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Fourth Australia-New Zealand
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Response of a Two-Dimensional Wedge by Taking the Effects of Shear and Bending Moment into Account

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The present work consists of a theoretical investigation of the response of a two dimensional elastic wedge subject to an arbitrary disturbance. Expressions are derived for the deflections and rotations together with shears and bending moments which develop in the wedge owing to an imposed time dependent disturbance. The frequencies of the wedge are for the two first modes of oscillation, and the moduli of elasticity are expressed by the n-th order of depth from the apex where $0 \leq n < 1$.

Offshore Technology Conference
1984, Houston, U. S. A. May 7-9,
1984

The coefficient of Friction between Sea Ice and Various Materials Used in Offshore Structures

Hiroshi SAEKI, Toshiyuki ONO	Hokkaido University
Naoki NAKAZAWA	Pacific Consultant Co., Ltd
Sachito TANAKA	Kawasaki Steel Corporation
Masafumi SAKAI	Taisei Corporation

When structures with inclined surfaces, such as cone type and inclined pile structures, are constructed in coastal and offshore cold regions, sea ice pressure must be considered in their design. In order to estimate this ice pressure, the relationship of the coefficients of static and kinetic friction between sea ice in various conditions and construction materials must be clarified.

The authors have been conducting, for four years, coefficient of friction experiments between sea ice and various commonly used offshore construction materials such as concrete and steel.

These coefficients have been found to be affected by the following :

- i) relative velocity
- ii) sea ice temperature
- iii) surface roughness of construction material

They have been found to be relatively unaffected by the following :

- i) contact area
- ii) vertical stress
- iii) growth direction of sea ice
- iv) water in the sea ice interface

Offshore Technology Conference
1984, Houston, U. S. A. May 7-9.
1984

The Distribution of Ice Pressure on Offshore Pile Structure and The Failure Mechanics of Ice Sheet

Hiroshi SAEKI	Hokkaido University
Toshiyuki ONO	Hokkaido University
Sachito TANAKA	Kawasaki Steel Corporation

The total ice force acting on offshore pile structures, located in cold regions, has already been investigated by many researchers. However, few papers have described the distribution of ice pressure on the structures and the failure mechanics of ice sheet. It is necessary to study them in order to design the pile structures, keeping in mind safety and economic factors. The results of our experiments on failure mechanics of an ice sheet are useful for dynamic analysis. For analysis of stress and, especially, local buckling of structures, it is essential to examine the distribution of ice pressure acting on the structures.

This paper describes a systematic study of these aspects through field tests with three rectangular piles (20, 40, 60 cm in width) in Saroma Lagoon to clarify the effect of aspect ratio. It is clear from our experiments on ice pressure that the distribution of ice pressure can be classified into two types according to the strain rate $\dot{\epsilon}$ ($=V/4B$, V : penetration velocity of pile, B : pile width) defined by Michell and Toussaint in each aspect ratio, B/h (h : ice thickness). It is our hypothesis that the failure periods of ice sheet are determined by the strain rate and the aspect ratio mentioned above.

Conference of Rivers '83, October
24-26, 1983, New Orleans,
Louisiana, U. S. A.

Phase Shifts of Pools and Their Depths in Meander Beds

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The objective of this study is to develop a new model for the prediction of the phase shift on the deepest scours of pools, based upon sequential tasks of the following approaches:

- (1) Arbitrary plane and bed forms of meander channels were expressed by using trigonometrical polynomials, and the approximate linearized solutions to the flow in such channels were obtained by using a two-dimensional shallow water flow model and the method of weighted residuals.
- (2) Sediment functions with respect to flow and transverse directions were derived, using the velocity solutions which contained the arbitrary amplitude and phase of bed waves.
- (3) The above functions were substituted into the continuous equation of sediment, and the equation related to some mean hydraulic parameters between amplitude and phase shift was derived.

The predicted value of the phase shift which was obtained by inserting the observed value of the

amplitude into the theoretical equation was in good agreement to the observed one, using the experimental data by the authors and other investigators.

Conference of Rivers '83, October
24-26, 1983, New Orleans,
Louisiana, U. S. A.

Effects of Bends and Alternating Bars on Meander Evolution

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It is generally known that fluid-mechanical states of the flow and bed topography on alluvial channels are affected by both centrifugal force from channel bends and action of alternating bars on beds.

These two actions mutually exert positive or negative influences upon the flow and bed topography, producing different connecting patterns of alternating bars and various plane forms of meanders.

The present study is intended to give some new insight into the relationship between the meander evolution and connecting figures of bars, using the results from the flume experiments of restricted meander channels in which two actions work mutually in opposing directions.

The results of this paper can be utilized to predict deeply scouring positions and their migration near apexes of meander loops for the bank protection, offering useful information on the analysis of formation and evolution of asymmetrical meander loops.

Proc. 7th Asian Regional Conference on Soil Mechanics and Foundation Engineering, Haifa, Aug. 1983

DILATANCY OF CLAY DURING SECONDARY CONSOLIDATION

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Undrained triaxial compression tests with pore water pressure measurement were performed on a saturated remolded clay consolidated under various conditions of duration and drainage. In order to investigate the effects of duration of secondary consolidation, magnitude of pore water pressure buildup due to arresting of secondary consolidation, and rate of strain during shear, on its dilatancy behaviors. Test

results indicate that dilatancy-stress ratio relationship is remarkably affected by the duration of secondary consolidation and also by the pore water pressure buildup due to the arresting of secondary consolidation as well as rate of strain. Moreover, it was also found that these three factors caused clay to develop positive dilatancy at the initial stage of shear, and the degree of strain rate dependency of dilatancy was not affected by the duration of secondary consolidation. Based on the test results, the authors proposed a new method of predicting stress-strain behavior of aged clay by using the data obtained from conventional isotropically consolidated undrained tests.

XIth International Congress of
Anthropological and Ethnological
Sciences, August 14-25, 1983,
Quebec & Vancouver, Canada

Prediction of Obligatory and Regulatory Non-Shivering and Shivering Thermogenesis

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Our prediction method of local muscle energy metabolic rates and quasi-basal metabolic rate B_1 was applied to examine seasonal change of obligatory non-shivering thermogenesis under optimal environmental conditions for Japanese males. The method was also applied to predict regulatory non-shivering thermogenesis and shivering thermogenesis under six kinds of cold environment.

The obligatory thermogenesis or B_1 s were 32.43 ± 12.59 (Mean \pm S. D.) kcal/h in summer and 67.32 ± 7.83 kcal/h in winter.

By making a comparison between B_1 of optimal and that of cold environment, the regulatory non-shivering thermogenesis was considered to be about 22 kcal/h.

The shivering thermogenesis of main muscle groups were predicted in nine resting and exercising items under six kinds of cold environment.

XIth International Congress of
Anthropological and Ethnological
Sciences, August 14-25, 1983,
Quebec & Vancouver, Canada

Local Muscle Energy Metabolic Rate in Different Types of Locomotion

Shintaro YOKOYAMA* and Keiichi YOSHIDA**

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Our previous prediction method of local muscle energy metabolic rate in static sustained contraction (YOKOYAMA, 1980 ; YOKOYAMA et al., 1982), which consisted of simultaneous measurements of total energy metabolic rate and integrated surface electromyograms, was improved in order to evaluate those in cyclical dynamic contraction.

The main improvements were the integrated method of electromyogram and the solution procedure of simultaneous equations. According to the present method local energy metabolic rates of main muscle groups were predicted in several types of locomotion or walking, running, cycling and so on.

These values are useful for the evaluation of physiological loads and thermogenesis within human body.

20th International Conference of
Safety in Mines Research Insti-
tutes. Oct. 3-7, 1983, Sheffield,
England

Disaster of coal and gas outburst at Yubari Shin Colliery

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K. HIGUCHI (Department of Mineral Resources Development Engineering, Hokkaido University)

Yubari-Shin-Tanko is situated at Yubari City, Hokkaido, Japan. It was a new coal mine which was opened in October 1970 and started production of high calorific coking coal in June 1975.

The output of coal in the last one year was about one million tons and the number of workers about 3,000. The coal mine was one of the principal coal mines in Japan.

A large scale coal and gas outburst occurred in a coal seam heading, 810 m under sea level, for the preparation of a longwall face on 16 October, 1981.

The volume of coal which burst out is estimated at about 4,000 m³ and that of gas 600,000 m³. This disaster is the largest coal and gas outburst in Japan in history. Moreover, the disaster was followed about ten hours later by an underground fire caused by gas explosion and the situation then became more serious. The death toll in the disaster was 93.

Prevention of coal and gas outbursts has been one of the most important objectives in Hokkaido coal mines.

This disaster caused a shock throughout all coal mines in Japan because the company had stated that sufficient preventive measures had been taken against coal and gas outbursts.

It also created a social problem because the company was no longer able to operate the mine. On the other hand, this disaster can be seen as a turning point, in research of coal and gas outbursts and technical measures in coal mines which require drastic promotion. This report give an outline of the disaster and shows the present counter-measures against coal and gas outbursts in Japan.

MMIJ/AusIMM Joint Symposium
1983, Oct. Sendai

Application of Acoustic Emission Techniques to Safety Problems in Japanese Coal Mines

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Recently, at some coal mines in Hokkaido, Japan, the acoustic emission activity occurring ahead of driving faces or during borings has been monitored tentatively in order to predict the hazard of coal and gas outbursts or rock and gas outbursts.

