

ABSTRACTS OF PUBLISHED PAPERS

(Accepted April, 2000)

CONDENSED MATTER AND MATERIAL

Current-Voltage Characteristics and Flux Creep in Melt-Textured $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$

Hirofumi YAMASAKI and Yasunori MAWATARI
Supercond. Sci. Technol. **13** 2 (2000) 202–208

We investigated the current-voltage (E - J) characteristics in melt-textured $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ strips by measuring the magnetic-field-sweep rate dependence of magnetization. We took account of the current density J distribution in the specimen using a previously developed method (Y. Mawatari et al, *Appl. Phys. Lett.* **70** (1997) 2300). For a wide temperature and magnetic-field range (60–80 K, 0.2–5.0 T), the E - J curves in the electric-field window $E = 10^{-10}$ – 10^{-5} V m⁻¹ exhibited power-law behavior $E \sim J^n$, and the power index n generally became smaller at higher magnetic fields and temperatures. In low magnetic fields ($B_a \leq 0.5$ T) the n -values were large (≥ 20), and thus, the Bean model becomes a good approximation. The E - J characteristics in the lower E window were also derived from the relaxation of magnetization, the flux creep, and we found that the wide-range E - J characteristics exhibit near power-law behavior but that there exist slight downward curvatures in the $\log E$ vs $\log J$ plots. This downward curvature reveals that the dissipation approaches zero when the current is substantially reduced. The drastic decrease of the flux creep, which was observed when the sample temperature was decreased in a fixed magnetic field, is consistent with the observed E - J characteristics.

n-Type Control by Sulfur Ion Implantation in Homoepitaxial Diamond Films Grown by Chemical Vapor Deposition

Masataka HASEGAWA, Daisuke TAKEUCHI,
Sadanori YAMANAKA, Masahiko OGURA,
Hideyuki WATANABE, Naoto KOBAYASHI,
Hideyo OKUSHI and Koji KAJIMURA
Japanese Journal of Applied Physics (1999)
L1519–L1522

n-type control was achieved by sulfur-ion-implantation in homoepitaxial diamond (100) films grown by chemical vapor deposition (CVD) for the first time. Sulfur-implantation was carried out with energies of up to 400keV at 400°C. The activation energy of the conductivity was 0.19~0.33eV depending on the conditions of ion implantation. A junction between this layer and a boron-doped p-type layer was fabricated by combining sulfur-implantation with gas-phase boron doping during CVD. The junction exhibited clear pn junction properties. The capacitance of the junction decreased with reverse bias voltage, which confirms that the depletion region of the junction was actually extended with the reverse bias voltage.

Reduction of the Interfacial Si Displacement of Ultrathin SiO₂ on Si(100) Formed by Atmospheric-Pressure Ozone

Akira KUROKAWA, Shingo ICHIMURA,
Ken NAKAMURA and Dae Won MOON¹
¹*Korea Research Institute of Standards and Science*
Applied Physics Letters **76** (2000) 493

We examined the structure around the interface of SiO₂ and Si using medium-energy ion scattering spectroscopy

(MEIS) to investigate the interfacial Si-displacement of an ultrathin silicon dioxide formed by oxidation of a Si(100) substrate with atmospheric-pressure ozone at a substrate temperature of 375°C. A thermally grown oxide with the same thickness as an ozone-formed oxide was also measured with MEIS for comparison. The ozone-formed oxide exhibited considerably less Si-displacement in the oxide layers near the interface than a thermally grown oxide, which indicates that an ozone oxide is homogenous. These results explain well our previous findings that an ozone oxide exhibits a constant HF etching rate of silicon dioxide while a thermally grown oxide slows the etching rate near the interface.

