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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

INFLUENCE OF VISCOSITY LOSS ON COUPLED VIBRATIONS OF UHF AT-CUT QUARTZ PLATES

Hitoshi Sekimoto

We numerically analyzed the influence that viscosity loss in quartz had on the unwanted coupling between fundamental thickness-shear (TS) and spurious modes. Classical mode-matching was utilized to solve the two-dimensional coupled vibrations in an AT-cut quartz plate with an inverted-mesa shape. Using this technique, we calculated the loci of admittance near the main TS response as a function of the loss factor. Also, the temperature behavior of frequency and conductance was examined for the main TS resonance. The results revealed that, for two strongly coupled vibrations of TS and spurious modes, two resonances on the real frequency-axis were combined into one with increasing loss, although there were still two resonances in the complex frequency-plane. We also found that the conductance-temperature behavior of the main TS response was more sensitive to mode coupling than the frequency-temperature behavior, and it therefore worked well as a detector of mode coupling.

RESEARCHES ON BIOELECTROMAGNETICS

Masao Taki

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

a. Exposure setups for in vitro studies have been developed to perform experiments on cellular level effects of electromagnetic fields (2.45 GHz).

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.

c. Induced current density was numerically evaluated in a human body who was exposed to magnetic field from an induction heating cooking hob.

d. 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, effect of 900 MHz electromagnetic field on melatonin synthesis in rats, promotion of N-Ethylnitrosourea induced central nervous system tumors in F344 rats, and so on.

e. Exposure associated with the use of mobile phones was assessed for epidemiological study to investigate possible link between mobile phone use and tumors in head and neck.

f. A small dosimeter was developed for a study on the characterization of power emitted

from mobile phones with automatic power control.

ACTIVE NOISE CONTROL

Masao Taki

Active noise control using magnetostrictive devices was investigated for applications to controlling noise from power transformer. The method attempts to drive the wall that transmit the sound directly, which is suggested effective in comparison with conventional loud speakers as second sources.

AUTONOMOUS ADAPTIVE PARTICLE SWARM OPTIMIZATION USING INFORMATION ABOUT GLOBAL BEST

Keiichiro Yasuda

The Particle Swarm Optimization method is one of the most powerful optimization methods available for solving global optimization problems. However, knowledge of autonomous and adaptive strategies for tuning the parameters of the method for application to large-scale nonlinear non-convex optimization problems is as yet limited. This paper describes an autonomous and adaptive strategy for tuning the parameters of the PSO method based on some numerical analysis of the behavior of PSO. The proposed autonomous and adaptive tuning strategy is based on self-tuning of the parameters of PSO, which strategy utilizes the information about the frequency of an updated global best of a swarm. The feasibility and advantages of the proposed autonomous adaptive PSO algorithm are demonstrated through some numerical simulations using two typical global optimization test problems.

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.

ABSOLUTE VIBRATIONAL DISPLACEMENT MEASUREMENTS BASED ON LASER SPECKLE METHOD WITH BURST RESONATOR DRIVING

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 g, which is mandatory for determining absolute displacement, a polynomial approximation is applied to an expression of the surface interference. This is because g is not directly obtained from general interference equations when the device being tested is excited by the burst signal. Although the sensitivity of this method is lower than that of the synchronized laser speckle system that we proposed at 2005 FCS, the simple measurement system and wide frequency range more than offset this disadvantage. The experimental results for AT-cut quartz resonators are presented.

AN SC-CUT OSCILLATOR TRACING FREQUENCY CHARACTERISTICS OF AT-CUT RESONATOR.

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 ShigeyoshiGoka

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.

VELOCITY TRACKING CONTROL OF BIPED WALKING BASED ON THE INVERTED PENDULUM MODEL

Takao Soma

A simplified control method for biped robot walking is presented. This method is simulated the way of walking of human being. Using PD control, biped walking is realized without complicated computation. this method is also characteristiced by not using tragectory planning. Consequently high flexibility in biped walking is achieved.