From these observational results, the acoustic emission activity after blasting in roadway drivage increased and decreased remarkably prior to the outbursts.

Such an unusual fracturing activity indicated the possibility of an early detection of the state of the outbursts hazard.

On the other hand, the acoustic emission activity due to the advance boring increased locally in the region of the stress concentration or the geologically weak band. Especially, the retarding of the discharge of cuttings from the acoustic emission activity was considered to be an useful information for judging the outburst hazard prior to roadway drivage.

9th International Congress on
Metallic Corrosion June 3-7, 1984
Toronto, Canada

Evaluation of Corrosion Inhibitors for Dezincification of 60/40 Brass.

Takenori NOTOYA and Tatsuo ISHIKAWA

Inhibition action of six different organic inhibitors for Dezincification of 60/40 brass was evaluated under potentiostatic conditions by the solution analysis of dissolved copper and zinc, and by the amount of electric charge after addition of the inhibitor. The measurements were conducted in 0.5 M NaCl containing acetic acid and sodium acetate buffer solution with pH 4.43 at 60 C. The inhibitors used include commercial inhibitors for either copper or zinc and chelating reagents for chemical analysis. Among six

inhibitors 2-mercaptobenzimidazole, benzotriazole and tolyltriazole were found to be effective not only in inhibiting dissolution of copper and zinc but also in controlling the growth rate of dezincification layer in 60/40 brass. The inhibitive action of these inhibitors are probably due to the formation of protective multilayer inhibitor film with copper and/or zinc on the brass surface.

The dezincification attack in 60/40 brass can be prevented by an addition of most promising inhibitors such as benzotriazole and tolyltriazole to corrosive environments.

6th Miami International Conference on Alternative Energy Sources Miami Beach, Florida, U. S. A., December 12-14, 1983

Latent Heat Recovery from Effluent Gases by Boilers in a Coal-Fired Power Plant

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Boiler efficiency can be improved by increasing combustion efficiency and/or by recovering waste heat from the effluent gas. The present study determines the rates of heat and energy gains in a simultaneous recovery of both latent and sensible heat.

Theoretical results are obtained through the numerical simulation of heat and mass transfer in a cross-flow tubular type heat exchanger in a 350MW thermoelectric power plant.

It is disclosed that an increase of 5 to 6 percent in the boiler efficiency may be achieved through latent heat recovery from the effluent gas at a temperature of 150°C.

The rate of a maximum corrosion on the heat transfer surface is predicted.

Society of Automotive Engineers
International Off-Highway Meeting & Exposition, Milwaukee, Wisconsin, USA, September 12-15, 1983

Nature and Reduction of Cycle-to-Cycle Combustion Variation in an IDI Diesel Engine with Ethanol-Diesel Fuel Blends

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Many of the promising alternative fuels have relatively low cetane numbers, and may result in combustion variation problems. This paper presents the characteristics of the cycle-to-cycle combustion

variations in diesel engines, and analyzes and evaluates the mechanism.

Combustion variations appear in various forms, such as variations in ignition lag, indicated mean effective pressure, maximum combustion pressure, or rate of heat release.

These variations are clearly correlated, and it is possible to represent the combustion variations by the standard deviation in the combustion peak pressure. The combustion variations are random (non-periodic), and are affected by the ethanol amount, intake air temperature, engine speed, and other various operating conditions.

Theoretical analysis based on the auto-ignition theory showed that all of these factors affecting the combustion variations could be correlated with the ignition lag ; a reduction in ignition lag is the most effective manner to reduce combustion variation.

Society of Automotive Engineers
International Congress & Exposition,
Detroit, Michigan, USA,
February 27-March 2, 1984

Achievement of Stable and Clean Combustion Over a Wide Operating Range in a Spark-Assisted IDI Diesel Engine with Neat Ethanol

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Spark-assisted diesel engines operated with alcohol fuels usually display misfiring or knocking problems. This paper presents an analysis of the factors influencing the ignition characteristics of ethanol in a swirl chamber diesel engine with a multi-spark ignitor. In the experiments, cycle-to-cycle combustion variations and the degree of knocking were investigated by changing engine parameters over a wide operating range.

The results of the investigations showed that stable ignition and smooth combustion is achieved when a flammable mixture is formed in the vicinity of the spark plug when only a small amount of the injected fuel has evaporated. By optimizing the design factors, operation with high efficiency and low exhaust emissions was achieved.

Society of Automotive Engineers,
International Congress & Exposition,
Detroit, Michigan, February
27-March 2, 1984

Formation of Soot Particulates in the Combustion Chamber of a Precombustion Chamber Type Diesel Engine

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Tadashi MURAYAMA
Dept. of Mech. Engrg., Hokkaido University

To clarify the formation processes of soot particulates in the combustion chamber, we sampled the gas during combustion in a precombustion chamber and a main chamber using an electromagnetic sampling valve, and ran a gas analysis by gas chromatography, examined the soot concentration, and size distribution and dispersion of soot particulates with a transmission electron microscope.

The following results were obtained: (1) In the prechamber soot particulates form at the period of rapid combustion in the initial stage rather than the end of the diffusion combustion. (2) Soot particulates which were formed in the prechamber were introduced into the main chamber, and a part of the soot particulates were burned. (3) Soot particulates formed at the initial stage of the combustion process exhibited a tendency to become smaller by oxidation. (4) If the oxygen concentration in the combustion chamber is above 5%, the combustion of soot particulates take place.

6th International Symposium on
Alcohol Fuels Technology,
Ottawa, Canada, May 21-25, 1984.

Nitric Ester Formation Resulting from Unburned Alcohol Emitted from an Alcohol Fueled S. I. Engine

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Hokkaido University
Youko KIMURA
Research and Development Center,
Toshiba Ltd.

Nitrous ester is one of the secondary pollutants which has arisen from alcohol fueling. The main objective of this paper is to determine the formation of nitric ester originating in the exhaust emissions issued from an S. I. engine fueled with methanol or ethanol. A part of the exhaust gas was diluted with air and stored in a reactor tube kept at room temperature.

The sample stored was exposed to ultraviolet rays. With the irradiation of UV, the formation of nitric ester from nitrous ester clearly took place.

In the case of ethanol emission, it was found that methylnitrite and methylnitrate besides ethylnitrite

and ethylnitrate were formed. From the results, it could be concluded that a part of unburned alcohol is converted to nitric ester through nitrous ester in the presence of nitrogen oxides in a long term exposure to UV light.

7th International Conference on
High Voltage Electron Micro-
scopy, Berkeley, USA, August 16-
19, 1983

Formation and Annihilation of Point Defect Clusters in Electron Irradiated Germanium

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Electron irradiation of germanium below 200k results in the formation of faulted interstitial loops on {113} planes after a fairly long incubation period. The formation is strongly dependent both on crystallographic orientation and electron diffraction conditions. After prolonged irradiation, small vacancy type defects (less than 50 Å) of higher density appear in the thinner part of a specimen normally free from interstitial type loops. The intensional contamination of a pure specimen by carbon deposition has been found to lead to the formation of vacancy type faulted loops on {113} planes at a narrow temperature range around 250°C. The analysis of the shrinkage behaviour of these defect clusters by annealing at above 500°C leads to the conclusion that the self-diffusion in germanium is carried with vacancy type point defects.

3rd All-Union School on Radia-
tion Physics of Solids, Telavi,
Georgian SSR, September 4-15,
1983

Radiation Damage of Solids with Electrons, Ions and Neutrons And Properties of Defects and Their Interactions

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The Method of study of radiation damage and lattice defects by high voltage electron microscopy is systematically described. Recent results on ion and neutron irradiation damage are presented. Materials studied are mainly metals and alloys, and at the same time some results on semiconductors and amorphous solids are included.

1) Nucleation of interstitial clusters and interstitial mobility, 2) Growth of interstitial clusters and vacancy mobility, 3) Thermal shrinkage of clusters and self-diffusion mechanism, 4) Replacement sequence collision damage and the effect of electron channeling, 5) Radiation induced diffusion of point defects, 6) Radiation induced segregation and point defect-solute interaction, 7) Radiation damage of amorphous metals and their dynamical structure, 8) Sub-cascade damage by D-T neutron irradiation, 9) Metastable defects in semiconductors, and 10) Roles of free interstitials released from cascade damage.

3rd Topical Meeting on Fusion
Reactor Materials, Albuquerque,
USA, September 19-22, 1983

The Japanese Experimental Program on RTNS-II and DT-Neutron Irradiation of Materials*

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Research project of D-T neutron radiation damage of materials with the rotating target neutron source RTNS-II of LLNL is explained with a brief explanation of the results obtained in the first year of the project. Wide variety of materials were irradiated at three temperatures ; 25°C, 200°C and 400°C up to 1×10^{18} n/cm². From the result of the observations of defect structures, discussions are made on the conditions for the defect cluster formation from cascade damage, type of defects, defects made from sub-cascade damage, correlation between defects and disordered zones, and the roles of free interstitials released from cascades. Future research plans are briefly presented.