Crystallization of Diamond Using Energetic Ion Beam up to 400 keV

Masahiko OGURA, Masataka HASEGAWA,
Yasunori TANAKA and Naoto KOBAYASHI
Diamond Films and Technology **9** (1999) 137–140

Diamond is one of the attractive wide-bandgap semiconductors with incomparable physical and electronic properties. However, n-type diamond has not yet been achieved due to low solubility of phosphorus (P), which is one of the best candidates of n-type dopants, and due to the difficulty in defect annihilation in the annealing process after ion implantation. In this work we have investigated the ion-beam-induced epitaxial crystallization (IBIEC) of diamond for the purpose of realizing the non-thermal-equilibrium process which enables the supersaturation of dopants. The damaged layers on crystalline diamond (100) samples were formed in the depth ranges of 0 - 60 and 0 - 120 nm by implantation of 40-keV ^{12}C ions with a dose of 1.3×10^{15} ions/cm² at a temperature of 300 K. These damaged layers were then crystallized by the annealing process with 400-keV ^{40}Ar ions with a dose range of 3×10^{13} - 1×10^{15} ions/cm² at a temperature range of 673 - 973 K. Rutherford backscattering spectrometry (RBS)-channeling measurements have revealed that the crystal recovery was markedly accelerated with the assistance of ion irradiation in the annealing process even at 673 K. From this point of view, the annealing process with several hundred keV ion beam can be applied to the crystallization of diamond and we suggest that this process is available for the doping of P into diamond beyond the solubility limit.

The Effect of Solute Silicon on the Hydrogen Precipitation in Aluminum

Masahiko OGURA, Tetsuya HIGUCHI¹,
Mitsuharu IKEDA¹, Akio ITOH¹ and
Nobutsugu IMANISHI¹

¹ *Department of Nuclear Engineering, Kyoto University*
The Proceedings of 12th International Conference on Ion
Implantation Technology (1999) 606–609

We have measured the hydrogen behavior in aluminum specimens containing a thin Al-Si alloy layer that was formed by implanting 30- or 78-keV silicon ions. The aim is to see any effect of the layer on the hydrogen precipitation. For the purpose, 30-keV hydrogen ions were implanted into the pure aluminum region far beyond the alloy layer to a dose of $1 \text{Å} \sim 10^{17}$ H/cm² at a temperature of 300 K. After the hydrogen implantation, the depth profile and thermal behavior of hydrogen were measured by the elastic recoil detection (ERD) method. When hydrogen is implanted into pure aluminum metal at 300 K, hydrogen is not retained in the sample. On the contrary, hydrogen was trapped in the pure aluminum region behind the Al-Si layer formed by implanting Si ions to a dose as low as $3 \text{Å} \sim 10^{14}$ Si/cm². The observed fact shows that the Al-Si layer influences the hydrogen trapping even in the pure aluminum region that contains no silicon. That is, the presence of the Al-Si thin layer in a near surface region obstructs the annihilation of vacancies formed by hydrogen itself in the pure aluminum region, as was proved by the hydrogen thermal behavior experiment.

Effects of Implanted Silicon on Hydrogen Behavior in Aluminum and Nickel

Nobutsugu IMANISHI¹, Masahiko OGURA,
Mitsuharu IKEDA¹, Ryuta MITSUSUE¹ and Akio ITOH¹
¹ *Department of Nuclear Engineering, Kyoto Univ.*
Nuclear Instrument and Method B **161-163** (2000)
401–405

We have used elastic recoil detection (ERD) to study the behavior of hydrogen in Si-implanted Al and Ni samples, with a particular emphasis on the effect of the grain boundaries formed by implanting additive elements on hydrogen precipitation. From the measured H depth profiles and their thermal behavior, it is shown that the presence of

an Al-Si layer in the near-surface region obstructs the annihilation of vacancies formed by hydrogen implantation in the pure Al region. In the case of Si-implanted Ni samples, hydrogen hardly precipitates except for the case of annealing procedure done at a relatively low temperature at which silicides are not formed but vacancies produced by the Si implantation are removed from the samples. These hydrogen trap sites were identified and the observed facts are explained well by taking into account the interface formed by the Si implantation.

