RIEC

Annual Report 2009

Research Institute of Electrical Communication, Tohoku University

Annual report of Research Institute of Electrical Communication 2009

Contents

1. Preface

I would like to express my sincere gratitude for your interest in and support for the research activities of the Research Institute of Electrical Communication (RIEC) of Tohoku University. Here, I report on the research activities that we undertook in 2009. I would sincerely appreciate any feedback you might like to provide.

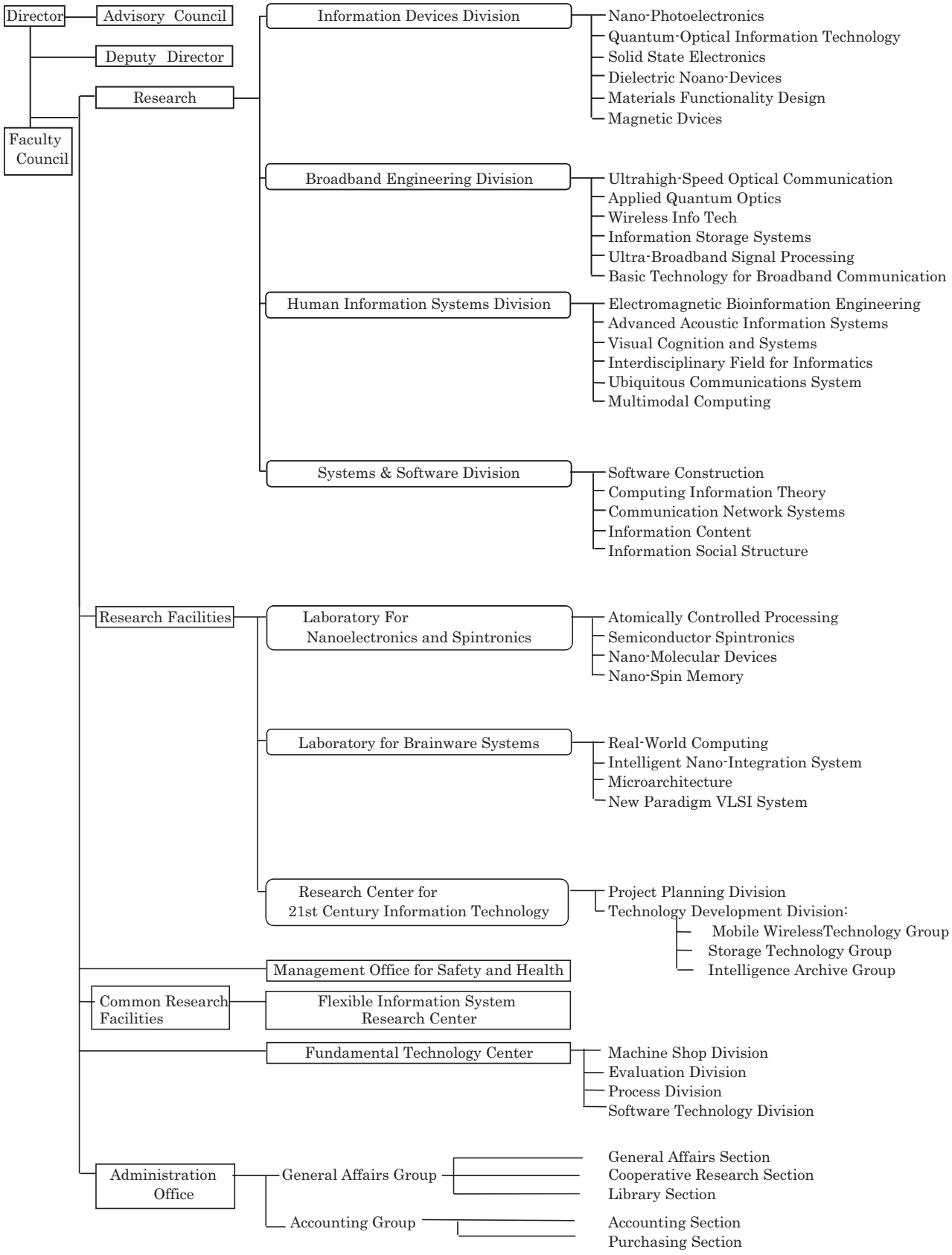
RIEC was established in 1935 as a research institute affiliated with the Faculty of Engineering, in response to pioneering work on information and communications such as the Yagi-Uda antenna and the magnetron, which were developed at the university. We have subsequently transferred our information and communications results to society, with "Research on theory and applications of intelligent information science and communication" as our mission. Close and smooth communication between people provides a foundation for the development of a society with a rich sense of humanity. The information and communication technology that supports this foundation is of increasing importance in today's information society. Thus, we have organized ourselves into four major research divisions with a 20-year perspective, two research facilities with a 10-year perspective, and a research center to realize commercialization with a 5-year perspective, which constitutes a system designed to respond quickly to social needs. Through close cooperation with the Electrical Engineering, Communication Engineering, Electronic Engineering, and Information Engineering departments in the Graduate School of Engineering, the Graduate School of Information Sciences and the Graduate School of Biomedical Engineering, we are striving to produce many international researchers and advanced engineers, while promoting cutting edge research.

The RIEC underwent a large transformation after Tohoku University was incorporated as a National University Corporation in 2004. In April 2010, we changed from a National Center for Co-operative Research to a Joint Usage/Research Center. We have to reconsider our purpose, and expose ourselves to global evaluation. At the same time, this is a chance to demonstrate clearly the importance of our institute to society. We shall accelerate technology exchanges and cooperation with industry and government through 70 cooperative projects of Types A, B, and S, and do our best to realize communication with the world around us.

We will appreciate your help and encouragement in the years to come.

Masataka NAKAZAWA,
June 28, 2010
Director, Research Institute of Electrical Communication (RIEC),
Tohoku University

2. Organization Chart



3.RESEARCH ACTIVITIES

Targets and achievements of the Information Devices Division

The main aim of the information devices division is to create new materials and devices for next generation communication technology.

To accomplish the goals of this division, we have the following 6 sub-divisions with different research fields. Furthermore, we also have a partnership with atomically controlled processing research section in the Laboratory for Nanoelectronics and Spintronics.

1. Nano-Photoelectronics
2. Quantum-Optical Information Technology
3. Solid State Electronics
4. Dielectric Nano-Devices
5. Materials Functionality Design
6. Magnetic Devices (Visitor Section)

The target and the summary of achievements of the each sub-division in 2009 are described in the following pages. In addition, about the summary of achievement of the atomically controlled processing research section will be written in the chapter of the Laboratory for Nanoelectronics and Spntronics.

Nanophotoelectronics

Exploring optical and electronic properties of nanometer-sized structures and their applications in photoelectronic devices

[Research Target and Activities]

Our main interest lies in studying the physical and chemical phenomena that take place in nanometer-scale regions and their applications in nanophotoelectronic devices. We investigate the material properties of nanostructures through their optical responses to the local excitation induced by electrons from the tip of a scanning tunneling microscope (STM), as illustrated in Fig. 1. In this year, we have successfully determined *local electronic density of states* of Ag(110) (2x1) O and *local dielectric functions* of Ni(110) (2x1) O by analyzing their STM light emission (STM-LE) spectra. A new finding is obtained concerning electron tunneling between the tip and a Au film covered by a self-assembled monolayer of thiol molecules. In order to activate various functions of each molecule at solid surfaces, its electronic isolation from the substrates is of importance. NaCl films with a monolayer thickness was successfully synthesized on Au(111) for this purpose, and their dynamics was investigated by STM. We are also interested in developing novel methods for measuring nanometer-scale surface properties. We have developed the new method that makes it possible to determine phonon energies (i.e., vibarational energies of solids) with the spatial resolution of STM. STM-LE is fundamentally weak. Hence, in STM-LE measurements one is frequently confronted with a difficulty arising from this weakness. We have found that a prism-coupled STM-LE geometry enhances tenfold the STM-LE intensities. The Finite-Differential-Time-Domain analysis, which is a numerical method for solving the Maxwell equations, was successfully applied to STM-LE spectra.

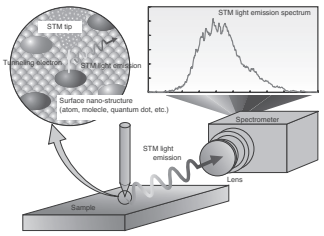


Fig. 1 STM light emission spectroscopy

[Staff]

Professor UEHARA, Yoichi Dr.
Assistant Professor KATANO, Satoshi Dr.

[Profile]

Dr. Yoichi Uehara obtained his D. Eng. degree from the Department of Engineering, University of Osaka prefecture in 1986, after which, he was initially appointed as an Assistant Professor at the Research Institute of Electrical Communication, Tohoku University. He eventually became a Full Professor at the institute in 2005. Dr. Uehara has worked on three main surface physics problems at Tohoku University: (1) light emission from metal-insulator-metal and metal-oxide-semiconductor (MOS) tunnel junctions, (2) low-energy electron spectroscopy, and (3) light emission spectroscopy of STM.

[Papers]

[1] Y. Hirata, K. Sakamoto, Y. Uehara, and S. Ushioda, "Tip-enhanced Raman scattering spectroscopy of nanometer-scale domains in Ni(110)-(2x1) O surface", Jpn J. Appl. Phys. **48**, 110206 (2009).
[2] Y. Uehara, M. Kuwahara, S. Katano, and S. Ushioda, "Scanning tunneling microscope light emission spectra of polycrystalline $Ge_2Sb_2Te_5$ and Sb_2Te_3", Solid State Commun. **149**, 1902 (2009).
[3] Y. Uehara and S. Ushioda, "Local density of states of partially oxidized Ag(110) surfaces observed using scanning tunneling microscope light emission spectroscopy", Jpn J. Appl. Phys. **49**, 035702 (2010).

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Quantum Optical Information Technology

Development of optoelectronic devices for quantum information and communication technology

[Research Target and Activities]

Current information and communication technology utilizes macroscopic and classical physical quantities, such as voltage or frequency of electric fields. The classical technology will reach the limit of information density and speed in the near future. The quantum-mechanical counterpart, "quantum information processing and communication technology", in which information is carried by microscopic and quantum-mechanical quantities, is expected to overcome the difficulty.

Our goal is to develop the quantum information devices utilizing quantum interaction between electrons and photons in semiconductor nanostructures, to get further understanding of their physics, and to apply them to practical quantum information technologies. We are particularly working toward the development of future quantum information devices utilizing entangled photon pairs and electron spins in semiconductor nanostructures.

In 2009, we have achieved (1) development of novel entangled photon sources and up-conversion photon detectors using quasi-phase matched devices, (2) measurement of ultra-low-light-level optical nonlinearity in a Si wire waveguide, and (3) quantum media conversion from photons to electron spins in semiconductor quantum structures.

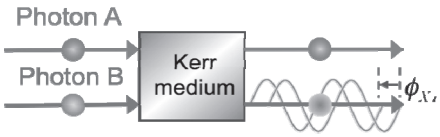


Fig. 1 Single-photon-level optical nonlinearity.

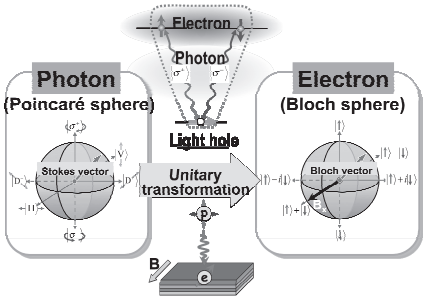


Fig. 2 Quantum media conversion from photon polarization to an electron spin.

