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Electrical and Electronic Engineering,

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ELECTRONIC-CIRCUIT AND SYSTEM ENGINEERING DIVISION

Research Projects

INFLUENCE OF VISCOSITY LOSS ON 3-D VIBRATIONS OF RECTANGULAR AT-CUT QUARTZ PLATES

Hitoshi Sekimoto

We introduced the viscosity loss of quartz, and analyzed 3-D coupled vibrations of a VHF rectangular AT-cut quartz plate with partial electrodes. Classical mode matching was utilized to solve the 3-D problem for forced vibration. >From the admittance chart near the main TS response, we extracted the variation of resonant frequencies and resistances with the magnitudes of mode coupling. The results revealed that we could estimate the lower bound of resonant resistances or the upper bound of Qs for VHF rectangular AT-cut plates by introducing the viscosity constants of quartz that were measured by Lamb and Richter. We also found that two series resonances on the real frequency axis could occur only within a limited range of the length-to-thickness ratio, and although each of two resonant frequencies was almost the same as that evaluated with an assumption of no losses, the corresponding resistances increased with the magnitudes of mode coupling.

THE BASIC CONCEPT AND DECENTRALIZED AUTONOMOUS CONTROL OF SUPER DISTRIBUTED ENERGY SYSTEMS

Keiichiro Yasuda

New small-scale dispersed generation systems, such as fuel cells and micro gas-turbines have made remarkable advances lately and they will be applied practically in the near future. Although a large number of researches on the introduction of small-scale dispersed generation systems have been carried out, only a small number of small-scale dispersed generation systems are considered in these researches. Therefore, little is known about problems to be solved in case where a large number of small-scale dispersed generation systems are introduced into electric power systems. This paper deals with a super distributed energy system that consists of a great number of dispersed generation systems such as fuel cells, micro gas turbines and so on. The behavior of a customer with a dispersed generation system is simulated as the Ising model in statistical mechanics. The necessity of a distribution network in super distributed energy systems is discussed based on the Ising model. The feasibility of decentralized autonomous control using vicinity information is also investigated on the basis of stability analysis of the Hopfield neural network model.

A PROXIMATE OPTIMALITY PRINCIPLE BASED TABU SEARCH

Keiichiro Yasuda

Most of the actual problems that have discrete structure can be formulated as a combinatorial optimization and many combinatorial optimization problems are supposed to be NP-hard from the viewpoint of complexity in a calculation theory. This means that it is extremely hard to obtain a strictly optimal solution within a feasible computation time. Meta-heuristics is a new paradigm that aims to obtain an approximate solution within a feasible computation time. In the meta-heuristics, Tabu search is one of the most effective algorithms for solving combinatorial optimization problems. While the intensification of Tabu Search is powerful, the diversification Tabu Search is not powerful. This paper proposes an algorithm - Multi Criteria Tabu Search coordinating the intensification and the diversification based on a Proximate Optimality Principle (POP) - which has several advantages for solving combinatorial optimization problems. The proposed algorithm is applied to some traveling salesman problems which are typical combinatorial optimization problems in order to verify the performance of the proposed algorithm.

AN ADAPTIVE PARTICLE SWARM OPTIMIZATION METHOD

Keiichiro Yasuda

This paper points out that meta-heuristics should have not only robustness and adaptability to problems with different structure but also adjustability of parameters included in their algorithms. Particle Swarm Optimization (PSO), whose concept began as a simulation of a simplified social milieu, is known as one of the most powerful optimization methods for solving nonconvex continuous optimization problems. Then, in order to improve adjustability, a new parameter is introduced into particle swarm optimization on the basis of the Proximate Optimality Principle (POP). In this paper, we propose adaptive Particle Swarm Optimization and the effectiveness and the feasibility of the proposed approach are demonstrated on simulations using some typical nonconvex optimization problems.