Ion-Beam Annealing of Diamond Using Ar Ions up to 400 keV

Masahiko OGURA, Masataka HASEGAWA,
Yasunori TANAKA and Naoto KOBAYASHI

Nuclear Instrument and Method B **161–163** (2000)
1047–1051

Damaged layers in crystalline diamond (100) samples were formed in the depth range of 0–90 nm by irradiation with 40 keV ^{12}C ions to a dose of $1.3 \times 10^{15} \text{cm}^{-2}$ at room temperature (RT), and successively annealed with and without 400 keV ^{40}Ar ions with doses up to $3.0 \times 10^{15} \text{cm}^{-2}$ at 773 K. Rutherford backscattering spectrometry (RBS)-channeling measurements have revealed that damaged layers were annealed much faster with ion beam assistance than without it. It has been shown that the annealing process using a several-hundred-keV ion beam as low as 773 K can be applied to the crystallization of diamond. This suggests the promising applicability of an annealing process with ion beams to the introduction of p- and n-type dopants and requisite successive crystallization.

Interferometric Measurement of Femtosecond Optical Pulses Emitted from a Fibre Probe

Hitoshi KAWASHIMA, Makoto FURUKI¹ and
Toshiro TANI

¹*The Femtosecond Technology Research Association*
Journal of Microscopy **194** (1999) 516–518

An interferometric technique is applied to a temporal analysis of the far-field radiation from a near-field optical fibre probe. A balanced homodyne scheme combined with

lock-in detection at dual harmonics allows one to evaluate the temporal form of weak signal pulses, even in the presence of some environmental vibrations that disturb the optical interference. The transmission properties of a small aperture are formulated theoretically. It is shown that the sub-wavelength aperture should not distort the femtosecond optical pulses temporally, which is consistent with the experimental observation.

Elongated shaped Si Island Formation on 3C-SiC by Chemical Vapor Deposition and its Application for the Antiphase Domain Observation

Yuuki ISHIDA, Tetsuo TAKAHASHI,
Hajime OKUMURA, Sadafumi YOSHIDA and
Toshihiro SEKIGAWA

Jpn. J. Appl. Phys **38** (1999) 3470–3474

We have investigated the early stage of Si growth on 3C-SiC. It was found that adsorbed Si atoms on a 3C-SiC surface form elongated shaped islands with sizes of a several micron meter long and parallel to $\langle 110 \rangle$ direction. The formation of anisotropic shaped islands can be explained by the anisotropic diffusion constant of Si adatoms on a 3C-SiC surface. We proposed a novel method to observe antiphase domains (APD) using this characteristic of Si island growth on 3C-SiC.

ELECTRONIC DEVICES

Use of Multiple Pairs of Gain and Saturable Absorber Regions for Semiconductor Optical-Pulse Compressor

Mitsuaki SHIMIZU, Yoshihiro SUZUKI, Seiji MUKAI
and Toshifumi HASAMA

Jpn. J. Appl. Phys. **39** Part 1, 2A (2000) 475–479

We propose a compact semiconductor optical-pulse compressor using multiple pairs of gain and saturable absorber regions. We performed numerical analysis of the operating characteristics using traveling-wave rate equations, and determined that picosecond optical pulses such as Q-switched or gain-switched pulses could be compressed efficiently. We also confirmed that this technique was

effective for compressing the 40 - 100-ps-wide optical pulse generated by commonly-used lasers, such as self-pulsating lasers. In addition, the effect of gain saturation was investigated, and found to be one of the important factors to determine the compressing characteristics.

Doping from/through thin CoSi₂

Kunihiro SAKAMOTO
Applied Plasma Science 7 (1999) 95–96

To attain heavily doped CoSi₂/Si contacts in ultra-thin SOI MOSFETs, Sb diffusion from Sb doped CoSi₂ and P diffusion from P-doped silicate glass through CoSi₂ were investigated. The former requires relatively higher diffusion temperature due to low Sb concentration in the CoSi₂. The latter forms low resistive Si at lower diffusion temperature. It was revealed that epitaxial CoSi₂ layers hinder P diffusion in contrast to poly crystalline layers those are almost transparent for P diffusion.