[Staff]

Professor: EDAMATSU, Keiichi Dr.
Associate professor: KOSAKA, Hideo Dr.
Assistant professor: MITSUMORI, Yasuyoshi Dr.

[Profile]

Keiichi Edamatsu received B.S., M.S., and D.S. degrees in Physics from Tohoku University. He was a Research Associate in Faculty of Engineering, Tohoku University, a Visiting Associate in California Institute of Technology, and an Associate Professor in Graduate School of Engineering Science, Osaka University.

[Papers]

[1] Generation of cross-polarized photon pairs via type-II third-order quasi-phase matched parametric down-conversion [S. Nagano, A. Syouji, R. Shimizu, K. Suizu, H. Ito, and K. Edamatsu: Jpn. J. Appl. Phys. **48**, 050205/1-3 (2009)]

[2] Electrical measurement of a two-electron spin state in a double quantum dot [N. Yokoshi, H. Imamura, and H. Kosaka: Phys. Rev. Lett. **103**, 046806/1-4 (2009)]

[3] High-flux and broadband biphoton sources with controlled frequency entanglement [R. Shimizu and K. Edamatsu, Opt. Express **17**, 16385-16393 (2009)]

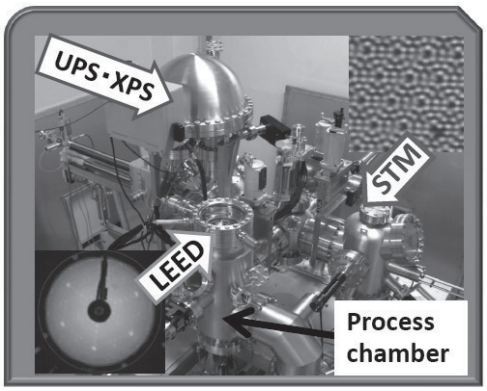
[4] All-optical phase modulations in a silicon wire waveguide at ultra-low light levels [N. Matsuda, R. Shimizu, Y. Mitsumori, H. Kosaka, A. Sato, H. Yokoyama, K. Yamada, T. Watanabe, T. Tsuchizawa, H. Fukuda, S. Itabashi, and K. Edamatsu: Appl. Phys. Lett. **95**, 171110/1-3 (2009)]

Solid State Electronics Laboratory

Ubiquitous Silicon Technology

[Research Target and Activities]

To realize the ubiquitous (or ambient intelligence) society, in which sensors and their networks are embedded in our ambience to support our daily life, a marriage between non-Si technologies suitable for environmental sensing and the Si technology suitable for signal processings is indispensable. To this goal, we investigate formation of ultrathin silicon-carbide (SiC) films on Si substrates, hoping to use them as a common interface between the two technologies. SiC is a group-IV compound that contains a pair of elements representative of both electronics (Si) and biology (C). It also bridges the gap between Si and other II-VI or III-V compounds. It is a widegap semiconductor that enables high-temperature operations. High enough strength and hardness of SiC make this material suitable for use in MEMS structures. We are developing gas-sensors, graphene-based ultrahigh-speed devices, LEDs, biosensors, MEMS structures, non-volatile memories, and photovoltaic cells based on the SiC/Si structures. What lies behind these applications is our original technology of SiC gas-source molecular-beam epitaxy (MBE) using organo-silane, which enables a high-quality, low-temperature SiC epitaxy on Si substrates. One of our most striking achievements in this field is the realization of the graphene-on-silicon structure, in which graphene, a most promising semiconducting material to be used in the next generation devices, is formed by use of surface modification of SiC/Si. Our research also covers the surface chemistry of Si-related surfaces, targeted to the control of nanostructure formation on Si and SiC surfaces. Fabrication of non-equilibrium Si structures such as amorphous-, microcrystalline-, and poly-Si thin films is also within our interests, and is being intensively investigated using atmospheric-pressure plasma-enhanced chemical vapor deposition (AP-PECVD).



The integrated system for graphene formation and analysis

[Staff]

Professor : SUEMITSU, Maki Dr.
Assistant Professor : FUKIDOME, Hirokazu Dr.
Technical Assistant : MIURA, Akemi
Postdoctoral Fellow : ALGUNO, Arnold Café Dr.

[Profile of Professor SUEMITSU]

Prof. Maki Suemitsu obtained bachelor degree on electronic enginnering (1975), Ph.D on electronic engineering (1980). He started his service at Research Institute of Electrical Communication (RIEC) as research associate (1980), and became associate professor (1990). He then became professor at Center for Inderdisciplinary Research (2003). Since 2008, he has been professor at RIEC. He has been engaged mainly on surfaces of semiconductor thin fims. He was awarded the 30 th Kumagai prize of the best paper from the Vacuum Soceity of Japan.

[Papers]

1. Epitaxial growth processes of graphene on silicon substrates, Jpn. Journal of Applied Physics, 49, (2010), pp 01AH03-1-4] H. Fukidome, Y. Miyamoto, H. Handa, E. Saito, and M. Suemitsu
2. SR-PES and STM Observation of Metastable Chemisorption State of Oxygen on Si(110)-16´2 Surface, Spring-8 Research Frontiers, 2008 (2009) pp82-83, Maki Suemitsu
3. Initial oxidation of Si(110) as studied by real-time synchrotron-radiation x-ray photomission spectroscopy, J. Vac. Sci. Technol. B27(1), (2009), pp547-550, M. Suemitsu, Y. Yamamoto, H. Togashi, Y. Enta,. Yoshigoe and Y. Teraoka

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Dielectric Nano-Devices

Research on Dielectric Nano Science and Technology

[Research Target and Activities]

Our main area of interest is evaluation and development of dielectric materials, including ferroelectric and piezoelectric materials and their application to communication devices and ferroelectric data storage systems. Our major contributions to advancement in these fields are the invention and the development of "Scanning Nonlinear Dielectric Microscope" (SNDM) which is the first successful purely electrical method for observing the ferroelectric polarization distribution without the influence of the shielding effect by free charges and it has already been put into practical use. The resolution of the microscope has been improved up to atomic scale-order. Therefore, it has a great potential for realizing the ultra-high density ferroelectric recording system.

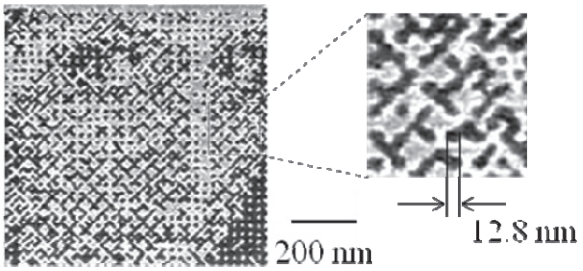

Fig.1 Digital bit data written on ferroelectric single crystal with the areal recording density of 4 Tbit/inch^2.

Major achievements of studies in 2009 are as follows: (1) Surfaces of various material (cf. silicon, titanium dioxide, strontium titanate) were observed with atomic resolution using non-contact SNDM. (2) Ferroelectric discrete track media were proposed as a novel recording method, which is expected to have improved retention characteristics. Additionally, high-accuracy servo tracking methods for ultrahigh-density ferroelectric data storage were also developed. (3) Dopant profiling method using SNDM was developed for analysis of semiconductor devices.

[Staff]

Professor : CHO, Yasuo Dr.
Assistant Professor : HIRANAGA, Yoshiomi Dr.
Assistant Professor : KIN, Nobuhiro
Technical Official : WAGATSUMA, Yasuo
Research Fellow : KOBAYASHI, Shinichiro Dr.
Research Fellow : OKAZAKI, Noriaki Dr.

[Profile of Professor Cho]

Yasuo Cho graduated in 1980 from Tohoku University in electrical engineering department. In 1985 he became a research associate at Research Institute of Electrical Communication Tohoku University. In 1990, he received an associate professorship from Yamaguchi University. He then became an associate professor in 1997 and a full professor in 2001 at Research Institute of Electrical Communication Tohoku University. During this time, his main research interests included nonlinear phenomena in ferroelectric materials and their applications, research on the scanning nonlinear dielectric microscope, and research on using the nonlinear dielectric microscope in next-generation ultrahigh density ferroelectric data storage (SNDM ferroelectric probe memory).

[Papers]

[1] Nobuhiro Kin,Yuhei Osa, and Yasuo Cho,"Observation of local dipole moment of Si atoms on Si (100) surfaces using noncontact scanning nonlinear dielectric microscopy", J. Appl. Phys., Vol.106, pp.014302-1-014302-5, 2009.
[2] Nozomi Odagawa and Yasuo Cho, "Dependence of long term stability on the initial radius of small inverted domains formed on congruent single-crystal $LiTaO_3$", Appl. Phys. Lett., Vol.95, pp.142907-1-142907-3, 2009.
[3] Yoshiomi Hiranaga and Yasuo Cho, "Intermittent contact scanning nonlinear dielectric microscopy", Rev. Sci. Instrum., Vol. 81, pp.023705-1-023705-5, 2010.

Materials Functionality Design

Computational Design of Functional Materials for Spintornics Devices

[Research Target and Activities]

Our research targets are as follows: (1) theoretical analyses of quantum phenomena which appear in materials and nanostructures for advanced information devices, (2) computational design of materials and nanostructures which possess new functionalities for improvement of device performance, and (3) development of new design procedures based on large-scale computational simulation techniques.

Our research activities in FY 2009 include computational materials design for spintornics as follows:
(1) Giant magnetoresistive devices using half-metallic Heusler alloys
We investigate the spin-dependent transport properties in Co_2MnSi/NM/Co_2MnSi (001) (NM = Au, Ag, Al, Cr, V) spin-valve structures theoretically on the basis of first-principles density-functional calculations. The compatibility of the Fermi surface projected onto the in-plane wave vector $k_{//}$ plays an important role in determining the interface resistance of each spin-valve. The resistance-area product in Co_2MnSi/Cr/Co_2MnSi (001) is larger of about 13 mΩμm^2 than that in Co_2MnSi/Ag/Co_2MnSi (001), which is in good agreement with recent experimental observations.

(2) New ordered alloy FeNi with perpendicular magnetic anisotropy
We investigate the magnetic anisotropy energy (MAE) of an $L1_0$-ordered alloy FeNi theoretically on the basis of first-principles density-functional calculations. The magnetization of FeNi prefers the [001] direction. While the MAE is almost unaltered against the contraction of the in-plane lattice constant, the MAE decreases remarkably with increasing the in-plane lattice constant (Fig. 1). The compressive stress arising from the lattice mismatch with buffer layers is favorable for achieving larger MAE in FeNi thin films.

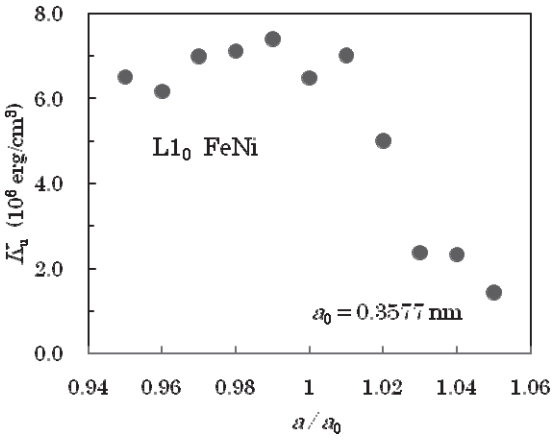

Fig. 1

[Staff]

Professor : SHIRAI, Masafumi Dr.
Assistant Professor : MIURA, Yoshio Dr.
Assistant Professor : ABE, Kazutaka Dr.

[Profile]

Masafumi Shirai was received the Doctor of Engineering degree from Osaka University in 1989. From 1988 to 1996, he was a Research Associate, and then an Associate Professor at Osaka University. From 2002 to the present, he has been a Professor at Tohoku University. Now his research interest is focused on computational design of functional materials and device structures in spintronics.