ABSOLUTE MEASUREMENT OF VIBRATIONAL DISPLACEMENT OF PIEZOELECTRIC DEVICES

Yasuaki Watanabe

A non-mechanical scanning method has been developed for mapping absolute vibrational patterns of piezoelectric devices based on a burst drive laser speckle method. By taking into account the statistical treatment for the distributions of the speckle intensity, the absolute vibrational shapes can be visualized. This method is based on a simple relation of coherent light interference on device surfaces and the linear relation of piezoelectricity. To derive the visibility gamma, which is mandatory for determining

absolute displacement, a polynomial approximation is applied to an expression of the surface interference. This is because gamma is not directly obtained from general interference equations when the device being tested is excited by the burst signal.

TEMPERATURE COMPENSATED SC-CUT CRYSTAL OSCILLATORS

Yasuaki Watanabe

To improve the temperature characteristics of SC-cut oscillators without degrading their phase noise and short term stabilities, an oscillator circuit has been designed. This circuit uses an AT-cut resonator as a temperature reference of the output frequency, that is, the oscillation frequency of the SC-cut circuit traces the temperature characteristics of the AT-cut resonator. Experimental results show that the frequency stability for the temperature is improved 30 times better than normal oscillators.

MINITUALIZATION OF CS ATOMIC CLOCKS

Yasuaki Watanabe and Shigeyoshi Goka

To establish practical ultra-small frequency standard system, we are researching the coherent population trapping (CPT) technology for super-fine structures in alkali atoms such as Cs and Rb.

APPLICATION OF CIP SCHEME TO COMPUTATIONAL ELECTROMAGNETIC FIELD ANALYSIS

Yukihisa Suzuki

New computational technique to analyze electro magnetic filed based on Cubic-Interpolated Propagation (CIP) scheme is investigated. CIP method has nature of good flux conservation as one of flux-corrected transport scheme, and does not required explicit absorption boundary condition (ABC). In this study, Maxwell equations are formulated into multi dimensional CIP scheme. CIP scheme for electro magnetic field indicate good performance rather than finite difference time-domain (FDTD) scheme on conservation of waveform and reduction of calculation costs caused by ABC.

DEVELOPMENT OF ESTIMATION TECHNIQUE ON INTERNAL 3D SAR DISTRIBUTION FOR THE DOSIMETRY OF HIGH FREQUENCY ELECTROMAGNETIC FIELD.

Yukihisa Suzuki

We have developed a new technique to estimate three-dimensional (3D) specific absorption ratio (SAR) distributions in transparency gel phantom. This technique is based on 3D temperature distribution imaging by means of micro-capsulated

thermo-chromic liquid crystal (MTLC). To realize this new technique, high polymer gel constructed from “carrageenan”, which is extracted from seaweed and has high transparency, is employed as the substrate of the tissue equivalent phantom. We can adjust a value of complex permittivity of phantom to that of muscle at 1.5GHz. We have performed 1.5GHz high frequency electromagnetic field exposure on the tissue equivalent phantom in which MTLCs are uniformly dispersed. Time evolutional images of two-dimensional (2D) temperature distribution inside of phantom are captured by CCD digital camera. Captured images are transformed into temperature value by using Hue-Saturation-Luminance (HSL) color scheme. Internal 2D SAR distribution on the cross section visualized by slit light is estimated from temperature elevation over a short period of time. This technique enables non-destructive and non-invasive SAR measurement within the phantom. It is possible to reconstruct 3D SAR distribution by sweeping imaging cross section with moving slit light.

STUDY ON THE EFFECT OF THE RELATIVISTIC ELECTRON BEAM INJECTION ON THE HIGH POLYMER MATERIALS

Yukihisa Suzuki

In the space environment, insulating materials used in spacecrafts are exposed to high-energy charged particles, such as electrons and protons, which are accelerated on the surface of the sun. In case of the irradiation with a large amount of the charged particles, the materials may sometimes melt and it gives a serious damage to the spacecraft. Hence, it is important to investigate the behavior of high-energy charged particle injected into high-polymer insulation materials. Relativistic electron beam irradiation experiment was performed to investigate the energy dumping distribution inside of epoxy resin, in which micro-encapsulated thermo-chromic liquid crystals (MTLCs) are uniformly dispersed. It is supposed from the preliminary result that energy dumping distribution has the peak in the vicinity of surface, and peak position becomes deeper according to increase of acceleration energy. The space charge accumulation is also measured by pulse electro-acoustic (PEA) method. It is found that the peak position for energy dumping caused by injected electrons is shallower than the accumulate position of space charge.