International Conference on
'Power Electronics and Variable-
Speed Drives' IEE, London ; 1-4
May 1984

A Microcomputer Controlled DC Motor Speed Regulator with Load Torque Estimation

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Department of Electrical Engineering

Recently, a microcomputer is being used for a DC motor speed regulating system as a digital PID controller. But a rotor speed drop cannot be recovered quickly in such a control system in a case where a load torque is suddenly applied. Also the advantage of a microcomputer is not fully utilized.

In this paper the State Space Control Method as an application of Modern Control Theory is described. However, this is not applicable for an actual system unless the load torque can be observed.

A simple formula for the estimation is presented. The estimation can be done by substituting the sampled armature current and the rotor speed.

This control method was applied for the DC motor speed regulating system and the experiments are compared with the simulations of this system. It is shown that the represented estimating method is useful as a general control method for the motor speed control system.

International Symposium and
Workshop on Dynamic Benefits of
Energy Storage Plant Operation,
May 7-11, 1984, Boston, USA

Strategic Usage of Superconductive Magnetic Energy for Electric Power Demand in the Year 2000 in Japan

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**National Laboratory for High Energy Physics

The appropriate size of Superconductive Magnetic Energy Storage (SMES) for the load in Japan in the year 2000 has been estimated. In connection with this, the benefit of SMES has been discussed from a stand point of fuel saving. In comparison with the Pumped Hydro Power Station (PHPS), it is clear that the economically optimized operation mode of SMES should be different from that of PHPS and the availability has been estimated for both storage systems from this stand point.

The beneficial operation strategy of SMES is proposed and in this connection the breakeven construction cost of SMES is given.

XVI International Conference on
Phenomena in Ionized Gases. 29th
August-2nd September 1983, Dus-
seldorf Fed. Rep. of Germany.

Nanosecond Image Intensifier Studies of Pulsed R. F corona in Air and Nitrogen.

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The progressive development of r. f plasmas when the voltage amplitude varies over a single cycle at 10 MHz has been investigated using a highly sensitive image intensifier system, gatable in time for a few nanoseconds and capable also of detecting well into the U. V region of the spectrum. In order to establish the nature of the controlling influence of space charge accumulations, the present experiment records a 10 nsec duration 'snapshot' of the r. f corona and examines the variation of the images with changes of gas pressure, peak value of applied voltage, phase position within an individual cycle and the stages of the applied voltage pulse.

The gases examined are N₂ and air. Comparison of the observations in these two gases provide an insight into the effect of electron attachment processes and of those collision interactions contributing to space charge accumulations and resulting also in ultra-violet radiation.

XVI International Conference on
Phenomena in Ionized Gases. 29th
August-2nd September 1983, Dus-
seldorf Fed. Rep. of Germany.

Spatio-Temporal Spjetroscopy of Pulsed R. F Corona in Air and Nitrogen.

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A highly sensitive image intensifier and a multi-channel optical analyser system (O. M. A II system) are used to investigate the r. f corona development in air and nitrogen. Spectral observations of r. f corona with time and spatial resolutions of 10 nsec and 0.2 mm respectively are reported together with the intensity ratios for the emission lines B² Σ_u⁺ (v'=0) - X² Σ_g⁻ (v''=0) of N₂⁺ ions and C³ Π_u (v'=1) - B³ Π_g (v'=3) of N₂ molecules to the line C³ Π_u (v'=0) - B³ Π_g (v''=2) of N₂ measured at pressures of 80,200 and 650 Torr.

Information on the electron energy distribution in the gap space, for different phases of the applied r. f voltage is obtained from data about the spatial and temporal variation of the intensity ratio. The electric field variations are estimated qualitatively and the space charge accumulation processes, taking into account the loss processes in r. f discharges, are discussed. Comparing the spectral data in air with that in N₂, the effect of electron attachment is also considered.

1984 IEEE International Conference on Plasma Science, St. Louis, U. S. A., May 14-16, 1984.

Dispersion Relation of Surface Waves for Noncircular Plasma Based on the Boundary Element Method

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In the cylindrical coordinates, plasma surface waves for the cold plasma with a noncircular cross section are studied using a boundary element method (BEM). From the formulation based on the BEM, we have two systems of simultaneous equations for the plasma and vacuum domains, respectively. Furthermore, application of the boundary conditions to two systems yields a characteristic equation, and the dispersion relation of the plasma surface waves is obtained.

For the plasma with a circular cross section, we can conclude from the numerical results based on the BEM that the relative error is less than 0.5% by using the boundary element with one tenth of the plasma radius and the characteristic of convergence has nearly a second-order accuracy.

On the other hand, for the toroidal plasma surrounded by the dielectric constant, the dispersion relation of the plasma surface waves is obtained numerically from an analysis based on the special functions in the toroidal coordinates.

1984 International Conference on Plasma Physics, Lausanne, Switzerland, June 27-July 3, 1984

MHD Equilibrium Analysis of Compact Toroidal Plasmas Using Finite Element and Boundary Element Methods

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MHD equilibria of compact toroidal plasmas are numerically analyzed by using a boundary element method (BEM). Boundary element solutions are compared with both analytical and finite element solutions, so that we can conclude the following :

- (1) the number of discretized boundary element in the BEM is less than that in a finite element method (FEM) by about a fourth.
- (2) equilibrium configurations of the poloidal flux function based on the BEM are in good agreement with analytical and finite element solutions.
- (3) maximum relative error of solutions for the BEM is less than that for the FEM by about a fourth.
- (4) distributions of relative errors for the FEM depend on space parabolically, while those for the BEM

are independent of space except near the boundary. Therefore, it is found that the BEM is available for solving the MHD equilibrium problem of the compact toroidal plasma.

13th International Symposium on
Acoustical Imaging, Minneapolis,
Minnesota U. S. A. Oct. 26-28, 1983

Holographic Imaging System Using Wideband Chirped Ultrasound

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Aiming for a higher lateral resolution in the ultrasound imaging, a new holographic technique is proposed. This method is based on a combination of the holographic principle and pulse compression technique. In this method, precisely controlled chirp signal is used as the ultrasound illumination and an image is reconstructed from the collected space-time signals by the FFTs.

An experimental system was built using a microcomputer. We reached a conclusion from experimental results using 6MHz under water ultrasound.

IEEE GaAs Integrated Circuit
Symposium, Phoenix, Arizona,
Oct. 25-27, '83

Properties of Surface Passivation Dielectrics for GaAs Integrated Circuits

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In spite of the recent rapid development of GaAs digital and analog integrated circuits, electrical properties of the dielectric layer on the semiconductor have neither been investigated in detail, nor been optimized. This paper presents the results of a systematic study on the properties of two commonly used surface dielectrics, i. e., SiO_2 and Si_3N_4 . It is shown that surface passivation becomes increasingly important as the integration level is increased.

Silicon dioxide and nitride films were prepared by plasma CVD processes in $\text{SiH}_4 + \text{O}_2$ and $\text{SiH}_4 + \text{N}_2$ gas mixtures under various conditions. Wet and plasma anodic oxide films were also prepared for comparison. Interface electrical properties of surface passivated semi-insulating (Cr-O doped or undoped) and semi-conducting GaAs wafers were investigated by C-V, DLTS, PCTS (photocapacitance transient spectroscopy (ref. 1)), and I-V measurements.

C-V, DLTS and PCTS measurements on MIS samples formed on passivated semiconducting wafers show high density of surface states, which cause surface Fermi level pinning. The nitride film tends to give a deeper pinning from the conduction band edge, although the details of N_{ss} distribution and the pinning

position are sensitive to the processing conditions.

I-V characteristics between two adjacent ohmic electrodes (AuGe/Ni) on semi-insulating wafers, are greatly affected by insulator deposition. The leakage current shows ohmic behavior up to a threshold voltage V_T , beyond which it increases sharply in proportion to 4-6th power of the applied voltage. The resistance in the ohmic region, R_{ohm} , is extremely sensitive to the processing conditions, and is always smaller than what is expected from the bulk resistivity. In addition, the dependence of R_{ohm} on the electrode distance, L , is quite different from that for bulk ohmic conduction. V_T is also sensitive to processing conditions. Under the same processing conditions, V_T is proportional to L . On the basis of the C-V, DLTS, PCTS and I-V results, a new model is proposed, where the surface-state conduction and the surface state filling with the two-dimensional space charge reduction effect controls the conduction and breakdown.

The present result clarifies the limitation of achievable packing density in GaAs VLSIs by the present technology, since V_T could be less than 100mV if the dielectric is not optimized. Also, the present model predicts fairly large and fluctuating subthreshold currents in low-power VLSI FET devices, which will affect the operation, yield and reliability of GaAs VLSIs. Implication of the present model to 1/f noise will also be discussed. Ref. 1 : H. Hasegawa and T. Sawada, J. Vac. Sci. Technol., 21 (2) 457 (1982)

Second International Conference
on Metal-organic Vapour Phase
Epitaxy, Sheffield, England, April
10-12, '84

Atomic layer doping of MOVPE GaAs

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To realize complex free-carrier profiles including planar doped structures by MOVPE, atomic layer doping, in which growth is suspended while doping gas is introduced, is investigated for the first time.