[Papers]

[1] M. Shirai, Y. Miura, and K. Abe, "First-principles calculations of half-metallic Heusler alloys: The effect of atomic disorder and interfaces", Epitaxial Ferromagnetic Films and Spintronic Applications, eds. A. Hirohata and Y. Otani, ISBN 978-81-308-0319-7, pp. 187-205, Research Signpost, 2009.
[2] T. Kanomata, Y. Kitsunai, K. Sano, Y. Furutani, H. Nishihara, R. Y. Umetsu, R. Kainuma, Y. Miura, and M. Shirai, "Magnetic properties of quaternary Heusler alloys $Ni_{2-x}Co_xMnGa$", Phys. Rev. B, Vol. 81, No. 21, Article no. 214402, pp. 1-6, 2009.
[3] Y. Miura, K. Abe, and M. Shirai, "Half-metallic behavior of Co_2MnSi/Co_2MnAl/MgO interface and its coherent tunneling conductance", J. Phys.: Conf. Series, Vol. 200, Article no. 052016, pp. 1-4, 2010.

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Broadband Engineering Division: Research Target and Results

In order to establish the future broadband communication systems and novel devices that are flexibly applied to the future ubiquitous ultra-large capacity information communication, research and development are carrying out over the wide bands of microwaves, millimeter/submillimeter waves, terahertz waves, and lightwaves with regard to the information generation, transmission, processing, storage, and semiconductor spintronics technologies.

(1) Wireless Information Technology

Research and development in wireless information technology are progressing toward Dependable Air for the next decade's wireless systems. To realize the Dependable Air, we are interested in developing the hybrid single-carrier and multi-carrier technique and LSI development of frequency domain equalization (FDE).

We are also actively engaged in work on following technologies for broadband, low-power consumption and small-size terminals; RF-CMOS power amplifier and synthesizer devices for millimeter-wave-band wireless modems, and GHz-band film bulk acoustic resonator (FBAR) filter and oscillator.

(2) Ultra-Broadband Signal Processing

We are developing novel, integrated electron devices and circuit systems operating in the terahertz region. One of our major concerns is a new material called “graphene,” a single-layered honeycomb-lattice carbon crystal. We have fabricated a graphene-channel FET utilizing heteroepitaxial graphene-on-silicon (GOS) material (provided by the group of Prof. Maki Suemitsu in RIEC) and demonstrated excellent electron drift mobility 20 times as high as that in Si MOSFETs.

We also succeeded in observation of amplified stimulated terahertz emission from femtosecond infrared laser-pumped GOS material. The results reflect the occurrence of the negative dynamic conductivity that has been theoretically predicted by our group, leading to realization of a new type of terahertz lasers.

(3) Ultrahigh-Speed Optical Communication

To achieve a global high-capacity optical network, we have been engaged in the research on ultrahigh-speed Optical Time-Division Multiplexing (OTDM) transmission and highly spectral-efficient coherent Quadrature Amplitude Modulation (QAM) transmission.

As regards the ultrahigh-speed transmission, 640 Gbit/s/channel DPSK signal was successfully transmitted over 525 km in a single polarization by using a novel ultrafast time-domain optical Fourier transformation technique. In coherent optical transmission,

we successfully achieved a QAM multiplicity as high as 256, and demonstrated a 64 Gbit/s transmission over 160 km with an optical bandwidth of 5.4 GHz. This indicates the possibility of a spectral efficiency exceeding 11 bit/s/Hz.

(4) Applied Quantum Optics

Novel functional semiconductor photonic devices are investigated to explore new generation photonic network systems. Ultra-broadband coherent terahertz (THz) wave radiation, called as "Tera-Photonics," is also studied.

Ultra-high-speed operation of semiconductor photonic active devices is being investigated. It is confirmed that the bandwidth can be broadened drastically to some tens of GHz by a novel passive feedback laser diode with an external cavity. Novel THz biosensors using surface plasmon resonance are also studied to achieve sensitive detection of biomolecules and THz imaging with sub-wavelength spatial resolution. High-quality THz resonators are successfully realized by using novel fabrication process.

(5) Information Storage Systems

Amount of digital information is rapidly growing year by year in this decade. High density magnetic recording technology to store the tremendous information is crucial to meet this strong demand. System technology to process data access to/from the disks plays another significant role.

For a high areal density of 2 Tbits/inch^2, a computer simulation based on LLG equation and experimental studies for high density read/write performance of perpendicular magnetic recording have been carried out. The areal density was examined with perpendicular bit patterned media. A novel storage architecture to reduce power consumption was developed and evaluated for petabyte-class large-capacity systems.

(6) Basic Technology for Broadband Communication (Mizuno Lab.)

Development of measurement instruments using the millimeter- and terahertz-wave region of the electromagnetic spectrum is the research object of this laboratory.

Passive millimeter wave imaging devices are being developed for security and medical applications. A prototype of 77 GHz PMMW imaging device was tested in-site at the Narita International Airport to demonstrate its usefulness for security applications in the fall of 2009.

(7) Basic Technology for Broadband Communication (Inutake Lab.)

Synthetic aperture radars (SAR) are useful for all-weather surveillance and rescue. In this fiscal year we have started to develop a real-time image, air-borne SAR under the research contract with Ministry of Land, Infrastructure, Transport and Tourism

(MLIT). Conceptual design of a spotlight-mode SAR system has been done, targeting at a high resolution (10 cm), small size and light weight (30-50 kg) at Ku-band, and development of a waveform synthesizer with a precise setting of delay-time has been done successfully. Scientists and engineers of universities and industries collaborate on the program.

(8) Laboratory for Nanoelectronics and Spintronics: Semiconductor Spintronics

The nanoscience and nanotechnology to control the quantum states in semiconductors, especially the spin-states and optical transitions, are investigated to realized new functional devices, such as memories and logic devices using spin states as well as quantum cascade lasers (QCL) with THz emission.

We performed direct magnetometry of electric-field effect on (Ga,Mn)As film, which showed the modulation of the Curie temperature as well as spontaneous magnetization, and elucidated the doping concentration dependence of the spin Hall conductivity of semiconductors quantitatively by systematic studies of the spin Hall effect. We also succeeded in lasing of THz-GaAs-based quantum cascade laser with a metal-metal waveguide structure, which is expected to reduce the threshold current density and raise the operation temperature.

(9) Laboratory for Nanoelectronics and Spintronics: Nano-Spin Memories

Technologies to realize advanced spin memory and logic devices using magnetic tunnel junctions (MTJs) consisting of ferromagnetic metal electrodes and insulating barriers are developing.

The TMR ratios of 78% at RT were realized in MgO-based MTJs with perpendicular anisotropy CoFe/Pd multilayers and CoFeB or Fe insertion. The TMR ratio of 122% at RT with RA =1.0 $\Omega\mu m^2$ were obtained in CoFeB/MgO/CoFeB MTJs. Operations of the world's first 32Mb SPRAM chip, ternary content-addressable memory, Lookup-Table employing the spin-transfer torque MTJs were verified.

Research Area of Ultrahigh-Speed Optical Communication

Advanced optical communication technologies approaching the Shannon limit

[Research Target and Activities]

With the vast growth of traffic on the Internet from simple text data to high quality voice, images, and real-time video, it has become increasingly important to realize a high-capacity and high-speed network to support the daily needs of modern communications. Ultrahigh-speed optical communication is the key technology for building such an interconnected world. This laboratory aims to achieve a global ultrahigh-speed optical network in the 21 century by engaging in the research of ultrashort pulse generation and transmission.

As regards ultrahigh-speed transmission, we successfully demonstrated 640 Gbit/s/channel single-polarization DPSK transmission over 525 km, in which a time-domain optical Fourier transformation (OFT) technique was adopted for improving the system tolerance to transmission impairments due to higher-order PMD. The OFT was successfully applied to a 640 Gbit/s DPSK signal, in which the strong chirp required for the OFT of a subpicosecond pulse is realized with a phase modulator operated in a round-trip configuration. As regards multilevel coherent transmission, 256 QAM coherent optical transmission was realized for the first time with a frequency-stabilized fiber laser and an optical PLL technique (Fig. 1). In this scheme, 64 Gbit/s (polarization-multiplexed 4 Gsymbol/s, 256 QAM) data were transmitted over 160 km with an optical bandwidth of 5.4 GHz, which corresponds to a spectral efficiency of more than 11 bit/s/Hz in a single channel.

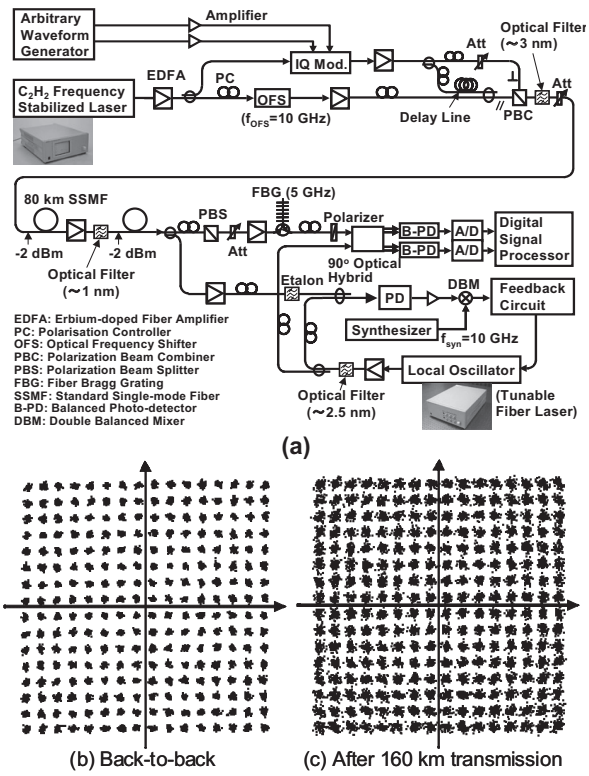

Fig. 1 256 QAM transmission setup (a) and constellations before and after transmission (b) and (c), respectively.

[Staff]

Distinguished Professor: NAKAZAWA, Masataka Dr.
Associate Professor: HIROOKA, Toshihiko Dr.
Assistant Professor: YOSHIDA, Masato Dr.
JSPS Fellow: KASAI, Keisuke Dr.

[Profile of Professor Nakazawa]

Prof. Nakazawa received a Ph. D. degree from the Tokyo Institute of Technology in 1980. In 1980, he joined the Ibaraki Electrical Communication Laboratory, Nippon Telegraph & Telephone Public Corporation. He was a visiting scientist at Massachusetts Institute of Technology in 1984-1985. In 2001, he moved to the Research Institute of Electrical Communication, Tohoku University as a professor, where he has been engaged in research on ultrahigh-speed optical communication including soliton transmission, nonlinear effects in fibers, mode-locked lasers, and photonic crystal fibers. He is the author and coauthor of over 400 journal articles and holds more than 100 patents. He is a Fellow of IEEE, OSA, and IEICE, and has received various awards including the 2002 Daniel E. Noble Award and 2005 OSA R. W. Wood Prize.