VELOCITY TRACKING CONTROL OF BIPED ROBOT USING PD CONTROL AND FUZZY CONTROL

Takao Soma

We proposed velocity tracking control of biped robot using PD control and fuzzy control. In these studies, we adopted velocity feedback control in direction of movement and orthogonal direction, respectively. Control rules are described by fuzzy rules in the method using fuzzy control. And this makes it an open possibility to control velocity in a

natural way similar to human walk. We also verified the usefulness of proposed methods through computer simulation.

THE DEVELOPMENT OF MEASUREMENT METHODS OF THE SCATTERING COEFFICIENTS AND THE COMPLEX PERMITTIVITY IN THE MILLIMETER AND MICROWAVE REGION

Toshio Kamijo

To remove an influence in the sample insertion hole which becomes a problem about the complex permittivity measurement of the material by the perturbed cavity resonator when the height of the resonator is low, we proposed an new type resonator without insertion holes. In the microwave and V-UHF band, we measured complex-dielectric-constant of the low-loss material such as rock salt and this new cavity clarified the usability. Also, we reviewed the possibility of the millimeter-wave permittivity measurement of the thin-film material using an open type Fabry Perrault type resonator.

CALCULATION OF BI-MESA STRUCTURES SUITABLE FOR MOUNTING

Shigeyoshi Goka

We calculated an improved bi-mesa structure, ones that has two mesa steps and is suitable for mounting using a two-dimensional finite element method in the X-Y'region. The frequency differences between clamp and free X-edge conditions were estimated as an index of mounting influences. When the outer mesa height was lower than 20% of the thick area, the frequency differences were less than 10% of standard-type bi-mesa resonator values. These results indicate that our bi-mesa structure has good separation from the mounting influences.

ULTRASONIC ELASTICITY MEASUREMENT OF BIOLOGICAL TISSUE

Takayuki Sato

An experimental device was developed based on the understanding that absolute estimation can be accomplished by adding a mechanical approach to static elastography. The device measures the loaded force with a compression board, and obtains sonograms with a transducer placed in the center of the compression board. In the sonograms of a two-layered phantom with known dimensions, the device detected the boundaries between the layers and the displacements in each layer were. The absolute Young's modulus was estimated with the compression force and the dimensions of the phantom. Simulations and experiments comfirmed the effectiveness of this device. Additionally, the three-dimentionalizing of the problem was discussed.

ELECTRONIC-CIRCUIT AND SYSTEM ENGINEERING DIVISION

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ELECTRICAL ENERGY AND APPLICATION OF ELECTRO-MAGNETICS ENGINEERING DIVISION

Research Projects

RESEARCHES ON BIOELECTROMAGNETICS

Masao Taki

Effects of electromagnetic field on human body are investigated to establish compatibility between human life and technology utilizing electromagnetic energy. The following studies have been done or are still ongoing.

a. Exposure setups for in vitro studies have been developed to perform experiments on cellular level effects of electromagnetic fields (2.45 GHz). A temperature regulation with a Pertier device is introduced and the performance is evaluated. The result indicates capability of temperature regulation at the location of cells even for high SAR exposures.

b. Effect of 2.45 GHz microwave exposures on the induction of heat shock proteins (hsp 70) was experimentally investigated by the measurement of the gene expression of hsp 70 using real time RT-PCR. The result shows that thermal effect is dominant and no stress effect of high frequency electromagnetic field is indicated.

c. Exposure assessment on a body area communication system is performed. The system utilizes electric field in the intermediate frequency region (3 kHz – 10 MHz). The SAR in the body and the radiated electromagnetic field is numerically evaluated.

d. Exposure associated with the use of mobile phones is made taking the SAR distribution in the head into account. Phones are classified in terms of SAR distribution in the head. The SAR at the location of the tumor is estimated using a numerical phantom model. The result is applied to the epidemiological study performed in Japan as a part of international collaborating study.

e. Experiments have been done in cooperation with research institutes for medical and biological science. Those experiments include effects of microwaves and millimeter waves on rabbit eye, gene mutation, induction of heat shock proteins, microcirculation of rat brain, and so on.

