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Electrical and Electronic Engineering,

Graduate School of Science and Engineering,

Tokyo Metropolitan University

ELECTRONIC-CIRCUIT AND SYSTEM ENGINEERING DIVISION

Research Projects

3-D analysis of coupled vibrations of rectangular AT-cut quartz plates with Tab electrodes

Hitoshi Sekimoto

We numerically analyzed the influence of strip tab electrodes on the coupled vibrations of the fundamental thickness-shear (TS) and flexural modes in a rectangular AT-cut quartz plate with rectangular central electrodes. It was assumed that the tabs were extended along the X axis and softly supported at two points on a single X-edge of the plate. We calculated the frequency spectra near the main TS response, for three types of tab configurations that possessed two-fold rotation symmetry about the X crystal axis of quartz as well as the rectangular plate and central electrodes. These results verified that the tabs could affect the coupling characteristics between the TS and spurious modes, and demonstrated that the coupling strength depended on both the tab width and tab arrangement. We also clarified each property for the three types of tab configurations.

Improved system for in-plane mode shape measurement based on two-laser speckle interferometer

Yasuaki Watanabe

Two-light-source laser speckle system for visualizing the in-plane mode shapes of high frequency piezoelectric resonators has been improved. Based on our previous reports, the measurement range of the vibration displacement was expanded by increasing the order of the polynomial approximation in the optical interference. A transformation from the 2D correlations between two laser-speckle images of the resonator-resting and -driving states to the vibration displacement maps was also developed. The performance gain of the measurement system using a combination of these improvements is demonstrated through the experimental results.

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.

Stability analysis of PD bipedal walking control using numerical method with guaranteed accuracy

Takao Soma

We have studied velocity control of biped robot using PD, PID and Fuzzy control. But we didn't discuss about stability of bipedal walking in our previous studies. In this study, we propose a stability analysis method of PD bipedal walking control using numerical method with guaranteed accuracy. In this method, invariant sets for bipedal walking is evaluated by interval arithmetic. Through computer simulation, validity of proposed method is confirmed.

Application of CIP scheme to computational electromagnetic field analysis

Yukihisa Suzuki

New computational technique to analyze electromagnetic field 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 electromagnetic 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.

Low power 85Rb CPT atomic clock

Shigeyoshi Goka

An 85Rb vapor cell atomic clock using a coherent population-trapping (CPT) resonance is proposed. The choice of 85Rb rather than conventional 87Rb is dictated by the lower ground-state hyperfine-splitting frequency fhfs of rubidium, that is, fhfs ~ 3.0 GHz in 85Rb and fhfs ~ 6.8 GHz in 87Rb, The results show that the CPT resonances at both 85Rb and 87Rb can be separately observed for the mixed vapor cell, and the line width of each CPT resonance is about 100 Hz. The frequency stabilities of the phase-locked output signals to each CPT resonance were < $7x10^{-12}$/day for 85Rb and < $6x10^{-12}$/day for 87Rb, respectively. In addition, the RF modulation signal power for 85Rb was 2 dB lower than that of 87Rb because of modulation efficiency characteristics of the VCSEL.

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 a 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 improved 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.

Development of strain optimization tool for elastography

Takayuki Sato

In the traditional elastography, strain distribution applied to the biological tissue have been non-uniform, thus geometries of target objects have been misinduced. Here, we have performed FEM analyses to find the most uniform condition of strain distribution, and ultrasonic echo analyses based on FDTD have been performed. Images of cross-correlational and strain distribution obtained from the pre- and post-deformation showed the effectiveness of the uniformalization of strain distribution.