[Papers]

[1] T. Hirooka, M. Okazaki, T. Hirano, P. Guan, M. Nakazawa, and S. Nakamura, "All-optical demultiplexing of 640-Gb/s OTDM-DPSK signal using a semiconductor SMZ switch," IEEE Photon. Technol. Lett., vol. 21, no. 20, pp. 1574-1576 (2009).
[2] P. Guan, M. Okazaki, T. Hirano, T. Hirooka, and M. Nakazawa, "Low-penalty 5x320 Gbit/s/single-channel WDM DPSK transmission over 525 km using time-domain optical Fourier transformation," IEEE Photon. Technol. Lett., vol. 21, no. 21, pp. 1579-1581 (2009).
[3] M. Nakazawa, S. Okamoto, T. Omiya, K. Kasai, and M. Yoshida, "256-QAM (64 Gb/s) coherent optical transmission over 160 km with an optical bandwidth of 5.4 GHz," IEEE Photon. Technol. Lett., vol. 22, no. 3, pp. 185-187 (2010).

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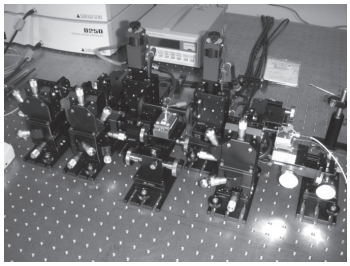
Applied Quantum Optics

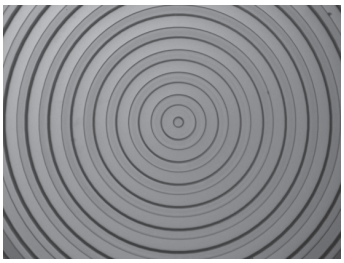
Research on Innovative Highly Functional Photonic Semiconductor Devices and Ultra-wide band coherent light sources, and their applications

[Research Target and Activities]

Novel functional semiconductor photonic devices including photonic integrated circuits are investigated to explore new-generation photonic network systems. We have also been studying ultra-broadband coherent terahertz (THz) wave radiation to explore novel science and technology, "tera-photonics".

Ultra-high-speed operation of semiconductor photonic active devices is being investigated It is confirmed by means of numerical simulation that the operation speed of laser diodes can be increased by controlling them with high speed signal light. It is also confirmed that the bandwidth can be broadened drastically by a novel passive feedback laser diode with an external cavity. Novel THz biosensors using surface plasmon resonance are also studied to achieve sensitive detection of biomolecules, high-spatial-resolution THz imaging beyond diffraction limit. High-quality THz resonators for local-field enhancement are successfully realized by using novel fabrication process.





Experimental setups for novel semiconductor photonic functional devices (left), and fabricated surface-plasmon THz-wave resonator (right)

[Staff]

Professor : YASAKA, Hiroshi Dr.
Associate Professor : SHIKATA, Jun-ichi Dr.

[Profile of Professor Yasaka]

Hiroshi YASAKA received the B.S. and M.S. degrees in physics from Kyusyu University in 1983 and 1985, and Ph.D. degree in Electronics Engineering from Hokkaido University in 1993. In 1985 he joined the Atsugi Electrical Communications Laboratories, Nippon Telegraph and Telephone (NTT) Corporation. Since then, he has been engaging in research and development on semiconductor photonic devices for optical fiber communication systems. From 2008 he has been a professor of Tohoku University. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan, the Japan Society of Applied Physics, the Physical Society of Japan, and IEEE/LEOS.

[Papers]

[1] K. Tsuzuki, Y. Shibata, N. Kikuchi, M. Ishikawa, T. Yasui, H. Ishii, and H. Yasaka, "Full C-band tunable DFB laser array co-packaged with InP Mach-Zehnder modulator for DWDM optical communication systems," IEEE Journal of Selected Topics in Quantum Electronics, vol. 15, No. 3, pp. 521-527, May/June 2009.

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Wireless Info Tech

For Realizing Dependable Air

[Research Target and Activities]

Research and development are progressing toward Dependable Air in the 21st century's wireless information technology. The Dependable Air immediately provides any information for everyone at anytime and anywhere.

For realizing the Dependable Air, we are interested in developing following wireless network; (1) next generation mobile broadband wireless access (MBWA), (2) dependable broadband wireless local area network (WLAN), and (3) ultra broadband wireless personal area network (WPAN).

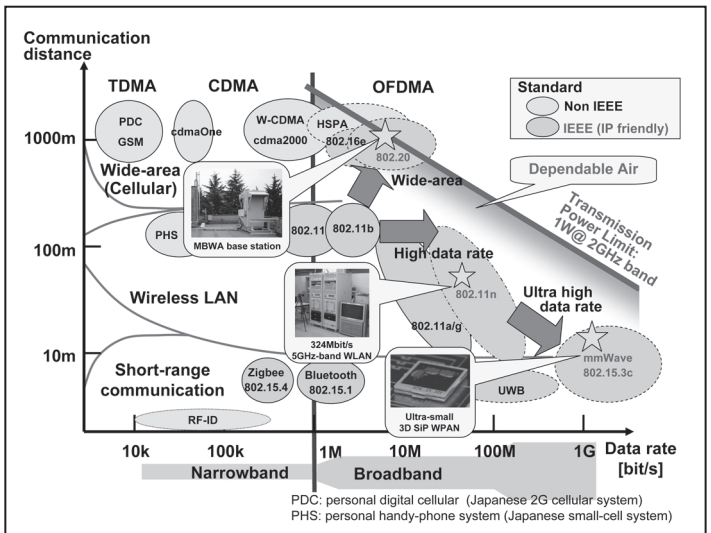

Fig. The target system of Wireless Info Tech.

In this year, we have discussed following technology for broadband, low power consumption and small size terminals; (1) RF power amplifier, synthesizer and mixer devices for millimeter wave and GHz-band wireless modems, (2) GHz-band film bulk acoustic resonator (FBAR) devices, (3) Ultra small antennas for mobile terminals, (4) Seamless interconnection technology using 3-dementional system in package (3D SiP), and (5) frequency domain equalizer (FDE) devices on application specific integrated circuit (ASIC). Moreover, we have evaluated the MBWA field trial using frequency hopping orthogonal frequency division multiple access (FH-OFDMA) system.

[Staff]

Professor: TSUBOUCHI, Kazuo, Ph. D
Assistant Professor: KAMEDA, Suguru, Ph. D

[Profile]

Prof. Tsubouchi received the Ph.D. degree in Electronics Engineering from Nagoya University in 1974. Since 1974, he has been with the Research Institute of Electrical Communication, Tohoku University. In 1982, he spent at Purdue University as a Visiting Associate Professor. He is currently the professor and the director of IT-21 Center. He received the 2005 Achievement Award from the IEICE, and “Minister of Education, Culture, Sports, Science and Technology, Award” in the Award for Persons of Merit in Industry-Academia-Government Collaboration in FY2007, et al. He is a member of the IEEE, the IEICE, the Physical Society of Japan, the Japan Society of Applied Physics, and the Institute of Electrical Engineers of Japan.

[Papers]

[1] S. Tanifuji, T. T. Thanh, S. Kameda, T. Takagi, and K. Tsubouchi, "5GHz band low phase noise Si-CMOS oscillator using FBAR", IEICE Electron. Express, vol.7, no.3, pp.165-169, 2010.
[2] S. Kameda, H. Oguma, T. Takagi, K. Tsubouchi, N. Izuka, Y. Asano, and Y. Yamazaki, "Feasibility Study of Downlink Transmission with 256 QAM Based on Results of MBWA System Field Trial," European Wireless 2009, pp.140-144, May 2009.
[3] I. Kashiwamura, S. Tomita, K. Komatsu, T. N. Hao, H. Oguma, N. Izuka, S. Kameda, T. Takagi, and K. Tsubouchi "Investigation on Single-Carrier and Multi-Carrier Hybrid System for Uplink," Proc. 20th Annual IEEE Int. Symp. Personal, Indoor and Mobile Radio Commun., Sept. 2009.

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Information Storage System

Research on Large Capacity Information Storage System Using Perpendicular Magnetic Recording

[Research Target and Activities]

Amount of digital information is rapidly growing year by year, which is projected to exceed 1000 Exa-byte (10^{21} bytes) in 2010. Extremely large storage capacity by high density magnetic recording for the information is thus required. Perpendicular magnetic recording was introduced in order to continuously develop areal density of hard disk drives beyond the conventional density limit, i.e., near future target of 1 Tbit/inch^2 and even larger than 5 Tbit/inch^2. Theoretical studies including a micromagnetic computer simulation in association with experimental approach are carried out for the next generation high density perpendicular recording.

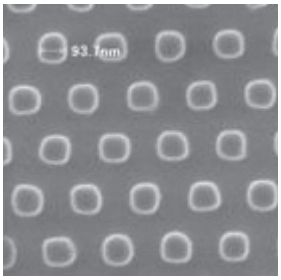

Fig 1 Fabricated bit patterned media

As we early proposed, magnetic nano-structure of recording media is the most essential parameter to achieve high density perpendicular recording. Bit-patterned medium (Fig 1) is one of promising candidates. An areal density of 2 Tbit/inch^2 was clarified to be feasible under the condition of good geographical and magnetic uniformity of the patterned dots and a writing head resolution. A shingled writing recoding with a wide track write head was also studied, which brought density increase by 50%. (Fig. 2)

In addition to the studies on magnetic recording, a novel low-power consumption architecture for the data centers in the internet was developed based on tiered operation of hard disk drives. The power reduction of 50% was confirmed from our simulation works.

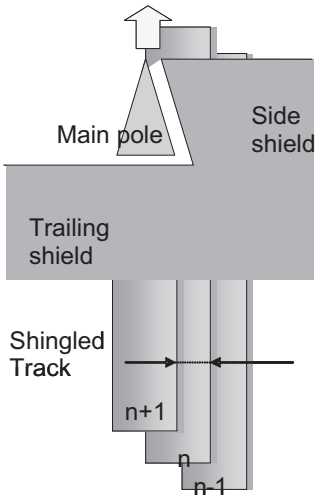

Fig 2 A proposed high field write head for shingled recording.

[Staff]

Hiroaki MURAOKA, Professor (since 2000)
Simon J. GREAVES, Associate Professor (since 2003)
Kenji MIURA, Assistant Professor (since 2003)
Sachiko KOBAYASHI, Secretary

[Profile]

In 1991, Professor Muraoka joined Tohoku University. Since then, he has been engaged in research on high-density magnetic recording devices, systems and recording theories, mainly for perpendicular magnetic recording. He received PhD degree in 1981. He is a Fellow of IEEE.