INFORMATION SCIENCE

An Evolvable Hardware Chip and Its Application as a Multi-Function Prosthetic Hand Controller

Isamu KAJITANI¹, Tsutomu HOSHINO²,
Nobuki KAJIHARA³, Masaya IWATA and
Tetsuya HIGUCHI

¹NEDO

²Univ. of Tsukuba

³NEC

Proceedings of the Sixteenth National Conference on Artificial Intelligence (AAAI-99) (1999) 182–187

This paper describes the application of genetic algorithms to the biomedical engineering problem of a multi-function myoelectric prosthetic hand controller. This is achieved by an innovative LSI chip (EHW chip), i.e., a VLSI implementation of Evolvable Hardware (EHW), which can adapt its own circuit structure to its environment autonomously and quickly by using genetic algorithms. This paper shows that the EHW chip controller is a viable alternative to neural network controllers. There

are plans to commercialize the prosthetic hand with the EHW chip, and the medical department of Hokkaido University has already decided to adopt this for clinical treatment.

An Evolvable Hardware Chip for Prosthetic Hand Controller

Isamu KAJITANI¹, Masahiro MURAKAWA,
Daisuke NISHIKAWA², Hiroshi YOKOI²,
Nobuki KAJIHARA³, Masaya IWATA,
Didier KEYMEULEN⁴, Hidenori SAKANASHI and
Tetsuya HIGUCHI

¹NEDO

²Hokkaido Univ.

³NEC

⁴JPL, NASA

Proceedings of the Seventh International Conference on Microelectronics for Neural, Fuzzy, and Bio-Inspired Systems (MicroNeuro'99) 179–186

This paper describes an Evolvable Hardware (EHW) chip, and the application of this chip as a controller for myoelectric prosthetic hand. The chip consists of Genetic Algorithm (GA) hardware, reconfigurable hardware logic, a chromosome memory, a training data memory, and a 16-bit CPU core (NEC V30). This paper also briefly introduces other EHW chips being developed as part of the Ministry of International Trade and Industry's (MITI) Real World Computing Project (RWCP), which include an analogue EHW chip for cellular phones, a neural network EHW chip capable of autonomous reconfiguration, and a data compression EHW chip for electrophotographic printers.

Evolvable Hardware Chips for Neural Network Applications

Isamu KAJITANI¹, Masahiro MURAKAWA,
Nobuki KAJIHARA², Masaya IWATA,
Hidenori SAKANASHI and Tetsuya HIGUCHI

¹NEDO

²NEC

Artificial Neural Nets and Genetic Algorithms (1999)
127–134

This paper introduces two Evolvable Hardware LSIs for neural network applications. They are developed as part of MITI's Real World Computing Project. One is self-reconfigurable neural network chip for ontogenic neural network processing, having the processing capability equivalent to 10 Pentium II chips. The other LSI is for pattern recognition for myoelectric artificial hand control.

3-D Motion Tracking of 3-D Objects Using Stereo Vision

Yutaka ISHIYAMA¹, Yasushi SUMI and Fumiaki TOMITA

¹Stanley Electric Co.,Ltd,

Journal of the Robotics Society of Japan **18** 2 (2000)

We propose the algorithm for 3-D 6-DOF motion tracking of 3-D objects by the segment-based stereo vision. Observable tracking points are selected from the sample points on the boundary segments or the nets of the curved surfaces of an object model based on the position and orientation of the object at each frame. The 3D motion parameters between two frames are obtained by searching for temporal correspondences of the tracking points and then their spatial correspondences. Repeating a constrained simple one-dimensional search for both correspondences makes it possible to track moving 3-D objects stably in real-time on usual workstation.

Real-World Applications of Analog and Digital Evolvable Hardware

樋口 哲也, 岩田 昌也,

ディディエ ケミュレン, 坂無 英徳,

村川 正宏, 梶谷 勇¹, 高橋 栄一,

戸田 賢二, メフラッド サラミ², 梶原 信樹³,

大津 展之

¹NEDO

²スウィンバン大学

³NEC

IEEE Transactions on Evolutionary Computation **3** 3 (1999)

RWCプロジェクトで開発中の進化型ハードウェアについて, ギガヘルツアーキテクチャ, ニューラル

ネットチップ, 自律ロボット, デジタル印刷用データ圧縮, 義手の詳細について述べている。

Evolvable Hardware Chips for Industrial Applications

樋口 哲也, 梶原 信樹¹

¹NEC

Communications of the ACM **42** 4 (1999)

