etch pit pattern on a cleavage plane.

HALOGEN-EXCHANGE FLUORINATION OF HETEROAROMATIC HALIDES WITH HF OR HF-BASE

Tsuyoshi FUKUHARA, Takafumi KIDA, Shoji HARA,
and Norihido YONEDA

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

Heteroaromatic halides such as halo-pyridines, -pyrimidines, -quinolines, -benzoxa (or thia) zole under went halogen-exchange fluorination readily by treatment with HF or HF-base solution to afford the corresponding fluorides in good yields.

$$Ar\text{-}X \xrightarrow{\text{HF or HF-Base}} ArF$$
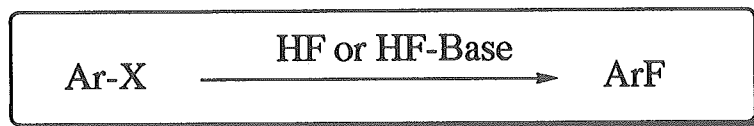
THE 14TH INTERNA-
TIONAL SYMPOSIUM ON
FLUORINE CHEMISTRY
July 31–Aug. 5, 1994
Yokohama, Japan

CYANURIC FLUORIDE-MILD AND EFFICIENT FLUORINATION

REAGENT FOR THE ACTIVATION OF ALKENYLBORONIC ACIDS

Shoji HARA, Shigeyuki ISHIMURA, Akira SUZUKI, and Norihiko YONEDA

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

Boronic acid derivatives are generally stable and easy to handle, but show low reactivity towards electrophiles, therefore activation is required to use them for further transformations. Recently, we reported the activation of boronic acid derivatives by introduction of fluorine on boron and their reaction with α, β-unsaturated carbonyl compounds.[1] During the course of the investigation for mild and effective fluorination reagent, we have found that cyanuric fluoride (1) is a highly efficient fluorination reagent for alkenylboronic acids (2) to activate them in the 1, 4-addition to α, β-unsaturated ketones (3) (eq. 1).

$$ (1) $$
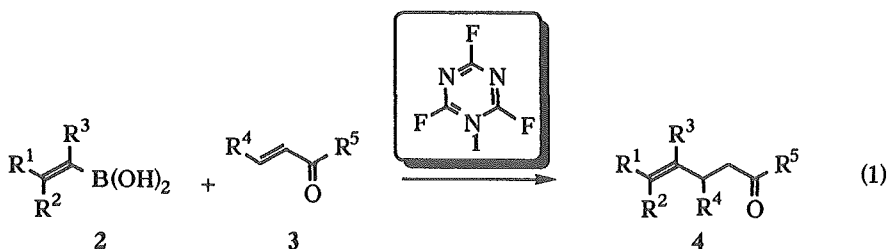
During the reaction, the stereochemistry of 2 is unchanged and undesired side reactions, such as 1, 2-addition reaction, can be avoided. Furthermore, since the reaction takes place under mild conditions, many kinds of functional groups such as keto, ester, cyano, halo, and ether in the substrate can survive. Consequently, this method is applicable for the stereoselective synthesis of multi-functionalized γ, δ-unsaturated ketones (4).

References

1) S. Hara, S. Hyuga, M. Aoyama, M. Sato, and A. Suzuki, Tetrahedron Lett., 31, 247 (1990); H. Fujishima, E. Takada, S. Hara, and A. Suzuki, Chem. Lett., 695 (1992); E. Takada, S. Hara, and A. Suzuki, Heteroatom Chem., 3, 483 (1992); E. Takada, S. Hara, and A. Suzuki, Tetrahedron Lett., 34, 7076 (1993);

302

PREPARATION OF AROMATIC FLUORIDES USING HYDROGEN FLUORIDE

Norihiko YONEDA

Division of Molecular Chemistry, Graduate School of Engineering,
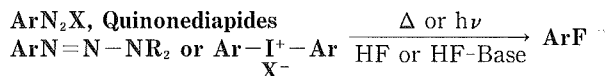Hokkaido University Sapporo, Japan

The utilization of HF, which is obviously among the most attractive fluorinating agents, will be discussed for the effective preparation of aromatic fluorides (ArF) employing some reactions as shown below.

1. *Deaminative fluorination of aminoarenes*

$$ArNH_2 \xrightarrow{\text{Diazotization}} [ArN_2{}^+] \xrightarrow[\text{HF or HF-Base}]{\Delta \text{ or } h\nu} ArF$$
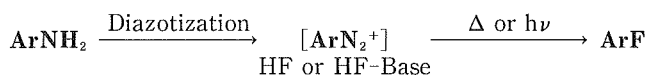
The primary factors for the effective preparation of ArF have been determined from the viewpoint of reaction mechanism in the one pot deaminative fluorination of aminoarenes (diazotization and decomposition in situ) in HF. Conclusively, the diazotization step seems to play the most important role in determining the yield of ArF. On the basis of the results, an industrial process for the photo-induced deaminative fluorination of aminoarenes has been successfully developed very recently at " TOHKEM PRODUCTS Corp." in Japan.

2. *Decomposition of arenediazonium salts, qinonediazides, arenetriazenes, or arenehalonium salts*

$$\begin{matrix} ArN_2X, \text{ Quinonediapides} \\ ArN=N-NR_2 \text{ or } Ar-\underset{X^-}{I^+}-Ar \end{matrix} \xrightarrow[\text{HF or HF-Base}]{\Delta \text{ or } h\nu} ArF$$

The fluoro-dediazoniation of ArN_2X using HF-base solution has been successfully carried out either thermally or photochemically to afford the corresponding ArF in good yields. Particularly, the photochemically induced reaction in HF-Pyridine was a useful tool for the preparation of ArF having polar substituents such as halogen, OH, OMe, CF_3 etc.

ArF are also formed efficiently by the thermal or photochemical decomposition of triazenes, quinonediazides or arenehalonium salts.

3. *Halogen-exchange fluorination of heteroaromatic halides*

$$ArX \xrightarrow[\text{HF or HF-Base}]{\Delta} ArF$$
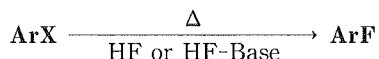
In general, the halogen-exchange fluorination of aromatic halides with HF is thermodynamically unfavorable. However, with heteroaromatic halides such as chloropyrimidines, the reaction proceeded readily affording the corresponding fluorides. Particularly, heteroaromatic chlorides underwent reaction effectively in a vessel open to the air, liberating HCl spontaneously.

The Cross-Coupling Reaction Between Organoboron Compounds and Organic Halides

Akira SUZUKI and Norio MIYAURA

Division of Molecular Chemistry, Faculty of Engineering,
Hokkaido University, Sapporo 060, Japan

The cross-coupling reaction of various organoboranes with organic halides in the presence of a catalytic amount of palladium complexes and bases was first reported to give versatile and useful methodologies for conjugated alkadienes, alkenynes, arylated alkenes, and allylic benzenes. Thereafter, syntheses of stereodefined trisubstituted alkenes and benzofused heteroaromatic compounds were presented. Although organoboranes with alkyl groups on the boron have not beon used successfully for the coupling, it was recently found that the reaction of 9-alkyl-9-BBN derivatives with 1-halo-1-alkenes or haloarenes under some conditions gave corresponding coupling products in excellent yields.

The recent progress of the reactions, including the reaction between sterically hindered arylboronic acids and sterically hindered haloarenes, the palladium-catalyzed carbonylative cross-coupling, and the synthesis of functionalized organotin compounds, is discussed.

Iodination of Compounds Containing Heteroatoms with Mercury (II) Oxide-Iodine Reagent

Kazuhiko ORITO, Masaru OHTO, Takahiro SASAKI,
Motoki YUGUCHI, Mitsuhiro TAKEO, Noriaki SIMOYAMA,
Hiroshi SUGINOME, and Masao TOKUDA

Laboratory of Organic Synthesis, Division of Molecular Chemistry, Graduate
School of Engineering, Hokkaido University, Sapporo 060, Japan

It was found that nuclear iodination of alkyl aryl ethers occurred easily with mercury (II) oxide-iodine reagent in dichloromethane at room temperature to give selectively mono-or diiodides in good yields. A similar treatment of aniline and its derivatives afforded the corre-

sponding 4-iodo derivatives. Application of these procedures to iodination of benzocyclic ethers and amines, such as 2, 3-dihydrobenzofurans and 3, 4-dihydro-2H-benzopyrans, indoles, indolines and 1, 2, 3, 4-tetrahydroquinolines, was successfully achieved to introduce an iodo atom on their aromatic rings, regioselectively. In contrast, under the identical conditions alkyl sulfides and even alkyl aryl sulfides were not iodinated, but found to be selectively oxidized to sulfoxides as exclusive products.

MECHANISM OF RADIATION-INDUCED DEGRADATION OF POLY (METHYL METHACRYLATE)

Tsuneki Ichikawa, Ken-ichi Oyama and Hiroshi Yoshida
Graduate School of Engineering, Hokkaido University
Sapporo, 060 Japan

ESR and gel permeation chromatographic measurements of poly (methyl methacrylate) γ-irradiated between 77K and 300K have been carried out to elucidate the mechanism of radiation-induced degradation of the polymer. It is revealed that the scission of the main chain does not take place immediately after the absorption of radiation energy but is induced by the intramolecular radical conversion of the side-chain $-COOCH_2$ radical to the tertiary $-CH_2-C(CH_3)-$ radical followed by the main-chain β-scission of the latter radical. The degradation does not take place below 190 K, because the side-chain radical starts to convert only above 190 K. The residual monomer in the polymer reacts with the side-chain radical below 190 K to generate the stable propagating-type radical, so that the degradation is suppressed even after warming the polymer to the ambient temperature.

International Symposium
IONIZING RADIATION
AND POLYMERS
Guadeloupe, France Nov. 14–
19, 1994

Mechanism of Radiation-Induced Degradation of Poly (methyl Methacrylate)
—Temperature Effect —

Tsuneki ICHIKAWA*and Hiroshi YOSHIDA

Faculty of Engineering, Hokkaido University, Kita-ku, Sapporo, 060 Japan

Effect of irradiation temperature on the main-chain scission of poly (methyl methacrylate) (PMMA) caused by γ-irradiation was studied by means of gel permeation chromatography and ESR spectroscopy. Although no temperature dependency was observed on the scission efficiency for purified PMMA, the efficiency for crude or monomer-doped purified PMMA was decreased by decreasing the temperature below ca. 200K. Above 200K the efficiency was constant and did not depend on the purity of PMMA. ESR study of the irradiated PMMA revealed that the suppression of the scission below 200 K is induced by the addition of methyl methacrylate monomer to primary radical species which otherwise cause the main-chain scission by warming the polymer above 200K. The primary radical generated above 200K immediately converts to the scission-type $-CH_2-C (CH_3) COOCH_3$ radical through the β-scission of the polymer main chain, so that the efficienc of the scisson does not depend on both the impurity and the irradiation temperature.

4th International Symposium
on ESR Dosimetry and Appli-
cations
München, Germany
May 15-19, 1995

Radiation Chemistry in Alanine Irradiated with Gamma-Rays and Ion-Beams

Hitoshi KOIZUMI, Tsuneki ICHIKAWA and Hiroshi YOSHIDA

Graduate School of Engineering, Hokkaido University
Kita-ku, Sapporo, 060 Japan

In order to examine the applicability of alanine/ESR dosimetry to high LET radiations, effect of radiation quality on the yield of free radicals from alanine was investigated using gamma-rays, 0.5~3 MeV H ions, 0.5~3 MeV He ions, and 175 and 460 MeV Ar ions. It was found that the yield of the free radicals is affected not only by the spatial distribution of radiation energy in a track but also by the migration and recombination of precursor radical ions occurring before the formation of the stable neutral radicals from the radical ions.

Surface Morphology and Electroluminescence of Porous Silicon Layer Prepared on P-Type Silicon with Electrochemical Etching in HF Aqueous Solutions

Kazuhiro SHIGYO, Masahiro SEO, Kazuhisa AZUMI, and Hideaki TAKAHASHI
Graduate School of Engineering, Hokkaido University, Sapporo, Japan

Maher AL-ODAM, and William H. SMYRL
Department of chemical Engineering and Materials Science
University of Minnesota, Minneapolis, Minnesota, U. S. A.

Porous silicon layer (PSL) was prepared on single crystal p-type Si (100) wafers with electrochemical etching under a galvanostatic condition in HF aqueous solutions to explore the optimum preparation condition of PSL for good adherence to the substrate and for good reproducibility of visible luminescence with high intensity. The surface morphology of PSL was observed with various microscopic techniques (SEM, TEM, AFM, and CLSM) and electroluminescence (EL) emitted from PSL during anodic oxidation in KNO_3 aqueous solution in addition to photoluminescence (PL) was measured to understand the luminescence mechanism. Both EL and PL intensities depended sensitively on HF concentration and specific resistivity of the substrate. The adherence of PSL to the substrate was evaluated from the SEM images of cross section of PSL. The optimum preparation condition of PSL was finally obtained when the specimen with specific resistivity of $\rho = 10$ ohm cm was electrochemically etched under a galvanostatic condition of $i = 1$ mA cm^{-2} for 250 min. The TEM image of PSL with a high magnification (5×10^5) has suggested that the quantum confinement effect is operative in the visible luminescence.

Evaluation of Uniform Corrosion Rate of Carbon Steel in Deaerated Carbonate Solutions

Kazuhiko NODA, Yasutake HIROTA, and Masahiro SEO
Graduate School of Engineering, Hokkaido University, Sapporo, Japan

The Polarization behaviors of iron and carbon steel were investigated in deaerated carbonate solutions with different pHs with relation to the prediction of the life time of overpack

materials for long term storage of nuclear wastes. Furthermore, the quartz crystal microbalance (QCM) technique was applied to evaluate the corrosion rate of iron thin film in deaerated carbonate solutions which was compared with the corrosion rate of iron and carbon steel measured by using inductively coupled plasma atomic emission spectroscopy (ICP-AES).

The corrosion of the carbon steel in alkaline solution proceeds with two processes of dissolution and precipitation in the active region. The degree of hydration of films formed on the iron thin film during anodic polarization in alkaline solution was determined by comparing the electric charge and mass change. The dissolution rate of carbon steel in neutral solution is 5.6×10^{-9}g cm^{-2} s^{-1} which is slightly higher than that (4.0×10^{-9}g cm^{-2} s^{-1}) of iron.

Piezoelectric Detection of Changes in Surface Energy of Gold Electrode in Perchlorate Solutions Containing Iodide Ions

Masahiro SEO, Kaoru UENO, and Yuuichi YAMAMOTO

Graduate School of Engineering, Hokkaido University, Sapporo, Japan

The changes in surface energy of gold electode in deaerated 1.0 mol dm^{-3} NaClO$_4$ solutions with and without iodide ions were sensitively detected by using a piezoelectric technique. The potential of electrocapillary maximum or pzc of gold electrode was evaluated from the piezoelectric signal curve. The addition of iodide ions shifted significantly pzc to the negative direction, indicating the strong contact adsorption of iodide ions. It was found from the iodide concentration dependence of pzc that the Esin-Markov relation held at pzc.

The piezoelectric signals at the high potentials far from pzc suggested the possibility of structural change or phase change of iodine adlayer with sign-reversal of total surface charge density. The model on monolayer formation of AuI was proposed to explain the structural change of iodine adlayer.