[Papers]

[1] Simon Greaves, Yasushi Kanai, and Hiroaki Muraoka, "Shingled Recording for 2–3 Tbit/in^2," IEEE Trans. Magn., 45, 10, 3823-3829, 2009. [Invited]
[2] Kenji Miura, Eiji Yamamoto, Hajime Aoi, Hiroaki Muraoka, "Estimation of Maximum Track Density in Shingled Writing," IEEE Trans, Magn. 45, 10, 3722-3725, 2009
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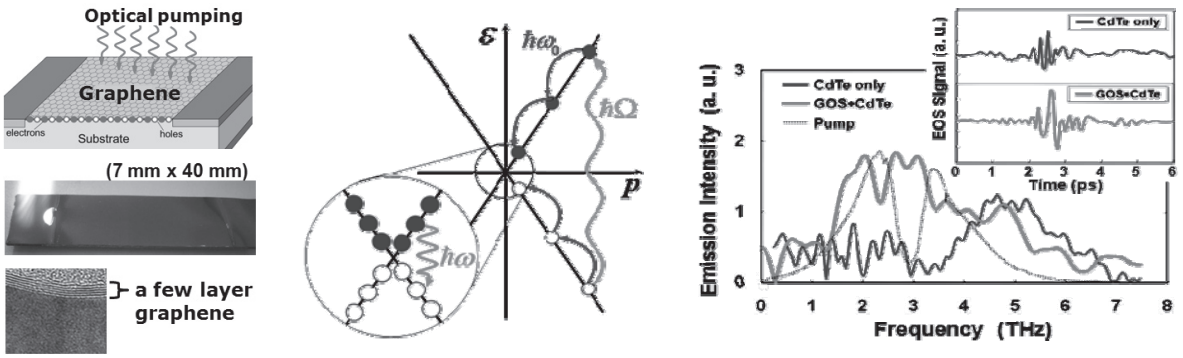
Ultra-broadband Signal Processing

Novel Millimeter-wave and Terahertz Integrated Electron Devices and Systems

[Research Target and Activities]



Carrier relaxation/recombination dynamics in optically-pumped graphene, leading to amplified stimulated terahertz emission

(Left: photo and TEM images of heteroepitaxial graphene-on-Si (GOS) sample (courtesy: Prof. Maki Suemitsu), center: intraband relaxation and radiative recombination of photogenerated electron/hole pairs resulting in emission of photons $\hbar\omega$, right: measured result demonstrating amplified stimulated terahertz emission from fs-IR-laser-pumped GOS; blue line: the incident wave, red line: emitted wave from the GOS)

We are developing novel, integrated electron devices and circuit systems operating in the terahertz (THz) region. We are pursuing new materials called "graphene," a single-layered carbon-atomic honeycomb lattice crystal featuring extraordinary carrier transport properties. We have theoretically predicted the occurrence of negative dynamic conductivity in the THz range for optically pumped graphene. Very recently we have succeeded in observation of amplified stimulated THz emission from femtosecond infrared-laser pumped heteroepitaxial graphene on Si (developed by Prof. Maki Suemitsu in RIEC). This will be the first big step ahead to a new principle THz laser. We have also succeeded in transistor operation by introducing graphene as a channel material in a Si-based FETs, demonstrating an excellent electron drift mobility by 20 times higher than that for Si MOS-FETs. The other theme includes the development of plasmon-resonant-based new type of THz emitter/detector devices.

[Staff]

Professor: OTSUJI, Taiichi Dr.
Associate Professor: SUEMITSU, Tetsuya Dr.
CREST Researcher: TAKABAYASHI, Masaru Dr.
JSPS Research Fellow: BOUBANGA TOMBET, Stephane Albon Ph.D. Secretary: UENO, Kayo

[Profile]

Prof. Taiichi Otsuji received the B.S. and M.S. degrees in electronic engineering from Kyushu Institute of Technology (Kyutech), Fukuoka, Japan, in 1982 and 1984, and the Ph.D. degree from Tokyo Institute of Technology, Tokyo, Japan, in 1994. After working for NTT Laboratories, Japan, since 1984, he joined Kyutech in 1999, as an associate professor, being a professor from 2002. Since 2005, he has been a professor at RIEC, Tohoku University, Japan. He is the recipient of the Outstanding Paper Award of the 1997 IEEE GaAs IC Symposium. He is a member of IEEE, OSA, IEICE, and JSAP.

[Papers]

[1] H. Karasawa, T. Komori, T. Watanabe, M. Suemitsu, V. Ryzhii, T. Otsuji, Dig. CLEO-Eu, CF8.3, Munich, June 2009.
[2] V. Ryzhii , A. Dubinov , T. Otsuji , V. Mitin , M.S. Shur, J. Appl. Phys., Vol. 107, pp. 054505-1-5, 2010.
[3] V. V. Popov, T. Yu. Bagaeva, T. Otsuji, and V. Ryzhii, Phys. Rev. B, Vol. 81, pp. 073404-1-4, 2010.
[4] Y. Tsuda, T. Komori, A. El Fatimy, T. Suemitsu, and T. Otsuji, J. Opt. Soc. Am. B, Vol. 26, pp. A52-A57, 2009.

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Basic Technology for Broadband Communication

Development of Measurement Instrumentation by the Millimeter and THz Wave

[Research Target and Activities]

Development of measurement instruments using the millimeter- and terahertz- wave region of the electromagnetic spectrum is the research target of this Division. Since the wavelength of this region is larger than that of the infrared and optical region, scattering by cloud, dust, flame, fabrics, skin, etc. is much smaller and since photon energy of this region is much smaller than thermal energy kTB at the room temperature, non-invasive measurement for materials is possible. In this Division passive millimeter wave imaging systems are now being developed for security and medical applications.

A prototype of 77 GHz PMMW imaging device was tested in-site at the Narita International Airport to demonstrate its usefulness for security applications in the fall of 2009.

[Staff]

Visiting Professor: MIZUNO, Koji Dr

[Profile]

Koji Mizuno was graduated from the Department of Electronic Engineering, Tohoku University, Sendai, in 1963 and was appointed Professor at the University in 1984. He was a visiting researcher at the University of London in 1972, and at California Institute of Technology in 1990. In 2004 he was appointed Professor Emeritus of Tohoku University and also Research Professor of RIEC. He is recipient of the IEEE Fellow grade in 1993, the Kenneth J. Button Medal in 1998, the Minister Award of MEXT (Ministry of Education, Culture, Sports, Science and Technology, Japan) in 2003, and IEEE MTT-Society Distinguished Educator Award in 2005.

[Paper & Book]

[1] H. Sato, K. Sawaya, an K. Mizuno, "Passive Millimeter-Wave Imaging Technology," J. Society of Instrument and Control Engineers, Vo. 48, No. 10, pp. 748-753, Oct. 2009. (in Japanese)

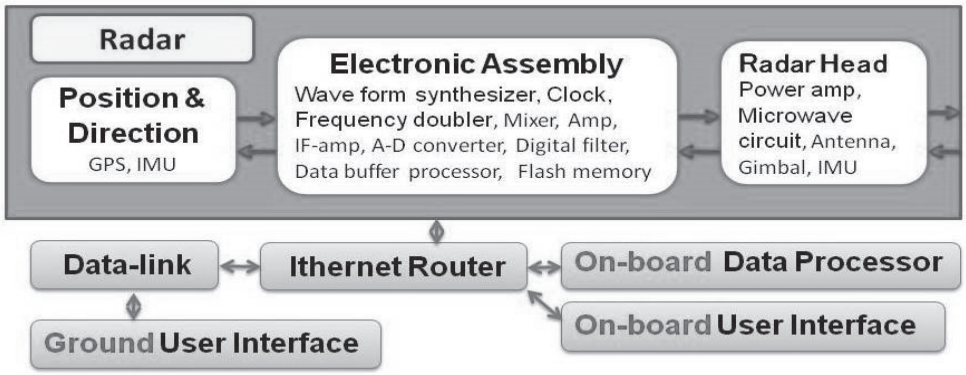
[2] K. Mizuno, in "Fundamentals of Millimeter-Wave Technologies," Institute of Electrical Engineers of Japan, pp. 280-288. Tokyo: Ohmsha, 2009. (in Japanese)

Basic Technology for Broadband Communication

High Resolution Synthetic Aperture Radar for Civilian Applications

[Research Objectives and Activities]

We are developing air-borne synthetic aperture radars (SAR) for civilian applications. The SAR is useful for all-weather surveillance and rescue in disastrous fires and smokes. Scientists and engineers from both universities and industries collaborate on this research project.



Schematic of Airborne Synthetic Aperture Radar System

Development of a high resolution (10cm), small size and light weight (30kg) SAR at Ku-band has been started in this year under the contract of Ministry of Land, Infrastructure, Transport and Tourism. Conceptual design of a real-time image-formation SAR system has been done, as shown above.

[Staff]

Visiting Professor ： INUTAKE, Masaaki Dr.

[Profile]

1966: Bachelor of Engineering, University of Tokyo.
1972: Doctor of Engineering, University of Tokyo.
1972-1974: Research Fellow, Institute of Space and Aeronautical Science, University of Tokyo.
1974-1980: Assistant Professor, Institute of Plasma Physics, Nagoya University
1980-1994: Associate Professor, Graduate School of Applied Physics, University of Tsukuba.
1994-2007: Professor, Graduate School of Engineering, Tohoku University.
2007-present: Visiting Professor, Research Institute of Electrical Communication, Tohoku University.
Researches: Microwave / laser-aided plasma diagnostics. Alfven wave physics and its applications to the wave heating of a fusion plasma and the acceleration of supersonic plasma flows in a magnetic nozzle for an advanced space propulsion. Prizes for Science & Technology (Research Category), Commendation for Science & Technology by the Minister of Education, Culture, Sports, Science and Technology, (April, 2008).

[Papers]

[1] Y. Kogi, H. Ikezi, A. Mase, M. Inutake, M. Sato, H. Hojo, "Split-beam SAR" (Applied for Patent 2009-150179).
[2] A. Mase, Y. Kogi, N. Ito, *et al.*, "Advanvement of Micro- wave Diagnostics for Magnetically Confined Plasmas", Plasma Devices Operations **17**, 98-116 (2009).
[3] X. Feng, M. Sato, Y. Zhang, *et al,* "CMP Antenna Array GPR and Signal-to-Noise Ratio Improvement", IEEE Geosci. Remote Sensing Lett. **6**, 23 -27 (2009).

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Aims and Achievements of Human Information Systems Division

Understanding the mechanisms of human information processing and realizing appropriate information communication environments are necessary for advanced information communication systems.

The aim of this division is to develop elementary and system technologies for the next generation of information communication systems that are in harmony with human and the environment. For the aim, Achievements of Human Information Systems Division covers the research fields of information creation of biological systems, information communication environments optimization and human information processing.

To achieve the aim, the division consists of the following four laboratories: Electomagnetic Bioinformation Engineering, Advanced Acoustic Information Systems, Visual Cognition and Systems, Interdisciplinary Field for Informatics, and Ubiquitous Communications System.

(1) Electomagnetic Bioinformation Engineering

(Aims) The aim of our division are to obtain the high accuracy sensor system for the signals from the human body or electric devices and to obtain the system for approaching action to the human body, by using the nano-scale controlled magnetic materials and by the development of the devices under the functions of the magnetics.

(Achievements) We proposed an extraordinary high sensitivity of the magnetic field sensor and the strain sensor by the technique of optimizing the anisotropy of the magnetic thin films. The manipulating technique for controlling the coagulation and the dispersion of the magnetic small particles, which will be used in the human body, was proposed. In addition, 3D position detecting system using magnetic markers was studied to improve its position accuracy. The study about the magnetic actuator driven by external magnetic field was carried out for micro-pump, micro-cantilevered actuator, and so on. The system supporting the medical operation under the endoscopes was studied accompanied with the medical doctors.

(2)Advanced Acoustic Information Systems

(Aims) To realize future high-definition communication systems with rich and natural sense of presence, acoustic information processing technologies based on good knowledge of human auditory system as well as multimodal perception relating to hearing are studied.

(Achievements) In 2009, we deepen the understanding human spaciotemporal perceptual processes of audio-visual and audio-vestibular information. This is particularly important to realize future multi-modal information processing and communication systems.

We clearly demonstrated that the alternation of sound location induces illusory visual motion when vision cannot provide accurate spatial information (sound-induced visuall motion: SIVM). We continued to develop methods, such as virtual auditory displays based on our accumulated knowledge of human auditory space perception, new auralization method for concert hall based on sound field simulation and sound reproduction method based on ambisonics techniques, and high-precision

analyzing method using a surrounding microphone array, to realize 3D immersive sound fields. They are keenly required to realize super-definition audio-visual communications in near future. Furthermore, we developed new signal processing algorithms of multiple description method for realizing high secrecy in voice over internet protocols (VoIP) , advanced digital hearing aids, and high-performance binaural speech enhancement providing proper spatial information.

(3) Visual Cognition and Systems

(Aims) To understand the vision-related brain functions in order to apply the knowledge to realize human oriented information communication systems.