進化型ハードウェアの概念を示すと共に, RWCプロジェクトで開発中の進化型ハードウェアのうち, ニューラルネットチップ, 自律ロボット, デジタル印刷用データ圧縮, 義手の詳細について述べている。

進化型ハードウェア

樋口 哲也

情報処理学会誌 **40** 8 (1999)

進化型ハードウェアの概念と, その産業応用として, 携帯電話用アナログ進化LSIや義手について述べている。

Evolvable Hardware Chips and their Applications

Hidenori SAKANASHI, Masaharu TANAKA¹, Masaya IWATA, Didier KEYMULEN, Masahiro MURAKAWA, Isamu KAJITANI² and Tetsuya HIGUCHI

¹Mitsubishi Heavy Industries, Ltd.

²NEDO

Proceedings of 1999 IEEE International Conference on Systems, Man, and Cybernetics (SMC'99) v559-v564

This paper describes Evolvable Hardware (EHW) chips and their industrial applications. EHW refers to hardware devices that can adjust their circuit structure to adapt to varying environments. Unlike traditional hardware, EHW is capable of autonomously changing its functionality whilst operating in a real environment, and thus represents a major new approach to hardware design

and development. In this paper, a number of the applications of EHW currently under development at the Electrotechnical Lab. are introduced, and, in particular, a data compression EHW chip for electrophotographic printers, which has achieved compression ratios twice those of the international standard methods, is described in some detail.

Data Refinement for Call-By-Value Programming Languages

Yoshiki KINOSHITA and A. John POWER

Computer Science Logic, 13th International Workshop, CSL '99 Springer LNCS 1683 (1999) 562–576

We give a category theoretic framework for data-refinement in call-by-value programming languages. One approach to data refinement for the simply typed lambda-calculus is given by generalising the notion of logical relation to one of lax logical relation, so that binary logical relations compose. So here, we generalise the notion of lax logical relation, defined in category theoretic terms, from the simply typed lambda-calculus to the computational lambda-calculus as a model of data refinement.

Interpretation of Grasp and Manipulation Based on Grasping Surfaces

Fuminori SAITO and Kazuyuki NAGATA

1999 IEEE International Conference on Robotics and Automation (1999) 1247–1254

A new method is proposed to classify and describe grasping and manipulation. It is based on the three functions of grasping surfaces, namely object-supporting, pressing and wrapping functions. The method provides a simple description for grasping and manipulation and it can express their physical fundamentals. The description is illustrated through example grasp and manipulation by a human hand. Because it is independent from specific hardware, the obtained interpretations of tasks by a human hand can be easily applied to robotic hand systems. The new method can be expected to change current approaches to designing robot hands.

Anisotropic Motion within a Protein: Comparison between X-ray Crystallography and Molecular Dynamics Simulation of Human Lysozyme

Yuto KOMIJI, Kazuaki HARATA¹, Yutaka UENO and Masami UEBAYASI¹

¹NIBH

JCPE Journal 12 1 (2000) 39–48

Anisotropic motion within Human Lysozyme was compared between experiment and computer simulation. Thermal ellipsoids for Ca atoms were compared between the temperature factors from the X-ray crystallography and molecular dynamics simulation. The agreement between the experiment and the simulation was not good, however. Possible explanations for the disagreement are discussed.

Continuous-Flow Apparatus for Hyperpolarization of ¹²⁹Xe : Optimized Structure of Cell for Efficient Spin Exchange at a High Concentration of Optically Pumped Rubidium.

Mineyuki HATTORI, Takashi HIRAGA and Tetsuo MORIYA

Proceedings of the RCNP workshop on spin polarized nuclear fusions (1999) 88–90

We propose a specialized apparatus for hyperpolarization of Xe. The flow-through type apparatus for the polarization of noble gas nuclear spins using high-power diode laser arrays (794.7nm, 12W) was constructed. The performance for the polarization of natural abundant Xe gas was evaluated. In order to optimize the pumping condition, the shape of pumping cell, flow rate and temperature of the cell was varied.