EXPERIMENTAL STUDY OF MODE-COUPLING STRENGTH OF AT-CUT QUARTZ RESONATORS WITH HIGH MESA STEP HEIGHT

Shigeyoshi Goka

Bi-mesa resonators with very high mesa steps were fabricated and their frequency-temperature characteristics measured as an index of the mode-coupling strength. The experimental results show that the rotation of the measured f-T data is in good agreement with the calculation in the range of low mesa step height. At large mesa step height, where the coupling strength is very low in the calculation, the measured f-T curve is quite different from the curve of the pure thickness-shear mode. These results indicate the validity of the mode-coupling and that choosing the minimal points in high mesa steps offers less advantage.

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.

DEVELOPMENT OF REAL-TIME 3D MEASUREMENT TECHNIQUE IN TEMPERATURE PROFILE AND ITS APPLICATION

Yukihisa Suzuki

Real-time 3D imaging technique in measuring temperature profile is developed with micro-capsulated thermo-chromic liquid crystal. This new method has advantage of nondestructive and noninvasive way in temperature measurement inside of materials.

We apply this method for dosimetry for biological body exposed to high frequency electromagnetic field, assessment of reliability for insulating materials under the irradiation of high energy charged particles in the space environment, and so on.

APPLICATION OF CIP SCHEME TO COMPUTATIONAL ELECTRO MAGNETIC 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.

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 created new resonators operating in 200 MHz, 2.4 GHz and 5.6-GHz 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.

ELECTRONIC-CIRCUIT AND SYSTEM ENGINEERING DIVISION

Recent Papers

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ELECTRICAL ENERGY AND APPLICATION OF ELECTRO-MAGNETICS ENGINEERING DIVISION

Research Projects

CONGESTION MANAGEMENT METHOD FOR ELECTRICITY MARKET

Ryuichi Yokoyama

After analyzing the Japanese situation of the electricity market and the transmission network, we developed methods for managing the transmission congestion. The objective of our methods is to produce a market price signal that strongly identifies the congested path. We based our approach on the market split concept and we modified to adapt it to the Japanese situation. An algorithm for the forward market and one for the spot market were translated in a computer program and tested on systems of several sizes to prove the effectiveness.

STUDY ON META-HEURISTICS APPLICATION TO AN EXPANSION PLAN OF DISTRIBUTION SYSTEMS

Ryuichi Yokoyama

In this study, we propose the new investment planning method of voltage controllers for distribution systems. It is increased to connect distributed generators to distribution systems and tend to control capital investments. Distribution systems have various configurations from the influence of geographical features. Therefore, it is required that an investment planning method can be flexible and solve within feasible time. the proposed method using meta-heuristics, which is know to find the semi optimal solution within a feasible time, is applied to a standard distribution test system to verify its practicability and performance.

ECONOMIC EVALUATION OF WIND GENERATIONS BASED ON ENVIRONMENT FACTORS

Ryuichi Yokoyama

This paper presents a wind plant economic evaluation and scenario analysis approach by taking environment factors into consideration. In order to install large-scale wind generators to power systems, active power controls by complimentary fossil fuel power generators are indispensable under the cooperation with power companies for maintaining system frequency. The new evaluation model of CO2 emission of thermal generators is proposed to regulate output fluctuations of wind generators.

VOLTAGE CONTROL METHOD ON RELIABILITY AND EFFICIENCY WITH TIME-VARYING LOADS IN CASE OF INTRODUCING DISTRIBUTED GENERATORS

Ryuichi Yokoyama

Recently, it is increased that distributed generators are introduced in distribution systems. However, it is often pointed out the issue, which is voltage variation by reverse power flow in distribution systems. Therefore, many methods have been proposed for issues. But the most of methods have not been considering time-varying loads, hence we propose voltage control method on reliability and efficiency with time-varying loads in case of introducing distributed generators.