The sequence of the atomic layer doping is, 1) stopping TMG flow to suspend the growth, 2) introducing doping gas to form a layer of dopant on the surface, 3) restarting the GaAs growth to incorporate the dopant layer. All growths are performed in a vertical reactor with a load-lock apparatus under atmospheric pressure using TMG and arsine. GaAs layers are grown at 670 C at a rate of 300 Å/min with $V/III=55$. The highest 77K mobility for undoped GaAs so far obtained in this system is 75,000 cm^2/Vs ($n=4.0 \times 10^{14} \text{cm}^{-3}$, 2.5 μm thick). Silicon from silane, which has a low vapor pressure of 10^{-11} Torr at 800°C, is chosen as a dopant to minimize reevaporation during the dopant layer formation. C-V profiling show that the sheet carrier concentration of a dopant plane is proportional to the amount of silane introduced. It also corresponds well with the calculated amount of donors assuming all incorporated silicon atoms for uniform doping reside on the surface for atomic layer doping, indicating that all the thermally decomposed silicon atoms remain on the surface and are incorporated in GaAs layer when the growth is resumed.

To show the effectiveness of atomic layer doping, a number of freecarrier profiles is synthesized by placing dopant planes in GaAs layer. C-V profiling show that indeed designed carrier profiles are realized in the epitaxial layer. Design procedure will also be discussed.

IEEE 1984 Microwave and Milli-
meter-wave Monolithic Circuits
Symposium, San Francisco, Cali-
fornia, May 29-30, '84

On-Chip Pulse Transmission in Very High Speed LSI/VLSIs

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Objective

There exist ever increasing demands for very high speed integrated circuits in areas of high-speed computation, signal processing, data links and related instrumentation. For example, LSIs with the propagation delay per gate t_{pd} of 10-30 ps are being developed in Japan using GaAs MESFET, HEMT and JJ technologies in order to construct a 10 GFLOPS super computer.

The average interconnection length on LSI/VLSI chips is known to increase with the gate count G as G^α with $\alpha=0.2-0.6$, and becomes 0.5-5 mm for $G=10^3-10^4$. Thus, speed is limited not only by the device itself, but by the fact that each gate should drive interconnections with a sufficient quickness. Previously, this effect has been treated in terms of the "lumped capacitance" of interconnections. However, the propagation time of an ideal TEM wave over 1 mm distance is typically 8-10 ps on a semiconductor substrate ($\epsilon_r=12-13$), and the validity of such an approach becomes very doubtful in high-speed LSI/VLSIs.

The purpose of the present paper is to investigate the transmission line effects of interconnection in very high-speed integrated circuits. Propagation delay, distortion, multiple reflection and crosstalk are analyzed, using single and coupled microstrip line models loaded with lossy or lossless semiconductor substrates. The result shows that interconnections should be treated as miniaturized microwave networks in the design of LSI/VLSIs with t_{pd} of below 100 ps.

Models and Methods of Analysis

The effects of the conductivity of semiconductor substrates on pulse transmission were analyzed, using the single and coupled microstrip line models. Such models may be rigorously analyzed numerically in frequency domain either by the spectral domain method (1) or by the finite element method (2), but these complicated numerical procedures are not practical for time domain analysis. The equivalent circuit approach by the present authors (3)-(5) was employed here for the time domain analysis. In order to include the skin effect in semiconductor under a microstrip with finite width more accurately than our previous analysis (5), a novel expression was derived by the rigorous mapping of the Helmholtz equation. A good agreement was achieved in a frequency domain between the present analysis and the finite element analysis (2).

For the analysis of the complicated crosstalk phenomenon, the coupled multi-conductor microstrip line model under the periodic excitation was employed. Mode impedances and propagation constants were determined using the periodic Green function. Then, crosstalk voltages were evaluated in a time domain for various loading and excitation conditions.

Results and Conclusions

The Main conclusions of the present study are as follows :

(1) Lumped capacitance approximation of interconnections cannot be used in LSI/VLSIs with t_{pd} of below 100ps. Microwave considerations are required in the logic, circuit and layout design of such very high

speed integrated circuits.

(2) Driving capability of device per unit layout area is essentially important for high-speed LSI/VLSIs. Heterojunction bipolar transistors (HBT) and HEMT seem promising, although their reported performances are still not sufficient to drive long interconnections at a high speed.

(3) Semi-insulating property of substrates offers a great advantage for high-speed pulse transmission in LSI/VLSIs. Semi-conducting substrates suffer from slow-wave mode, mode transition and strong inductive coupling.

(4) Crosstalk can be a serious problem in high-speed LSI/VLSIs. Insertion of ground lines beside the active line reduces the crosstalk, but the dynamic ringing must be considered. A shielded multi-level planar interconnect scheme is proposed to reduce crosstalk and facilitate interconnect design.

References

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Electronic Materials Conference,
Santa Barbara, California, June
20-22, '84

Surface Breakdown and Light Emission at Electrodes on Surface Passivated Semi-insulating GaAs Substrates

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Electrical breakdown between adjacent ohmic electrodes serving as the device electrodes or interconnection imposes an ultimate limitation to the packing density of GaAs LSI/VLSIs. For instance, surface breakdown threshold had been reported to be closely related to the side-gating threshold of the adjacent FET [1]. This paper reports a detailed systematic study on the surface I-V characteristics between ohmic electrodes (AuGe/Ni) formed on surface passivated semi-insulating GaAs LEC and HB substrates. Light emission associated with breakdown was observed for the first time, and a new model for breakdown and FET side-gating is proposed.

Plasma CVD SiO₂ and Si₃N₄ films were formed as the passivation dielectrics and surface I-V characteristics before and after insulator deposition and after a high temperature annealing (800°C, N₂) were investigated in detail together with MIS interface study and Rutherford backscattering study. I-V characteristics are linear to a certain breakdown voltage V_T at which the current sharply increases by 5-

6 orders of magnitude and changes into V^2 dependence at higher currents. Ohmic resistance and breakdown voltage are very sensitive to the processing conditions. Under the same conditions, however, V_T is proportional to the electrode distance. Above V_T , light emission initiates at the edge of the anode electrode. In the unannealed samples, the emission is uniform and its intensity increases roughly in proportion to the square of currents. Annealing reduces V_T and makes the emission non-uniform.

The previously proposed mechanism of the surface breakdown and FET side-gating is based on the classical trap-filled space charge limited current conduction, which cannot account for the light emission. A new model for surface leakage and breakdown is proposed here in which surface state filling gives rise to a localized intense electric field at the anode edge, and triggers an avalanche. This model can explain the observed linear dependence of V_T on spacing, sensitivity of resistance and V_T to processing conditions and effect of annealing. The side gating of FETs can be explained by electron injection from the avalanche plasma.

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Electronic Materials Conference,
Santa Barbara, California, June
20-22, '84

Room Temperature Deposition of Silicon Nitride Films Using Very Low Frequency (50Hz) Plasma CVD

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This paper reports the deposition of silicon nitride at room temperature using low frequency (50Hz) plasma CVD. The resulting silicon nitride films showed a refractive index of 2.0, which compares favorably with Si_3N_4 grown by thermal CVD process. In addition, there is no need of frequency conversion apparatus for 50 Hz plasma, which would result in inexpensive PCVD system with less overall power consumption.

Capacitance coupled PCVD system was used with nitrogen and silane or disilane in this work. Silicon nitride films with refractive index of 2.0 were obtained at silane/nitrogen ratio of 1/9 at total pressure of 1.2 Torr with 2W input power. Growth rate of the film was 80 Å/min. Increase of silane partial pressure resulted in higher refractive index, which is an indication of Si rich silicon nitride. Resistivity of the film was also maximized at 90% nitrogen partial pressure, which was 10^{15} Ohm cm. Using disilane, smaller disilane to nitrogen ratio than for silane/nitrogen combination was needed to obtain a low refractive index as 2.0.

The emission spectrum of the plasma was investigated as a function of nitrogen partial pressure maintaining the total pressure at 1.2 Torr. The intensity of emission from excited Si states ($4s^1 P^0$) in plasma increased with increasing N_2 partial pressure and showed maximum at around 70% N_2 , whereas the intensity of 2nd positive band emission from excited N_2 molecules ($C^3 \Pi_u$) increased exponentially by increasing N_2 partial pressure. Maximum of the product of both intensities appears at about 90% N_2 partial pressure, which coincides with the optimum deposition condition for silicon nitride films. This fact suggests that both excited species are equally needed for the deposition of nearly stoichiometric silicon nitride.

International Conference on Coal
Science Pittsburgh, Aug. 1983.

Investigation of CO-steam Hydrogenation of Coal Using both Chemical and Microscopic Techniques

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Takemura and Ouchi (1982) investigated Co-steam hydrogenation of coals with Co-Mo catalyst. Even in the absence of vehicle solvents the conversion of coals was fairly high, despite the poor contact between solid coal and catalyst particles. Partial thermal decomposition of the coal probably yielded small amounts of liquids which might act as a vehicle. When a vehicle solvent was used, the coal was partially dissolved in the solvent and the nascent hydrogen, generated on the catalyst surface, hydrogenated both dissolved material and solvent. If this is the case, direct interaction between the solid coal and the catalyst would not occur. The mobility of certain catalysts during hydrogenation, i. e. SnCl_2 and ZnCl_2 , and their ability to penetrate coal, have been described by Kriz et al. (1979), Shibaoka and Russell (1979) and Shibaoka et al. (1980). Under normal hydrogenation conditions Mo in Co-Mo catalysts remains immobile. However, our preliminary results suggest that Mo is mobile under CO-steam hydrogenation conditions and hence the above mechanism should be modified if Mo is to migrate to the coal surface. Thus there is a direct contact between it and solid coal, and the water-gas shift reaction can take place on the coal surface.