**Continuous-Flow Apparatus for
Hyperpolarization of ^{129}Xe : Optimized
Structure of Cell for Efficient Spin Exchange at
a High Concentration of Optically Pumped
Rubidium.**

Mineyuki HATTORI, Takashi HIRAGA and
Tetsuo MORIYA
European Radiology **9** B 14 (1999)

We propose a specialized apparatus for hyperpolarization of Xe. The flow-through type apparatus for the polarization of noble gas nuclear spins using high-power diode laser arrays (794.7nm, 12W) was constructed. The performance for the polarization of natural abundant Xe gas was evaluated. In order to optimize the pumping condition, the shape of pumping cell, flow rate and temperature of the cell was varied.

OPTICS AND RADIATION

**炭素 1s 電子 , 酸素 1s 電子の遷移領域で励起
されたアセトンからのフラグメントイオン
収量のエネルギー依存性**

鈴木 功, 齋藤 則生
Chem.Phys. **253** (2000) 351–359

アセトン を CK 殻 , OK 殻 イオン化領域の単色軟 X 線で励起 , イオン化して生ずるフラグメントイオンを飛行時間型質量分析計で測定した。光子エネルギーを変えた時のイオン収量は光吸収係数とほぼ同様であったが , π 状態への励起とリドベルグ状態への励起では , 前者は水素を含むフラグメントの収量が多かった。

**X-ray Emissions from Clusters Excited by
Ultrashort Laser Pulses**

Eisuke MIURA, Hiroshi HONDA¹,
Keisuke KATSURA¹, Eiji TAKAHASHI¹ and
Kiminori KONDO¹
¹TARA, Univ. of Tsukuba
Proceedings of SPIE **3886** (2000) 320–330

Properties of X-ray emission from rare gas clusters excited by ultrashort laser pulses were investigated. *M*-shell emissions from Xe clusters excited by Ti:sapphire (800 nm) and KrF (248 nm) laser pulses were compared under the same irradiation conditions. For the KrF laser irradiation, the absolute X-ray yield in the wavelength region from 0.8 nm to 1.6 nm was estimated to be $3\mu\text{J}/\text{sr}$ per pulse, which was 20 times higher than that for the Ti:sapphire laser irradiation. Absolute X-ray yields in the wavelength region from 2 nm to 20 nm were measured for various rare gas clusters excited by a KrF laser pulse. For Xe, the X-ray conversion efficiency in the wavelength region from 5 nm to 20 nm was measured to be 1.1 %/sr, which was comparable to that for irradiating solid targets. The high X-ray conversion efficiency for Xe was brought about by the high absorption fraction of the laser light in the gas jet containing clusters.

**Evidence for Wavelength Dependence of Xe
M-Shell Emission from Clusters**

Hiroshi HONDA¹, Eisuke MIURA,
Keisuke KATSURA¹, Eiji TAKAHASHI¹ and
Kiminori KONDO¹
¹TARA, Univ. of Tsukuba
Physical Review A **61** (2000) 023201-1–023201-4

X-ray yields of *M*-shell emission from Xe clusters excited by Ti:sapphire (800 nm) and KrF (248 nm) laser pulses were compared under the same irradiation condition that was experimentally well characterized. Xe clusters were irradiated by 350-fs laser pulses of 20-mJ energy. For the KrF laser irradiation, the absolute x-ray yield in the wavelength region from 8 Å to 16 Å was estimated to be 38 μJ per pulse. The x-ray yield was 20 times higher than that for the Ti:sapphire laser irradiation. It was found that the x-ray yield from clusters in the keV region depends on the pump laser wavelength.