STUDY ON RELATION BETWEEN REACTION PRODUCTS AND NOX REMOVAL CHARACTERISTICS IN PLASMA-ASSISTED SELECTIVE CATALYTIC REDUCTION OF NOX

F. Tochikubo, S. Uchida, T. Watanabe

Since the gas discharge plasma easily converts NO to NO_2, which can be reduced more actively in selective catalytic reduction with hydrocarbons (HC-SCR), the plasma-assisted HC-SCR is an effective method for NOx reduction from diesel engine exhaust gases. In this work, the relation between NOx removal and reaction products is investigated in plasma-assisted HC-SCR in simulated flue gas as parameters of gas composition, plasma specific energy and catalyst temperature. C_2H_4 is used as a hydrocarbon and commercially available Al_2O_3 is used as a catalyst. After the plasma treatment of simulated flue gas, HCHO and HCOOH were generated as by-products, while NO was effectively converted to NO_2. These by-products were confirmed to be reactive at lower catalyst temperature than C_2H_4 in HC-SCR. The relation between NOx removal and reaction products suggests that HCHO and HCOOH contribute the effective NOx reduction at low catalyst temperature in plasma-assisted HC-SCR.

GLOW DISCHARGE FORMATION OVER WATER SURFACE AT SATURATED WATER VAPOR PRESSURE AND ITS APPLICATION TO WASTEWATER TREATMENT

F. Tochikubo, S. Uchida

With the aim of wastewater treatment using active reaction of OH radicals generated in gas discharges, DC, LF(100 kHz) and RF(13.56 MHz) glow discharges were generated over water surface at saturated water vapor pressure. Low pressure glow discharge over water surface has an advantage for uniform OH radical production close to the water surface. Very stable and uniform glow discharge was obtained with RF power source. The effective OH radical production was confirmed from the strong optical emission of $OH(A^2\Sigma^+ \rightarrow X^2\Pi)$ close to the water surface. The $OH(A^2\Sigma^+ \rightarrow X^2\Pi)$ emission intensity near the water surface increased almost linearly with increase of discharge power. N,N-dimethyl-p-nitrosoaniline (RNO) solution as a persistent test pollutant was treated

by RF glow discharge over water surface. We confirmed that RNO solution was decolorized certainly by OH radicals generated in the RF glow discharge. It was found that the degradation of target compounds by OH radicals was concentrated near the water surface in the solution because very slow diffusion of target compounds limited the reaction rate.

FUNDAMENTAL PROPERTY OF CAPACITIVELY COUPLED MICROPLASMAS DRIVEN BY HIGH-FREQUENCY POWER SOURCE

F. Tochikubo, S. Uchida

Based on the pd (pressure × characteristic dimension) scaling law, microplasma is known to be a non-equilibrium plasma source with dimensions of tens to hundreds micrometers at high gas pressure. The aim of this work is to clarify the fundamental characteristics of capacitively coupled microplasmas driven by high-frequency power source, experimentally and theoretically. Breakdown voltage, electrical property, discharge morphology and optical emission of the microplasma were carefully investigated as parameters of electrode configuration, gap length and gas pressure. The use of high frequency power source showed the advantage of stable plasma formation at low applied voltage. Numerical simulation was performed for dielectric barrier micro-discharge with coplanar electrode configuration. We investigated the influence of electrode arrangement such as gap length and electrode width on the property of high-frequency driven microplasma as well as the detailed physical breakdown mechanism. The high plasma density in high-frequency driven microplasma will cause the increase of gas temperature by Joule heating through collision dominated kinetic energy exchange between charged species and neutrals. Therefore, we developed the plasma simulation code coupled with gas dynamics to evaluate the gas temperature increase and gas vortex appearance.