Compensation technique of systematic error involved in traditional measurement of thermal pain threshold

Takayuki Sato

Thermal pain threshold is widely known in medical and physiological fields as about 45 ◦C which was measured with the traditional contact-type thermal dolorimeters. It is predicted that there is a considerable temperature difference, because a temperature measurement sensor and perceptive nerves are insulated with poor heat conductors. Thus, the purposes of this study are to numerically quantify the temperature difference between the sensor and the receptor, and to estimate the true pain threshold temperature. By performing heat transfer simulations based on the finite element method with a precise skin tissue model, changes in the temperature of the receptor with time were analyzed. As result, the systematic errors in the traditional measurements were about -2 ◦C and thus the true threshold temperatures were estimated as about 43 ◦C. This temperature is known as the temperature of cell death and excitation of perceptive nerve (C-nerve).

Parameter adjusting method of PID control for MIMO systems

Kenichi Tamura

It is well known that PID parameter adjusting method for MIMO system is one of the tasks in the PID controller design. We proposed that several effective PID parameter adjusting methods for MIMO systems which have some difficult characteristics (nonlinearity, unstable, non minimum phase, uncertainty, etc.) to apply conventional method. Concretely, they are (1) the method using adaptive control theory (2) the method using hi-gain output feedback (3) the method using nonlinear programming. In any case, we confirmed the effectiveness of our proposed method by various numerical experiments.

ELECTRONIC-CIRCUIT AND SYSTEM ENGINEERING DIVISION

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ELECTRICAL ENERGY AND APPLICATION OF ELECTRO-MAGNETICS ENGINEERING DIVISION

Research Projects

Research of iron loss evaluation of the inductors

Toshiaki Shimizu

In order to increase the power density of the power converters, reduction of the volume and loss of the inductor is essential. We have been studied an accurate measuring method of the hysteresis loss of the inductor core of those are operating in the actual inverters. Based on the results of the research, we have developed a inductor loss analyzer which enables to measure the iron loss dynamically operating in the inverter circuit. Furthermore, we have studied the loss variation in many operating condition such as the modulation index, the power factor. As a result, we obtained many data useful for designing a high power density converter.

Research on the power decoupling technology used in the single-phase photovoltaic inverters

Toshiaki Shimizu

Especially in the single-phase photovoltaic inverters, the power pulsation appeared on the dc-bus capacitor harms the conversion efficiency of the system. Hence we need to reduce the pulsation power from the dc-bus capacitors. Traditionally, an electrolytic capacitor has been used. However, since the lifetime of the electrolytic capacitor is relatively shorter and it results in shorten the whole life time of the PV generation systems, we need to develop a new method which does not use the electrolytic capacitor. We have been developed many kinds of inverter topology by applying a power decoupling theory in which no electrolytic capacitor is used. However, the conversion efficiency of the decoupling system is lower than the conventional inverter system even though the power pulsation mitigation and small capacitor is realized. In this study, a novel inverter circuit topology with a forward-converter concept is developed. We made an experimental setup with 500[W] output power and tested the basic characteristics. We confirmed that the proposed system has higher conversion efficiency compared to the one on the former power decoupling inverter systems.

EMI noise mitigation on the power converters

Toshiaki Shimizu

EMI noise current flows from the power converter increases because of high dv/dt and high switching frequency of the power devices. In this research, noise mitigation not only for external problem but also for internal noise problems in the converter system is studied.

Suppression of motor surge voltage in ASD system

Toshiaki Shimizu

A novel motor surge voltage suppression method is proposed in this study. A feature of the developed system is that the surge suppression unit is connected to the motor terminal in parallel whereas the conventional system is connected in series. Hence the power loss caused by the surge suppression unit is minimized and hence the whole conversion efficiency on the ASD system can be improved. We have made a 3kW experimental setup, and tested the effectiveness of the proposed system.

Development of high power density converter

Toshiaki Shimizu

We have developed a high-power density single-phase inverter with 500[W] output power rating. The distinctive feature is that the thickness of the inverter is very thin, 15[mm], and hence the thermal resistance of the whole inverter PCB can be reduced. Then re resultant power density is increased about 3times compared to the conventional inverter structure.