International Conference on Coal
Science Pittsburgh, Aug. 1983.

Coal Liquefaction by The In-situ Hydrogen Generation, Metal-Water System

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Coal was liquefied by the in-situ generated hydrogen from zinc and water in an autoclave. The effects of the reaction time, temperature, type of solvent and the rank of coal were investigated. The solvent has a very marked effect on the conversion of coal to material soluble in benzene. Preliminary studies with model compounds show that the reaction cleaves effectively the dibenzyl ether and to some extent the C-C bonds in the debenzyl. The hydrogenation of the aromatic structure is low.

The 5th International Meeting on
Boron Chemistry, Swansea, U. K.,
July 11-15, 1983

**Haloboration and its Application to Organic Synthesis
(Invited Lecture)**

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Recently, it has been discovered that B-halo-9-borabicyclo [3, 3, 1] nonanes (B-X-9-BBN, X=Br, I) react with 1-alkynes stereo-, regio-, and chemoselectively to give the corresponding (Z)-2-halo-1-alkenylborane derivatives in excellent yields. Such haloboration reactions occur only at terminal C≡C bonds, but not at internal C≡C, terminal and internal C=C bonds.

The haloboration adducts thus obtained have proved to be valuable intermediates in the synthesis of a wide variety of alkenyl halides, such as 2-halo-1-alkenes, (Z)-1-alkynyl-2-halo-1-alkenes, (E)-, or (Z)-1,2-dihalo-1-alkenes, 1-iodo-1-alkenes, and (Z)- δ -halo- γ , δ -unsaturated ketones.

Further application of the haloboration to the synthesis of target compounds such as natural products is also discussed.

The Annual Meeting of the "Division de Chimie Organique de la Société Chimique de France," Palaiseau, France, September 12-15, 1983

**Some Aspects of Organic Synthesis Using Organoboranes
(Invited Lecture)**

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The reaction of (E)- or (Z)-1-alkenyldiorganoboranes readily obtainable by hydroboration, with either (E)- or (Z)-1-alkenyl halides in the presence of a catalytic amount of palladium catalysts and bases gives the corresponding (E, E)-, (E, Z)-, (Z, E)-, or (Z, Z)-conjugated alkenes stereo- and regioselectively, while retaining the configuration of both the starting 1-alkenylboranes and haloalkenes. In connection with the development of the above cross-coupling reaction, a new and convenient method for the synthesis of stereodefined alkenyl halides via the haloboration of alkynes is also discussed.

In addition, the novel and convenient synthetic methods of 1-alken-3-yne and 3-alkyn-2-ones from 1-methoxy-1, 2, 3-butatrienyltrialkylborates are reviewed briefly.

The 2nd Japan-Korea Seminar on
Organic Reactions of Synthetic
Utilities, Kyoto, May 28-31, 1984

**Recent Progress of the Organic Synthesis Using
Organoboron Compounds and the Application to Natural Product Syntheses
(Invited Lecture)**

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In order to confirm the utility of new synthetic reactions using organoboron derivatives which were recently disclosed in our laboratory, the syntheses of some kinds of natural products were examined by means of such boron compounds.

Thus, the versatility of the cross-coupling reaction between 1-alkenyldi-organoboranes and organic halides in the presence of palladium catalysts and bases was demonstrated by the stereospecific syntheses of trans (C₁₀)-allo-farnesene, bombykol and its three geometrical isomers, and humulene. Sulactol, transgeranyl acetate, and trans-nerolidol were readily synthesized by applying the haloboration reaction of alkynes in good yields. The reaction of ate-complexes prepared from B-alkylcatecholboranes and 1-methoxy-1, 2, 3-butatrienyllithium, was found to be remarkably useful for the synthesis of α -turmerone and tagetone.

THE Sixteenth Research Conference (The Sixth Conference on High Polymers), Osaka, Japan, October 17-21, 1983

**An Aspect on the Structural Irreversibility Between
Cellulose I and II Families**

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In our previous work, it was concluded that the structural irreversibility between cellulose I and II families resulted from the difference on the thermodynamical stability between chain conformations of the two families.

Sarko, Blackwell have proposed that the irreversibility resulted from the difference of the chain polarity. An examination was conducted to see which proposal is more reasonable. IR and ¹³C NMR spectra of the cellulose polymorphs showed common characteristics on the bands related to the chain conformation within the polymorphs of the same family. It was confirmed experimentally that the uniplanar structure of (1 $\bar{1}$ 0) was retained during transformations between polymorphs of cellulose I and II families.

These facts did not support the mechanism of reverse of chain direction on the transformation from I

to II in a fibrous state proposed by Sarko et al.

It was considered that our proposal was more reasonable.

Pacific Region Meeting of the
Fine Particle Society, Honolulu,
Hawaii, U. S. A., August 1-5, 1983

Porosity Estimation of Random Packings of Ternary Mixture

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Tosu, Saga-ken, Japan

Tatsuo TANAKA

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Hokkaido University

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The authors have recently proposed a theoretical formula estimating the overall average porosity of a random packing of various sized spheres. While several confirmations were made of the theory in the original presentation*, the theory should widely be tested further by experiments. In this presentation we attempt the porosity estimation of ternary packings by the proposed theory.

Our theoretical considerations lay the basis on a simplified packing model*. Every sphere (solid particle) of a random packing is in direct contact with neighbors having an average diameter. Geometrical arguments based on the model lead to a mathematical description of the total (bulk) volume of the space in a packing, and hence of the packing porosity. The theoretical formula thus derived shows that the overall average porosity of a fully mixed packing is a function of both porosity value of single component and the size distribution of particles. Taking into consideration the probable effect of macro pores notwithstanding, we calculated the porosity values for several ternary mixtures. These theoretical results were examined by using past experimental data. A general agreement can be observed between the computed values and the experiments.

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Pacific Region Meeting of the
Fine Particle Society, Honolulu,
Hawaii, U. S. A., August 1-5, 1983

Evaluation of the Upper Limit of Explosible Dust Concentration Using a Uniform Dispersion Model

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On the basis of the uniform dispersion model of uniform sized particles, several characteristics of dust explosions have thus far been calculated in our laboratory, i. e., the minimum ignition temperature, the lower limit concentration, the flame propagation velocity and the maximum rate of pressure rise. The cubical law regarding the maximum rate of pressure rise was proven to be valid, leading to a new design formula for the calculation of vent ratio.

Using the same model, the present paper deals with the upper limit of explosible dust concentration in terms of oxygen concentration. This limit is defined as the maximum dust concentration resulting in the propagation of a flame which consumes a definite amount of oxygen allocated to one solid particle. Comparisons with the existing data are reasonable.

An evaluation of this upper limit will be particularly useful in view of the scarcity of data arising from the difficulties inherent in experimental techniques.

1983 Prague Meeting of Macro-
molecules 25th Microsymposium
Processing and Long-Term Stabi-
lities of Hydrocarbon Polymers
Prague, July 18-21, 1983

Radical Migration as an Elementary Process in Degradation

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ESR studies of polymer radicals provide us good evidences for a radical migration in polymer matrix, which is similar to elastic collision of a molecule in a gas phase. The radical migration plays an important role in degradations of polymers. Activity of antioxidant is also influenced by the radical migration.

U. S. -Japan Cooperative Science
Seminar on Piezoelectric Poly-
mers,
Honolulu, U. S. A. 17-23 July 1983

**Ferroelectric Properties in Poly (vinylidene fluoride)
and its Related Copolymers**

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A theory for phase transitions in polymer ferroelectrics is developed on the basis of statistical mechanics. In the present models a crystal consists of linear dipole chains composed of the trans and gauche bondings in two ways ; the first being free for the $g^+ g^-$ bonding (Model I) and the second being forbidden for it (Model II).

By introducing two order parameters, polarization and gauche content, into a dipolar chain crystal, both models show that the ferroelectric phase transition changes from the second order to the first order, depending on the relative value of the energy difference between the trans and gauche bondings. The theory also provides semi-quantitative descriptions of thermal hysteresis and the compositional dependence of Curie temperature in vinylidene fluoride and trifluoroethylene copolymers.

International Conference on Laser
Guangzhou, China, September 6-9,
1983

**Reflection hologram scanner using a
computer-generated corrector mask**

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A new type of polygonal hologram scanner is described which combines a reflection volume hologram recorded on dichromated gelatin with a computer-generated mask. Rotating the scanner causes the aberration-free reconstructed spot to scan on a curved locus. A flat scanning plane is desirable in many applications. The phase function required to the field-curvature correction is defined as the sum of a spherical wavefront and a nonspherical wavefront. The coefficients of nonspherical wavefront are determined by using the technique of damped least-squares optimization. The flat-field scan spots are compared with those by the uncorrected scanner. A significant improvement in the spots whose diameters are 100 μm can be seen at large angles.