ACTIVE NOISE CONTROL

Masao Taki

Vibration actuator using magnetostrictive devices is developed for the purpose of applications to active noise and vibration control. The actuator is mainly driven by electromagnetic force at lower frequencies, as well as driven by magnetostrictive force at higher frequencies. The performance of a prototype of the actuator is characterized, and preliminary investigation is made to apply the actuator to active noise control.

DEVELOPMENT OF DIELECTROPHORETIC MICROFILTERS

Satoshi Uchida

The trapping and concentration processes of bacteria are extremely important elements in various detection methods. At the present time, mesh filters and collection beads are used generally. However, there are some problems such as time waste and the rising cost due to their frequent exchange. In the present work, we developed a new concentration apparatus, i. e. dielectrophoretic microfilter, in which bacteria are trapped or released electrically. *Escherichia coli* in the suspension were separated successfully from other organic matters by adjustment of driving frequency. In addition, it was possible to trap and to concentrate large mount of *Escherichia coli* using the present electrode designated as comb-like structure.

MONITORING OF METABOLIC ACTIVITY FOR MICROORGANISM USING DIELECTROPHORETIC METHOD

Satoshi Uchida

Adequate control of fermentation is key of quality preservation in brewing industry. Actually, the process is managed by the specialists as master brewers. However, the constant monitoring is difficult and instability due to human error is indwelled. In the future, it is desirable to detect the state of alcohol yeast rapidly and automatically. In the present work, the metabolic activity for microorganism was investigated using dielectrophoretic impedance measurement method (DEPIM). For the suspension of *Escherichia coli*, the electrical conductance between electrodes was changed non-linearly against heat treatment temperature. Furthermore, determination of live or dead, geometry variation, extent of damage for cell membrane, and respiration metabolism are examined. It is verified that the conductance change was inclusively reflected in their biological characteristics. This result suggested that the present technique was useful in immediate distinction of metabolic state of bacteria.

INVESTIGATION OF HIGH-EFFICIENCY STERILIZATION USING DIELECTROPHORETIC CONCENTRATION AND LOW VOLTAGE PULSE

Satoshi Uchida

Immediate sterilization is essential in food production processes because of strictness of food sanitation. However, it is difficult for conventional heat treatment to deal with all foods. In the present work, new treatment method was examined, i. e. pathogenetic bacteria were detected and concentrated in micro channel by dielectrophoresis and were sterilized by pulse electric field under low voltage and low electric power conditions. At frequency as 100 kHz, *Escherichia coli* were concentrated efficiently. In addition, when a pulsed voltage of is applied by high-speed semiconductor switch, 90 % of the bacteria became extinct in one hour. Under the present condition, sterilization efficiency was

improved to 25 times by the additional effect due to dielectrophoretic concentration.

NUMERICAL ANALYSIS OF FUNDAMENTAL PROPERTIES IN NITROGEN MICROPLASMA

Satoshi Uchida

Microplasmas, a kind of atmospheric pressure plasmas, are available for various applications because of the high plasma density and minute structure. However, for the effective utilization, it is essential to investigate the behavior of microplasmas under various discharge conditions. In the present work, we simulated discharge structure of microplasmas in nitrogen under various conditions and analyzed the fundamental discharge characteristics. It was shown that imbalance of gain and loss for the charged particles in the discharge space prevents the formation of glow discharge in nitrogen. Moreover, we examined trapping effect by radio frequency for supply of electrons. This result suggested that stabilized formation of the nitrogen microplasma is realizable in the range of frequency as 10 MHz.