An EQCM Study on Corrosion of Iron Thin Film in Deaerated Neutral Solutions

Masahiro SEO, Kengo YOSHIDA, and Kazuhiko NODA
Graduate School of Engineering, Hokkaido University
Sapporo, Japan

An electrochemical quartz crystal microbalance (EQCM) was applied to investigate the corrosion behavior of iron thin film in deaerated neutral solutions. The iron thin film with a thickness of 200 nm was electroplated on the gold electrode of quartz crystal. The dissolution of iron thin film at the natural immersion in pH 6.48 borate solution was promoted by the circulation of the solution. The dissolution rate at the natural immersion was higher in circulated phosphate solution than in circulated borate solution in spite of the same pH value of 6.48.

The net current flowed through the external circuit during galvanostatic polarization near the corrosion potential was successfully separated into the iron dissolution current and hydrogen evolution current. The Tafel plots of the iron dissolution current and hydrogen evolution current were made to evaluate the corrosion mechanism. The difference in the corrosion mechansim between borate and phosphate solutions was discussed from the Tafel slopes.

It has been pointed out that the application of EQCM to the active dissolution of iron thin film at the anodic potential far from the corrosion potential needs a caution against the deposition of corrosion products on the surface or the accumulation of dissolved species near the surface. The solution analysis by ICP-atomic emission spectroscopy has revealed that the dissolution rate of iron thin film is higher than that of iron plate in both borate and phosphate solutions.

BIOLOGICAL CONTROL OF CELLULOSE

Kenji TAJIMA, Masashi FUJIWARA and Mitsuo TAKAI

Division of Molecular Chemistry, Graduate School of Engineering,
Hokkaido University, Sapporo 060, Japan

The enhancement of bacterial cellulose (BC) productivity using sucrose as a carbon source has been obtained by the co-cultivation of two different types of acetic acid bacteria. BC yields for the given mix ratio of bacteria were larger than that of control. The contents of water-soluble polymer (WSP) in the BC composites (BCCs) are a range of 5-30 wt.-%. This will be due to the formation of glucose and fructose through the hydrolysis of sucrose by sucrase secreted from *Acetobacter* sp. In addition, this preparation method would be applied to synthesize a new type of BC having both high biodegradability and other functions.

THE NMR STUDIES ON THE STRUCTURE OF CELLULOSE
2-DIMENSIONAL SOLID STATE NMR APPROACH

Tomoki ERATA, Tamio SHIKANO, Yu-ichi SHIMIZU,
Mitsuo TAKAI and Jisuke HAYASHI

Division of Molecular Chemistry, Graduate School of Engineering,
Hokkaido University, Sapporo 060, Japan

A two-dimensional C-H correlation NMR measurement (HETCOR) was performed for making clear of the structure difference between two types of native celluloses, Iα and Iβ, which were recently distinguished by ^{13}C NMR measurements. HETCOR spectra are presented for the native cellulose from *Cladphora* sp. The remarkable difference of correlation peaks between Iα and Iβ especially on C1 and C4 was observed, which indicates the essential structure difference of those two types of native celluloses.

310

IMPROVEMENT OF ALKALINE-OXYGEN DELIGNIFICATION EFFICIENCY

J.-Y. CHEN, Y. SHIMIZU, M. TAKAI, and J. HAYASHI.
Department of Applied Chemistry, Faculty of Engineering,
Hokkaido University, Sapporo 060, Japan

The lignins in the pulps and waste liquors, which were cooked under different temperatures were isolated and analyzed. It was found that the lignin was degraded drastically at the bonds of β-O-4 and α-OR at cooking temperatures of up to 180℃, thus, the residual lignin cooked at 180℃ was degraded into a smaller size than at 170℃ or 160℃. Furthermore, splitting of β-O-4 and α-OR produced more hydroxyphenyl, C-OH and C=O at the C-α position, which could improve the reaction activities of the residual lignin.

These results showed that the cooking temperature at 180℃ improved the efficiency of the oxygen delignification.

Production and Crystallization of 1-Kestose

Shinich KINOSHITA and Hiroyuki TAKEDA
Applied Biochemistry, Department of Molecular Chemistry, Faculty of
Engineering, Hokkaido University, Sapporo, Japan

A fungal strain, NO-1 was isolated from soil as a 1-kestose producer and it was identified as *Scopulariopsis brevicaulis*. This strain produced 60 g of 1-kestose for 72 h at pH 7.0 and 30 ℃ in a 500-ml conical flask containing 25 ml of medium containing 100 g of sucrose, 10 g of yeast extract, 0.6 g of urea, 1 g of K_2HPO_4, and 0.3 g of $MgSO_4 \cdot 7H_2O$ in 1 l. When it was culti-vated in a 2.5-1 jar-fermentor with 150 g of sucrose and 15 g of yeast extract, it produced 95 g of 1-kestose for 68 h. From the culture broth, 1-kestose was crystallized, and its purity was 98.0% with a yield of 71.0%. The crystals were recrystallized and 99.9% of the purity was obtained with a yield of 78.0% By using the crystals the general properties of 1-kestose was determined and most of data were clearer than those of literature. A scheme for the large scale purification of 1-kestose was proposed.

When the strain was cultivated in the medium comprising of sucrose and xylose, it produced a new sugar, xylosyl fructoside. Now, we are optimising the culture condition and searching its uses.

Approximate Model Following Control for Nonlinear Systems

Masahiro YOKOMICHI, Masasuke SHIMA

Faculty of Engineering, Hokkaido University, Sapporo, Japan

In this paper, we study nonlinear model following control problem with stability (NMFS, for short) and nonlinear asymptotic model matching problem (NAMM, for short). The former problem without stability is already solved by Isurugi and Shima for minimum phase case. We mainly consider the non-minimal phase case and give some sufficient conditions for the above problems by means of invariant manifold approach, which is used in the output regulation problem.

A New Method for Improved Performance and Surface Roughness in Stereolithography

Hiroyuki NARAHARA

Control and Information Engineering, Division of Systems and Information Engineering, Faculty of Engineering, Hokkaido University, Sapporo JAPAN.

ABSTRACT

In Stereolithography there is a need to balance rapidity and preciseness. To reduce surface roughness, a method building with thinner layers is currently used, although this causes an increase in processing time. As surface roughness is mostly the result of stair stepping in the slicing process, the surface roughness depends on slicing pitches and model shapes. This paper proposes a new stereolithography process which enables both rapid and precise manufacturing. The extent of rapid performance is also analyzed and compared with the conventional process. In order to fabricate a model of the same surface roughness, the proposed method requires less layers and is faster than the conventional method. Experimental results show that there is a reduction of surface roughness.

312

Optimal Control of a Three Phase Boost Rectifier for Unity Power Factor and Reduced Harmonics

Shoji FUKUDA and Kenya KOIZUMI

Department of Electrical Engineering, Hokkaido University, Sapporo, Japan

A vector controlled IM drive system consisting of a boost rectifier, inverter and induction motor is considered with emphasis placed on the rectifier side. Boost rectifiers can supply DC power while maintaining a sinusoidal AC current with an arbitrary value of fundamental power factor. They are required to simultaneously control both the DC voltage and the reactive current. A DSP-based discrete-time integral-type optimal regulator is considered for the control, because it can provide a robust control system and can accommodate for the computational delay in the output. To obtain higher control performance a DC load current feedforward signal from the inverter side is added. The validity of the proposed method is demonstrated by experimental results.

Introduction of the Harmonic Distortion Determining Factor and its Application to Evaluate Real Tme PWM Methods

Shoji FUKUDA

Department of Electrical Engineering, Hokkaido University, Sapporo, Japan

Yoshitaka IWAJI

Hitachi Research Laboratory Co., Ltd, Hitachi, Japan

Frequency spectra of inverter output currents are one of the important factors considered when evaluating PWM methods. These spectra are, however, influenced not only by the PWM method itself, but by the operating conditions of the inverter such as the switching frequency or load parameters. The harmonic distortion determining factor (HDDF) is considered to be a common quality index that represents the intrinsic spectral property of individual PWM methods. As it is closely related to the RMS values of harmonic motor currents or rorque ripples and, because it is almost independent of the operating conditions, the HDDF is quite useful for evaluating PWM methods. In this paper four typical carried based PWM methods and two space vector based PWM methods are compared and evaluated based on their HDDF values.

Modeling and Control of a Neutral-Point-Clamped Voltage Source Converter

Shoji FUKUDA and Akira SAGAWA

Department of Electrical Engineering, Hokkaido University,
Sapporo, Japan

Neutral-point-clamped voltage source PWM converters (NPCC) are able to reduce harmonic currents, without requiring the devices to be operated at a high frequency switching, and are suitable for high voltage systems because of their circuit structure. The NPCCs, however, have a problem that the neutral point potential (NPP) varies when the current flows into or out of the neutral point. The variations cause voltage deviations in the input waveforms as well as unbalanced voltage stress on the devices. This paper describes a controlling method for NPCCs. It is shown that the system can be modeled by 3-input 3-output 5th-order state equations. The controller is designed based on the optimal regulator theory in order to achieve the control of DC voltage, power factor (PF) and NPP, simultaneously. The validity of the proposed method is demonstrated by simulation.

Using Harmonic Distortion Determining Factor for Harmonic Evaluation of a Neutral Point Clamped Inverter

Y. IWAJI, T. OKUYAMA, T. IKIMI
Hitachi Research Laboratory Co., Ltd., Hitachi, Japan

S. FUKUDA
Department of Electrical Engineering, Hokkaido University,
Sapporo, Japan

This paper describes new harmonic evaluation scheme of neutal point clamped (NPC) inverters. The scheme use the harmonic distortion determining factor (HDDF). The HDDF has been introduced as a common quality index in order to evaluate harmonic chracteristics of 2-level PWM inverters. As the HDDF represents the intrinsic property of PWM methods and is almost independent of the operating coditions, it is quite useful for evaluating PWM methods. In addition, The HDDF is also useful for predicting the harmonic properties in AC drives. If HDDF values for individual PWMs are known and the parameters of the inverter AC drive system are given, the approximate harmonic chracteristics, such as the current har-

monics or torque ripples, can be easily calculated using HDDF values. In this paper, HDDF values of two types of NPC PWM methods are shown, and the approximate harmonic characteristics calculated by the HDDF approach are discussed.

High Precision Control for Variable Speed Driving System with Periodical Disturbances based on Optimal Repetitive Control

Yuzo ITOH, Takeshi TSUCHIYA, Akiko NII
Department of Electrical Engineering, Hokkaido University,
Sapporo, Japan

Shin-ichiro KON
Numazu Operation Division, Meidensha Corporation, Numazu, Japan

Motor speed control system constructed by usual control system designing method, such as PI control and/or optimal control, cannot eliminate the fluctuation of the speed error when speed reference of the system and load torque is changed with the time elapsed. The cases that positioning reference of the industrial robot arm is varied in periodic and motor is loaded by periodical disturbance such as compressor are the typical examples.

In this paper, a novel control system designing method, named optimal repetitive control which gives undertaking the stability of controlled system and dose not lose control performances even if angular speed would be changed is presented. The proposed control method is applied to DC motor variable speed driving system having the periodical load torque and its control performance of high precision for speed command and good response for desired value is confiremed in simulations and experiments.

315

Introduction to Hybrid Type Linear Vernier Motor
and Its Fundamental Analysis

Yoshitaro MATSUSHIMA
Shizuoka University, Hamamatsu, Japan

Yoshihisa ANAZAWA
Akita Unibersity, Akita, Japan

Yuzo ITOH
Hokkaido Unibersity, Sapporo, Japan

The linear motor of various type have been widely used for obtaining a straight line motion in the various fields such as factory automation and traffic transportation.

In this paper, a new developed type linear motor which produces a large thrust force at low speed area without any mechanical conversion system is introduced. The linear motor is named as Hybrid Type Linear Vernier Motor (HBLVM) which generates the thrust force by utilizing of magnetic slots harmonic flux.

To obtain the fundamental characteristics of HBLVM, the Unified Theory is applied. The voltage equations and the steady state thrust expression on γ-δ axis coordinate for HBLVM are analized. Therefore, the optimized machine design is become very easy.

The Application of Fuzzy Dynamic Programming to Uncertainty
in Power System Operation

G. R. GIBSON, H. KITA, K. NISHIYA* and J. HASEGAWA
Department of Electrical Engineering, Hokkaido University, Japan
*Hokkaido Institute of Technology, Sapporo, 006, Japan

This paper presents a new approach for solving multistage decision problems in power system operation by using a new fuzzy dynamic programming method. To investigate its validity, the hydrothermal scheduling problem is used as an example problem. Within this problem, uncertainty elements exist such as load demand and natural hydraulic flows which

can be expressed by fuzzy functions and numbers. In addition, a new fuzzy decision making technique is introduced and is referred to as the dominant relation. This technique selects the dominant pass from among feasible passes. Simulation results showed that the application of fuzzy functions together with the dominant relation technique produces solutions with operating bands. This allows system operation flexibility.

Assessment of Static Voltage Stability Limit Based on the Complex-valued NR Load Flow in Power Systems

H. Kita, E. Tanaka, J. Hasegawa, K. Nishiya* and T. Fukushima**

Department of Electrical Engineering, Hokkaido University, Japan
*Hokkaido Institute of Technology, Sapporo, 006, Japan
**Hokkaido Electric Power Company, Sapporo, 060, Japan

This paper presents a methodology for determining a 'real' voltage stability limit (RVSL) of power systems considering operating constraints and voltage stabilizing effects by the installation of VAR sources. The necessary and sufficient conditions for a system state to be on the RVSL are derived, and the marginal power demand and the marginal SC installation are determined based on these conditions. To search for the RVSL mathematically, a preventive control method previously developed by the authors for enhancing the voltage stability is applied, and two types of algorithm which differs in search direction fundamentally are presented. In one method, we can obtain the RVSL where marginal power is larger relatively. In the other method, the RVSL which is closest to a current operating condition can be obtained. The basic causes for its difference are discussed in detail and illustrated by numerical examples.

Daily Load Forecasting Using a Neural Network Combined with Regression Analysis

Ryo SATOH, Eiichi TANAKA and Jun HASEGAWA
Department of Electrical Engineering, Hokkaido University, Japan

A load forecasting model combining an artificial neural network (ANN) with multiple regression analysis is proposed. This model is able to reflect nonlinear relationships between inputs (temperature, cloudiness and general weather conditions) and outputs (forecasted load values) without analytical efforts. To improve the learning characteristics, "dead bands" are introduced into the error values and the computed outputs. Furthermore, various techniques are adopted to overcome problems associated with the fundamental back-propagation method. From the simulation results, the effectiveness of the proposed correcting model is confirmed; the dead bands performed stable correction and improvement in accuracy was achieved for the summer period which is normally inferior to other periods.

Emergency Control Strategy for Enhancing the Transient Stability Based on the Transient Energy Function Method

H. KITA, A. KATO, J. HASEGAWA and K. NISIYA*
Department of Electrical Engineering, Hokkaido University, Japan
*Hokkaido Institute of Technology, Sapporo, 006, Japan

The power system security is not necessarily maintained for all postulated contingencies even by the preventive control measures because of several constraints. Thus, for such unstable contingencies, it is necessary to implement emergency control measures for stabilization immediately after the contingency has occurred. As emergency control strategies, it is well-known that control measures such as generator shedding and load shedding are quite effective. However, such measures may cause localized supply interruption, therefore, it is necessary for power system operators to minimize the amount of supply interruption incurred when carrying out stabilization measures on the power system. Accordingly, the adequate assessment of the

transient stability while considering the emergency control is a very important problem. This paper presents a new method for quantitatively and accurately assessing the transient stability after the generator shedding is implemented, by extending concepts of the transient energy function (TEF) method. Further, this paper presents an algorithm for determining the desirable amount of emergency control based on the above assessment method.