Development of high-frequency current output inverter

Toshiaki Shimizu

A novel high-frequency inverter with high-conversion efficiency suitable for use in plasma processing is developed. The distinctive feature of system is that an immittance conversion element which converts the voltage source to current source is effectively used in the inverter circuit. A resonant type gate drive circuit which enables to reduce the gate drive current is also developed. We have made a 13.56 MHz/100 W prototype and tested the operation characteristics. It is found that the proposed inverter can operate at the frequency of 13.56 MHz stably, but the conversion efficiency at high output voltage condition is lower than that we expected.

Exposure assessment for epidemiological studies on possible association between brain tumor and use of mobile phones

Masao Taki

There have been concerns about possible association between risk of brain tumors and prolonged use of mobile phones. International collaborative epidemiological study has been conducted under the coordination by International Agency of Research on Cancer (IARC). This study is a part of this project which proves means to exposure assessment in consideration of spatial distribution of specific absorption rate (SAR) of energy emitted from mobile phones. We proposed a method to estimate 3D SAR distribution in the brain from limited data of SAR obtained in the routine measurement for compliance testing. The method has been applied to Japanese case-control study, which provided an evidence that the association is unlikely to exist.

Assessment of a body area communication system with electrical coupling in consideration of electromagnetic compatibility with human body

Masao Taki

Body area network system is a communication system around the human body, which works as a transmission pathway for the electromagnetic signal. The human body affects the radiation of electric and magnetic field. The exposure of human body by this system should be assessed. In addition the effect of the system on the implanted medical devices should be examined. The electromagnetic compatibility is an important issue in this technology. We examined such various aspects of electromagnetic compatibility based on the numerical simulation with FDTD method for an electrically coupled body area network system.

Development and assessment of exposure setups for experiments on biological effects of millimeter waves

Masao Taki and Yukihisa Suzuki

It is necessary to develop exposure setup that provides well-characterized exposure conditions. We developed an exposure apparatus for 60 GHz millimeter waves for in vitro experiments. We also developed measurement system for electric constants of culture medium and cell suspension based on waveguide penetration method. Temperature measurement by using Micro-encapsulated Thermo-chromic Liquid Crystals (MTLC) was applied to experimental dosimetry of millimeter waves. It is shown that MTLC provides means to estimate SAR distribution by millimeter wave exposure.

Application of electrical gas discharges for environmental purification technologies

Fumiyoshi Tochikubo

We have studied the removal processes of nitrogen oxides (NOx) by means of selective catalytic reduction with hydrocarbons (HC-SCR) with assistance of plasma chemical reactions. In this work, we simulated the whole processes of plasma-enhanced HC-SCR for nitrogen oxides removal. The simulation model consists of plasma simulation and catalysis simulation. First, single filamentary microdischarge in dielectric barrier discharge was calculated to evaluate the radical production yield as a function of specific input energy. Second, the chemical reaction process in the discharge reactor was calculated to find the gas reforming property by the plasma. This plasma simulation was applied to NO oxidation process in atmospheric pressure $N_2/O_2/NO/C_3H_6$ mixtures under various discharge conditions. Finally, the catalytic reaction process was modeled using simple mass balance equations in gas-phase and on catalyst surface. The catalytic reaction simulation was tested for the reduction of nitrogen oxides on γ-Al_2O_3 catalyst.

Electrical gas discharge in bubbles in water is also carried out for wastewater treatment.

Numerical simulation of atmospheric pressure non-thermal plasmas

Fumiyoshi Tochikubo

We have carried out the numerical simulation for two types of non-thermal plasmas, atmospheric pressure glow discharge (APGD) with assistance of Penning ionization, and dc microplasma with noble gas flow in the atmosphere. To investigate the influence of Penning ionization on the APGD formation, effective ionization coefficient was evaluated by Boltzmann equation analysis in Ar with C_2H_4 or C_2H_2 additive. In addition, spatiotemporal structure of APGD in dielectric barrier discharge configuration, fluid simulation was carried out. To investigate the dc microplasma with noble gas flow in the atmosphere, fluid simulation was carried out for the system where He gas is flowing from a nozzle into N_2.