International Conference on Laser
Guangzhou, China, September 6-9,
1983

Uniforming the Gaussian intensity distribution of a collimated laser beam

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A set of holographic filters was developed to convert the Gaussian intensity distribution of a collimated laser beam into a uniform one. The design and the fabricating method of the holographic filters are presented and some experimental results are shown. The holographic filters may be used in optical measurements or in optical information processings, in which a Gaussian laser beam is used as the light source.

*C. Y. Han is on leave from the Changchun Institute of Optics
and Fine Mechanics, Academia Sinica, Changchun, China.

U. S. -Japan Cooperative Science
Seminar on Piezoelectric Poly-
mers,
Honolulu, Hawaii,
U. S. A., July 17-23, 1983

Relaxation Spectroscopy of Poly (vinylidene fluoride)

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The relaxation spectra and their temperature dependences for the four relaxation processes in poly (vinylidene fluoride) found in the temperature range from -180°C to 130°C are determined by using stress relaxation measurement and complementary dielectric loss measurement. These relaxations are designated as α_M , β , γ_1 and γ_2 in the order of descending temperature. A comparative study of the characteristics of the relaxations in poly (vinylidene fluoride) and poly (ethylene) shows that these relaxations in poly (vinylidene fluoride) correspond to the α_2 , β , γ_1 - and γ_2 -relaxations in poly (ethylene) respectively. Further, a slight loss process is found in poly (vinylidene fluoride) in the temperature range between the α_M -region and the β -region and it is thought to correspond to the α_1 relaxation in poly (ethylene). The temperature dependence of relaxation times for the β -relaxation is expressed by WLF equation and the glass transition temperature is estimated to be ca. -42°C .

22nd Symposium on Engineering
Aspects of Magnetohydrodynamics,
Mississippi State University,
Starkville, Mississippi, USA.,
June 26-28, 1984

Fluctuation Analysis of Combustion Plasma in the Electrode Boundary Layer of an MHD Generator by Power Spectrum Method

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The measurement and analysis of fluctuations occurring in the MHD plasma are important since the life of electrodes strongly depends on temperature fluctuations at the electrode boundary-layer. In the present study, we performed experiments using a propane-oxygen combustion plasma with 1 wt % K added. The combined use of the light polarization line reversal method for measurement of the temperature and Burg's method for spectrum analysis was proved to be effective in the investigation of fluctuation phenomena. Comparing the fluctuations of plasma itself without currents with those of electrode boundary-layer plasma with current, the former was found to have a significant effect on the latter according to fluctuations arising from arc discharge.

22nd Symposium on Engineering
Aspects of Magnetohydrodynamics,
Mississippi State University,
Starkville, Mississippi, USA.,
June 26-28, 1984

Electrothermal Instability Analysis for an Open-Cycle MHD Plasma Under Two-Component Magnetic Field

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A general dispersion relation for the electrothermal ionization wave in a thermal equilibrium weakly ionized magnetohydrodynamic plasma was obtained under the static magnetic field with two components, which were perpendicular to the plasma flow direction. The theory was applied to a significant diffuse to arc transition phenomena in an open-cycle MHD generator, namely the Faraday current constriction on continuous- and infinitely segmented electrodes, and to the plasma-initiated Hall field breakdown over the electrode spacer. It was found that the shaped B-field configuration with one component normal to plane electrode and the other parallel component extremely reduced at the electrode wall considerably relaxes the arc transition characteristics.

Third International Conference on
Particle Induced X-Ray Emission
(PIXE) and its Analytical Applica-
tions, Heidelberg, July 18-22, 1983

Investigation of Environmental Problems Caused by Studded Tires of Automobiles Using PIXE

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The PIXE technique was successfully applied to the investigation of environmental problems caused by studded tires of automobiles. The dust samples were collected on stacked filters in Sapporo and some other cities in Japan and Europe. PIXE measurements were performed using 2 MeV proton beams. The results were compared with those of different cities. The main component of dust particulates were Al, Si, Ca, Fe and so on. The vertical distribution of dust quantity in the city of Sapporo was determined by PIXE in April and June. The quantity in April decreases exponentially with the height from the ground. And the effect of dust particulates due to studded tires is observed up to the altitude 60 m. On the other hand in June, the quantity on the ground is one-tenth of that in April, and it is almost unchanged with the distance in the vertical direction. Concentration of Ca in the dust particulates in the area, where the studded tires are used, increases by factor 2 to 4 in comparison with that in the ordinary soil.

Third International Conference on
Particle Induced X-Ray Emission
(PIXE) and its Analytical Applica-
tion, Heidelberg, July 18-22, 1983

Application of PIXE to the Study of Nuclear Fusion Materials

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The PIXE technique was applied to the analysis of impurity elements deposited on the surface probe and the fixed ring limiters of the JIPP T-II stellarator/tokamak fusion device. Various elements were identified as impurities contaminating the plasma discharge. Heavy elements were originated from the composite materials of a vacuum vessel and limiters. The particle flux of such heavy elements varied depending upon the direction of transport. The particle flux of iron and molybdenum along the toroidal field was 5×10^{13} atoms/cm² · discharge that was almost five times larger than another direction in the scrape-off plasma. Their deposition behavior was almost identical and suggested that the impurity source

of molybdenum and iron should be the same place in the experimental fusion device. However, light impurities such as aluminum and silicon showed different deposition behavior.

Third Topical Meeting on Fusion
Reactor Materials, September 19-
22, 1983 Albuqueroue, New
Mexico

Scanning Auger Microanalysis Study of 304 Stainless Steel Surface Irradiated with Helium and Argon Ions

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Microanalysis of 304 stainless steels whose surfaces were irradiated with 100keV He and 2 keV Ar ions was performed by means of a scanning Auger electron microscopy technique. Many blisters and exfoliated layers appeared on the surfaces with the He irradiation. Auger analysis revealed that the surface of exfoliated layers was enriched with Cr-oxide. The thickness of the enriched layer was observed to be more than 10 nm in depth. The result suggests that the irradiation induced segregation of Cr-oxide was associated with the exfoliation of blister skins. The surfaces with the Ar irradiation showed many sputter-cones. The Auger analysis of these sputter-cones revealed that C atoms were deposited at the top of the sputter-cones. The result suggested that the sputter-cones were formed due to the deposition of C atoms whose sputtering yield was smaller than the stainless steel.

Third Topical Meeting on Fusion
Reactor Materials, September 19-
22, 1983 Albuqueroue, New
Mexico

Surface Analysis of TiC Limiter Exposed in JIPP T-II Stellarator/Tokamak Hybrid Device

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The surfaces of TiC (20 μ m) coated limiters were investigated after four-month plasma exposure with tokamak and stellarator type discharges in JIPP T-II. Three types of surface damage were observed as 1) a large melted spot having many macrocracks, 2) a large exfoliated surface of the coating and 3) a color

changed region without exfoliation of the coating. The position of damages observed on the ring limiters and the rail limiter revealed that the damages of 2) and 3) were associated with the asymmetric cross-sectional shape of the stellarator type plasma. The quantitative AES analysis was performed for identification of surface impurities (Si, P, C, etc.) transported from the plasma and for depth composition analysis of the limiters. It was found that C atoms were depleted from the subsurface region and O atoms accumulated to produce a thick Ti-oxide layer (1500 Å). The thickness of the oxide and the amount of retained Fe atoms in the subsurface region were also found to be associated with the asymmetric shape of stellarator type plasma.

Third Topical Meeting on Fusion
Reactor Materials September 19-
22, 1983 Albuquerque, New Mexico

Surface Characterization of Aluminum Alloy 2017 as a Vacuum Vessel for Nuclear Fusion Devices

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The surface characterization of a type 2017 aluminum alloy was performed to examine their potentials for the use of nuclear fusion devices mainly from a view point of vacuum engineering. Three different samples treated with milling (Sample A), discharging (Sample B) and chemical etching (Sample C) were examined in terms of their surface morphology by surface profilometry, scanning electron microscopy, and xenon adsorption. The surface roughness factor was obtained as 5.9, 42.8 and 9.0 for sample A, Sample B and Sample C, respectively. The thicknesses of surface oxide layers were measured by the sputter-AES method as 40 Å, 80 Å and 70 Å for Sample A, Sample B and Sample C, respectively. Outgassing characteristics of these surfaces were measured by a thermal desorption method. H₂O, CO and CO₂ were main outgassing components and the maximum desorption temperature was observed in the range between 110°C and 160°C. The surface roughness factor and the thickness of the surface oxide layer were found to be important factors for outgassing characteristics.

The IX International Vacuum
Congress and V International
Conference on Solid Surfaces,
Sep. 26-Oct. 1, Madrid, Spain

A Fundamental Study of Cryopumping Systems with Charcoal Sorption Panel

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A fundamental study of cryopumping of a charcoal sorption panel with a refrigerator was performed aimed at applications in nuclear fusion experiments. Typical pumping speeds at the cryopanel temperature of 10.4 K for hydrogen, helium and argon were obtained as 3.5×10^{-1} , 1.6×10^{-2} and $1.0 \text{ m}^3/\text{s}$, respectively, in the range of throughput less than $1 \times 10^{-4} \text{ Pa} \cdot \text{m}^3/\text{s}$. The pumping speed was found to increase linearly on a semilogarithmic plots with the inverse of adsorption temperature. The activation energy of hydrogen capture on the charcoal was estimated between 100 J/mol to 240 J/mol, which is nearly equal to the heat of fusion of hydrogen. Several experiments to improve cryopumping performance were also carried out by modification of the shape of the cryopanel, and by evaporation of titanium onto the panel and etc.