The Application of Fuzzy Dynamic Programming to the Hydrothermal Scheduling Problem

G. R. GIBSON, H. KITA, J. HASEGAWA, K. NISHIYA* and T. HONMA**

Department of Electrical Engineering, Hokkaido University, Japan

*Hokkaido Institute of Technology, Sapporo, 006, Japan

**Hokkaido Electric Power Company, Sapporo, 060, Japan

This paper presents a new fuzzy dynamic programming approach together with 2 fuzzy decision making techniques for solving multistage decision problems in power system operation. The first technique, called the dominant relation, selects the optimal decision on the basis of the physical position of a given decision function with respect to another. The second technique, called the preference factor, determines the mathematical preference of one decision function with respect to another by comparing the overlap between functions with their area. To investigate the validity of the fuzzy dynamic programming approach together with that of the 2 fuzzy decision making techniques, they were applied to the hydrothermal scheduling problem. Simulation results showed that both techniques provide an operating band, however, the preference factor solutions were superior because its operating band width is narrowed.

An Application of Genetic Algorithms to the Distribution System Loss Minimization Re-configuration Problem

DaiSeub CHOI and Jun HASEGAWA

Department of Electrical Engineering, Hokkaido University, Japan

This paper presents a new method which applies a genetic algorithm for determining which sectionalizing switch to operate in order to solve the distribution system loss minimization re-configuration problem. In addition, the proposed method introduces a new limited life feature for performing national selection of individuals. Simulations were carried out in order to verify the effectiveness of the proposed method. These results showed that the proposed method is effective in dealing with the problems of homogeneity and genetic drift associated with the population in the initial state.

Multipurpose Usage of Decentralized SMES in Advanced Power Distribution Networks

J. HASEGAWA, K. NARA*, E. TANAKA and H. KITA

Deapartment of Electrical Engineering, Hokkaido University, Japan

* Ibaraki Uuiversity, Hitachi, 316, Japan

This paper presents a new electric power distribution system named Flexible, Reliable, Intelligent and Energy Conservative Distribution System (FRIENDS) and the role of dispersed energy storage systems in the FRIENDS. In the FRIENDS, the distribution network consists of a set of meshed networks extended over every demand side block. At the end point of the ditribution network, facilities to control the quality of electricity are installed, and each consumer is able to independently select the appropriate quality ; therefore, a quality-rate control can be attained. The energy storage systems will become an important technology for a non-interrupted power supply and the demand side management (DSM) in the FRIENDS. In this paper, an electric power system with decentralized superconducting magnetic energy storage systems (SMES) is invertigated as a part of the development of the FRIENDS.

320

Evaluation of Levitation and Suspension Forces of a Bulk HTSC in Microgravity Experiments

Masanori TSUCHIMOTO, Hiroshi WAKI, Kazuhiko YAMAYA
and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Kiyotaka MATSUURA and Norio HOMMA
Dept. of Research and Development, Hokkaido Electric Power Co., Inc.
Sapporo, Japan

Levitation and suspension forces between a permanent magnet and a bulk high T_c super-conductor are examined in microgravity experiments at the Japan Microgravity Center at Kamisunagawa, Hokkaido, Japan. Microgravity of $10^{-4}G$ is obtained during 10 seconds. Different experimental results are obtained for a melt processed and a sintered Y–Ba–Cu–O samples. The experimental results are evaluated by using the numerical methods. Stiffness of restoring forse and stable equilibrium of the melt processed sample is discussed from view points of pinning effect.

Experimental and Numerical Evaluation of Total Shielding Current in a Bulk HTSC

Masanori TSUCHIMOTO, Hiroshi WAKI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Hiroshi TAKAICHI and Masato MURAKAMI
ISTEC, SRL, Div. 7, Tokyo, Japan.

When a magnet is moved at a fast speed to a bulk high T_c superconductor (HTSC) in experiments, the levitation force shows fast growth and decay depending on speed of the magnet. Total shielding current of the HTSC is evaluated from experiments with a Rogowski coil. Voltage is induced in the Rogowski coil when a Nd–B–Fe cylindrical magnet is moved to the HTSC in the zero-field-cooling case. Experimental results show that the dynamic property is explained by the flux flow-flux creep theory. An axisymmetric numerical code is also applied to the analysis to evaluate and to discuss the dynamic levitation force.

Numerical Analyses of Trapped Field Magnet
and Stable Levitation Region of HTSC

Masanori TSUCHIMOTO, Hiroshi WAKI, Tomoaki KOJIMA
and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Since maximum magnetic energy of the permanent magnet is limited from saturation of ferromgnetic material, application of a trapped field HTSC magnet (TFM) is proposed in several reports. If shielding current is large enough, a several tesla magnet will be obtained with the TFM. The permanent magnet and the TFM is first discussed from magnetic field configuration and property of the levitation force. Stable levitation regions of the HTSC on a ring magnet and on a solenoid coil are calculated with the critical state model and the frozen field model. It is shown that the present methods are useful analyze electromagnetic phenomena of the HTSC.

Regularized Formulas for BE Analysis of Eddy Current Problems

Hajime IGARASHI and Toshihisa HONMA
Faculty of Eng., Hokkaido University, Sapporo, Japan

This paper provides new regularized formulas for the boundary element analysis of the modified Helmholtz equation describing eddy current fields. The present formulas are shown to regularize near singularity in the kernels and effectively to improve the accuracy in the computation of fields near boundaries.

322

A Numerical Computation of External Q of Resonant Cavities

Hajime IGARASHI, Yasushi SUGAWARA and Toshihisa HONMA
Faculty of Eng., Hokkaido University, Sapporo, Japan

This paper describes a simple numerical method based on the finite element method for the analysis of the resonant frequencies and external Q values of a waveguide loaded cavity. The present method solves a second order proper equation with a damping term, which can be reduced to a linear one. It is shown that the present method provides the resonable resonant frequencies and corresponding Q values for wide range of the electromagnetic coupling.

A Precise Integrator for Charged Particle Motion

Hideke KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper presents a integrator for charged particle motion. Especially, it is shown that one can construct "explicit scheme" precise integrator when charged particle motions are simulated. Simulations for the three example, uniform magnetic field, the Harris magnetic field and the Halbach wiggler, show us acuracy of this integrator.

Gauge and Boundary Conditions in Time Dependent Analysis of Electromagnetic Fields

Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Wake fields are typical transient electromagnetic phenomena, which require any numerical methods for the analysis, because experimental observation of the phenomena is almost impossible. Then, Boundary Element Method (BEM) is suitable for the wake field analysis, because the fields are homogeneous and mesh generation is easer than FDM or FEM type numerical scheme. From this point of view, this paper considers a method of BE analysis of wake fields. Especially, it is shown that the Dirichlet type boundary codition can be used for perfect conductor surface when scalar and vector potentials are used as unknown variables. And then, shape dependence of wake fields accelerator are discussed using the BEM.

Analysis of Levitation Force on HTSC for Magnetic Field Configuration

Masanori TSUCHIMOTO and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Levitation force between permanent magnets and a high T_c superconductor (HTSC) is analyzed numerically based on the critical state model. Size and combination of the magnets are examined to obtain the large levitation force. An axisymmetric code is applied to the evaluation of basic properties of the levitation force, and a thin plate approximation code is applied to the analysis of a partial model of a flywheel. There are the size of the magnets and the magnetic field configuration to obtain the maximum levitation force for a given size of the HTSC. Obtained results will be useful to design the flywheel system with HTSC

Regularized Boundary Element Methods for Potential Problems

Hajime IGARASHI and Toshihisa HONMA
Faculty of Eng., Hokkaido University, Sappro, Japan

This paper describes a novel boundary element method that completely dissolves the corner singularities. The present method, based on subtraction of the singularities, solves the integral equations for the regularized potential and for the leading Fourier coefficients which govern the corner singularities. The method is shown to give an accurate solution to the Motz problem.

Numerical Simulations of Magnetic Brush Formation Phenomena

Zoltan CSAHÓK, Toshihisa HONMA*, Hajime IGARASHI* and Tamas VICSEK
Department of Atomic Physics, Eötvös University, Budapest, Hungary
*Faculty of Eng., Hokkaido University, Sapporo, Japan

We have developed models capable of describing magnetic brush formation phenomena. In particular, we investigate the effects of physical parameters (applied magnetic field, etc.) on the correlations and the structure. Three models are presented, which point out different aspects of the brush growth process.

Gauge and Boundary Conditions in Time Dependent Analysis
of Electromagnetic Fields

Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper discuss a relation between gauge and boundary conditions in time dependent analysis of electromagnetic fields. Especially, electromagnetic fields surrounded by a perfect conductor are considered here. Boundary conditions for scalar and vector potentials have been serious problems in electromagnetic fields analysis. Authors show that scalar and vector potentials can be put zero on boundaries in this paper. And then, it is also shown that this gauge condition is convenient for numerical simulations of electromagnetic fields.

Simulation of Levitation Force of Bulk High Tc Superconductors

Tomoaki KOJIMA, Masanori TSUCHIMOTO and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Levitation force between permanent magnets and a high T_c superconductor (HTSC) is analyzed numerically based on the critical state model. Constitutive reation shows nonlinear properties of HTSC. Size and combination of the magnets are examined to obtain the large levitation force. It is shown the levitation force depends strongly on the magnetic field configuration.

Numerical Analysis of Rediation Field from FEL Considering Electron Distrivution

Junji MATSUOKA, Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper discusses radiation fields from the Free Electron Lasers (FEL) using numerical simulation, Especially, bunching effects of electrons are considered. The simulation method consist of two parts, electron trajectory calculation and calculation of radiation fields from the electrons. Then, the radiation field analysis shows that the rediation power spectrum distribution strongly depends on the electron bunch length and the observation point and that the radiation patterns are quite different for frequencies.

An Application of Bulk High T_c Superconductors to HTSC Flywheel

Masanori TSUCHIMOTO and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

The axisymmetric code and the thin plate eddy current code are applied to the analysis of the levitation force between permanent magnets and bulk high T_c superconductors (HTSC). In the HTSC flywheel model, ring magnets and the HTSC are arranged in a concentric circle. There are the size and the combination of the magnets to obtain the maximum levitation force for the HTSC. Application a field-cooled HTSC as a trapped field magnet is also discussed in the evaluation of the levitation force.

On Wake Fields Reaction Force Which Acts on Electron in Accelerator Cavity

Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

This paper discusses a wake fields reaction force, which acts on electron in an accelerator cavity. When electrons pass though a discontinuity in the accelerator cavity, the electromagnetic fields, which are produced by the electrons, are disturbed. After that, the disturbed fields can not follow the electrons, but stay around the discontinuity as trasient electromagnetic fields (wake fields). Then, the wake fields act reaction force on the electron and the electrons loss its energy. The first part of this paper concerns with anaysis of the wake fields. The calculation method of the wake fields is based on the Boundary Element Method (BEM). Application of BEM to this analysis enable us to consider the wake fields to separate them into two parts, the self-fields of the electrons and induced fields by discontinuity. In the second part of this paper, reaction force for the electrons, which is caused by the wake fields, are considered using the results of the wake fields analysis.

On Wave Properties of Lienard-Wiechert Superpotentials

Hideki KAWAGUCHI and Toshihisa HONMA
Faculty of Engineering, Hokkaido University, Sapporo, Japan

Authors have shown that the Lienard-Wiechert potentials can be expressed using the superpotentials (a new representation of the Lienard-Wiechert potentials). The new expression is wave form equation for charged particle coordinate. The wave property for the particle coordinate, however, is belong to classical theory and independent of "quantum mechanical" one. This paper considers the wave property which the Lienard-Wiechert potentials posses within the classical theory.

Finite Element and Histologic Analyses of Tooth for the Correlation between Stress Distribution and Osteoclast Appearance

K. YAMAMOTO, Y. SATOH*, M. NISHIHIRA, H. MORIKAWA**,
H. ISHIKAWA*, S. NAKAMURA*, and M. WAKITA*

Division of Biomedical Engineering, Hokkaido University, Sapporo, Japan
*School of Dentistry, Hokkaido University, Sapporo, Japan
**Asahikawa National College of Technology, Asahikawa, Japan

Mechanical stress or bone distortion is believed to be a primary component in the initiation of the cellular response to an orthodontic force. In the present study, the relationship between the osteoclast appearance and the stress distribution around a tooth was investigated at a microscopic level. A retraction force of 100 g was applied to a maxillary cat canine for two weeks. Tissue sections 30 μm in thickness were prepared for the microscope observation of a tooth and the surrounding structures. Most osteoclasts appeared in the lateral portion of the alveolar wall adjacent to a cell-free zone and in the open cleft of the alveolar wall. The distribution of the cells was compared with that of the mechanical stress obtained from a specimen specific 2-D FEM model. The osteoclast appeared in a restricted region of a certain magnitude of stress and there was a relatively good agreement between two distributions.

Resorption Rate of the Alveolar Bone during Orthodontic Treatment Estimated from Clinical Measurements and 3-D FEM Analysis

H. MORIKAWA, K. YAMAMOTO*, Y. SATOH**, H. ISHIKAWA**,
and S. NAKAMURA**

Asahikawa National College of Technology, Asahikawa, Japan
*Division of Biomedical Engineering, Hokkaido University, Sapporo, Japan
**School of Dentistry, Hokkaido University, Sapporo, Japan

The force-movement relationship at the crown during orthodontic treatment is a commonly used parameter for controlling and evaluating a therapeutic procedure. From a biomechanical point of view, the stress-resorption relationship at the tooth root is more essential than the force-movement relationship. This paper describes a method for estimating the stress-resorp-

tion relationship, which is based on clinical measurements of 3-D tooth movement and on a 3-D finite element method (FEM). From the 3-D tooth movement, the amount of bone resorption around the tooth was determined. The FEM model for estimating the stress consists of a bracket, a tooth, a periodontal membrane, and an alveolar bone. The resorption rates were obtained from the relationship between the bone resorption and the stress in the priodontal ligament.

Elasticity Measurement of Artery Using Intravascular Ultrasound Imaging

K. YAMAMOTO, T. FUTAMURA*, T. ARAI, M. NISHIHIRA, and T. MIKAMI*

Division of Biomedical Engineering, Hokkaido University, Sapporo, Japan
*Faculty of Engineering, Hokkaido Tokai University, Sapporo, Japan

This paper describes the feasibility of the elasticity measurement of the artery using an intravascular ultrasound imaging technique. We have developed a measurement system which consisted of an intravascular probe, a pulser and receiver unit, a catheter-tip manometer, and a personal computer. Echo signals and blood pressure wave-forms were fed into the computer to construct cross-sectional images of the artery for the time course analysis of the luminal area during the pulsation. A pressure to area curve was obtained to calculate the volume elasticity of the artery. Ev values of the aorta measured on dogs increased gradually with the distance from the heart and were consistent with those measured by another control method. These results demonstrate the feasibility of arterial elasticity measurement using the intravascular technique.

330

Ultrasonic Measurement of Transverse Flow with a Single Transducer by a Time-Domain Correlation Method

M. SHIKUTANI, X. ZHANG and K. YAMAMOTO

Division of Biomedical Engineering, Hokkaido University, Sapporo, Japan

The present study reports a method for measuring a transverse flow normal to the axis of an ultrasound beam with a single transducer by a time-domain correlation technique. This method is based on the decreasing correlation of consecutive RF echoes with the movement of random scatterers. Theoretical analyses of this method were carried out, including the evaluation of statistical errors. The good agreements with the results of computer simulation and phantom experiments were obtained. Both the axial and the transverse components of flows which had various angles to the beam were measured in the phantom experiments. The beam angles were estimated with an accuracy better than 3 degrees.