Growth of LiNbO₃ Epitaxial Films by Oxygen Radical-Assisted Laser Molecular Beam Epitaxy

Koji MATSUBARA, Shigeru NIKI,
Masanobu WATANABE, Paul FONS, Kakuya IWATA
and Akimasa YAMADA
Applied Physics A **69** (1999) S.679–681

LiNbO₃ films were epitaxially grown on c-sapphire substrates using oxygen radical assisted laser molecular beam epitaxy (MBE). X-ray diffraction based structural analysis showed the films were epitaxial. Triple-axis rocking curve measurements of the LiNbO₃ (0 0 0 6) reflection revealed that the film was highly c-oriented with an extremely narrow mosaic; the full width at half maximum of the LiNbO₃ (0 0 0 6) rocking curve was 0.0036 deg., comparable to the value of high quality bulk crystals. The surface of the film was very smooth with a surface roughness rms value as measured by atomic force microscope of 0.4 nm for a film with thickness of 15 nm. Chemical composition of the film measured by X-ray photoelectron spectroscopy (XPS) was stoichiometric within the accuracy of XPS measurement.

MEASUREMENT AND STANDARD

Nondestructive Detection of Flaw in Carbon-Fiber-Reinforced Plastics Using High-Tc Superconducting Quantum Interference Device

Naoko KASAI, Daisuke SUZUKI,
Yoshimi HATSUKADE¹ and Masao KOYANAGI
¹*Waseda Univ.*
J. Jpn. Appl. Phys. **39** 3 (2000) 1399–1404

The nondestructive detection of small cracks and deep-lying flaws in structures is important for safety inspection. Carbon-fiber-reinforced plastics (CFRP) are complex materials for use in aircrafts and structures. We investigated the possibility of detecting flaws in CFRP using a nondestructive evaluation system using high-Tc superconducting quantum interference device (SQUID). A SQUID system for the nondestructive evaluation was developed using a SQUID magnetometer and a SQUID gradiometer fabricated based on a YBCO thin film. Holes,

the diameters of which were equal to or larger than 0.4 mm, were made in CFRP plates and all holes except the smallest one were detected by a current-injection method using this system. The results show that the location and the diameter of the holes can be estimated from the distribution of the magnetic flux density, B_z , measured by the magnetometer or the distribution of the first-order gradient of B_z , dB_z/dx , measured by the gradiometer. The effect of texture of the carbon fiber in CFRP on the magnetic signal strength was discussed.

Observation of Fatigue in Low Alloy Steel A533B by SQUID

Naoko KASAI, Satoshi NAKAYAMA¹,
Yoshimi HATSUKADE² and Mitsuru UESAKA³
¹*Seiko Instruments Inc.*
²*Waseda Univ.*
³*Univ. of Tokyo*
J. Japan Society Applied Electromagnetics and Mechanics **8** 1 (2000) 16–22

The magnetic changes caused by the fatigue on low alloy steel A533B were measured using a non-destructive evaluation system based on superconducting quantum interference device. The SQUID is low T_c and has a concentric second order gradient type pick-up coil. The magnetic changes appeared when the specimen was applied cyclic fatigue loads. The magnetic image of the results varied corresponding to the fatigue condition. The fatigued parts were inferred from the magnetic changes. The SQUID system could magnetically detect early fatigue degradation. But more studies are necessary to know quantitatively the level of fatigue.

Realization and Measurement Method of UHV/XHV Condition

Shingo ICHIMURA
JHPI **38** 2 (2000) 73–84

Current technologies to establish UHV and XHV conditions and present methods to measure UHV/XHV conditions were summarized and discussed. From the view point of UHV/XHV generation, the importance of

controlling outgassing from vacuum chambers was first explained based on the equation of evacuation. Then several methods effective to reduce the outgassing rate were introduced. Those methods are application of electrochemical polishing, vacuum pre-baking, BN and TiN coating on SUS, and also the adoption of other materials than SUS such as aluminum and copper. The outgassing from pumping system and also the reduction of it were also discussed. As to UHV/XHV measurement, several principal problems associated with XHV measurement were first discussed, which were followed by the introduction of new XHV gauges and new measurement methods developed to overcome those problems.