(Achievements) We achieved results in the fields of visual attention, motion perception and color perception. Firstly, we succeeded to measure distribution of visual attention while people tracking a moving object, and the measurements showed that the visual system has difficulty to pay attention to different location other than the object tracked. This knowledge is useful to model the function of visual attention. Secondly, we showed that only slow motion detectors contribute to detection of global motion and also that it is different from the attention-based motion system. Since slow motion signals have been paid little attention both in vision and image processing, the result provided new view of role of motion signals in visual processing. Thirdly, we have clarified that color information in human visual cortex is not coded by the combinations of red-green and blue-yellow components through functional brain-imaging technique and its analysis by image-classification technique.

(4) Interdisciplinary Field for Informatics

(Aims) The interdisciplinary field of research combining nanobiotechnology and information technology attracts our exceeding interests. These studies stand on the development of new materials created by self-assembly of functional molecules and nanomaterials, leading to new classes of biosensing devices.

(Achievements) Ag nanosheet composed of AgMy is sensitive to photocatalytic reaction and changes the color from yellow to gray when the decomposition of myristate cappings and the fusion of silver cores take place. By use of Ag nanosheet as a marker, we found TiO2 nanotube anatase crystals synthesized by anodic oxidation exhibit extremely high remote photocatalytic activity. UV spectra and SEM images confirmed that only 10-20% of TiO2 nanotubes on surface decomposes the entire surface of AgNPs nanosheet. This lateral remote reaction was observed only for TiO2 nanotubes but not for commercial TiO2 powders.

(5) Ubiquitous Communications System

(Aims) The goal of ubiquitous communications is to realize communications environments in that everybody can communicate with anybody, anywhere and anytime through the research and developments on radio propagation characteristics, antennas and radio equipment with which customers can communicate universally. Towards this goal, the core technologies to realize Super Broad Band Indoor Wireless Communications, millimeter wave beam forming antenna and CMOS RF amplifier for portable terminals have been studied. Also, it is included to contribute or to lead

IEEE standardization based on “Japanese technologies.”

(Achievements) Millimeter wave beam forming antennas and RFCMOS amplifiers together with propagation characteristics have been studied and have yielded following:

1) As results of beam forming antenna with 4-elements employing discrete phase control (90 degree step), following have been clarified by computer simulations:
   i. Antenna gain variation is as small and practical as 0.9 dB,
   ii. Slot-type antenna has shown the best gain/beam performance among of the candidates studied so far,
   iii. The antenna beam can be controlled well by 11 combinations of the discrete phases for four antenna elements.
2) Based on the computer simulation results together with fixed phase shifters, a prototype slot-type antenna was fabricated and measured. The results on antenna gain and beams show good agreements with the design.
3) CMOS 60 GHz amplifiers have been challenged by Class-B operation and the computer simulations showed about 20% power added efficiency and fabricated RFIC indicated high possibility of achieving 20 % power added efficiency as well.
4) Moreover, a simulator based on ray-tracing to find out the positions and sizes of artificial reflectors to enhance communications probability has been developed.

By leading COMPA (Consortium for Millimeter wave Practical Applications, Chair: Shuzo Kato) and integrating other 17 overseas Partners (17 organizations in all) who have agreed to COMPA’s proposal, the millimeter wave standardization (IEEE802.15.3c) was completed in September, 2009. It is the first successful IEEE 802 Standardization carried out from the very beginning up to the end, managed and negotiated with many others by Japanese organizations to promote the Japanese technologies. This will be a good success example for Japanese industry to learn for the future standardization.

Electromagnetic Bioinformation Engineering

Communication with human body

[Research Target and Activities]

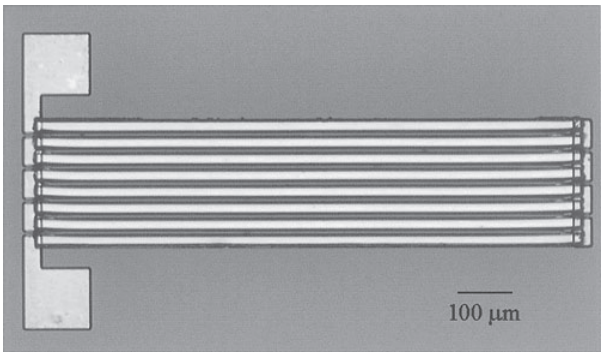

Fig.1 Sensitive magnetic field sensor

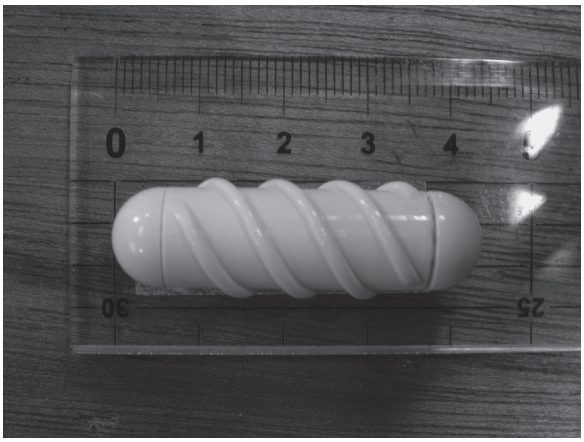

Fig. 2 Magnetic actuator for capsule-endoscope

The magnetic field sensor with very high sensitivity was produced. In this work, new processes for controlling the anisotropy of the magnetic thin films were approached and a huge change of the impedance of the sensor was obtained. On the work of wireless magnetic motion capture systems, the factors in the detection accuracy were quantitatively clarified. The magnetic actuators such as the micro-pump, and the cantilevered actuator with the magnetostrictive thin films were studied. The work for the magnetic actuator for the capsule-endoscope was carried out with a company of the medical equipments.

[Staff]

Professor: ISHIYAMA, Kazushi Dr.
Assistant Professor: HASHI, Shuichiro Dr.

[Profile of Professor ISHIYAMA]

He received his MS and PhD degrees in Electrical Engineering from Tohoku University in 1986 and 1993, respectively. He is currently working as a professor in Research Institute of Electrical Communication, Tohoku University. His research interests are in the area of magnetics and magnetic applications.

[Papers]

[1] S. Hashi, S. Yabukami, H. Kanetaka, K. Ishiyama, K.I. Arai, "Numerical Study on the Improvement of Detection Accuracy for a Wireless Motion Capture System," IEEE Trans. Magnetics, Vol.45(2009), pp. 2736-2739.
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[3] Y. Suwa, S. Hashi, K. Ishiyama, “Study of strain sensor using FeSiB magnetostrictive thin film,” IEEE Trans. Magnetics, Vol.46(2010), pp.666-669.

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Advanced Acoustic Information Systems

Development of next generation communication systems

[Research Target and Activities]

The main interest of this laboratory is a study of the information processing in the human auditory system. We are, at the same time, aiming at the realization of a 'comfortable' sound environment exploiting digital signal processing techniques. Three-dimensional sound image control by high-definition virtual auditory displays based on simulating transfer functions of sound paths from sound sources to listeners' external ears, and a sound field simulator based on precise sound field analysis and control are two examples. These systems are expected to provide a high-quality 3D virtual sound space, which is keenly required to realize in the multimedia communications, cyberspace systems and supre-definition audio-visual display systems. Moreover, in 2009, we put a lot of efforts to investigate the spatiotemporal integration process of multisensory information processing. Furthermore, in 2009, we developed new signal processing algorithms of digital watermarking, advanced digital hearing aids, and high-performance two-stage binaural speech enhancement.

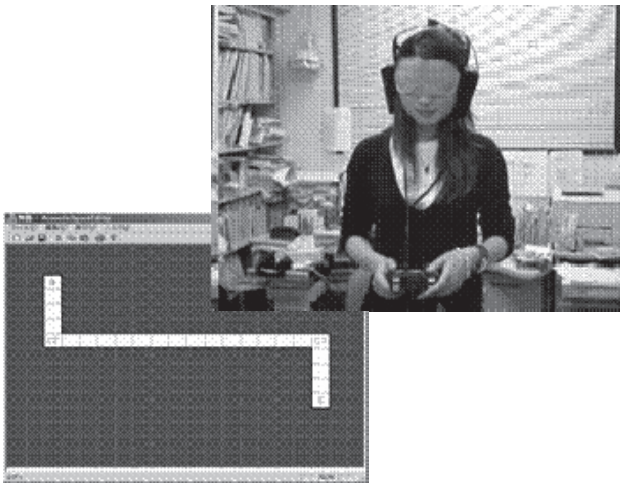


Fig. 1 Application for training spatial cognition based on high-definition virtual auditory display

[Staff]

Professor: SUZUKI, Yôiti Dr.
Associate Professor: IWAYA, Yukio Dr.
Assistant Professor: SAKAMOTO, Shuichi Dr
Technical Official: SAITO, Fumitaka
Research Fellow: CUI, Zheng Lie Dr., KOBAYASHI, Maori Dr., OKAMOTO, Takuma Dr., OTANI, Makoto Dr. and TERAMOTO, Wataru Dr.

[Profile of Professor SUZUKi Yôiti]

SUZUKI Yôiti graduated from Tohoku University in 1976 and received his Ph. D. degree in electrical and communication engineering in 1981. His research interests include psychoacoustics, high-definition auditory display and digital signal processing of acoustic signals. He received the Awaya Kiyoshi Award and Sato Prize from the Acoustical Society of Japan. He served as a president of the Acoustical Society of Japan from 2005 to 2007. He is a fellow of the Acoustical Society of America.

[Papers]

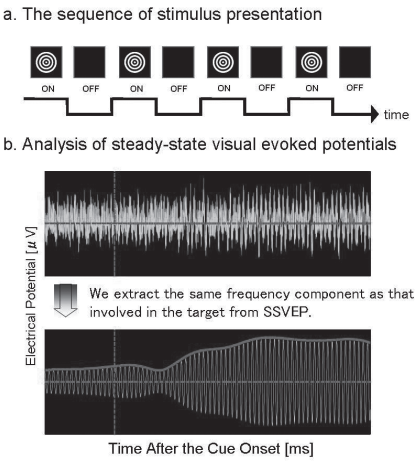
- S. Hidaka, Y. Manaka, W. Teramoto, Y. Sugita, R. Miyauchi, J. Gyoba, Y. Suzuki and Y. Iwaya: "Alternation of sound location induces visual motion perception of a static object," PLoS ONE, 4, e8188, 2009
- A. Honda, H. Shibata, Y. Iwaya, J. Gyoba and Y. Suzuki: "Transfer effects on communication and collision avoidance behavior from playing a three-dimensional auditory game based on a virtual auditory display," Applied Acoustics, 70, 868-874, 2009
- J. Li, S. Sakamoto, S. Hongo, M. Akagi and Y. Suzuki: "TS-BASE/WF: Two-Stage BinAural Speech Enhancement with Wiener filter Based on Equalization-Cancellation Model," Proc. 2009 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics (WASPAA2009), 133-136, 2009

Visual Cognition and Systems

Vision sciences for visual communication

[Research Target and Activities]

In order to realize human oriented information communication systems and visual environments gentle to humans, it is necessary to understand the functions of the human visual system. The aims of visual cognition and systems laboratories are to investigate on vision functions in the human brain and to apply the knowledge to human factors and image sciences.



1. 3D motion mechanisms

There are several processes for perception of motion in depth. We revealed the importance of interocular velocity differences. We have been studying the properties of the interocular velocity differences. We found that the specificity of spatial frequency in the 3D motion-in-depth process is different from that in the 2D motion process. This suggests that the 3D motion process is independent of spatial scale on the retina.