INFLUENCE OF PENNING IONIZATION ON HIGH PRESSURE GLOW DISCHARGE FORMATION

F. Tochikubo

The purpose of this work is to clarify the role of metastable species for high pressure glow discharge formation in rare gases. Periodic variation of metastable density in dielectric barrier discharge in Ar was measured by the laser absorption method in addition to the electrical measurement and the visual observation of discharge figures. Numerical simulation based on the fluid model was also performed under the same condition as the experiment. To evaluate Penning effect for glow discharge formation, tiny amount of ethylene is added to Ar. Ethylene addition resulted in the disappearance of filamentary discharge columns, increase of discharge current, increase of upper gas pressure limit for glow formation. The measured Ar($1s_5$) density was about $10^{10}cm^{-3}$ in

the center of the discharge, and ethylene addition induced the decay of Ar($1s_5$). Reaction rate coefficient between Ar($1s_5$) and ethylene was roughly estimated to be 1.2×10^{-10} cm^3s^{-1}. The numerical simulation showed that Penning ionization was dominant to sustain the discharge with ethylene addition into Ar while electron impact ionization was dominant in pure Ar.

ANALYSES OF FUNDAMENTAL PROPERTIES IN MICROPLASMAS EXCITED BY RADIO FREQUENCY:

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 radio-frequency excited microplasmas under various conditions and analyzed the fundamental discharge characteristics. Moreover, the critical frequency of breakdown voltage was derived from the classical discharge theory. The value almost agrees with the present numerical results.

HIGH-SPEED DETECTION OF BACTERIA BY DIELECTROPHORETIC TECHNIQUE:

Satoshi Uchida

Explosion of hospital infection and epidemic food poisoning by malignant bacteria is one of the most serious problems in the contemporary society. Therefore, full-time monitoring of bacteria is come under review to prevent the infection from occurring. However, the effective technique with fast detection and high selectivity for bacteria has not established at this moment. In this work, we developed a monitoring system of bacteria by dielectrophoretic concentration and impedance measurement. Adherent fragments were not almost observed on the surface of detecting cell with an interface affinity agent. By adequate regulation of the flow rate and driving frequency, Escherichia coli and was detected quickly. Moreover, specific time constant for each bacteria was obtained by rapid change of applied voltage.

A SHUNT HYBRID FILTER FOR HARMONIC COMPENSATION OF A THREE-PHASE DIODE RECTIFIER WITH A CAPACITIVE

Keiji Wada

This study discuses static and dynamic performance of a shunt hybrid filter applied to a 400-V transformerless ac-to-dc power conversion system. The hybrid filter is formed by a passive filter consisting of an LC filter tuned at the 7th-harmonic frequency, and a small-rated three-phase voltage-source PWM inverter. The control system of the

fully-digital-controlled PWM inverter is based on feedback and feedforward control. The validity of this system is confirmed by experimental results obtained from a 400-V, 15-kW laboratory system. The experimental results show that the hybrid filter brings a significant reduction in ac current harmonics to the power conversion system.

DYNAMIC BEHAVIOR OF A BTB SYSTEM BASED ON SERIES CONNECTION OF SIXTEEN CONVERTER CELLS UNDER A SINGLE-LINE-TO-GROUND FAULT CONDITION

Keiji Wada

This study deals with a 21 level self-commutated BTB system for the purpose of power flow control between transmission networks. The aim of this study is to do experimental verification of BTB system in term s of the control strategy and the operating performance under a single-line-to-ground fault condition.

STUDY ON A NEW TYPE SURFACE MOTOR

Junichi Tsuchiya

In recent time, Linear motors have been increased in the industrial application because it can obtain linear motion without gears and belts. Moreover, some linear surface motors that move two directions on the x-y plane, have reported and studied. We developed a new type surface motor (SFM).