Fundamental investigation of dielectrophoretic effect on parasitic microorganism in emulsion

Satoshi Uchida

Emulsion is a mixture of two or more immiscible liquids. One liquid is dispersed in the other using interfacial active agents. The characteristics have made available for foods, skin lotion, medicals, detergent and so on. However, we cannot perfectly protect the applications from bacterial infection by antiseptic agents because of the appearance of drag resistant bacteria. Therefore, it is necessary to develop rapid and simple monitoring system for bacteria in emulsion. In the present work, we investigated the behavior of bacteria in emulsion using dielectrophoretic method. It was shown that frequency profiles of the collection rate of bacteria strongly depend on the viscosity and conductivity of emulsion, and the composition of oil droplet. Using electrical impedance, fluorescence area and fluorescence strength methods, we compared with their sensitivities each other quantitatively.

Numerical simulation of spatiotemporal behavior of bacteria in dielectrophoretic filter

Satoshi Uchida

Recently, various microdevices using dielectrophoretic effect have been developed and have been applied to the operation and measurement of bioparticles. However, it is difficult to determine experimentally the optimum structures for various applications and conditions. In the present work, we analyzed fundamental dielectrophoretic characteristics of modeling bacteria in the collection parts of microfilter numerically. We calculated the arrival time of bacteria on the collection parts

and clarified the existence of dead area. The dependence of collection area on operating parameters, structure factors and kinds of medium and bacteria was also shown quantitatively.

Numerical analysis of fundamental properties in microplasmas

Satoshi Uchida

Microplasmas are a kind of high-pressure and non-thermal equilibrium discharges. Since the discharges can be obtained by various generation methods, they are expected to be industrial applications. On the other hand, microplasmas easily transfer to high-density and high-temperature state because of frequent collision reactions. In the present work, we simulated the discharge structure of microplasmas and investigated the fundamental discharge characteristics under various conditions using a fluid model. In a microcell with electrode array, gas was drifted by joule heating due to ions, and the state of plasma was different by location. It was also quantitatively shown that we can reduce the mean gas temperature effectively by introducing the external flow having faster velocity than thermal convection.

A study of EMI noise of inverter circuits

Keiji Wada

Recently, design procedure of a power electronics circuit structure is discussed for high power density circuits or thin structure converters. Then the control circuit may connect close to the power circuit. When a pulse current flows into the power circuit, it radiates a magnetic field and it may produce a near field noise voltage to the control circuit. This research shows the measurement results of a near field noise voltage and the induced electromotive force of a small area loop antenna.

Development of a magnetic field generator at 20 kHz using a voltage-source inverter

Keiji Wada

This research discusses a design of a magnetic field generator at 20 kHz using a single phase inverter and a series LC resonant circuit. The design of a coil and resonant capacitors is discussed in detail. The validity of the coil design is confirmed by experimental results obtained from an experimental circuit. Moreover, a novel coil structure for generating a uniformity magnetic field is presented.

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.

The construction of the optimum design system of electromechanical devices integrated with simulation and optimization

Junichi Tsuchiya

Recently, an optimum design of electromechanical devices with Metahuristics and an electromagnetic field analysis simulator is proposed. This system has high generality and flexibility that the highly accurate electromagnetic field analysis obtained by the complex simulation can be used for optimization immediately. The optimum design system of electromechanical devices that integrates optimization and the simulation can achieve a further performance improvement of electromechanical devices.

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

Phosphorus removal and recovery from treated water of sewage disposal plants with zirconium ferrite adsorbent by superconducting high gradient magnetic separation

Daisuke Ito

Zirconium ferrite particles are good adsorbent for phosphate ion. The magnetic separation characteristics for removal of phosphate from treated water of sewage disposal plants with the adsorbent have been studied to prevent eutrophication of closed bay and pond. Very rapid magnetic filtration velocity, i.e., 106 times larger than that of percolation method, regeneration properties of the adsorbent and zero emission of excess sludge indicate that the zirconium ferrite is the excellent adsorbent for phosphorus removal and recycle from the treated water of sewage disposal plants with the superconducting high gradient magnetic separation.