2. Measurement of the shift of visual attention using steady state brain wave

In order that visual attention shifts independently of gaze, we need devised ways for the measurement of the shift of visual attention. Although the property of the shift of visual attention has been examined in detail by psychophysical studies, those methods are very complicated and limited in temporal resolution. Previous studies have not been success in the measurement of the shift of visual attention. We succeeded the measurement of the shift of visual attention using the steady state visual evoked potential (SSVEP) in which brain wave is induced by a flicker stimulus consisting of temporally sinusoidal wave. We found that our method can discern the difference between transient attention and sustained attention.

[Staff]

Professor	:	SHIOIRI, Satoshi
Associate Professor	:	KURIKI, Ichiro
Assistant Professor	:	MATSUMIYA, Kazumichi
Postdoctoral fellow	:	OGIYA, Mitsuharu MATSUBARA, Kazuya

[Profile]

Professor Shioiri graduated Tokyo Institute of Technology and received Dr. Eng in 1986. He was a postdoctoral researcher at University of Montreal from 1986 to 1989. From June of 1989 to April of 1990, he was a research fellow at Auditory and Visual Perception Laboratories of Advanced Telecommunications Research Institute. He moved to Chiba University at May of 1990, where he spent 15 years as an assistant professor, an associate professor, and a professor of Department of Image Sciences Department of Image, Information Sciences and Department of Medical Systems. In 2005, he moved to Tohoku University. Since then, he has been a professor of Research Institute of Electrical Communication of Tohoku University. His research interests cover early, middle and high level vision, including motion perception, depth perception, color vision, visual attention, eye movements, modeling of visual functions and comparison of the conscious and unconscious vision processes.

[1] S. Shioiri, D. Kakehi, T. Tashiro, and H. Yaguchi: "Integration of monocular motion signals and the analysis of interocular velocity differences for the perception of motion-in-depth", *Journal of Vision*, vol. 9, no. 13, article 10, pp.1-17, 2009.

[2] S. Shioiri, and K. Matsumiya, "Motion mechanisms with different spatiotemporal characteristics identified by an MAE technique with superimposed gratings" *Journal of Vision*,vol. 9, no. 5, pp.1-15, 2009.

[3] Y. Kashiwase, K. Matsumiya, I. Kuriki, and S. Shioiri: "Comparison of the time course of attentional shifts with endogenous and exogenous controls", *Society for Neuroscience* (SfN), Chicago, USA, October, 2009.

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Interdisciplinary field for informatics

Fabrication and Application of Plasmonic Ag Nanosheet

[Research Target and Activities]

The interdisciplinary field of research combining nanobiotechnology and information technology attracts our exceeding interests. These studies stand on the development of new materials created by self-assembly of functional molecules and nanomaterials, leading to new classes of biosensing devices. The plasmons, especially the combination of surface plasmons propagating along the metal-organic interface and local surface plasmons on metal nanoparticles is crucial to control and manipulate localized light in nanoscale for nanosensing.

Our main topic, "plasmonic silver nanosheet", obtained one remarkable success in its application this year. Ag nanosheet composed of AgMy is sensitive to photocatalytic reaction and changes the color from yellow to gray when the decomposition of myristate cappings and the fusion of silver cores take place. By use of Ag nanosheet as a marker, we found TiO_2 nanotube anatase crystals synthesized by anodic oxidation exhibit extremely high remote photocatalytic activity [3]. UV spectra and SEM images confirmed that only 10-20% of TiO_2 nanotubes on surface decomposes the entire surface of AgNPs nanosheet (Fig. 1). This lateral remote reaction was found only for TiO_2 nanotubes but not for commercial TiO_2 powders(~ m). This difference in remote photocatalytic activity between the TiO_2 nanotubes and powders is probably correlate to the different life time of produced radicals produced on each surface, although a further investigation is necessary.

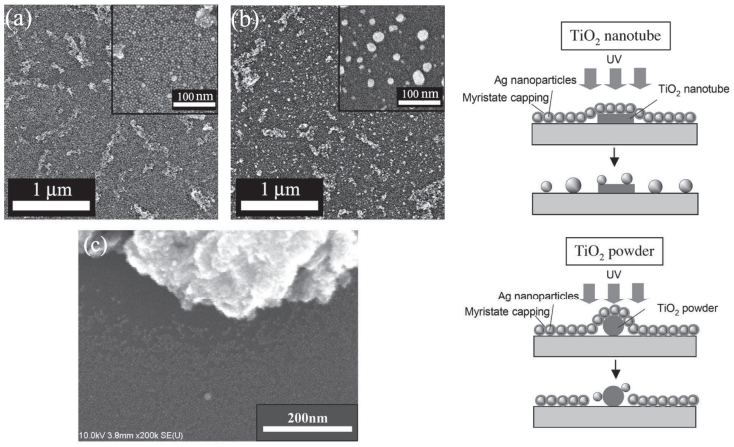

Fig. 1 SEM images of Ag nanosheet on TiO_2 nanotube-modified Si(100) wafer before (a) and after (b) 100 min UV irradiation, and that on TiO_2 powder-modified Si(100) wafer after 100 min UV irradiation (c).

[Staff]

Professor TAMADA Kaoru Dr. (from Oct. 2007)

[Profile]

1984 B.S.chemistry, Nara Women's University, 1984-1991 JSR Co. Ltd. 1991-1993 University of Wisconsin-Madison. 1994 Dr of science, Nara Women's University, 1994-1995 RIKEN frontier international program. 1995-2004 National institute of materials and chemical research (NIMC) and National institute of advanced industrial science and technology (AIST). 1997 Australian national university, 1998-1999 Max-planck institute for polymer research, 2001-2004 National University of Singapore. 2003-2004 Group Leader, Bio-photonics group, Research institute of photonics, AIST. 2005-2007 Associate professor, Department of electronic chemistry, Tokyo institute of technology. 2006-2009 Adjunct professor, Department of physics, NUS, Singapore. 2007-date Professor, Research institute of electrical communication, Tohoku university.

[Papers]

[1]Photoisomerization of azobenzene containing self-assembled monolayers investigated by Kelvin probe work function measurements, T. Nagahiro, H. Akiyama, M. Hara, K. Tamada, J. Electron Spectroscopy and Related Phenomena, 172 (1-3), 2009, 128-133.

[2] Tunable Surface Plasmon Band of Position Selective Ag and Au Nanoparticles in Thin Block Copolymer Micelle Films, H. Acharya,J. Sung, B.-H. Sohn, D.H. Kim, K. Tamada, C. Park, Chem. Mater. Chem. Mater. 2009, 214248-4255.

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Contact to Professor Kaoru TAMADA : tamada@riec.tohoku.ac.jp

Ubiquitous Communications System

Research and Development on Super Broadband Wireless Communications

[Research Target and Activities]

[Target]

The goal of ubiquitous communications is to realize communications environments in that everybody can communicate with anybody, anywhere and anytime through the research and developments on radio propagation characteristics, antennas and radio equipment with which customers can communicate universally.

[Activities]

Millimeter wave beam forming antennas and RFCMOS amplifiers together with propagation characteristics have been studied and have yielded following:

1) Based on the computer simulation results together with fixed phase shifters, a prototype slot-type antenna was fabricated and measured. The results on antenna gain and beams show good agreements with the design.
2) CMOS 60 GHz amplifiers have been challenged by Class-B operation and the computer simulations showed about 20% power added efficiency and fabricated RFIC indicated high possibility of achieving 20 % power added efficiency as well.

By leading COMPA (Consortium for Millimeter wave Practical Applications, Chair: Shuzo Kato) and integrating with other 17 overseas Partners (17 organizations in all) who have agreed to COMPA's proposal, the millimeter wave standardization (IEEE802.15.3c) was completed in September, 2009. It is the first successful IEEE 802 Standardization carried out from the very beginning up to the end, managed and negotiated with many others by Japanese organizations.

[Staff]

Professor: KATO, Shuzo Ph.D.
Associate Professor: NAKASE, Hiroyuki Ph. D.
Assistant Professor: SAWADA, Hirokazu Ph. D.

[Profile of Professor Shuzo Kato]

Prof. Shuzo Kato received his Ph. D degree in electrical and communications engineering from Tohoku University, Sendai Japan in 1977. From 1977 to 1995, he worked at NTT (Nippon Telegraph and Telephone) Research Laboratories in Japan, specializing personal and satellite communications systems R&D. He founded Pacific Communications Research Corp. focusing on ASIC, SW and system design for PCS In 1995, at the same time he served as Senior Executive Vice President, and later as President of Uniden Corporation. From January 1999 to July 2001, he served as Executive Vice President, Mitsubishi Wireless Communications Inc (MWCI) in USA, as well as President, Mobile Communications Technology Center of MWCI in San Diego, CA responsible for mobile phone technology development up to real/sellable and high yield cell phones with all certificates (FCC, CTIA and inter-operability). From 2002 to 2005, he served as Executive Vice President of Teradyne Japan responsible for P/L, Engineering, Production and Global Marketing as well as President and CEO of Omni Wireless Inc., in California, USA. He currently is Professor, Research Institute of Electrical Communications, Tohoku University, Japan, Program Coordinator, Ubiquitous Mobile Communications at NICT (National Institute of Information and Communications Technology) working on wireless communications systems R&D focusing on millimeter wave communications systems. He has been serving as Vice-chair of IEEE802.15.3c Task Group working on millimeter wave systems standardization and Chair of COMPA (Consortium of Millimeter Wave Systems Practical Applications) promoting millimeter wave systems globally. He has published over 200 technical papers, held over 75 patents (including a patent which became DOD (Department of Defense, USA) standard in 1998), co-founded International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC). He is a Fellow of the IEEE and IEICE Japan and served as an Editor of IEEE Transaction on Communications, Chairman of Satellite and Space Communications Committee, COMSOC IEEE, a Board Member of IEICE Japan.

[Papers]

1. S. Kato, H Harada, R Funada, T Baykas, C-S Sum, J. Wang, M A. Rahman , "Single Carrier Transmission for Multi-Gigabit 60-GHz WPAN Systems," IEEE J. Sel. Areas Commun., Vol. 27, No. 8, Oct. 2009.
2. S. Kato, H. Harada, F. Kojima, R. Funada, T. Baykas, C-W. Pyo, Z. Lan, C-S.Sum, J. Wang, and M. A. Rahman,"Millimeter Wave (60 GHz) Wireless PAN Standardization Activities and Super Broadband Applications," Proc. PIMRC 2009, Tokyo, Sept. 2009.
3. H. Sawada, H. Nakase, S. Kato, M. Umehira, K. Sato, Hiroshi Harada, "Millimeter-wave Propagation Characterization for Multi-gigabit Video Transmission System," Proc. APMC 2009, Singapore, Dec. 2009.

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Research Targets and Activities of Systems & Software Division

The goal of System & Software Division is to realize Ubiquitous environment. In an ideal ubiquitous environment, everyone can communicate with anybody, anywhere, with any kind of information, at any time, freely and in real time. Our division has the following five research fields related to such high-level system, software and contents by integrating computer and communication:

— Software Construction: Reliable and high-level software.
— Computing Information Theory: Fundamental theory of new software.
— Communication Network: Symbiotic computing.
— Information Content: Network-oriented contents management and utilization technology.
— Structure of Information Society (Visitor Section).

An overview of research results from Apr. 2009 to Mar. 2010 of these fields except the visitor section is described in this section.

(1) Software Construction

We have been researching on theoretical foundations for flexible yet reliable programming languages, and have been conducting a development project of SML#, a new programming language in the ML family, that embodies some of our research results such as more flexible static typing and high-degree of inter-operability with existing languages and databases. The major results of 2009 academic year include the following. (1) A type theoretical foundations for foreign function interface. We developed a type theory for functional languages that can inter-operate with polymorphic and higher-order functions defined in the C language, and developed a compilation algorithm for such a functional language based on the type theory. (2) Development of the SML# Compiler. The last year's development includes a compiler back-end that produces an x86 object file in the standard format compatible with C and other languages.