Finite Element Analysis of Stress around a Moved Tooth and Correlation with Osteoclast Distribution

K. YAMAMOTO, Y. SATOH*, M. NISHIHIRA, H. MORIKAWA**,
H. ISHIKAWA*, S. NAKAMURA* and M. WAKITA*

Division of Biomedical Engineering, Hokkaido University, Sapporo, Japan
*School of Dentistry, Hokkaido University, Sapporo, Japan
**Asahikawa National College of Technology, Asahikawa, Japan

This paper describes the relationship between the osteoclast appearance and the stress distribution around a retracted tooth. We observed osteoclasts on tissue sections of the cat canine subjected to experimental tooth movement. Based on morphology of each section, we developed a 2-D specimen-specific finite element model to estimate a stress distribution in the periodontal ligament. The osteoclasts appeared in the restricted region of a certain magnitude of stress. The results reveal that there is a close correlation between the stress and the osteoclast distributions and suggest that the present method is useful for understanding the process of bone remodeling.

Morphology Evaluation of Heart Rate Variability Power Spectrum

H. BAKARDJIAN and K. YAMAMOTO
Division of Biomedical Engineering, Hokkaido University, Sapporo, Japan

A relatively simple feature 'fractal number' reflects adequately differences in the morphol-
ogy of power spectral patterns. The spectral region area ratios are well-known estimators of
the heart rate variability, but the fractal numbers are able to be complementary evaluations of
the particular spectral morphologies. We investigated 30 heart rate variability spectra and
applied wave recognition technique to the power density series of the R–R, Q–Q and S–S varia-
bility curves. Comparisons between spectral region area ratios and fractal number ratios
showed the functionality of the morphology estimator as an appropriate complementary tool
for clinical assessment of the sympatho–vagal balance at the sinus node.

Relationship between Osteoclast Appearance and Stress Distribution in the Periodontal Ligament during Experimental Tooth Movement

K. YAMAMOTO, M. NISHIHIRA, Y. SATOH, H. MORIKAWA**,
H. ISHIKAWA* and S. NAKAMURA*
Division of Biomedical Engineering and *Department of Orthodontics,
Hokkaido University, Sapporo, Japan
**Asahikawa National College of Technology, Asahikawa, Japan

In the present study, we investigated the relationship between the osteoclasts appearance
and the mechanical stress distribution by means of histological and finite element analyses.
The maxillary canine of two cats was continuously retracted by an initial force of 100 and 200
g, respectively, for two weeks. Tissue sections around the tooth root were obtained for his-
tological analysis to examine the locations of osteoclasts in the periodontal ligament (PDL).
Based on morphological structures of each tissue section, we developed a specimen–specific 2–D
finite element model. The stress distribution within the PDL obtained by each of the 2–D
analyses was compared with the osteoclasts appearance observed on each tissue section. Most
of the osteoclasts appeared in the region of a certain stress level, which was about 40–50 kPa.
It is clearly demonstrated that the cell appearance closely correlates with a certain level of the
principal stress in the PDL.

Determination of Alveolar Bone Resorption Rate during Process of Remodeling Caused by Orthodontic Force

H. MORIKAWA, M. NISHIHARA*, S. YAMANAMI*, K. YAMAMOTO*,
Y. SATOH**, H. ISHIKAWA** and S. NAKAMURA**

Asahikawa National College of Technology, Asahikawa, Japan
*Faculty of Engineering, Hokkaido University, Sapporo, Japan
**School of Dentistry, Hokkaido University, Sapporo, Japan

A resorption rate of bone is one of the basic parameters for describing a remodeling process of the hard tissue. Orthodontic treatment utilizes the biomechanical responses of the alveolar bone to orthodonic force. This paper describes a new technique to estimate an alveolar bone resorption rate from the clinical measurements of 3-D movement of a tooth during the treatment. The stress distributions around the tooth were estimated using 3-D finite element models to obtain a resorption rate to unit stress. The resorption rate estimated from 6-patient data was found to be 0.8 μm/(kPa $\cdot$ day) in average, ranging from 0.5 to 2 μm/(kPa $\cdot$ day), in the canine of the patients.

Consideration of the 'Sensory-Motor Coordination' to an Optic and Acoustic Stimulation

Kazutaka MITOBE, Makoto TAKAHASHI, Mitsutaka KATO, Toru KATO,
Masahiro KIMURA and Tohru IFUKUBE
Hokkaido University, Sapporo, Japan

The angle error between the indicated angle and the target angle was measured as a function of the target angle (Case 1). This result was compared with the angle error between the indicated angle and the angle informed by an operator using spoken words (Case 2). From the experimental results, the degree of error increased in the peripheral area. We discussed the reason why the error became larger in case 1 than in case 2 and also discussed how the virtual reality system should be constructed based on these findings.

Design of a New Electrolarynx having a Pitch Control Function

Norihiro UEMI, Tohru IFUKUBE, Makoto TAKAHASHI
and Jun'ichi MATSUSIMA
Hokkaido University, Sapporo, Japan

We have developed a new electrolarynx which can allow laryngectomees to control voice intonation by using their respiration. The device consists of three parts. The first part is a pressure sensor that can detect expiration air pressure produced from a stoma. The second part is an electrical circuit that can convert air pressure into a pitch frequency for voice. The third part is an electromechanical vibrator that can be attached to the neck. From the experimental results, the optimal air flow resistance and the optimal transform function between the pitch frequency and expiration pressure were found.

An Electrolarynx having a Pitch Control Function

Tohru IFUKUBE, Norihiro UEMI, Makoto TAKAHASHI
and Jun'ichi MATSUSIMA
Hokkaido University, Sapporo, Japan

In order to improve a conventional electrolarynx, we have proposed a new method that can allow laryngectomees to control voice intonation by using their respiration. This method was evaluated through the following two experiments as a parameter of a transform function. The first one was an experiment to measure the accuracy of pitch control using the respiration of laryngectomees and the second one was psycho physical experiment regarding the degree of naturalness of the electrolarynx voice. From the experimental results, it was found that the pitch pattern of the electrolarynx voice became clearly similar to the pattern produced from a normal subject after one day training.

334

Ceramic materials for heart valves

Yoshinori MITAMURA, Toshio YUHTA*, and Youfu WANG**

School of Engineering, Hokkaido Tokai University, Sapporo 005, Japan

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

**Beijing University of Astronautics and Aeronautics, Beijing 100083, China

One approach for developing suitable mechanical heart valves is surface modification of materials used in heart valves. In our heart valve, the metal occluder and housing surfaces are modified with alumina and TiN films. In this study blood compatibility and mechanical durability of alumina and TiN films were investigated.

Both sputtered alumina and TiN films activate fewer platelets and lower the intrinsic coagulation factor XII better than does the segmented polyurethane known to have excellent blood compatibility. The ceramic valve, consisting of a single crystal alumina disc and TiN valve ring, has the safety factor of more than seven times greater than anticipated. It can be concluded that the surface modification of durable materials by sputtering alumina or TiN thin films is promising for future artificial heart valve development.

Biotelemetry Using Indirect Light Transmission

Koichi SHIMIZU and Katsuyuki YAMAMOTO

Department of Bioengineering, Faculty of Engineering, Hokkaido University, Sapporo, 060 Japan.

An optical technique was introduced to be applied to the telemetry of biological signals, such as an ECG (electrocardiogram). The application of the optical technique makes possible the high-speed data-transmission of large capacity, as well as improving the EMC (electromagnetic compatibility) problems. However, in this technique, the discrimination of the different transmitters has been difficult. To solve this problem, we have applied the spread spectrum technique to the optical biotelemetry. With the developed technique the usefulness of optical biotelemetry in clinical use will be expanded.

Trans-body Imaging of Animal Body with Near-infrared Light

Koichi SHIMIZU, Masataka KITAMA and Katsuyuki YAMAMOTO
Department of Bioengineering, Faculty of Engineering,
Hokkaido University, Sapporo, 060 Japan.

    A fundamental study was conducted to realize the trans-body imaging of a living animal using a near-infrared light. The internal structure of mouse abdomen was made visible without using any contrast media. The local hypoxic part inside the body was visualized noninvasively in the transillumination image. Two techniques, called a differential and a contact techniques, were newly developed to suppress the scattering, reflection and refraction at the body tissue. Using these techniques, tomographic imaging of mouse abdomen was attempted. In this study, the feasibility of trans-body imaging using the near-infrared light was verified.

Development of A Ring-type Vital Sign Telemeter

Masaji YAMASHITA and Goro MATSUMOTO
Hokkaido Institute of Technology, Sapporo, Japan

Koichi SHIMIZU
Faculty of Engineering, Hokkaido University, Sapporo, JAPAN

    A ring-type telemeter was developed to monitor a vital sign of the person who needs long-time and continuous monitoring. A photoplethysmographic signal is detected at a finger. An alarm system informs the emergency by an alarm sound or by dialing an emergency number automatically. It is easy to wear all day long, and would be useful for the old person who lives by himself/herself. It can be used for the simple monitoring of the patient with cardiac or cerebrovascular problems in his/her home. A test-system was manufactured, and the feasibility of this technique was investigated. The fundamental functions of this system were tested to be satisfactory, and the feasibility of this technique was verified.

336

Electron Impact Ionization and Attachment Coefficients in NO_2/He Gases and Estimated Electron Collision Cross Sections for NO_2

Y. SAKAI, T. OKUMURA and H. TAGASHIRA

Department of Electrical Engineering, Hokkaido University,
Sapporo 060 Japan

The electron-impact ionization α/p_o and attachment coefficients η/p_o, where p_o is the gas pressure at 0°C, are measured by a steady-state Townsend method for NO_2/He mixtures with the fractional NO_2 partial pressure K($=0$-1) and for $50 < E/p_o < 500$ V/cm/Torr ($141 < E/N < 1410$Td). Values of α and η measured in a wide range of K are useful for estimation of the cross sections, since a type of the cross sections for NO_2 is completely different from those for He. More information on NO_2 cross sections are expected to be derived in this mixtures. On the basis of the present data of α and η, and referring an available momentum transfer cross section for N_2O and other cross sections for NO_2, a set of the electron collision cross sections for NO_2 are estimated.

INFLUENCE OF MIST CONCENTRATION ON BREAKDOWN STRENGTH OF SV90 VAPOR-MIST DIELECTRICS

Yosuke SAKAI*, Hiroaki TAGASHIRA*, Tomio OKADA*
and Yoshitake NAKAGAMI**

*Department of Electrical Engineering, Hokkaido University,
Sapporo, 060 Japan
**Fuji Electric Company, Ichihara, Chiba, Japan

The AC and lightning impulse breakdown voltage V_s of vapor-mist dielectrics, SV90 ($C_7 F_{16}O_4$), in quasi-and non-uniform fields were measured, and the influence of mist concentration and its diameter on the V_s was discussed. The results showed that the lightning impulse V_s under quasi-uniform field increased significantly with increasing the mist concentration, but that the AC V_s increased only slightly with the mist concentration.

Studies of the Creepage Discharge on the surface of Artificial
Acid Rain by High-Speed Schlieren Photography

Y. NAKAO*, H. ITOH*, K. ASKA Juste*, T. SAKAGUCHI*,
Y. SAKAI**, H. TAGASHIRA**

*Department of Electrical Engineering, Muroran Institute of
Technology, Muroran 050, Japan
**Department of Electrical Engineering, Hokkaido University,
Sapporo, 060 Japan

High speed Schlieren photography and photo-optical current measurement technique were employed to investigate the propagation of an impulse breakdown across a model surface of acid rainwater.

When samples of similar electric conductivities and different pH values were used, it was found that the discharge characteristics and the current waveform are strongly voltage dependent; however, direct evidence was not available as concerns the influence of the ionic ingredients or the pH value on the discharge growth.

Electron Swarms in the Upstream Region of an Electron Source

H SUGAWARA, Y SAKAI and H TAGASHIRA
Dept. of Electrical Eng., Hokkaido Univ., Sapporo, Japan.

Exponential spatial growth of electron swarms under steady-state Townsend conditions may be observed not only in the downstream region of an electron source but also in the upstream region due to backward diffusion. This is caused by a large value of the relative electron density gradient coefficient. Relations between swarm parameters in the upstream region, deduced assuming an exponential spatial distribution for the electrons, were found to have interesting characteristics. For example, the sign of the diffusion modified electron drift velocity, $Vd = Ws - \alpha Ds$, is positive when the gas is electro-positive, and negative when the gas is electro-negative. A propagator method modified for analysis in the upstream region is applied to quantitatively confirm this property. An example of the occurrence of backward diffusion is found in a steady-state Townsend experiment between parallel plane electrodes. In this case, the effect of electron absorption at the anode is transmitted towards the cathode by a mechanism similar to the backward diffusion of electrons.

338

A Property of Electron Swarms in the Upstream Region under the
Steady-State Townsend Condition

H TAGASHIRA, H SUGAWARA and Y SAKAI

Department of Electrical Engineering, Hokkaido University,
Sapporo 060 Japan

Exponential spatial growths of electron swarms in gases, which may be observed in steady-state Townsend conditions, are observed not only in the downstream region from the electron source but also in the upstream region due to backward diffusion. Deduced relations between swarm parameters in the region were found to have peculiar characteristics. The sign of electron drift velocity Vd depends on whether the gas medium is electro-positive or -negative. Its propriety is confirmed by the electron energy distribution calculated by a propagator method modified for analyses in the upstream region.

Parallel Computing of Electric Discharges
— Electron Flow in Phase Space —

H SUGAWARA, Y SAKAI and H TAGASHIRA

Department of Electrical Engineering, Hokkaido University,
Sapporo 060 Japan

A technique named "Propagator Method" is presented for analysing electron energy distributions and electron swarm parameters such as mean energy, drift velocity, ionization frequency, etc. in gas discharges. In the propagator method, electron inflow and outflow are calculated with Green's function for every small region defined in phase space consisting of real space and velocity space, in which coordinates of an electron represent the position and velocity of the electron. The method is suitable for vector operation by pipeline processing since almost all parts of the calculation scheme consist of sequential summation of products.

One of the most characteristic differences between the electron flow and a traditional fluid is that a microscopic velocity of each electron, which is an important quantity for representing physical or chemical reactions with gas molecules, are not unique for the position. The elec-

tron velocity has a distribution for every position. That requires a number of elements which represent small regions in multi-dimensional phase space in case a kind of finite element method is employed.

As another difference, the electron motion includes collision processes with gas molecules. Electron velocity changes instantly at the collision, and that can be regarded as a jump in velocity space. A part of the electron flow in velocity space is not continuous. A restriction for the electron motion under the electric field is introduced into the propagator method for satisfying the conservation law of energy. Illustration of the technique of the propagator method and some results by the method are presented.

Removal of Surface State Effects from Near-Surface Quantum Structure by A Novel Interface Control Technique

Satoshi KODAMA, Satoshi KOYANAGI, Tamotsu HASHIZUME
and Hideki HASEGAWA

Department of Electrical Engineering and Research Center for Interface
Quantum Electronics, Hokkaido University, Sapporo 060, Japan,
TEL : +81-11-706-6509, Fax : +81-11-706-7890

For successful development of mesoscopic electronics based on quantum wave devices and single-electron devices, highly uniform quantum structures should be fabricated near surface for planar integration. Compound semiconductors are very promising for this purpose because of availability of high-precision epitaxy and various self-organizing mechanism. However, serious problems are expected to arise from presence of surface states, as manifested by recently reported PL efficiency degradation [1-3] in near-surface quantum wells (QWs).