Removal of radioactive heavy metal ions from solution by superconducting high-gradient magnetic separation with zirconiumferrite adsorbent

Daisuke Ito

Zirconiumferrite particles are good adsorbent for uranium ions. The magnetic separation characteristics for removal of radioactive ions, i.e. uranium and radium ions, from solution with the adsorbent of zirconiumferrite particles have been studied. By a 10 Tesla superconducting high-gradient magnetic separator, 10 ppb uranium ions in sample solution could be reduced to less than 1 ppb level successfully with the 100 ppm adsorbent addition. Adsorption time dependence for the uranium ions at pH = 7 shows that the effective adsorption sites are located on the particle surface. A different adsorption property due to pH control also suggests that the zirconiumferrite adsorbent can be recycled by the pH control of solution.

Study on structural and electrical properties of MEMS devices based on III-nitride semiconductors

Tsugunori Okumura and Seiji Nakamura

In this study, we have investigated the structural and electrical properties of $Al_xGa_{1-x}N/GaN$ heterostructure with the “micro-origami” technique. The lattice strain, bending deformation, and variations of piezoelectric charge as well as a two-dimensional electron gas (2DEG) density of $Al_xGa_{1-x}N/GaN$ were analyzed for a basic bimetal model by using the finite element method and the finite difference method. As a result, the 2DEG density at the $Al_{0.2}Ga_{0.8}N/GaN$ hetero-interface with bending by lattice strain was found to decrease approximately 37%. This result suggests that the 2DEG density is controllable in the micro-origami type of MEMS structures.

Demonstration of ppm-order hydrogen gas detection by Pd/AlGaN/GaN transistor-ased sensors

Seiji Nakamura and Tsugunori Okumura

Hydrogen is clean energy source for use in fuel cells and internal combustion engines. However, widespread use of hydrogen as a fuel will require hydrogen sensing because of its flammability and explosively. Reliable, cheap, compact, and safe hydrogen sensors are needed for monitoring ambient air for leaked hydrogen. In this study, the hydrogen sensing properties of AlGaN/GaN high electron mobility transistors with Pd gate electrodes are demonstrated for ppm-order detection in air. We found that the 1 ppm hydrogen in air can be detected by the fabricated devices as a current variation of 1.6 mA. By using the least-square fit to the experimental data, the reliable lower detection value of hydrogen concentration for the present device can be estimated to be about 0.5 ppm, i.e., a natural hydrogen concentration in the air.

Investigation of electrical properties of process-induced defects in n-GaN and n-GaAs

Seiji Nakamura and Tsugunori Okumura

For fabrication of the semiconductor devices, the plasma process is widely used. However, the plasma process often induces damages in semiconductors. In this period, we have studied the electrical properties as well as generation mechanism of defects in both n-GaN and n-GaAs exposed to fast atom beam (FAB). The increase in leakage current and decrease in carrier density were clearly observed in both n-GaN and n-GaAs Schottky diodes exposed FAB only for several tens of seconds. The behavior of FAB-induced defects has been studied by using UV light illumination and annealing techniques.

Change of spin-magnetic moment of electron in semiconductor

Shigeru Sasabe

Recently, correct value of the spin-magnetic moment of the electron due to electric current was obtained by the present authors. The current was expressed as transition matrix element between positive energy and negative energy solutions of Dirac equation. The possibility of the change of the spin-magnetic moment in the semiconductor was also pointed out. Following that results, we roughly estimated the rate of the change for the InSb-type semiconductor. We estimated the change of coulomb potential also, and examined to apply to nuclear fusion in condensed matter.