The IX International Vacuum
Congress and V International
Conference on Solid Surfaces,
Sep. 26-Oct. 1, Madrid, Spain

Compositional Changes in Surface Region of SiC Single-Crystal Due to Hydrogen and Helium Ion Irradiation

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Compositional changes in the surface region of single-crystal SiC (0001) due to heat treatment and light ion irradiation in the keV range were studied with the use of AES. The heat treatment at 1000°C formed a carbon enriched layer with a thickness of 20 Å on the top surface and a silicon depletion layer below this layer. Both hydrogen and helium ion irradiation caused depletion of silicon atoms in the near surface

region and depletion of carbon atoms in the deeper surface region. TRIM computations revealed that in the process of slowing down of incident hydrogen ions, their kinetic energy was transferred preferentially to silicon atoms in the near surface region and to carbon atoms in the deeper surface region. This tendency explains the formation of each altered layer.

Proceedings of the IX International Vacuum Congress and the V International Conference on Solid Surfaces, September 26-October 1, 1983, Madrid, Spain

Physical and Chemical Sputtering of Low-Z Compound Materials

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A summary is given for the physical and chemical sputtering data of graphites and several carbides. There is a great variation of data by different investigators and it was evaluated by finding general tendencies. In addition to our studies of the surface segregation, the sputtering processes and the energy distribution of sputtered ions by using well-defined surfaces of low-Z carbide materials were demonstrated.

The IX Int. Vacuum Congress and
V Int. Conf. on Solid Surfaces,
Sept. 16. -Oct. 1, 1983, Madrid,
Spain

Energy Analysis of Sputtered Atomic and Molecular Ions

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Energy distributions of positive cluster ions sputtered from various target materials were studied. The high energy part of the energy distributions could be expressed by the function, E^{-N} , where E is the kinetic energy of sputtered ions. We analyzed the N values obtained from 20 different ion-target systems, including experimental data measured by the present authors and by others, as a function of the mass number of sputtered cluster ions. As a result, the N value was found to be dominantly characteristic of only the target materials. A general equation could be deduced to describe N in terms of the mass number A of a sputtered atomic or molecular ion and the atomic number Z of a target material in the form,

$$N(A, Z) = \alpha(Z) A + C(Z)$$

where $\alpha(Z) = 0.51 z^{-0.92}$ and $C(Z)$ is the value which changes periodically for the elements composing the target material.

The 6th International Conference
on Plasma Surface Interactions in
Controlled Fusion Devices,
Nagoya, May 14-18, 1984,

Surface Probe Measurements of Impurities and Hydrogen Isotopes in the Heliotron E Device

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Particle flux measurements in the divertor region of the Heliotron E helical system were performed during currentless plasma discharges. A rotatable amorphous silicon probe was utilized to measure retained deuterium by NRA and titanium by AES. An isotopic exchange experiment revealed that gas release from wall surfaces did not change the composition of plasma during discharges. The particle flux at the probe surface was found to be an almost linear function of plasma density.

The 6th International Conference
on Plasma Surface Interactions in
Controlled Fusion Devices,
Nagoya, May 14-18, 1984,

TiC Formation on Ti Evaporated Graphite Probe by Plasma Exposure in JIPPT-IIU

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A graphite probe with Ti films (60 nm) were exposed to the scrape off layer plasma of JIPPT-IIU to study TiC formations which were promoted by plasma-wall interactions. After 4 discharges of ohmic heated H₂ plasma with $n(e) = 2 \times 10^{13}/\text{cc}$, $T_e = 700\text{eV}$, $T_i = 350\text{eV}$, the probe surface was analyzed using PIXE, RBS, AES and XPS. The highest concentration of TiC_{0.6} was observed on the electron drift side. About a half of pre-evaporated Ti was lost at the point of ion drift side with the radial distance of 230 mm

far from the center of the plasma. These results indicate that the large heating effect of runaway electron bombardment and the high sputtering yields of multicharged metallic impurities such as Fe^{2+} were present.

The 6th International Conference
on Plasma Surface Interactions in
Controlled Fusion Devices,
Nagoya, May 14-18, 1984

**Deuterium Retention Studies of Amorphous Silicon Probe Exposed
to JIPP T-IIU Plasma by Thermal Desorption Spectroscopy**

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N. NODA, K. TOI, S. TANAHASHI and J. FUJITA.

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A high performance thermal desorption spectroscopy (TDS) was constructed and applied to probe studies of the plasma in JIPP T-IIU. Both analyses of quantity and peak temperature of deuterium desorption were made by TDS as a function of radial distance, electron density and ion temperature. Nuclear reaction analysis (NRA) was also provided for radial-profiling of deuterium in the probes. Three amorphous silicon probes were exposed to each one discharge plasma in JIPP T-IIU and measured by TDS in a temperature range of room temperature to 973 K and with a raising rate of 10 K/min. The radial distribution of deuterium retention in the amorphous silicon probe obtained by both TDS and NRA were in good agreement. No shift of peak temperature was observed with changes of the radial distance, the surface composition of impurities and the quantity of deuterium retained, however, the peak was shifted with the change of ion temperature in the plasma. The result is explained by a simple model from which a relation between peak temperature of TDS and projected range of deuterium in the silicon probe is derived. The possibility of energy estimation of the deuterium incident flux to the silicon probe by TDS method is proposed.

The 6th International Conference
on Plasma Surface Interactions in
Controlled Fusion Devices,
Nagoya, May 14-18, 1984,

**Surface Microanalysis of C+SiC Coating
on Limiter/Armor Exposed in Doublet III**

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Limiter/armor tiles coated with a new C+SiC alloy have been tested in Doublet III. Sections of an exposed tile have been examined with surface microanalysis for compositional changes and impurity concentrations. The major impurity elements observed were Ti, O, Ni, Cr, Al, and Fe, with minor amounts of Cl, Ca, and S. Arc track regions showed low Ti, Ni, and Fe, otherwise the distribution was fairly uniform. Depth profiling of impurities showed impurity diffusion into the coating up to depths ranging from 1000 to 5000 nm.

The 6th International Conference
on Plasma Surface Interactions in
Controlled Fusion Devices,
Nagoya, May 14-18, 1984,

Surface Analysis Studies for Plasma Wall Interactions in Torus Devices

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Effective utilization of surface analysis techniques in connection with surface probes is reviewed. AES, XPS, PIXE, RBS, NRA and TDS were used for the measurements of impurity and deuterium behaviors and in-situ erosion yields in the scrape-off plasma of JIPP T-IIU tokamak and Heliotron E helical devices. The energies of the incoming oxygen impurity ions onto the probe surface were determined to be 560-596 eV and 270-300 eV for the directions perpendicular and parallel to the magnetic field line, respectively in Heliotron E. Desorption energies of deuterium from an amorphous silicon probe after exposure to the edge plasma of JIPP T-IIU were closely related to the ion temperatures of the main plasma. An in-situ measurement of the erosion yield of titanium at the ion side of the limiter position gave 1.3×10^{16} atoms/cm² discharge.

The 6th International Conference
on Plasma Surface Interactions in
Controlled Fusion Devices,
Nagoya, May 14-18, 1984,

Analysis of the Plasma-Wall Interaction in the Heliotron E Device

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We have analysed the plasma-wall interaction (PWI) of the currentless plasmas with the temperature, density, and volume averaged beta value of T_{eo} , $T_{io} \leq 1.1$ keV, $\bar{N}_e = 2 - 10 \times 10^{13}$ cm⁻³, and $\bar{\beta} \leq 2\%$. We have observed that PWI takes place mainly where the divertor field line crosses the chamber wall (called divertor traces). Boundary plasmas were measured with electro-static probes, which demonstrated the presence of the divertor region with the parameter range of $N_{ed} = 10^{10} - 10^{11}$ cm⁻³ and $T_{ed} = 10 - 50$ eV. Surface analysis techniques (ESCA, AES, and RBS) are applied to analyze the short term surface probes (Si, Graphite, and SS) and long term test pieces (SiC, TiC, and SS). The metallic impurities (Fe and Ti) are preferentially sputtered in the divertor trace.

The 5th International Symposium
on Passivity, Bombannes, France,
May 30-June 3, 1983

Optical and Impedance Studies of Nickel Passivation Film in Neutral Solution

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and Norio SATO
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The passive film on nickel was studied by 3-parameter reflectometry and impedance measurements. It was found that the complex refractive index and the dielectric constant of the film increased with the anodic potential of the film formation, indicating that the nonstoichiometric composition of the film is potential-dependent. The electrode impedance of passivated nickel consists of a film capacitor and an electric double layer capacitor at the film surface.