The purpose of this paper is to show that our novel silicon interlayer based interface control scheme is extremely powerful in removing the surface-state-induced PL intensity reduction in the AlGaAs/GaAs near-surface QWs. Recovery of PL efficiency as large as 10^3 is realized by the novel passivation technique for the first time.

Novel Quantum Well Wire Fabrication Method Using Self-organized Multiatomic Steps on GaAs (001) Vicinal Surfaces by MOVPE

S. HARA, J. MOTOHISA, T. FUKUI and H. HASEGAWA

Research Center for Interface Quantum Electronics and Faculty of Engineering,
Hokkaido University, North13 West8, Sapporo 060, Japan,
Fax : +81-11-716-6004, Phone : +81-11-706-7172

Recently, a novel quantum well wire fabrication method using multiatomic steps on vicinal substrates has been demonstrated by metalorganic vapor phase epitaxy (MOVPE) [1], and by molecular beam epitaxy (MBE) [2]. Such an in-situ self-organizing fabrication method is very promising because high density nano-meter size quantum well wires (QWWs) can be fabricated without any damage-introducing processes such as lithography and dry etching, and because the size of QWWs can be controlled only by adjusting the crystal growth conditions. However, for GaAs QWW formation, the height and spacing of the steps fluctuate especially on AlGaAs lower barrier layer surfaces [1]. In this paper, we report on formation and optical characterization of self-organizing QWWs using multiatomic steps on (001) GaAs vicinal substrates, and improvement of their size uniformity achieved by forming more coherent multiatomic steps on AlAs lower barrier layer surfaces.

In-Situ Photoluminescence and Capacitance-Voltage Characterization of InAlAs/InGaAs Regrown Heterointerfaces by MBE

T. SAITOH, H. TOMOZAWA, T. NAKAGAWA, H. TAKEUCHI and H. HASEGAWA

Research Center for Interface Quantum Electronics and Department of Electrical
Engineering, Hokkaido University, North13, West8, Sapporo 060, Japan

Abstract

This paper characterize the electronic properties of InAlAs/InGaAs MBE regrown interfaces by combined use of in-situ photoluminescence surface state spectroscopy (PLS³) and

capacitance-voltage (C-V) techniques. It is shown that the interface state density at continuously grown InAlAs/InGaAs inter-face is low and comparable with that of uninterrupted Al-GaAs/GaAs interface and that the effect of the growth interruption was surprisingly small whereas the same interruption resulted in almost 10^2 times reduction of the PL efficiency for AlGaAs/GaAs system. It is also shown that high density of surface states exists at MBE InGaAs surface. Interruption after the growth of bottom InAlAs layer in InAlAs/InGaAs/InAlAs system also leads to appreciable generation of interface states, but it is much smaller as compared with the case of AlGaAs/GaAs/AlGaAs system.

Fabrication of Highly Strained InAs Quantum Dots Grown by Molecular Beam Epitaxy

Kanji YOH, Hayato TAKEUCHI, Toshiya SAITOH,
Hajime FUJIKURA and Hideki HASEGAWA
Research Center for Interface Quantum Electronics,
Hokkaido University N13, W8, Sapporo 060 Japan

InAs heterostructures are interesting material system to achieve quantum effect devices that operate at high temperatures because of its extremely low effective mass of electrons and large conduction band discontinuity [1-3]. The InAs heterostructure based on antimonides provides a promising material system for the present goal for its relatively low lattice-mismatch. However, it suffers from inherent gate leakage current [4] and lack of impurity control [5-7].

In the present paper, we report the fabrication and characterization of quantum dots using highly strained InAs heterostructures based upon completely arsenide system. The heterostructure is illustrated in Fig. 1. The lattice mismatch between InAs and rest of the layers is approximately 3.2%. The designed InAs thickness of 40A was chosen so that the actual InAs thickness fall well within the critical thickness of$=50 Å$. The strong confinement of electrons in the narrow InAs quantum well limits the electron mobility in the present approach because the penetration of electron wave function into the barrier layer causes enhanced interface roughness scattering and results in low mobility. To compromize, we have employed a chair-shaped well, as shown in the inset in Fig. 1, where thin InGaAs layer is inserted under the InAs channel layer. In this way, one can maintain relatively high mobility by attracting the wave function toward downward in the InGaAs layer where electron mobility is relatively high, while maintaining the major portion of it in the InAs well.

342

Fabrication of GaAs/AlGaAs Quantum Dots by Metal-Organic Vapor Phase Epitaxy on Patterned GaAs Substrates

J. MOTOHISA, K. KUMAKURA, M. KISHIDA, T. YAMAZAKI*,
T. FUKUI, H. HASEGAWA

Research Center for Interface Quantum Electronics and Faculty of Engineering, Hokkaido University, North 13 West 8, Sapporo 060, Japan

and K. WADA

NTT LSI Laboratories, 3-1 Morinosato, Wakamiya, Atsugi-shi, Kanagawa 243-01, Japan

We report on a growth process on patterned GaAs (001) substrate during metal-organic vapor phase epitaxy (MOVPE) and a novel approach for the fabrication of AlGaAs/GaAs quantum dot (QD) structures. The patterned substrate have an array of holes on the surface and those holes are partially filled with GaAs by MOVPE growth, followed by GaAs/AlGaAs quantum well structures. Detailed investigation on growth process on such patterned substrates revealed the presence of complicated two-dimensional migration of Ga and Al between different facets. Formation of GaAs dots was directly confirmed by spatially resolved cathodoluminescence measurements.

A Novel Formation Method of Quantum Dot Structures by Self-limited Selective Area Metalorganic Vapor Phase Epitaxy

K. KUMAKURA, K. NAKAKOSHI, J. MOTOHISA, T. FUKUI and H. HASEGAWA

Research Center for Interface Quantum Electronics and Faculty of Engineering, Hokkaido University, North 13 West 8, Sapporo 060, Japan

Telephone : +81-11-706-7172, Telefax ; +81-11-716-6004

Low dimensional electron confinement systems, such as quantum wires and dots, have been attracting much attention because of their novel electrical and optical properties. Particularly

recently self-organized quantum dot (QD) formation in highly strained InGaAs/GaAs systems, is very promising for fabrication homogeneous and ultra high density quantum dot array. However, the difficulties controlling the position and size of QDs still remain [1, 2].

The purpose of this paper is to demonstrate a novel formation method of uniform GaAs quantum dot structures using selectice area metalorganic vapor phase epitaxy (MOVPE). A low pressure horizontal MOVPE reactor was used with TMGa, TEAl, AsH3 as source materials. GaAs (001) substrates having 2μm $\times$ 2μm square windows in a SiN_x mask were used. The mask size was 100μm$\times100\mu$ms quare as schematically shown in Fig. 1. GaAs micropyramidal structures having four-fold symmetry {011} facets were grown at 730℃ on GaAs masked substrate. Under these growth conditions, no growth occurs on {011} facet sidewalls and SiN_x mask [3]. For characterization, scanning electron microscope (SEM), atomic force microscope (AFM) and photoluminescence (PL) measurements were used.

Characterization of InAs Quantum Dots Fabricated by MBE and Wet Chemical Etching

Kanji YOH, Hayato TAKEUCHI, Toshiya SAITOH
and Hideki HASEGAWA

Research Center for Interface Quantum Electronics, Hokkaido University,
North 13, West 8, Kita-ku, Sapporo 060 Japan,

We have fabricated highly strained InAs quantum dots based on completely arsenide heterostructures grown on InP by MBE. Blue shifted strong photoluminescence was obtained from millions of quan-tum dots with the average lateral size of approximately 2000Å square.

InAs heterostructures are interesting material system to achieve high temperature operation of quantum effects due to the extremely low effective mass of electrons in InAs, and large conduction band discontinuity. In order to decrease the stability problem of InAs heterostructure based on antimonides, strained InAs heterostructures based on arsenides have been grown on semi-insulating InP substrates by molecular beam epitaxy. The 3.2% lattice mismatch between InAs and InGaAs/AlInAs system allows to grow 40Å of strained InAs without lattice relaxation. The standard structure consists of 3000Å of $(In_{53}Ga_{47})$ As buffer layer grown on a semi-insulaing InP substrate, 7000Å of $(In_{52}Al.48)$ Sb bufferlayer, 60Å of $(In_{53}Ga_{47})$ As, 40Å of InAs, 30Å of AlAs, 20Å of undoped $(In_{52}Al_{48})$ Sb barrier layer, 600Å of silicon doped $(In_{52}Al._{48})$ Sb layer and 50Å of $(In_{52}Al._{48})$ Sb cap layer. The designed InAs thickness of 40Å was chosen so that the actual InAs thickness fall well within the critical thickness of 50Å. Inserted thin InGaAs layer under the InAs channel was intended to reduce the mobility degradation effect by the strong confinement of electrons in the 40Å quantum well. In this way, one can maintain relatively high mobility by attracting the wave function toward downward in the InGaAs layer where electron mobility is relatively high, while maintaining the

major portion of it in the InAs well.

The conventional optical lithography was used with the original mask dot size of 1m square followed by the wet chemical etching. The dot shape was verified by atomic force microscope (AFM) and the photoluminescence meansurements have been performed on the qantum dots which is compared with that of a two dimensional electron gas system. Uniform pyramidshaped patterns were obtained by chemical etching. The photoluminescence intensity per unit area from the dots were much stronger than the 2D quantum wells by a factor of 500. The peak photon energy from the lowest subband in the dot was higher than the corresponding signal from the 2D quantum well by 5.9 meV, indicat-ing that the electrons are laterally confined in a rectangular shape of the order of 740 Å square. Comparison of the average dot size (2000 Å) and the electron confinement size (740 Å) estimated by the energy shift suggests that the electrons are depleted in the periphery of the dot and the depletion depth is approxi-mately 630 Å from the edge.

Multiatomic Step Formation Mechanism of MOVPE Grown GaAs Vicinal Surfaces and Its Application to Quantum Well Wires

T. FUKUI, J. ISHIZAKI, S. HARA, J. MOTOHISA and H. HASEGAWA

Research Center for Interface Quantum Electronics and Department of Electrical Engineering, Hokkaido University

Abstract

The multiatomic step formed on GaAs vicinal surfaces by metalorganic vapor phase epitaxy (MOVPE) are studied by atomic force microscopy (AFM). An AFM image of epitaxially grown GaAs surface showed coherent multiatomic steps with extremely sharp edges over a wide area. The average height and spacing of the multiatomic steps are 1.2-8nm and 30-110nm, respectively. These terrace widths change with the growth conditions. Narrower terrace widths are obtained at higher growth rates, and under higher AsH_3 partial pressures and higher impurity doping conditions. The results suggest that the migration distance of Ga atom on the terrace and the sticking coefficient at the step sites depend on these growth conditions.

Using multiatomic steps, GaAs/AlGaAs quantum well wires (QWWs) were grown on a GaAs vicinal surface. Cross-sectional transmission electron microscope and photoluminescence show the successful fabrication of QWWs.

SURFACE ELECTRICAL BREAKDOWN CHARACTERISTICS OF MOLECULAR BEAM EPITAXIAL LAYERS GROWN AT LOW TEMPERATURES

H. HASEGAWA***, K. SASAKI*, S. SHIOBARA*and S. SUZUKI*

*Department of Electrical Engineering and **Research Center
for Interface Quantum Electronics, Hokkaido University,
North 13, West 8, Sapporo 060, Japan
Tel : +81-11-706-6519 Fax : +81-11-706-7890.

GaAs epitaxial layers grown at low temperature (LT) by molecular beam epitaxy (MBE) or so-called GaAs LT buffers have attracted considerable attention due to its unique semiin-sulating (SI) and other properties which remove side-gating phenomena in HEMTs and MES-FETs [1] , remove surface Fermi-level pinning as a surface passivation [2] layer, realizes optical switching with ultra-fast carrier dynamics [3] and causes optical non-linearity. However, the basic mechanism responsible for its unique semi-insulating property is not yet clarified, being disputed between the EL2 cluster model [4] and the As cluster-induced Fermi level pinning model [5].

The purpose of this paper to study the surface electrical conduction behavior of the GaAs LT buffer for the first time in order to gain practical information concerning its applicability to planar integration as well as to gain insights into its electrical conduction mechanism.

The sample structures are shown in Fig. 1 (a) and (b). The LT buffer was grown by standard MBE on an LEC SI substrate. The observed growth temperature dependence at the surface resistance is shown in Fig. 2 where a sharp transition to SI substrate was observed.

Improvements of Drain Current Characteristics of InAs Field-Effect Transistors by the Surface Reaction of Platinum Gate

Kaniji Yoh, Hayato Takeuchi and Hideki Hasegawa

Research Center for Quantum Interface Electronics, Hokkaido University
N13 W8, Kita-ku, Sapporo 060 Japan

Satoshi Izumiya and Masataka Inoue

Department of Electrical Engineering, Osaka Institute of Technology
5-16-1 Omiya, Asahi-ku, Osaka 535 Japan

Abstract

We report the fabrication process and characterization of platinum-gated InAs heterojunction FETs and platinum/semiconductor Schottky interface by Ratherford Backscattering Spectroscopy.

High performance InAs heterojunction field-effect transistors based on antimonides have been shown to have higher potential in achieving high transconductance [1-2] compared with conventional HEMTs based upon GaAs or InGaAs-channel FETs. However, it has been known that it is difficult to achieve decent drain-current modulation characteristics by the gate voltage application [3]. It was suspected that the AlGaSb or AlSb barrier material easily gets oxidized because of its high aluminum contents and hence degraded gate voltage swing. One of the solutions would be to make use of the clean Schottky junction formation by the surface reaction of the gate material and the semiconductor. Platinum gate has been known to react with GaAs surface forming controllable clean Schottky junction, i. e., $PtAs_2$/GaAs [4-5]. This technique was mainly applied to GaAs MESFETs to control the threshould voltage [6]. We have applied this technique on InAs/(AlGa) Sb heterojunction transistors and obtained dramatic effect in achieving high yield of decent FET operation. Improvements of current modulation was clearly observed in the current voltage characteristics of an InAs FET. When the gate anneal procedure was done after ohmic contact formation (Fig. 1 (a)), improvements of the I-V characteristics was not as dramatic as expected because of the ohmic contact degradation. When the gae annealing process was done prior to the ohmic contact formation (Fig. 1 (b)), improvements of the current voltage characteristics of an InAs FET were dramatic (Fig. 2). The transconductance of the hardly operating device has been improved to show 80mS/mm. Rutherford Backscattering Spectroscopy (RBS) on the platinum/(AlGa) Sb junction suggested (Fig. 3) the formation of platinum alloy (probably antimonide) at the surface with the same annealing condition as the improved InAs FET.

Selective MBE growth of InGaAs and InAlAs on high-index facets and its application to fabrication of InGaAs ridge quantum wires

H. Fujikura and H. Hasegawa

Research Center for Interface Quantum Electronics and Department of Electrical Engineering, Hokkaido University, Sapporo 060, Japan

Introduction

Recently, quantum wires and quantum dots have attracted significant attention because of new quantum mechanical phenomena in solid-state physics and their device applications. For realizing quantum wires and quantum dots, various approaches have been made. Among them, selective and self-organizing growth is promising method because of absence of process-induced damages (1)-(3). To achieve selectivity and self-organizing motion, growth on high index facets is particularly interesting because of possible growth rate modification and related material transfer.