Improvement of critical current density for MgB_2 superconductor tapes fabricated by PIT process

Osuke Miura

B-rich and SiC doped MgB_2 tapes were fabricated by a modified in-situ PIT method with two stage heat treatment. B composition ratio and an amount of SiC doping were systematically changed. The effect of pre-heating and final heating conditions on Jc-B properties was also studied. Mean grain size of MgB2.8 specimens reduced to about 100 nm by increasing SiC doping 5.7%. In low fields Jc slightly increased for a little SiC doped specimens. On the other hand, in high fields Jc obviously increased with increasing SiC doping. Maximum Jc reached 1.8×10^3 A/cm^2 at 3 T, 20 K for MgB2.8 specimen doped SiC 5.7 mol%. Birr also increased with increasing SiC doping. Jc systematically increased with the decrease of temperature of pre-heat treatment. In contrast Jc systematically increased with the increase of temperature of final heat treatment. Best Jc of 8.6×10^4 A/cm^2 at 20 K, 0 T was achieved for specimen with 700 ^{o}C for 5 hours + 800 ^{o}C for 1 hour heating.

Development of high critical current density $REBa_2Cu_3O_y$ coated conductors with artificially controlled flux pinning nano-structure

Osuke Miura

A metal-organic deposition (MOD) technique is suitable for mass production of $REBa_2Cu_3O_y$ (REBCO) coated conductors because this technique is a non-vacuum and cost effective process. Especially, a MOD technique using metal-naphthenates and metal-octhenates is a relatively simple one with no removal of fluorine during the process. In addition, metal-naphthenates and metal-octhenates have the advantages of a moderate viscosity and a pyrolysis behavior so that coating and heating process are fairly easy. In this study, we have investigated the relation between surface morphology, micro structure and critical current densities REBCO films made by the MOD technique using metal-naphthenates and metal-octhenates. REBCO films were prepared by firing precursor films on $LaAlO_3$ single-crystal substrates at a low oxygen partial pressure under various heating conditions. Their properties of the REBCO films depended strongly on the heating conditions. An EuBCO film calcined at 450 ^{o}C for 20 min and fired at 830 ^{o}C for 2 h achieved high Tc of 92.0K and Jc of 1.04 MA/cm^2 at 77.3 K at self-field, respectively.

Study on superconducting rectifier using the asymmetric shaped artificial pinning centers

Osuke Miura

We started the study for development of superconducting rectifiers using the asymmetric shaped artificial pinning centers. The step-shaped grooves were introduced

as asymmetric flux pinning centers in 0.5 μm thick Nb films by the lithographic technique. In field-cooling conditions it was clarified that an addition of neodymium permanent magnets for applying magnetic fields was very important to make asymmetric critical current densities when the polarity of the transport current was changed. By measuring critical current density for Nb films with circuit-grooves with different depth, critical current densities corresponding to the pinning potential of the grooves were confirmed.

Research on resonant tunneling diodes and its ultimate monolithic device characteristics towards ultra-high frequency applications

Michihiko Suhara

Resonant tunneling diode (RTD) is a device proposed to exceed the limit of the ultra-high-speed operation by the size reduction rule of a conventional transistor. The wideband operation to the terahertz belt is theoretically possible based on the ultra-fast phenomenon of the quantum mechanical resonant tunneling. However, the reason why RTD cannot become substitution of the previous device yet in this region of research so far depends on the thing not being overcome problems shown as follows. The first is that we have not sufficiently shown ultimate device functions and characteristics of the RTD which exceed conventional devices. The second is that we should overcome the low output power problem as far as one RTD is applied. The third is that we should overcome the difficulty of the input/output separation because RTD is intrinsically two terminal devices. In this year, towards the above mentioned first target, we have done an analysis of teraherz characteristics of self- complementary antenna to monolithically integrate with RTDs and analysis of ultimate characteristics of active inductor based on RTDs.

ELECTRONIC MATERIAL AND DEVICE ENGINEERING DIVISION

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