STUDY ON FUNDAMENTAL PROPERTY OF MICROPLASMA

Fumiyoshi Tochikubo

Microplasma is typically a nonthermal plasma source with high plasma density and micrometer size at high gas pressure. The aim of this work is to clarify the fundamental properties of capacitively coupled microplasma experimentally and theoretically. In the experiment, we have investigated the breakdown voltage, discharge morphology and time-resolved optical emission of capacitively coupled microplasma driven by an rf or a pulsed voltage in glass capillary in noble gas (helium or argon) as parameters of electrode geometry, gas pressure and gas flow rate. We have paid attention to the plasma generation at downstream for plasma jet application. Numerical simulation based on fluid approximation model is carried out with consideration of gas dynamics to investigate the interaction between plasma and gas dynamics because local heating in microplasma results in ion wind and gas temperature increase, and also external gas flow contributes the plasma control. In this work, we applied our simulation model to the microplasma analysis in closed cell and gas flowing narrow channel. We have also investigated the dc microplasma in atmospheric pressure helium to study its plasma structure.

GENERATION AND APPLICATION OF ATMOSPHERIC PRESSURE GLOW DISCHARGE

Fumiyoshi Tochikubo

The purpose of this work is to clarify the role of metastable species for high pressure

glow discharge formation in rare gases. The influence of Penning effect on high pressure glow discharge formation is investigated in Ar-C_2H_4 mixtures in dielectric barrier discharge configuration. Optical emission spectroscopy from the glow discharge was carried out as well as the spatiotemporal measurement of Ar($1s_5$) by laser absorption spectroscopy. The detail of Penning ionization process from excited Ar atom was evaluated by Boltzmann equation analysis. Using the reaction set of Penning ionization, Penning effect in Ar-C_2H_4 glow discharge was theoretically investigated by one-dimensional fluid mode. The addition of C_2H_4 drastically decreased the breakdown voltage and efficiently contributed to stable glow discharge formation at higher pressure. Small amount of C_2H_4 addition in Ar can be applied for carbon film deposition in atmospheric pressure plasma process.

APPLICATION OF ELECTRICAL GAS DISCHARGES FOR ENVIRONMENTAL PURIFICATION TECHNOLOGIES

Fumiyoshi Tochikubo

Plasma-assisted catalytic reduction of nitrogen oxides (NOx) from exhaust gas is investigated experimentally. Following our previous work, the relation between by-products and NOx removal was carefully investigated. Aldehyde and carboxylic acid as a by-product from hydrocarbon in the discharge plasma efficiently contributed to the NOx reduction on catalyst. Electrical gas discharge in bubbles in water is also carried out for wastewater treatment.

A STUDY OF EMI NOISE OF INVERTER CIRCUITS

Keiji Wada

This research discusses common-mode EMI problems for AC module inverters and shows an installation point for a common-mode chokes to reduce the noise voltage. In addition, it discusses noise currents in a control or gate-drive circuit of a 200-kHz PWM inverter. When the MOSFETs of the inverter are turned-on or -off, the noise current flows into the control and drive circuits. Three suppression methods are presented.

A STUDY OF A HYBRID ACTIVE FILTER FOR SUPPRESS HARMONIC CURRENTS

Keiji Wada

This research presents steady and transient states of a transformerless shunt hybrid filter consisting of a threephase passive filter tuned to the 7th-harmonic frequency, and a small-rated active filter based on a three-phase voltage-source PWM converter. The validity of the hybrid filter is confirmed by experimental results obtained from a 400-V, 15-kW laboratory system.

STUDY ON A HALBACH-TYPE PM SURFACE MOTOR

Junichi Tsuchiya

The motor drive system becomes complex and high performance as the industrial machine device develops. Moreover, the drive of multi-degrees-of-freedom is requested. Then, the research of the surface motor that is a kind of a multi-dimensional movement is paid to attention. We developed a new type surface motor (SFM).