Paying attention to the high mobility and the large conduction band discontinuity of InGaAs/InAlAs system, we have recently studied the growth characteristics of this system on nonplanar substrates and attempted formation of quantum wires by selective molecular beam epitaxy (MBE) (4)-(6). In this paper, we present novel results on MBE characteristics of $In_{0.53}Ga_{0.47}As$ and $In_{0.52}Al_{0.48}As$ layers on prefabricated ridge structures with (311) A facets and their successful application to fabrication of InGaAs ridge quantum wires. Sample structures were investigated by scanning electron microscope (SEM). Low temperature photoluminescence (PL) and cathodoluminescence (CL) measurements were made to characterize the fabricated InGaAs ridge quantum wires.

348

A NOVEL PASSIVATION TECHNOLOGY OF InGaAs SURFACES USING Si INTERFACE CONTROL LAYER AND ITS APPLICATION TO FIELD EFFECT TRANSISTOR

S. SUZUKI*, S. KODAMA*and H. HASEGAWA***
*Department of Electrical Engineering and **Research Center
for Interface Quantum Electronics, Hokkaido University,
North 13, West 8, Sapporo 060, Japan
Tel : +81-11-706-6519 Fax : +81-11-706-7890.

In spite of the recent remarkable progress achieved in heterostructure microelectronics based on HEMTs and HBTs, the surfaces and interfaces of the compound semiconductors are still not well controlled. Since surfaces and interfaces play more and more inportant roles as the device sizes are scaled down, establishment of an appropriate passivation technology is a vital issue for future progress. The purpose of this paper to present a novel passivation technique of air-exposed InGaAs surface using the Si interface control layer (Si ICL). The details of processing together with XPS and electrical characterization are presented. To demonstrate effectiveness of the technique, metal-insulator-semiconductor field effect transistor structures are fabricated, and their electrical characteristies were evaluated.

The basic passivation seheme having an MBE grown ultrathin Si ICL and an outer insulator is shown in Fig. 1. The Si ICL with thickness of 10A is grown by MBE at 250°C. The pseudo-lattice matting of Si layer with InGaAs is confirmed by RHEED patterns. Subsequently, a thick SiO_2 is deposited by photo-CVD. Figure 2 shows the XPS analysis of the I-S interfaces with and without Si ICL after formation of an outer insulator. The role of the Si ICL is not only to reduce the I-S interface state density by relaxing a lattice disordering at the In-GaAs surface, but also to prevent direct oxidation or nitridation of the InGaAs surface at formation of an outer insulator.

The present interface control technique was successfully applied to realiza InGaAs MIS-FET by entirely UHV-based process [1]. For an air-exposed InGaAs surface, good interface properties comparable to those by UHV-based process can be obtained by performing an HF treatment on InGaAs before MBE Si ICL growth. Interface states density distributions form C-V

Determination of interface state density distribution and surface recombination velocity on passivated semiconductor surfaces by photoluminescence surface state spectroscopy

T. Saitoh and H. Hasegawa

Research Center for Interface Quantum Electronics and
Department of Electrical Engineering, Hokkaido University,
North 13, West 8, Sapporo 060, Japan

Keywords: Photoluminescence, surface state density, interface state density, surface recombination velocity, interface control layer

Abstract

The photoluminescence (PL) surface state spectroscopy (PLS^3) technique recently proposed by the authors allows an in-situ, contactless and non-destructive characterization of the passivated surfaces. The surface/interface state density (N_{ss}) distribution and the surface recombination velocity (S) of the device surface under any operation conditions can be determined. Various passivation processes of Si wafers are characterized in terms of the values of S under various sunlight intensities in view of solar cell applications. The tech-nique is also applied to characterization of passivated GaAs and InGaAs surfaces, including those having silicon interface control layers.

PHOTOLUMINESCENCE-BASED MEASUREMENT TECHNIQUE OF SURFACE RECOMBINATION VELOCITY FOR HIGH EFFICIENCY SILICON AND COMPOUND SEMICONDUCTOR SOLAR CELLS

T. SAITOH, T. NAKAGAWA, K. YOH and H. HASEGAWA
Research Center for Interface Quantum Electronics and
Department of Electrical Engineering, Hokkaido University,
North 13, West 8, Sapporo 060, Japan

ABSTRACT

This paper shows that our recently proposed photoluminescence surface state spectroscopy (PLS³) technique allows an in-situ, contactless and non-destructive determination of the value of the effective surface recombination velocity (S) under sunlight illumination and the surface/interface state density (N_{ss}) distributions. This technique is successfully applied to measurement of the values of S at variously passivated Si surfaces. A best value of 3,000 cm/s is obtained under 1 sun condition for thermal oxidation. S is greatly reduced under concentrated sunlight. N_{ss} distributions at compound semiconductor surfaces and heterointerfaces are also characterized to optimize the fabrication process of compound semiconductor solar cells. Formation of Si interface control layer (ICL) between InGaAs and SiO_2 greatly reduces the interface states. Growth interruption at AlGaAs/GaAs hetero-interface produces high density of interface states. InAlAs/InGaAs heterointerfaces are also investigated. These results indicate that the new PLS³ technique is useful for the characterization and optimiza tion of the fabrication processes of the silicon and compound semiconductor solar cells.

Fabrication of InGaAs Ridge-Quantum-Wires by Selective Molecular Beam Epitaxy and their Characterization

H. FUJIKURA and H. HASEGAWA

Research Center for Interface Quantum Electronics and Deparment of
Electrical Engineering, Hokkaido University, Sapporo 060, Japan,
Telefax +81-11-706-7890, Phone +81-11-706-6519

InGaAs/InAlAs ridge quantum wires were sucdcessfully fabricated by selective molecular beam epitaxy (MBE) for the first time. Prior to wire fabrication, detailed data on selective growth characteristics were taken by using test structures. Then, triangular shaped InGaAs ridge quantum wires with a width of 300 Å were fabricated, using the selectivity data. Photoluminescence (PL) measurements detected strong and narrow peak from the wires which showed a blue shift of 159meV with respect to the InGaAs band-gap. This value agree excellently with the calculation.

InGaAs Insulated Gate Field Effect Transistors Using Sillicon Interlayer Based Passivation Technique

S. SUZUKI, S. KODAMA, H. TOMOZAWA and H. HASEGAWA

Research Center for Interface Quantum Electronics and Department
of Electrical Engineering, Hokkaido University,
N-13, W-8, Sapporo 060, Japan

Introduction

Recently, compound semiconductor high speed devices (HEMT, HJFET etc.) using InP-based materials have demonstrated excellent performance owing to superb electron transport properties of InGaAs. One of the application areas of these devices is the microwave and millimeter wave movable communication which is expected to become more and more important in the so-called "multi-media"era. However, since such an application requires in most

cases battery operation, gate leakage currents inherently present in the Schottky gate structure, gives a severe constraint. Lack of low power dynamic memory also limits the functional capability of the system using thses devices. These problems can be solved by having insulated gate devices whose realization has, however, been hitherto hindered by the lack of a suitable passivation technology.

Recently, we have shown that the surface state density can be greatly reduced by inserting an MBE grown ultra-thin Si interface control layer (Si ICL) at the interface between InGaAs and the passivation dielectric films (1) on the basis of the disorder induced gap state model (2). Such a technique has been applied to fabrication of planar (3) and recessed gate MISFETs (4), photoconductive detectors (5) and to passivation of near surface quantum wells (6).

The purpose of this paper is to investigate the applicatility of the Si ICL-based passivation technique to construction of InGaAs insulated gate field effect transistor (IGFET) devices such as MISFETs and HEMTs. Since most of our previous work has been done in a UHV-based system where the Si ICL was grown on the fresh MBE surface of the compound semiconductor, one of the key problems is how to make the present technique applicable to air-exposed surfaces. Here,HF treatment were applied to InGaAs and InAlAs surfaces. Basic insulator-semiconductor structures were fabricated and characterized by XPS, I-V and MIS C-V techniques. Fat MISFTEs and HEMT were also fabricated and feasibility of the present technique is successfully demonstrated.

A Novel Surface Passivation Scheme for Compound Semiconductor Using Silicon Interface Control Layer and Its Application to Near-Surface Quantum Wells

Satoshi Kodama, Satashi Koyanagi and Hideki Hasegawa
Department of Electrical Engineering and Research Center for Interface
Quantum Electronics, Hokkaido University, Sapporo, 060, Japan,
Phone: +81-11-706-6519, FAX: +81-11-706-7890.

The recently proposed novel passivation scheme using a structure of SiO_2/ultra thin silicon interface control layer (Si ICL)/compound semiconductor was father improved by addition of ultra thin silicon nitride and applied to passivation of near-surface quantum wells. Processing sequence for the improved structure was characterized and optimized with the use of *in-situ* XPS and C-V techniques. The improved passivation scheme was applied to passivation of near-surface $Al_{0.3}Ga_{0.7}As$/GaAs ($80\,\text{Å}$)/$Al_{0.3}Ga_{0.7}As$ quantum wells, leading to recovery of PL intensity.

Behavior of the Multilayer Step of MOVPE Grown GaAs on Vicinal (001) GaAs Substrate Investigated by Atomic Force Microscopy

J. ISHIZAKI, K. OHKURI, S. HARA, J. MOTOHISA,
T. FUKUI and H. HASEGAWA

Research Center for Interface Quantum Electronics and Department
of Electrical Engineering, Hokkaido University, Sapporo 060, Japan,
Phone +81 (011) 706-6519, Fax +81 (011) 707-9750

The atomically controlled semiconductor structure is very important for fabricating the quantum effect devices. Recently, the multilayer step structure was observed on vicinal (001) GaAs surface in metalorganic vapor phase epitaxy (MOVPE) by the transmission electron microscopy (TEM) [1] and the atomic force microscopy (AFM) [2, 3]. This multilayer step structure is expected to apply the new fabrication technique of the quantum wire [4]. In this paper, the behavior of the multilayer step on vicinal (001) GaAs substrate during MOVPE is investigated using AFM in air.

A Novel Wire Transistor Structure with In-Plane Gate Using Direct Schottky Contacts to 2DEG

H. OKADA[1], K. JINUSHI[1], N.-J. WU[1], T. HASHIZUME[1]
and H. HASEGAWA[1, 2]

[1]Department of Electrical Engineering, Hokkaido University,
Sapporo 060, Japan
[2]Research Center for Interface Quantum Electronics, Hokkaido
University, Sapporo 060, Japan

Fine semiconductor wire structures having extremely high electron mobility are attractive for applications to future devices in quantum regime. For realization of wire structures with desired perfection and quality, suitable fabrication methods of damage-free structures are

required. Special growth techniques such as preferential growth technique and growth-cleavage-regrowth technique have been used to realize burried wires and edge quantum wires. However, they do not seem to be suitable for large scale planer integration. On the other hand, the wire transistors based on electrical control of the depletion width are very simple, and have potential use for many electronic devices and LSIs.

The purpose of this paper is to propose and fabricate a novel wire transistor structure with in-plane gate using direct Schottky contacts to AlGaAs/GaAs quantum well (QW). The novel wire transistor structure is shown in Fig. 1, where the effective width of the wire is modulated by the change of the width of quasi-planer depletion layer with bias. It is shown in this paper that the novel structure can be realized by a combination of the electron beam (EB) lithography and the in-situ selective electrochemical technology which we have recently shown[1,2] to be capable of forming a direct Schottky contacts to QWs with two dimensional electron gas (2DEG).

In-Situ PHOTOLUMINESCENCE-BASED CHARACTERIZATION OF SURFACE DAMAGES OF COMPOUND SEMICONDUCTORS GROWN AND PROCESSED IN A UHV-BASED SYSTEM

Hideki HASEGAWA, Toshiya SAITOH, Takayuki NAKAGAWA
and Takayuki SAWADA
Research Center for Interface Quantum Electronics and Department
of Electrical Engineering, Hokkaido University, Sapporo 060 Japan

Although various microprocessing technologies are applied to semiconductor surfaces, there exists at present no established way to characterize in-situ the process-induced electronic damages of the processed surfaces that are most relevant to device performance. The purpose of the present paper is to apply our recently proposed photoluminescence (PL) surface state spectroscopy technique [1] for in-situ characterization of variously processed surfaces of GaAs, AlGaAs and InGaAs which are prepared and processed in a ultra-high vacuum (UHV) based integrated fabrication/characterization system. The method allows in-situ, non-destructive and contactless determination of the surface state density distributions (N_{ss}) on the grown and processed surfaces.

Fabrication and Characterization of Quantum Wire Transistors with Schottky In-Plane Gates Formed by an *In Situ* Electrochemical Process

Hideki HASEGAWA, Tamotsu HASHIZUME, Hiroshi OKADA, and Keiichiro JINUSHI

Research Center for Interface Quantum Electronics and Department of
Electrical Engineering, Hokkaido University, Sapporo 060, Japan

Novel Schottky in-plane gate (IPG) quantum wire transistors were fabricated for the first time, and their transport properties were investigated. For fabrication of transistors, an Al-GaAs/GaAs quantum well wire (QWW) was produced by etching, and platinum IPG electrodes were directly formed on both edges of the QWW by a new *in situ* electrochemical process. The current-voltage ($I-V$) characteristics of the fabricated long-channel and short-channel devices exhibited good field effect transistor operation at 3–300 K. Simple theoretical models assuming either a constant mobility or a constant velocity were developed. They provide a reasonably good phenomenological description of the observed $I-V$ characteristics. Limitations of the models are also discussed. At low temperatures, the short-channel device exhibited sharp quantized conductance steps in the units of $2e^2/h$ near pinch-off, indicating one-dimensional ballistic quantum transport. The first plateau of the conductance step remained visible up to 40 K, which is the highest reported so far for the AlGaAs/GaAs system. © *1995 American Vacuum Society.*

Silicon Interlayer Based Surface Passivation of Near-Surface Quantum Wells

Satoshi KODAMA, Satoshi KOYANAGI, Tamotsu HASHIZUME
and Hideki HASEGAWA

Research Center for Interface Quantum Electronics and Department of
Electrical Engineering, Hokkaido University,
North 13, West 8, Sapporo 060, Japan

In view of the urgent necessity to establish a suitable passivation technology applicable to compound semiconductor quantum structure surfaces, the latest version of the silicon interlayer

based passivation process was applied ot passivation of $Al_{0.3}Ga_{0.7}As/GaAs/Al_{0.3}Ga_{0.7}As$ near-surface quantum wells (QWs). The process utilizes an ultrathin molecular beam epitaxy silicon/ultrathin photo-enhanced chemical vapor deposition (photo-CVD) silicon nitride double layer as the interface control layer together with a main passivation dielectric of thick photo-CVD SiO_2 layer. The effectiveness of passivation was studied by comparing the photoluminescence (PL) intensities ta passivated samples with those of unpassivated QWs that showed exponential decrease with reduction of surface-to-well distance. A complete recovery of PL intensity was achieved by passivation with a maximum recovery factor larger 10^3, consistent with reduced interface state densities in low $10^{10}cm^{-2}eV^{-1}$ range recently realized on $In_{0.53}Ga_{0.47}As$ metal-insulator-semiconductor capacitors using the same technique. © *1995 American Vacuum Society.*

C-V and EBIC Study of Direct Schottky Contacts to Quantum Wells Formed by In-Situ Selective Electrochemical Process

T. HASHIZUME[1]*, H. HASEGAWA[2,3] and N.-J. WU[3]

[1] Hokkaido Polytechnic College, Otaru 047-02, Japan

[2] Research Center for Interface Quantum Electronics,
Hokkaido University, Sapporo 060, Japan

[3] Department of Electrical Engineering, Faculty of Engineering,
Hokkaido University, Sapporo 060, Japan

Depletion properties of direct Schottky/quantim well (QW) contacts farmed by the *in-situ* sclcctive electrochemical process were systematically characterized by the C-V and EBIC techniques. The EBIC images clearly showed that the barrier exists at the edge of the QW layer. It was found that the capacitance of the Schottky/QW contact depends linearly on $\ln(1/V_{bi}-V)$, where the V_{bi} is built-in voltage, and that the depletion width obtained from the EBIC measurcmcnts is proportional to the applied voltage. These results demonstrate that well-behaved depletion characteristics of the Schottky/QW systems can be realized. Prcliminary results of the QW wire with the Schottky/QW barriers are also presented.