This new type of SFM consists of many electromagnets as a stator and two pairs of permanent magnet 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 of this SFM is analyzed, and improved. Moreover the excitation pattern for the rotation 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 AN ELECTRONIC BALLAST WITH A BOOST-TYPE CONVERTER APPLIED TO HID LAMPS

Masato Osato

Recent developments in HID (High Intensity Discharge) lamps have increasingly been attracting interest due to their highly efficient operation and excellent color

characteristics. These lamps are suitable for various applications, including automobile headlamps and back lamps for projectors. The HID lamps exhibit negative-resistance characteristics in the operating regions, and the lamp resistance varies over time. Consequently, a current-limiting device called a 'ballast' is needed. Conventional ballasts, which operate at low frequencies (50 or 60 Hz), are not the most practical solution, due to their large size, excessive weight, and low efficiency.for. In this study, a novel type of solid-state electronic ballast is presented. This ballast can supply high frequency power (100 kHz) to a 70 W metal-halide lamp, one of the HID lamps, without an acoustic resonance. The key feature of the ballast's circuit topology is the application of a boost-type converter. The proposed circuit is composed of a reactor, a switching device, a capacitor, and an output transformer. Based on the results obtained from analyses and experiments, the proposed ballast is more useful than the conventional one.

ELECTRICAL ENERGY AND APPLICATION OF ELECTRO-MAGNETICS ENGINEERING DIVISION

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ELECTRONIC MATERIAL AND DEVICE ENGINEERING DIVISION

Research Projects

REMOVAL OF HEAVY METALS FROM SOLUTION BY HIGH GRADIENT MAGNETIC SEPARATION HGMS WITH SUPERCONDUCTIG MAGNET

Daisuke Ito

Heavy metal cleaning from polluted water is one of the challenges for us. Iron sulphide FeS particles produced by sulphate reducing bacteria are an excellent adsorbent for a wide range of metal ions in solution. In order to evaluate the applicability for the FeS adsorbent to the radioactive ions in solution, we studied adsorption characteristics to uranium ion. Magnetic component of the FeS particles were collected with an open gradient magnetic separator OGMS and adsorbed uranium ion in a well-water at Ningyou-toge uranium mine to the magnetic FeS adsorbent could remove by the technology of the high gradient magnetic separation HGMS successfully.

The magnetic iron sulphide particles were produced by the sulphate reducing bacteria Desulfovibrio Vulgaris Miyazaki. By a 10 Tesla superconducting high gradient magnetic separator HGMS, 6.3 ppb uranium in solution in water extracted from an well at Ningyo-Toge mine could be reduced to 0.66 ppb by the 100 ppm adsorbent addition. Adsorption characteristics for the isotopes, i.e., U-234, U-235 and U-238 ions, were also studied.

ISSUES ON BASIC PROCESS TECHNOLOGY FOR GAN-BASED ELECTRON DEVICES

Tsugunori OKUMURA

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. Therefore, it is important to fabricate GaN devices without surface damages. In this study, photoelectrochemical processes have been studied for low damage GaN devices process. In addition, the electrical properties as well as generation mechanism of defects in n-GaN introduced during plasma process have been studied.

It was demonstrated that GaN surfaces were etched smoothly and controllably by photoeletrochemical etching. In addition, Schottky barrier diodes with high device performance were realized by electrodepositing Ni on n-GaN.

On the other hand, 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 an reverse bias annealing or ultraviolet illumination.

SPIN-MAGNETICMOMENT G-FACTOR OF DIRAC ELECTRON OBTAINED BY HUANG'S EXPECTATION VALUE

Shigeru Sasabe

The correct g-factor of the Dirac electron is obtained. We evaluate the magneticmoment of the Dirac electron by using Huang's expectation value. The correct ratio of magneticmoment and spin (i.e. g=2) is obtained exactly. The reason why we can obtain correct g-factor is considered. We found that the negative energy state of the Dirac equation works essentially. Transition-current from positive energy state to negative energy state makes spin-mageneticmoment for the electron.