This new type of SFM consists of many electromagnets as a stator, and a Halbach-type permanent magnets as a mover. Consequently, the mover is free from the connection of the wire, then the mover can rotate itself in addition to linear motion on the x-y plane by the excitation of the stator coils. This SFM might be useful for the application in the space sealed up, because the mover and stator are completely separate. We experimented in the prototype, confirmed the operation, and measured a basic characteristic. We are researching an analysis of the motion and a new driving method. The linear motion and rotational motion of this SFM is analyzed, and improved. Moreover a new method to measure the mover's position is examined and optimized.

On the other hand, we are developing a novel SFM that uses the bulk superconductor. The mover composed of the bulk superconductor is supported by the pinning force, and levitate. And the mover moves freely on the x-y plane.

STUDY ON A ULTRASONIC MOTOR USING A COILED STATOR

Junichi Tsuchiya

A micro motor that works in the blood vessel is requested by medical. However, it is already a limit in the motor of a past principle. The supersonic wave motor based on a new principle is researched. We make the new micro supersonic wave motor that uses coiled type Stata for trial purposes, and are examining the characteristic. It is easy to miniaturize, and as much as 1mm or less in the diameter is also possible in this motor because of a simple structure. Moreover, there is a feature of operation in the liquid and the rotation of the midair axis.

ELECTRICAL ENERGY AND APPLICATION OF ELECTRO-MAGNETICS ENGINEERING DIVISION

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ELECTRONIC MATERIAL AND DEVICE ENGINEERING DIVISION

Research Projects

RESEARCH ON REMOVAL OF PHOSPHATE AND RADIOACTIVE HEAVY METALS FROM WATER BY HIGH GRADIENT MAGNETIC SEPARATION WITH HIGH FIELD SUPERCONDUCTING MAGNET

Daisuke Ito

Today, water eutrophication by phosphros and pollution by heavy metals are the challenges for us. Recently, it was found that schwertmannite particle is an good adsorbent for metal ions in solution. In order to evaluate the applicability for the schwertmannite adsorbent to the phosphrus and radioactive ions in solution, we studied adsorption characteristics to the phosphate and uranium ions. Adsorbed phosphate and uranium ions in solution to the schwertmannite adsorbent were removed successfully by the technology of the high gradient magnetic separation HGMS with using a 10 Tesla superconducting magnet.

Electrical and optical characterization of deep-levels in semi-insulating GaN

Tsugunori Okumura

GaN-based High Electron-Mobility Transistors (HEMTs) are promising candidates for high temperature and high power microwave applications owing to the material properties such as large band gap energy, high saturation velocity, and high drain current density. However, there are serious problems for AlGaN/GaN HEMTs such as “Current Collapse”. It is considered that “Current Collapse” stems from both surface states of the AlGaN layer and deep levels in the semi-insulating (SI)-GaN layer. In this study, the electronic and optical properties of high-resistive SI-GaN epitaxial layers are characterized in order to clarify the deep levels which are responsible for high resistivity.

COULOMB POTENTIAL WEAKEND BY SELF-FIELD OF ELECTRON

Shigeru Sasabe

The largest obstacle for a realization of the nuclear fusion is Coulomb potential. It is pointed out that Coulomb potential may be weakend in some region due to the self-field of the charged particle.

CHARACTERIZATION OF ARGON FAST ATOM BEAM SOURCE TOWARDS APPLICATION TO SEMICONDUCTOR DRY ETCHING PROCESS

Michihiko Suhara

Towards an application for the mesa etching process of semiconductor quantum devices, a saddle-field argon fast atom beam source was characterized in terms of energy

distribution spectra for residual ions and neutralization coefficient under various process conditions. The neutralization coefficient was evaluated to be in the order of 90 % and slightly depended on operating parameters. Argon FAB etching was performed to form a mesa structure of GaInP/GaAs triple-barrier resonant tunneling diodes, and clear negative differential resistance characteristics were obtained with high yields.

ANALYSIS OF RADIATION CHARACTERISTICS ULTRA BROADBAND MONOLITHIC ANTENNAS INTEGRATED WITH SEMICONDUCTOR DEVICES

Michihiko Suhara

We analyzed a design rule for monolithic integration of on-chip antennas and semiconductor devices towards realization of ultra broadband integrated devices in terahertz region. Effect of geometrical parameters of finite sized self-complementary antenna and semiconductor mesa structures on radiation performance was analyzed.