Schottky Contacts on n-InP with High Barrier Heights and
Reduced Fermi-Level Pinning by a Novel Electrochemical Process

N.-J. WU[1], T. HASHIZUME[1], H. HASEGAWA[1,2] and Y. AMEMIYA[1]

[1] Department of Electrical Engineering,
[2] Research Center for Interface Quantum Electronics, Hokkaido Uviversity
Sapporo 060, Japan, Phone: 011-706-6080, Fax: 011-706-7890

Schottky contacts with nearly ideal thermionic emission characteristics on n-InP were fabricated by a novel *in situ* electrochemical process. The novel electrochemical process reduces Fermi-level pinning. The Schottky barrier height was found to change over a wide range (from 0.35 to 0.86eV), depending on the workfunction of the contact metals. The Pt/InP contact gave the highest barrier height of 0.86eV. The results of atomic force microscopy (AFM) and XPS measurements indicate that the navel electrochemical process produces a smooth and oxidefree interface.

A Novel Schottky In-Plane Gate Quantum Structures
Fabricated by In-Situ Damage-Free Electrochemical Process

T. HASHIZUME, H. OKADA, K. JINUSHI and H. HASEGAWA
Research Center for Interface Quantum Electronics and Department of
Electrical Engineering, Hokkaido University, Sapporo 060, Japan,
TEL: +81-11-706-7171, Fax: +81-11-716-6004

In view of applications to future functional electronic devices, much attention is currently paid to quantum effect devices using nano-scale structures. Paticularly, the so-called in-plane gate (IPG) structure is attractive since its electric field configuration perpendicular to the edge of two-dimensional electron gas (2DEG) can produces strong and efficient confinement of carriers into a quantum wire or dot. Previously, such structures were produced by using focused ion beam and reactive ion etching where resultant material damage may be a critical issue.

The purpose of this paper is to demonstrate for the first time that a novel "Schottky" IPG

quantum wire transistor can be fabricated on a $Al_{0.3}Ga_{0.7}As$/GaAs quantum well (QW) wafer by applying the novel low-damage *in-situ* electrocehmical process recently developed by authors' group.[1]   The main results are listed below.

Passivation of Surface States on GaAs and InP Based Quantum Structures by a Sillicon Interface Control Layer

Hideki HASEGAWA, Satoshi KODAMA, Kengo IKEYA, Hajime FUJIKURA and Tamotsu HASHIZUME

Research Center for Interference Quantum Electronics and Department of Electrical Engineering, Hokkaido University, Sapporo 060, Japan

Availability of high-precision epitaxy and various self-organizing mechanism makes compound semiconductors very attractive as quantum effect materials. However, high density surface states are known to be present on these materials whihc makes near-surface integration of quantum devices practically impossible Because of this, previous compound semiconductor quantum devices were mostly of buried type utilizing so-called the split-gate technique etc.   In order to fully utilize the self organized quantum dots for integrated device fabrication, for example, a suitable means of passivation is indispensable.

The purpose of this paper is to show that our novel silicon interface control layer based passivation technique is extremely powerful in passivating the surface states on GaAs and InP based quantum structures. By applying the technique to the free surface of AlGaAs/GaAs near-surface quantum well with the surface-to-well distance of 50 Å, more than 1000 times increase in the photoluminescence intensity has been achieved.

Properties of Metal-Semiconductor Interfaces Formed on GaAs, InP and Their Quantum Structures by Novel In-Situ Electrochemical Process

T. HASHIZUME, N.-J. WU, S. UNO and H. HASEGAWA

Research Center for Interface Quantum Electronics and Department of
Electrical Engineering, Hokkaido University Sapporo 060, Japan
Phone : +81-11-706-6080, Fax : +81-11-706-7890

Recently, we have shown that high-quality Schottky interfaces can be formed on GaAs surface and AlGaAs/GaAs/AlGaAs quantum well (QW) edges by a novel in-situ electrochemical process.[1,2] The purpose of this paper is to report the structural and electrical properties of Schottky interfaces formed on GaAs, InP and their quantum structures by such a technique.

Self-organization Phenomenon of Strained InGaAs Grown on InP (311) Substrates by Metalorganic Vapor Phase Epitaxy

Jiro TEMMYO, Atsuo KOZEN and Toshiaki TAMAMURA
NTT Opto-electronics Laboratories
3-1 Morinosato Wakamiya, Atsugi-shi, Kanagawa, 243-01 Japan

Richard NÖTZEL, Takashi FUKUI and Hideki HASEGAWA
Research Center of Interface Quantum Electronics, Hokkaido University
W8, M13, Kita, Sapporo, 060 Hokkaido, Japan

Introduction

Precise carrier confinement in reduced dimensional structures such as quantum wires and quantum dots is believed to give a novel density state and improve the performance of optical devices. Since 1984 much work[1-3] has been done using a natural formation technique by epitaxial growth and/or a combination of fine lithography, etching and quantum well growth.

However, up to now, no superior optical performances has been obtained compared to that of quantum wells. A coherent islanding phenomenon of strained InGaAs films on a GaAs (100) substrate[4], called the Stranski–Krastanow epitaxial growth mode, has recently been receiving attention again as a useful method for making quantum dot structures[5-6] because of its potential for creating damage-free nanostructuctures. There are some problems, however, such as the inevitable two-dimensional wetting layer residue, poor size-controllability, no ordering, and very narrow optimum growth conditions. Uufortunately, room temperature photoluminescence emission (PL) from buried InGaAs islands have yet been reported.

On the other hand, we have recently found a new phenomenon of the self-organized formation of strained InGaAs microstructures during epitaxial growth by metalorganic vapor phase epitaxy (MOVPE) on a GaAs (311)B surface[7]. This results in nano-scale InGaAs quantum disks surrounded by lower AlGaAs barriers due to mass-transport. On GaAs (311)A surfaces, one-dimensional faceting due to step bunching forms quasi-quantum wire-like morphologies. These phenomena during growth interruption may come from the lower barrier height for adatom migration on high-index planes, compared with that on the (100) surface. The excellent crystal quality and homogeneity in size manifests itself in high PL efficiency and extremely narrow PL spectra at room temperature[8]. Moreover, we have achieved low-threshold operation of quantum disk laser with a self-organized nanostructure as an active region at room temperature[9-18]. The question arose as to whether the self-organization due to strained systems occurs universally in other III–V compound semiconductor systems. Here, we report that self-organization can occur similarly on InP substrates.

DLTS Study of Deep Levels in Si-Doped $In_xAl_{1-x}As$ Layers Grown by Molecular Beam Epitaxy

H. TOMOZAWA, A. MALININ, T. HASHIZUME and H. HASEGAWA

Department of Electrical Engineering and Research Center for Interface
Quantum Electronics, Hokkaido University, Sapporo, 060, Japan
Phone : +81-11-706-6875, Fax : +81-11-706-7890

Deep levels in Si-doped MBE $In_xAl_{1-x}As$ (x=0.39−0.61) layers were systematically investigated for the first time by DLTS measurements and PL measurements, changing the alloy composition. Two kinds of deep electron traps, E1 and E2 were observed for all the alloy compositions. From the observed dependence of trap level position on the alloy composition, observed traps were not DX-center-like donors but most probably normal deep donors associated with Γ-band.

Passivation and Control of Semiconductor Interfaces by Interface Control Layers

H. HASEGAWA

Research Center for Interface Quantum Eqectronics and Department
of Electrical Engineering, Hokkaido University, North 13, West 8,
Sapporo 060, Japan

Abstract

A novel approach for passivation of semiconductors using an interface control layer (ICL) is presented and discussed. After reviewing briefly roles of interface, the origin of Fermi level pinning and a new PL-based interface characterization method, the concept and possible candidates of the ICL are presented. The ICL is inserted at the I-S interface. and has the role of removing the interface states by providing a coherent and smooth transition of bonds at the interface. A specific example of use of an ultra-thin silicon interface control layer (Si ICL) is then discussed in more detail. Details of interface formation and micro-structural and electronic characterization of the novel passivation structure are presented together with its applications to field effect transistor fabrication, surface passivation of quantum structures and control of metal-semiconductor and semiconductor-semiconductor interfaces.

362

Study of As_4 Beam Induced P-As Exchange Reaction on InP Surface by Photoluminescence and X-ray Diffraction

B, X. YANG, L. HE,[+] and H. HASEGAWA

Research Center for Interface Quantum Electronics and Department of Electrical Engineering, Hokkaido University, N13, W8, Sapporo 060, Japan

[+]Present address: Shanghai Institute of Technical Physics, Chinese Academy of Science, Shanghai, People's Rep. of China.

Introduction

For MBE and MOCVD growth of III-V compound heterostructures containing phosphorus and arsenic compounds, control of the P-As exchange reaction at the growth interface is one of the major factors affecting the interface quality. Although several reports (1-5) have mentioned the presence of this exchange reaction, a detailed investigation has not been made so far,

This paper presents for the first time the result of a detailed investigation on the P-As exchange reaction which takes place on the InP surface when it is exposed to As_4 beam. Characterization was made by growing an additional InP cap layer on the As_4 beam exposed InP surface and analyzing the resultant $InP/InAs_xP_{1-x}/InP$ single quantum well (QW) structure shown in Fig. 1 by photoluminescence (PL) and X-ray diffraction (XRD) measurements. The results provide quantitative data on the rate and depth of the exchange reaction as a function of growth parameters which may be useful for MBE growth of P and As containing heterostructures.

Unpinning of Fermi Level at InP Schottky Diode Interfaces Produced by Novel *In Situ* Electrochemical Process

N.-J. WU, T. HASHIZUME, H. HASEGAWA and Y. AMEMIYA

Department of Electrical Engineering and Research Center for Interface
Quantum Electronics, Hokkaido University N-13, W-8, Sapporo 060, Japan.

Introduction

Schottky contacts on n-InP have potentially wide applications in high-speed eledtronic and optoelectronic devices. However, the InP Schottky diodes have produced only low Schottky barrier height (SBH) of about 0.4eV due to the firm interfacical Fermi-level pinning.[1] Though some approaches by inserting oxide interlayer or applying surface treatments have been used to produce Schottky diodes with high SBHs, but the diodes showed poor re-producibility and poor reverse current-voltage characteristics.[2,3] This has been an obstacle to formation of practically useful InP Schottky diodes.

The paper demonstrates that the pinning of Fermi level can be removed at InP metal-semi-conductor interfaces produced by the novel *in situ* electrochemical process.[4,5] The process consists of anodic etching of InP and subsequent cathodic deposition of metal, both of which are done *in situ* in the same electrolyte. InP Schottky diodes with various metals (Ag, Sn, Cu, Co, Pd, Ni and Pt) have been formed by using different electrolytes based on chloric or sulfuric acid and containing barricr metal ions. The diodes exhibited nearly thermionic emis-sion characteristics. SBH changed over a wide range from 0.35eV to 0.86eV. The Pt/InP diodes gave the highest SBH of 0.86eV which is the highest value ever reported for an intimate metal contact to InP.

PHOTOELLIPSOMETRY CHARACTERIZATION OF ELECTRONIC PROPERTIES FOR InP

Tadashi SAITOH, Kensaku NAKAMURA and Yi-Ming XIONG

Division of Electronic and Information Engineering, Tokyo University of Agriculture and Technology Koganei, Tokyo 184, Japan

Hideki Hasegawa

Research Center for Interface Quantum Electronies. Hokkaido University Sapporo 060, Japan

ABSTRACT

Photoellipsometry, a contactless optical method, was used for the characterization of doped InP semiconductor materials. Two types of InP samples were investigated, namely, p-InP substrate and undoped InP thin laver (with a thickness of 100 nm) on heavily deped n-InP substrate, Our main objective was to determine surface built-in electric field strength, broadening, and critical point energies for each given sample. The measured spectra were analyzed using the Franz-Keldysh theory with the inclusion of broadening effects. Good agreement found between the measured and calculated spectra indicates that theories and models used were appropriate for the samples studied and that the calculated results were reliable.

Surface Damage on InP Induced by Photo-and Plasma-Assisted Chemical Vapor Deposition of Passivation Films

Tamotsu HASHIZUME and Hideki HASEGAWA

Research Center for Interface Quantum Electronics and Department of
Electrical Engineering, Hokkaido University, Sapporo 060

Introduction

Achievement of low surface damage is a key issue in processing steps for fabrication of advanced InP electronic and optoelectronic devices. Insulating films prepared by various CVD techniques have been used for passivation of device surfaces. However, virtually nothing is known on surface damage.

The purpose of the present paper is to systematically characterize process-induced near-surface defects in InP introduced during photo-and ECR-assisted techniques for insulator deposition compared to conventional PECVD technique. The standard Schottky deep level transient spectroscopy (DLTS) technique, the metal-insulator-semiconductor (MIS) DLTS technique and MIS capacitance-voltage (C-V) techniques were applied to characterize the surface damage in ECR treated, PECVD SiO_2 deposited and photo CVD SiO_2 deposited InP surfaces.

The analysis has shown that photo CVD SiO_2 deposition is superior to PECVD SiO_2 deposition due to absence of process-induced bulk traps and to smaller density of interface states with a narrower spatial distribution.

Transmission Electron Microscopy Characterization of Ductile-regime Turned Single-crystal Si Surfaces

Takayuki SHIBATA, Atsushi ONO, Kenji KURIHARA, Shigeru FUJII,
Eiji MAKINO, and Masayuki IKEDA

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

Diamond turning of single-crystal silicon was carried out at extremely small depths of cut of 100 nm and 500 nm using an ultra-precision lathe with high stiffness and accuracy. The natural diamond cutting tool used had a tool-nose radius of 0.8 mm, and a rake angle of -40°. A polished silicon sample of 11 mm in diameter was fastened onto the spindle, and then turned along the [110] direction on the (001) plane. Surface features were observed by an atomic force microscope (AFM) and a Talystep plofilometer, and the surface damages were observed directly by a cross-section transmission electron microscope (TEM) method. Then, the mechanism of ductile-regime turning of single-crystal silicon was studied.

At the depth of cut of 100 nm, a mirror surface with a surface roughness of about 20 nmR_{max} was obtained and continuous chip was formed, indicating perfect ductile-regime turning. At the depth of cut of 500 nm, the surface roughness increased to about 80 nmR_{max}. Although an external view of the sample was mirror like, no continuous chip was observed, and plastic deformation and brittle fracture occurred during turning.