FABRICATION AND CHARACTERIZATION OF TRIPLE-BARRIER RESONANT TUNNELING DIODE BASED ON SEMICONDUCTOR HETEROSTRUCTURE AND ITS APPLICATION FOR ULTRA-HIGH SPEED OPERATION AND ANALYSIS FOR SIZE-REDUCTION RULE OF ON-CHIP INTEGRATED LOG-PERIODIC SPIRAL ANTENNAS AND SPIRAL INDUCTORS

Michihiko Suhara

Fabrication techniques and characterization of GaInP/GaAs triple-barrier resonant tunneling diode based on semiconductor heterostructure and its application for ultra-high speed operation are studied. Analysis for size-reduction rule and optimized structures of on-chip integrated log-periodic spiral antennas and spiral inductors are investigated.

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

Osuke Miura

We have been studying RE123 coated superconductors with high Jc at 77 K in high magnetic fields by using nano-structure control technology. In this study we have developed Ic- B measurment system which can measure magnetic field angle dependence of Ic up to 100 Amps at 77 K. Superconducting 10 T magnet system with persistent current mode sufficiently reduces line noise resulting in achievement of sensitive Ic criterion of 1mV/cm even in a short sample 10 mm long.

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

Osuke Miura

We have been studying critical current density improvement of inter-metallic MgB2 superconductors by using powder-in-tube method. In this study SiC doped MgB2 tapes were fabricated by PIT method to introduce low Tc phases as pinning centers into MgB2

crystals due to C substitution on B sites. Though Tc decreases with increasing amount of SiC doping, Jc increases in high fields. Irreversibility field also increased by SiC doping.

STUDY ON EPITAXIAL GROWTH OF HYDROGEN-FREE III-NITRIDE SEMICONDUCTORS BY MOLECULAR BEAM EPITAXY AND APPLICATION TO SENSING DEVICES FOR HYDROGEN GAS

Seiji NAKAMURA

Hydrogen gas is a very promising material for storage as well as transport of energy, and hence it will be utilized in our immediate surroundings. The objective of this research is to develop a robust sensing device for hydrogen gas under various surroundings. We focus attention on chemical and thermal hardness of III-nitrides. For the growth of III-nitride epitaxial layers, the metalorganic chemical vapor deposition (MOCVD) technique have mainly been used to date. However, there are a large number of hydrogen atoms in the MOCVD-grown III-nitride epitaxial layers, because hydrogen is a carrier gas or a component of metalorganic sources. Therefore, it is important to establish the growth of the hydrogen-free III-nitride epitaxial layer for the high-sensitive hydrogen gas sensor based on III-nitrides, On the other hand, a molecular beam epitaxy (MBE) is one of the crystal growth techniques without hydrogen for epitaxial layers of III-nitride semiconductors and has feasibilities or advantages in device fabrication. However, MBE-grown III-nitride films usually show poor qualities to date compared with MOCVD-grown ones. The objective of this work is to establish the optimized MBE growth process for hydrogen-free III-nitride semiconductors.

In this period, we have investigated heteroepitaxy of GaN on sapphire substrates by RF-MBE, paying attention to the process conditions on nitridation of the substrate surface and growth of the low temperature buffer layer; both are indispensable to the initial stage of the epitaxial growth of GaN highly mismatched to sapphire. The growth parameters, i.e., the substrate temperature, the processing duration, and the Ⅴ/Ⅲ ratio have been optimized by characterizing the surface morphology, the x-ray diffraction and photoluminescence as a reference. As a result, it is found that the low-temperature and long-time nitridation by using nitrogen radical source is crucial for the two dimensional growth of GaN epitaxial layers. In addition, Pd/GaN Schottky diodes were fabricated and their electrical characteristics were measured with and without hydrogen atmosphere. A thin Pd film of 20 nm was deposited on n-GaN with an electron density of $2x10^{17}$ cm^{-3}. The diode current becomes almost double under forward bias of 0.3 V by introducing hydrogen gas.

ELECTRONIC MATERIAL AND DEVICE ENGINEERING DIVISION

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