A PROPOSAL OF BROADBAND HIGH-Q MONOLITHIC ACTIVE INDUCTORS

Michihiko Suhara

Planar thin-film spiral inductors are widely used in monolithic microwave integrated circuits (MMICs), however performances of the spiral inductor, such as self-resonant frequency and Q-factors, are limited by conductive loss due to eddy current produced in the device structure. Moreover, the spiral inductor is hardly scaled down and always occupies large area in the MMICs to obtain desired inductance. We propose and analyze a novel broadband high-Q active inductor on the basis of integration with resonant tunneling diodes revealing negative differential resistance up to sub-millimeter regime.

ACHIEVEMENT OF HIGH CURRENT DENSITY ON RE123 COATED SUPERCONDUCTORS USING NANO-STRUCTURE CONTROL TECHNOLOGY

Osuke Miura

In this research, we have improved critical current density Jc for $GdBa_2Cu_3O_7$ thin films made with the ex-situ method by the BaF_2 process, successfully. In order to obtain the optimum conditions when it is made, increasing rate of the heat treatment temperature, oxygen partial pressure, film thickness and preprocessing condition were changed during the thin film deposition. Highest Jc value of over 2.1MA/cm^2 at 77.3K was obtained. The magnetic field dependency of Jc has plateau region below a characteristic field B*. This region is corresponding to the single vortex pinning mechanism. The density of effective pins and elementary pinning force were estimated from the direct summation model. We also discuss the relationship between flux pinning properties and microstructures of films. We have also studied Y_{123} coated superconductors with APC columnar defects by newly developed Ic- B-q measurement

system which can measure magnetic field angle dependence of Ic up to 100 Amps at 77 K. Jc peaks was derived at B//c corresponding to existence of effective pinning centers due to one dimensional columnar defects.

IMPROVEMENT OF CRITICAL CURRENT DENSITY IN MGB2 SUPERCONDUCTORS USING POWDER-IN-TUBE METHOD

Osuke Miura

MgB_2+x (x=-0.3-3.3) tapes were fabricated by the in-situ powder-in-tube method with two-stage heat treatment, starting from amorphous B powder and Mg flakes to avoid excessive oxidation. We studied characteristics of MgB_2 tapes synthesized with non-stoichiometric Mg : B ratios on purpose to introduce effective pinning centers such as non-reacted materials and secondary phases. Jc increased drastically with increasing B composition ratio. The maximum Jc reached 1.7 ×105 A/cm^2 at 4.2 K, 1 T for $MgB_{2.8}$, 3.3×103 A/cm^2 at 4.2 K, 5 T for $MgB_{3.3}$ and 1.9 ×105 A/cm^2 at 20 K, 0 T for MgB2.6. These values are 3-30 times higher than that for stoichiometric MgB2 tape. Analyses based on the grain boundary pinning theory revealed two factors for improvement of Jc. One is an increase of grain boundary density due to suppression of grain growth in Mg poor condition. The other is an enhancement of elementary pinning force at grain boundaries due to the existence of non-superconducting phases.

STUDY ON LOW-TEMPERATURE RECOVERY OF PLASMA-INDUCED DEFECTS IN N-GAN

Seiji Nakamura

GaN is one of the most promising materials for applications in high-power and high-frequency electronic devices. For fabrication of the GaN-based devices, the plasma process is widely used, for example dry etching and deposition of insulating films. However, the plasma process often induces damages on GaN surfaces. In this study, the electrical properties as well as generation mechanism of defects in n-GaN introduced during plasma process have been studied.

The electrical characterization revealed that the silicon donors in n-GaN exposed to plasma was passivated due to the intrinsic defects related to the deficiency of nitrogen. Furthermore, we have found that the Si donors in n-GaN exposed to plasma were reactivated by the ultraviolet illumination even at room temperature.

ELECTRONIC MATERIAL AND DEVICE ENGINEERING DIVISION

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