Cross-section TEM observations revealed that the turned surface layers had been converted into an amorphous structure. The continuous chips obtained were also amorphous. The thickness of the layers was about 150 nm in spite of the depth of cut. Under the amorphous layer, another damaged layer with many dislocations was formed, the thickness of which was about 2 μm and 3 μm at the depths of cut of 100 nm and 500 nm, respectively. At the depth of cut of 500 nm, microcracks were formed through the accumulation of excessive dislocations. At both depths of cut, the dislocations were mostly oriented along the $<110>$ directions within the {111} planes. It is concluded that ductile-regime turning based on plastic deformation is realized by the phase transformation to an amorphous state and deformation related to the {111}$<110>$ slip systems.

Learning from Examples with Typed Equational Programming

Akira ISHINO and Akihiro YAMAMOTO

Department of Electrical Engineering Hokkaido University,
Sapporo, Japan

In this paper we present a constructive method of learning from examples using typed equational programming. The main contribution is a concept of type maintenance which appears to be theoretically and practically useful. Type maintenance is based on polymorphic types and is not applicable to a type system without polymorphism. Because equational programming possesses good properties of both functional programming and logic programming, we will refine results in inductive inference of logic programs and that of functions. Our learning method is based on the type maintenance, the generalization given by Plotkin and Arimura et al. and the technique finding recursion given by Summers.

Integration of Synthetic Media and Databases

Yuzuru TANAKA

Electrical Engineering Department, Hokkaido University
Sapporo, 060, JAPAN

The recent development of multimedia technologies and object-oriented modeling and development technologies are expanding the ways of modeling, presenting, accessing, and manipulating various kinds of information stored in databases. However, we still lack systematic ways of integrating database systems with application systems dealing with multimedia documents and tools. This paper proposes an integrated framework for media objects and databases. This framework uses the IntelligentPad system not only to support the continual process of recording, storing, distributing, sharing, editing and representing various intellectual resources, but also to assimilate database systems into the integrated environment of pads. This assimilation only requires the development of a proxy pad for each of the different database systems.

From Augmentation Media to Meme Media

Yuzuru TANAKA

Electrical Engineering Department, Hokkaido University

Sapporo, 060, JAPAN

Computers as meta media are now evolving from augmentation media vehicles to meme media vehicles. While an augmentation media system provides a seamlessly integrated environment of various tools and documents, meme media system provides further functions to edit and distribute tools and documents. Documents and tools on meme media can easily replicate themselves, recombine themselves, and are naturally selected by their environment, namely the society of their authors and users. Their accumulation in their users' community will from a meme pool, which will bring rapid evolution of documents and tools. The IntelligentPad architecture provides a standard framework called a pad that works as a meme medium. When applied to microworlds, it will bring more flexibility to the environments, and more opportunities of creative thinking to their users.

Meme Media and Its World-Wide Pool for the Exchange and Evolution of Knowledge

Yuzuru TANAKA

Electrical Engineering Department, Hokkaido University

Sapporo, 060, JAPAN

Computers as meta media are now evolving from augmentation media vehicles to meme media vehicles. While an augmentation media system provides a seamlessly integrated environment of various tools and documents, meme media system provides further functions to edit and distribute tools and documents. Documents and tools on meme media can easily replicate themselves, recombine themselves, and are naturally selected by their environment, namely the society of their authors and users. Their accumulation in their usurs' community will form a meme pool, which will bring rapid evolution of documents and tools. The IntelligentPad architecture provides a standard framework called a pad that works as a meme medium. When applied to multimedia dartabases, it will allow us manage not only articulated objects but also non-articulated objects in a generic manner.

IntelligentBox: a Constructive Visual Software Development System for Interactive 3D Graphic Applications

Yoshihiro OKADA and Yuzuru TANAKA
Electrical Engineering Department, Hokkaido University
Sapporo, 060, Japan

This paper proposes a constructive visual software development system for interactive 3D graphic applications. Our system called the IntelligentBox is an extension of the 2D media construction system IntelligentPad to 3D application systems. While the IntelligentPad represents any object as a pad, i.e., a reactive 2D media component with a card image, which can be manually pasted on another pad to define a compound document, the IntelligentBox represents any objects as reactive 3D visual objects that can be combined with other reactive 3D visual objects. Both provide uniform frameworks for the concurrent definition of both geometrical compound structures among reactive objects and their mutually interactive functional linkages. The IntelligentBox allows us to easily combine existing primitives in order to compose various interactive 3D compound objects and their coordination mechanism. It works as a user-friendly rapid-prototyping software development system for interactive 3D graphic applications and computer animations.

Constructing Predicate Mappings for Goal-Dependent Abstraction

Yoshiaki OKUBO and Makoto HARAGUCHI
Department of Systems Science, Tokyo Institute of Technology,
Yokohama, Japan

This paper is concerned with an abstraction for SLD-refutation. In most studies on abstraction, any goal is proved with a fixed abstraction neglecting differences of goals. On the other hand, we propose a new framework for Goal-Dependent Abstraction in which an appropriate abstraction can be selected according to each goal to be proved. Towards Goal-Dependent Abstraction, this paper tries to construct an appropriate abstraction for a given goal. The appropriateness is defined in terms of Upward-Property and Downward-Property. Our abstraction is based on predicate mapping. Given a goal, candidate predicate mappings are

generated and tested in their appropriateness. To find appropriate abstraction efficiently, we present a property to reduce the computational cost of candidate generation. The numbers of pruned candidates are evaluated in both of the best and worst cases. Some experimental results show that many useless candidates can be pruned with the property and constructed abstractions fit our intuition.

Analogical Logic Program Synthesis from Examples

Ken SADOHARA

Department of Systems Science, Tokyo Institute of
Technology, Yokohama, Japan

Makoto HARAGUCHI

Division of Electronics and Information Engineering,
Hokkaido University, Sapporo, Japan

This paper presents an algorithmic learning theory for analogical synthesis of logic programs from their examples. An analogical synthesizer is defined as a kind of inductive inference machine that uses analogy. More precisely speaking, it synthesizes target programs from their examples, given a source program to which the target programs should be similar. One of the difficulties in realizing an efficient analogical synthesizer is to distinguish useless and inappropriate similarities from the other. A similarity is inappropriate if every similar program with respect to the similarity is not correct. If our synthesizer cannot refute such similarities then it would waste computational resources without succeeding to find a desired program. To cope with this hard problem on analogical synthesis, this paper first applies the notion of refutably inferable class of linear programs, and obtains a basic synthesizer. It has a function of refuting inappropriate similarities. Secondly this paper investigates another method of refuting inappropriate similarities, using an analogous technique that has been employed for theorem proving with abstraction. Incorporating this method into the basic synthesizer, we obtain a more efficient one. All the synthesizers presented in this paper are proved to identify a similar correct program in the limit, given a source program.

Toward PAC-Learning of Weights from Qualitative Distance Information

Ken SATOH, Seishi OKAMOTO

Fujitsu Laboratories Limited, Kawasaki, Japan

This paper discusses a mathematical analysis for learning weights in a similarity function. We provide a PAC learning framework for weights with qualitative distance information. Qualitative distance information in this paper represents how a case is similar to another case. We give a mathematical analysis for learning weights from this information.

In this setting, we show that we can efficiently learn a weight which has an error rate less than ε with a probability more than $1-\delta$ such that the size of pairs in qualitative distance information is polynomially bounded in the dimension, n, and the inverses of ε and δ, and the running time is polynomially bounded in the size of pairs.

A Top Down Proof Procedure for Default Logic by Using Abduction

Ken SATOH

Fujitsu Laboratories Limited, Kawasaki, Japan

In this paper, we present a correct goal-directed proof procedure for the extension membership problem of arbitrary consistent propositional default theories. This procedure is obtained by extending our previous procedure for general (abductive) logic program with integrity constraints so that clauses instead of atoms can be used in a head or a body of rules. Moreover, this procedure is complete if a default theory is finite. We also show that this procedure can be used for consistency checks of addition of rules.

372

Computing Prioritized Circumscription by Logic Programming

Toshiko WAKAKI

Gunma Polytechnic College, Gunma, Japan

Ken SATOH

Fujitsu Laboratories Limited, Kawasaki, Japan

We extend Gelfond and Lifschitz method in order to expand applicable class with keeping its computational efficiency. Our idea is to transform a given circumscription into a logically equivalent one in which difficulties disappear. In this paper, we show it can be done by making use of Lifschitz's result that some parallel circumscription can be replaced by an equivalent first-order theory. As a result, some class of prioritized circumscription, which cannot be handled by Gelfond and Lifschitz's method, can be compiled into logic programs by our method.

Formulation of Dispersive and Anisotropic Properties in Spatial Network for Vector Potential

Norinobu 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. In this paper, I propose the treatment of the dispersive and anisotropic properties such as magnetized ferrite and magnetized plasma. Utilization of both the current continuity law including the vector potential and polarization vector itself and the conservation law of generalized momentum including the vector potential and the kinetic momentum of dipoles of polarization can introduce simpler expressions for each property than that by the electromagnetic field variables.

Formulation of Dispersive and Gyro-Anisotropic Properties in Spatial Network for Vector Potential

Norinobu 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. In this paper, I propose the treatment of the dispersive and gyro-anisotropic properties. Utilization of both the current continuity law including the polarization vector itself and the conservation law of generalized momentum including the vector potential can introduce simpler expressions for each property than that by the electromgnetic field variables. Validity of the treatment is examined by showing good agreement of the computed results by the proposed method with analytical ones.

Impedance Matching for an Annular Circular Polarized Microstrip Antenna Using Two Perturbation Stubs

Nozomu ISHII and Kiyohiko ITOH
Faculty of Engineering, Hokkaido University

In the microstrip antenna with a probe feed, it is often not possible to operate it with a zero reactance at the designed frequency because the self inductance of the prove is added to the input impedance. It is proposed that by means of matching stubs added of the periphery of the patch, the excess reactance is canceled. Few examples exist on the analytical studies of the operating principle of such a proposal. In the present paper, it is noticed that this matching stub resemble in its shape the metal piece added for resolving the degeneracy in the design of circularly polarized annular microstrip antenna with a one point feed. Then, the effects of these two metal pieces and the feed pin are analyzed by means of the eigenfunction expansion method and the perturbation method.

374

A Continuous G/T Measurement Technique for Satellite Broadcasting Receivers

Kiyohiko ITOH, Yasutaka OGAWA and Yuliman PURWANTO
Department of Electronic Engineering, Faculty of Engineering,
Hokkaido University, Sapporo 060 JAPAN

Weather conditions affect the performance of satellite broadcasting receiving antennas. Snow accretion on antennas degrades G/T seriously because it reduces a received signal power and also can increase an antenna noise. We need to establish a continuous G/T measurement technique to evaluate the effect of the weather conditions to the satellite broadcasting receivers. This paper presents the continuous measurement of G/T for the satellite broadcasting receivers. We describe details of the measurement method. We need to obtain a noise level in the satellite broadcasting channel. We propose to estimate the noise level from the values at the outside of the channel. Then, we show measurement results of the G/T values under snowy and rainy weather conditions. We discuss the weather effects on each receiver.

A Vector Finite Element Method with Hybrid Edge/Nodal Elements for Optical Waveguiding Problems

Masanori KOSHIBA
Department of Electronic Engineering, Hokkaido University,
Sapporo, Japan

A vector finite element method with hybrid edge/nodal elements is described for the analysis of optical waveguiding problems. Edge and nodal elements are, respectively, used to descretize transverse and axial components of the electric or magnetic field. The use of edge elements avoids spurious solutions and provides a direct solution for the propagation constant, and therefore, the present approach can treat a wide range of optical waveguides composed of a medium whose material constant varies with frequencies (dispersive) or a medium with loss or gain (complex medium).

An Analysis/Design Tool for Optical Waveguides : PHOTONIX-GUIDE

Masanori KOSHIBA and Yasuhide TSUJI
Department of Electronic Engineering, Hokkaido University,
Sapporo, Japan

The finite element method (FEM) has been widely used for the solution of various optical waveguiding problems, and recently the vector FEM (VFEM) has been utilized as a waveguide solver of CAD packages. Although the VFEM enables one to compute accurately the mode spectrum of a waveguide with arbitrary cross section, it has been known to include nonphysical spurious solutions and require long computer time. In this paper a simple scalar FEM (SFEM) is introduced and is utilized as a solver of PHOTONIX-GUIDE (PHOTONIC Simulator for optical waveGUIDE) which is an analysis/design tool for step-index and graded-index optical waveguides with arbitrary cross sections.

Analysis of Electromagnetic Waveguide Bends by Three-Dimensional Finite Element Method with Edge Elements

Koichi HIRAYAMA, Kengo AKIKAWA, Yoshio HAYASHI
Department of Electrical and Electronic Engineering, Kitami Institute
of Technology, Kitami, Japan

Masanori KOSHIBA
Department of Electronic Engineering, Hokkaido University,
Sapporo, Japan

An approach based on the finite element method (FEM) with the rectangular-parallelepiped edge element is proposed for the analysis of electromagnetic waveguide bends. Here, in order to treat the uniform waveguide with arbitrarily shaped cross section, the analytical relations in the uniform waveguide are constructed numerically by using the FEM with the rectangular edge element. To confirm the validity and versatility of this approach, bends of a hollow waveguide, a half-filled dilectric waveguide, and a finline are analyzed.

Vector Finite Element Solution of Lossy Planar Transmission Lines

Md. Shah ALAM, Masanori KOSHIBA

Department of Electronic Engineering, Hokkaido University,
Sapporo, Japan

Koichi HIRAYAMA and Yoshio HAYASHI

Department of Electrical and Electronic Engineering,
Kitami Institute of Technology, Kitami, Japan

The vector finite element method with hybrid edge/nodal triangular elements is extended for the analysis of lossy planar transmission lines. In order to handle lossy conductor transmission lines, the present approach includes the effect of finite conductivity of a metallic area. Dissipations in metallic conductors and dielectrics are calculated directly by considering a complex permittivity for the lossy region of interest. Numerical examples are computed for various waveguiding structures, and the results obtained agree well with the earlier theoretical and experimental results.

A Finite Element Analysis of Three-Dimensional Lossy Chirowaveguides

Sinji MARUYAMA and Masanori KOSHIBA

Department of Electronic Engineering, Hokkaido University,
Sapporo, Japan

A numerical approach based on the vector finite element method with hybrid edge/nodal elements is described for the analysis of three-dimensional lossy chirowaveguides. To confirm the validity and usefulness of the present approach, numerical examples are shown for lossless and lossy circular chirowaveguides.

Finite Element Method for Modeling Lossy Planar Transmission Lines with Arbitrary Cross Section

Masanori KOSHIBA

Department of Electronic Engineering, Hokkaido University,
Sapporo, Japan

Different formulations for the vectorial wave analysis of electromagnetic waveguides by the finite element method are reviewed, with emphasis on the application of thesse formulations to planar transmission lines, such as microstrip lines, finlines, and coplanar waveguides. In order to eliminate spurious solutions and to handle sharp metal edges, hybrid edge/nodal elements are introduced. The edge and nodal elements are used for the transverse and axial fields, respectively.

Quantum Interference Phenomena in an Electron-Wave Directional Coupler with Finite Coupling Length

Ryosaku KAJI and Masanori KOSHIBA

Department of Electronic Engineering, Hokkaido University,
Sapporo, Japan

A new type of quantum field effect directional coupler with finite coupling length is studied with the equivalent network approach. The coupler to be analyzed is composed of GaAs/$Ga_{1-x}Al_xAs$ material system and has finite external potential barriers and longitudinal discontinuities. Although this structure is analogous to that in an optical counterpart, there is no radiation loss. Numerical results show that the effects of the longitudinal interference appear as a short periodic behavior of the transmission probabilly and the effects of the beat of two normal modes appear as a long periodic behavior of the transmission probability.