The 5th International Symposium
on Passivity, Bombannes, France,
May 30-June 3, 1983

Reflectometry of Iron Passivation Films in Neutral Borate and Acidic Phosphate Solutions

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Three-parameter reflectometry was applied to measure the passive oxide film on iron. In a neutral solution the refractive index of the film changes around the Flade potential where the film composition appears to change. As the solution pH decreases, the optical density of the film increases, indicating that the film is more dehydrated in a more acidic solution. The absorption spectrum of the film shows two absorption edges at 2 eV and at 2.6 eV corresponding to two electron energy gaps in the passive film.

International Conference on Ellip-
sometry and Other Optical Met-
hods for Surface and thin Film
Analysis, Paris, France, June 7-10,
1983

An In-Situ Reflection-Spectroscopic Study Applied to Anodic Oxide Films on Iron, Nickel, and Titanium

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3-Parameter reflectometry is applied to characterize the anodic thin oxide films on iron, nickel, and titanium. The passivation film on iron exhibits the absorption spectrum and hence the transition levels of electron are analogous to that of the bulk Fe_2O_3 . The passivation film on nickel has no characteristic features in the optical spectrum, but its extinction index is highly dependent on the anodic potential. The anodic oxide film on titanium has a band gap about 3.2 eV, which is comparable to the band gap 3.05 eV of bulk TiO_2 .

The 16th Meeting of the Electrochemical Society, Washington, D. C., U. S. A., October 9-14, 1983

Ion Permeability of Corrosion Precipitate Films
(Address for the Outstanding Achievement Award of the Corrosion Division
of the Electrochemical Society, Inc.)

Norio SATO
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Hokkaido University

This address demonstrates the important role played by corrosion precipitate surface films in the corrosion propagation of substrate metals. The corrosion precipitate films are found to possess the ion-selective property. They are usually anion-selective in acid solutions but they turn to be cation-selective in solutions more basic than a specific pH defined as the point of iso-selectivity pH_{pis} , which is characteristic of the individual corrosion precipitate. Multivalent anion adsorption shifts the pH_{pis} of precipitate films to a more acidic pH and multivalent cation adsorption to a more basic pH. It is shown that anion-selective precipitates accelerate the corrosion of metals because aggressive anions such as chloride ions migrate through the precipitates to the metal surface. Cation-selective precipitates will decelerate the corrosion preventing aggressive anions from migrating to the metal surface. The most corrosion-resistant precipitates are of bipolar nature consisting of an anion-selective layer on the metal side and a cation-selective layer on the solution side. Such bipolar precipitates lead to the passivation of metals.

Third International Conference on
Quantitative Surface Analysis,
National Physical Laboratory,
Teddington, UK, November 22-24,
1983

Depth-profiling of a Surface Oxide Film/Metal System

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Depth-profiling of pure metal surface (Fe, Ni and Cr) oxidized in pure oxygen gas was performed with the simultaneous use of Auger electron spectroscopy and argon-ion sputter-etching techniques to evaluate the depth-resolution of the film/substrate interface. An argon ion beam of 1 kV, $40 \mu\text{A} \cdot \text{cm}^{-2}$ was used for sputter-etching. The thickness (10~50 nm) of surface oxide films was measured by a multiple angle of incidence ellipsometer. The average sputtering rate of films was estimated from the linear relation between the film thickness, L_f , ellipsometrically obtained and the sputtering time, τ_f , required for film removal. The broadening of the composition profile, ΔL , in the film/substrate interface zone due to sputter-etching was measured as a function of film thickness, L_f .

Depth-profiling was also performed for the iron-chromium and nickel-chromium alloy surfaces exclu-

sively subjected to selective oxidation of chromium. By taking the relative depth-resolution of $\text{Cr}_2\text{O}_3/\text{Cr}$ system into account, a chromium depletion zone formed in the underlying alloy was exactly evaluated as a function of oxidation time, oxidation temperature and oxygen partial pressure.

The 9th International Congress on
Metallic Corrosion, Toronto,
Canada, June 3-7, 1984

Ion Selectivity and Electro-Osmosis in Porous Precipitate Films of Hydrated Iron (III) Oxide

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Ion selectivity and electro-osmotic flow in porous precipitate films of hydrated iron (III) oxide have been studied by measuring the membrane potential and volume flux. The ion selectivity of the films depends on the concentration of H^+ ions and on the valency of coexisting ions in electrolyte solutions. The films are anion selective in LiCl , NaCl , and KCl solutions more acidic than a critical pH defined as the point of iso-selectivity pH_{pis} , and the electroosmotic flow takes place in the direction of chloride ion transport. The mole ratio of transferring water to transferring chloride ion determines the maximum chloride concentration in an inner solution between the porous film and the metal substrate. It is shown that the ion selective and electro-osmotic property of precipitate films plays a significant role in the corrosion of metals.

9th International Congress on
Metallic Corrosion, Toronto,
Canada, June 3-7, 1984

An Auger Study on Selective Surface Oxidation of Ni-Cr Alloys

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A series of Ni-Cr alloy specimens were oxidized for 1 h at 693~823 K in pure oxygen at a pressure of 1.33×10^4 Pa. The depth-profiling of oxidized surfaces, performed by the simultaneous use of Auger electron spectroscopy (AES) and argon-ion sputter-etching technique, reveals that the Cr component is selectively oxidized and that a Cr-depletion zone is formed in the underlying alloy. The thickness of the Cr depletion zone depends on the bulk alloy composition and increases with the increasing oxidation temperature. The values of the interdiffusion coefficient of underlying alloy, estimated from the Cr depletion profile by taking the composition broadening at the film/alloy interface due to sputter-etching

into account, are two or three orders of magnitude larger than the values extrapolated from the lattice diffusion data of the corresponding alloy obtained at elevated temperature.

The 4th International Conference
on Phonon Scattering in Con-
densed Matter, August 22-26, 1983,
Stuttgart, Germany

Thermal Boundary Resistance between Small Particles and Liquid He-3

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A review is presented of the current status of investigations on the anomalous thermal resistance of the boundaries between small particles and liquid He-3 observed at temperatures below about 10 mK.

The 4th International Conference
on Phonon Scattering in Con-
densed Matter, August 22-26, 1983,
Stuttgart, Germany

Anharmonic Decay of High-Energy LA Phonons

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The effects of lattice dispersion upon the anharmonic interaction are found to significantly enhance the spontaneous decay of high-energy LA phonons, leading to the decay rate depending on the frequency more strongly than ν^5 .

The 4th International Conference
on Phonon Scattering in Con-
densed Matter, August 22-26, 1983,
Stuttgart, Germany

Phonon Focusing in Highly Dispersive and Isotopically Impure Crystals

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The dispersive effects and isotope scattering are found to be substantial to understand observed phonon focusing of near 1-THz TA phonons in highly dispersive and isotopically impure crystals.

Third International Symposium
Data Analysis and Informatics,
Versailles, France, Oct. 4-7, 1983

On the Sensitivity of Parameters in Latent Class Analysis

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Latent class analysis, originated by Lazarsfeld, is known as a technique for analyzing the interrelations among dichotomous questions. A main effort so far has been made to estimate the latent parameters contained in the model on the basis of observations.

The aim of the present paper is to show that the latent parameters are extremely sensitive to the observation errors. Although, by a Monte Carlo study, the unstability of the latent parameters has been discussed from the point of view of the estimation methods ; Gibson's or Green's method and so on, it is shown in this paper that the instability or sensitivity does not depend on the estimation method, but it is essentially caused by the structure of the latent class model.

IFAC Symposium on Fuzzy Information, Knowledge Representation and Decision Analysis, Marseille, France, July 19-21, 1983

On Some Properties of Finite and Countable Fuzzy Random Variables

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The theory of fuzzy random variables (Kwakernaak, 1978) is extended to cover finite and countable fuzzy random variables.

Based on the concepts of strong α -cuts, binary operations of fuzzy numbers and the representation theorem, a modified fuzzy random variable is defined. A measurability and an expectation of the modified fuzzy random variable are also shown. A superior, an inferior limit and a limit of a sequence of countable fuzzy numbers are also defined and their properties are examined. These lead to the definitions of a superior limit, an inferior limit and a limit of a sequence of fuzzy random variables. Their measurability is shown. It follows that

- (1) A convergence property for a sequence of fuzzy random variables holds and it gives a fuzzy version of Lebesgue's convergence theorem.
- (2) If an infinite series of countable fuzzy random variables exists, the operations of expectation and summation are exchangeable in turn.

1983 International Conference on Coal Science,
Pittsburgh, Pa., U. S. A., August
15-19 1983

On The Mechanisms and Kinetics of Initial-Stage Coal Liquefaction

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This study aims to elucidate comprehensively the mechanisms of reactive coal fragment stabilisation during the initial stage of coal liquefaction. Systematic experiments under a wide range of conditions were performed using a micro-autoclave which could rapidly be heated and cooled in an infrared image furnace. The experimental results showed that the initial rate of coal conversion to the pyridine-soluble fractions was increased by catalysts up to a level for cases with excessive hydrogen-donor solvents even when the reaction was initiated with non-donor solvents, and that the gaseous hydrogen was indirectly transferred to the reactive fragments through the solvents and the coal-derived liquids.

The effect of the initial hydrogen-donor concentration was evaluated on the basis of a kinetic model consisting of such reaction steps as i) thermal cracking, ii) hydrogenation of the reactive fragments by the donor and its intermediates and iii) hydrogenation of the spent donor back to the donor. The estimated results were successfully compared with those observed.