ENERGY TECHNOLOGY

Experiments on a Tokamak Device with Force-Balanced Coils

Junji KONDOH, Kansuke FUJII¹,
Yasuhiro KOMATSU¹, Akira SATO¹,
Shunji TSUJI-IIO¹ and Ryuichi SHIMADA¹

¹*Tokyo Institute of Technology*

Electrical Engineering in Japan **130** 3 (2000) 19–29

High field is very favorable for magnetically confined fusion devices such as a tokamak, but electromagnetic force derived from the field becomes a fatal problem. Especially, the largest in-plane centering force hinders toroidal field coils from operating at higher fields. Although variable pitch multi-helical coils, we are calling force-balanced coils (FBCs), by which this force is drastically reduced, was proposed for the coil system of tokamak, there had been no tokamak device with FBCs. Therefore, TODOROKI-1, a small tokamak device with FBCs, are manufactured and experiments are started. In this paper, the structure of TODOROKI-1 is indicated, and stray magnetic field and centering force on FBCs are investigated. The plasmas have been generated in the device and attempts for better plasmas are beginning.

Application of a Force-Balanced Coil to a Tokamak Device

Junji KONDOH, Takashi FUJITA¹, Hiroaki TSUTSUI¹,
Yoshihisa SATO¹, Shunji TSUJI-IIO¹ and
Ryuichi SHIMADA¹

¹*Tokyo Institute of Technology*

Electrical Engineering in Japan **130** 3 (2000) 39–48

High field is very favorable for magnetically confined fusion devices such as a tokamak, but electromagnetic force derived from the field becomes a fatal problem. Especially, the largest in-plane centering force hinders toroidal field coils from operating at higher fields. Variable pitch multi-helical coils, we are calling force-balanced coils (FBCs), by which this force is drastically reduced, are proposed for the coil system of tokamak. FBC can also provide poloidal flux swing for plasma breakdown and current induction during the ramp-up phase of the coil current. In this paper, it is indicated how to design FBC for tokamak. The fusion reactor-size FBCs are designed and compared with that of the conventional toroidal field coil system.

Development of Efficient Forward Raman Pulse Compression System for E-beam Excited KrF Laser ASHURA

Yuji MATSUMOTO, Eiichi TAKAHASHI,
Kenji KUWAHARA, Isao MATSUSHIMA,
Isao OKUDA and Yoshiro OWADANO

Proceedings of SPIE, High Power Lasers in Energy Engineering **3886** (2000) 382

We have developed a simple method of power multiplication. In this method, multi-path forward Raman amplifier is used. By multi-path amplification, it is possible to transfer almost all energy from long duration pump pulse to short Stokes pulse with small numbers of beams. The demonstration experiments of this method have been carried out by using a short pulse Stokes generator, a forward Raman Preamplifier and a forward Raman pulse compressor. Pump light is one of the sequential output pulses from the e-beam excited KrF laser system ASHURA. Short Stokes pulse is generated in the Stokes generator filled with a mixture of methane and

hydrogen gases as Raman scattering medium. The Stokes pulse is amplified to almost half of pump intensity by the Raman preamplifier also filled with same kinds of mixed scattering medium. The Raman pulse compressor is a 5-path amplifier with total Raman gain of 10. In latest experiments, the output Stokes pulse grew up 3.2 times pump intensity by Raman conversion of pump power of 70%. The waveform of output Stokes was similar short pulse as initial Stokes light.

The First Plasma Rotation Measurement in a Large Reversed-Field Pinch Device, TPE-RX

Hajime SAKAKITA, Yasuyuki YAGI,
Yoichi HIRANO, Shigeyuki SEKINE,
Takeshi OSAKABE¹, Haruhisa KOGUCHI,
Toshio SHIMADA and Isao HIROTA

¹*Nihon Univ.*

Journal of the Physical Society of Japan **69** 3 (2000)
635–638

The plasma rotation velocities in both toroidal and poloidal directions are measured by the Doppler shift of the impurity spectral line in a new large reversed-field pinch device, TPE-RX. It is found that the magnitude of the toroidal rotation velocities varies with the plasma current. The poloidal rotation velocities are almost zero in the plasma current region studied here. The radial electric field around the plasma edge region varies with the plasma current under some assumptions. This behavior is discussed in relation to both the finite Larmor radius effect and the magnetic field line stochasticity.