(2) Computing Information Theory

Aiming at combining program transformation methods and automated theorem proving methods, we continued to pursue the possibility of program transformation by second-order templates based on term rewriting. We proposed a second-order generalization algorithm and based on this, we implemented a method to extract second-order templates from concrete program transformations. Although many automated termination provers have been proposed recently, little work is reported on automated confluence provers. We developed an automated confluence prover ACP for term rewriting systems based on several divide-and-conquer methods such as direct sum decomposition and commutative decomposition. Applying decreasing diagram technique and incremental extension technique, we developed new methods for proving confluence of term rewriting systems. Other research results of this year include a new termination proof of simply typed S-expression rewriting

systems and a new procedure for disproving head normalization of infinity term rewriting systems.

(3) Communication Network

We have studied new management schemes for next generation ubiquitous networks (SCOPE project, 2007-2009, Ministry of Internal Affairs and Communications) and promoted standardization activities for "Network Mobility Management Information Base (NEMO-MIB)" in IETF WG. As an outcome of this work, we have succeeded in international standardization of NEMO-MIB on 14th April, 2009 (RFC 5488). We have also issued a press release on this standardization on 23rd July, 2009, which had attracted wide press coverage. In the field of "Symbiotic computing", we have refined the details of its model and architecture, and have developed some prototype systems, such as supervisory support system for elderly people (uEyes) and real/cyber integrated space (SymbioZone). We have published six papers in international journals, including one invited paper. Moreover, we had also demonstrated our systems in Forum on Information Technology (FIT2009) and RIEC open house which had attracted people from academic and industrial fields.

(4) Information Content

We have been developing creation technologies, retrieval technologies and distribution technologies for information content. We are developing DMD (Digital Movie Director), which makes it possible to generate 3DCG animation content only by text (scenario) input, and automatic human-pose estimation technology for cloth fitting room. Besides we are studying a high-performance video shot boundary detection technology, automatic video metadata generation technology and so forth. Furthermore, we are proposing a new cyclic broadcasting method and an overlay multicast technology for low-cost & high-performance video distribution.

Software Construction

Foundations for Developing High-level and Reliable Programming Languages

[Research Target and Activities]

Today's software systems are becoming more and more complicated due to the need of integrating various computation resources available in the Internet. A key to control the complexity and to enhance the reliability of such a system is to develop a high-level programming language that can directly represent various resources and automatically detect potential inconsistencies among the components in a system. Based on this general observation, our research aims at establishing both firm theoretical basis and implementation method for flexible yet reliable programming languages for advanced applications. Research topics on theoretical foundations include: logical foundations for compilation, verification of low-level code, and type-directed compilation for polymorphic languages. We are also developing a new practical ML-style programming language, SML#, which embodies some of our recent results such as *record polymorphism*, *rank1 polymorphism*, and *high-degree of inter-operability with existing languages and databases*.

The major results of 2009 academic year include the following. (1) A type theoretical foundations for foreign function interface with C. One major weakness of functional languages is the lack of inter-operability with C and other languages. To overcome this weakness, in this research, we investigated type theoretical properties of inter-operability between an ML style polymorphic language and the C language, and developed a type system for an ML-style polymorphic functional language with powerful foreign function interface. The developed type system allows an ML programmer to call C functions seamlessly without writing complicated and error-prone stab functions. The target C functions can even be polymorphic and higher-order ones. These results solve the long standing problem of the lack of inter-operability in ML-style functional languages. (2) Development of the SML# Compiler. In the last year, we developed the following methods and components. (i) A compilation method that enables SML# object files to be statically link with C library. (ii) A compiler back-end that produces x86 object files in the standard object file format so that they can be statically linked with C object files using an ordinary linker. (iii) A prototype module for seamless inter-operation with an SQL database system. The module first type-checks SQL expressions based on record polymorphism and compiles them to code that interact with an SQL database server.

[Staff]

Professor OHORI, Atsushi（2005-）

Assistant Professor UENO, Katsuhiro（2009-）

[Profile]

Professor Atsushi Ohori was born in 1957. He received his BA degree in Philosophy from University of Tokyo, 1981; received his MSE degree in Computer and Information Science from University of Pennsylvania, 1986; and received his Ph.D. degree in Computer and Information Science from University of Pennsylvania, 1989. He worked for Oki Electric Industry as a programmer, a researcher and a senior researcher from 1981 until 1993. From 1989 until 1990, he spent one year in University of Glasgow as a postdoctoral research fellow funded by Royal Society Research Fellowship. In 1993, he joined Research Institute for Mathematical Sciences, Kyoto University as an Associate Professor. In 2000, he joined Japan Advanced Institute of Science and Technology as a Professor. In 2005, he moved to RIEC, Tohoku University as a Professor.

[Papers]

[1] Liu Bochao, Atsushi Ohori, A Flattening Approach for ML Module Compilation and Implementation, Computer Software, Vol. 26, No. 3, pp 136-154, 2009.

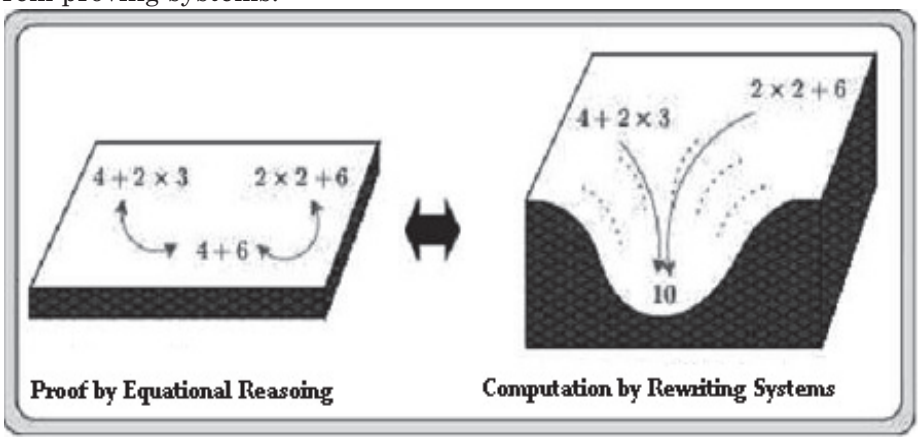
[2] Katsuhiro Ueno, Atsushi Ohori, Foreign Function Interface of SML#, Computer Software, April, 2010 (to appear) (in Japanese)

Computing Information Theory

Towards a New Software Paradigm Arising from Computation and Proof

[Research Target and Activities]

We are working on the development of a new software paradigm that arises from computation and proof. For this, we focus on a rewriting formalism which offers both flexible and effective reasoning with equations. In the rewriting formalism, proofs by equational reasoning and computations by rewriting systems can be combined in a unified framework (see the figure above). We aim at applying our new paradigm to the development of formal techniques for construction and verification of reliable software. We are currently working on rewriting theories for termination, confluence, program transformation, and program verification. Recent research activities include higher-order rewriting systems, automated inductive theorem proving, combination of functional-logic languages and automated theorem proving systems.



[Staff]

Professor : TOYAMA, Yoshihito Dr
Associate Professor : AOTO, Takahito Dr
Assistant Professor : KIKUCHI, Kentaro Dr

[Profile of Professor TOYAMA]

Yoshihito Toyama was born in 1952. He received his B.E. from Niigata University in 1975, and his M.E. and D.E. from Tohoku University in 1977 and 1990. He worked as a Research Scientist at NTT Laboratories from 1977 to 1993, and as a Professor at the Japan Advanced Institute of Science and Technology (JAIST) from 1993 to 2000. Since April 2000, he has been a professor at the Research Institute of Electrical Communication (RIEC) of Tohoku University. His research interests includes term rewriting systems, program theory, and automated theorem proving.

[Papers]

[1] Takahito Aoto and Toshiyuki Yamada, Argument filterings and usable rules for simply typed dependency pairs, In Proceedings of the 7th International Symposium on Frontiers of Combining Systems (FroCoS 2009), Trento, Italy, LNAI 5749, pp.117-132, 2009.

[2] Takahito Aoto, Junichi Yoshida and Yoshihito Toyama, Proving confluence of term rewriting systems automatically, In Proceedings of the 20th International Conference on Rewriting Techniques and Applications (RTA 2009), Brasília, Brazil, LNCS 5595, pp.93-102, 2009.

[3] Junichi Yoshida, Takahito Aoto, Yoshihito Toyama, Automating Confluence Check of Term Rewriting Systems (in japanese), Computer Software, Vol.26, No.2, pp.76-92, 2009. crexamples-080920.tgz

[4] Satoshi Shimazu, Takahito Aoto, Yoshihito Toyama, Automated Lemma Generation for Rewriting Induction with Disproof (in japanese), Computer Software, Vol.26, No.2, pp.41-55, 2009.

[5] Takahito Aoto, Sound lemma generation for proving inductive validity of equations, In Proceedings of the 28th International Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS 2008), Bangalore, India, Dagstuhl Seminar Proceedings, Vol.08004, pp.13-24, 2008

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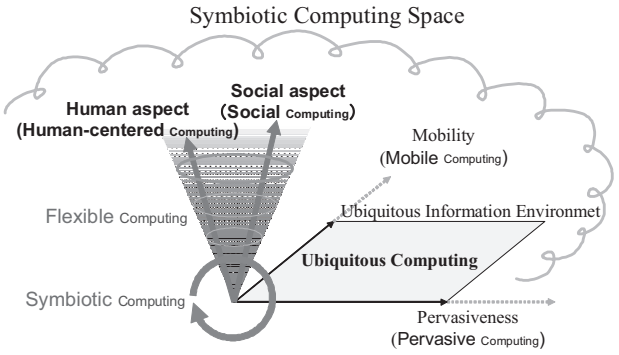
Communication Network Systems

Information Communication Systems based on Symbiotic Computing

[Research Target and Activities]

Aiming towards the next generation ubiquitous stage we are pursuing a research on information and communication paradigm, called "Symbiotic computing". The purpose of this work is to establish a method comprising of flexible information and telecommunication system with the co-existence of human and IT environment. This computing paradigm operates with stability while satisfying user and system provider's criteria. We have been promoting both theoretical and practical researches of Symbiotic computing based on the concept of flexible information network where human and IT environment co-exist. Our focus also includes performance evaluation of super-high-speed network and its efficient management.



Concept of Symbiotic Computing

(1) Symbiotic computing: Theory and application.
(2) Symbiotic society and health-care/watch-over support/real-cyber space integration
(3) Measurement/analysis of super-high-speed wide-area networks, and mobile network management.

In 2009, for Symbiotic computing research, we have studied model and architecture of Symbiotic computing in detail. We had also demonstrated our systems in Forum on Information Technology (FIT2009) and RIEC open house. For network management research, we have investigated IPv6 network mobility support and designed a MIB specialized in network mobility. We also promoted standardization activities in IETF Working Group. As an outcome of this work, we have **succeeded in international standardization** of NEMO-MIB on 14th April, 2009 (RFC 5488). We have also issued a press release on this standardization on 23rd July, 2009, which had attracted wide press coverage.

[Staff]

Professor: SHIRATORI, Norio Dr. Associate Professor: SUGANUMA, Takuo Dr.
Visiting Associate Professor: CHAKRABORTY Debasish Dr. Secretary: Kaori Moriya

[Profile]

Prof. Shiratori was bone in 1946 in Miyagi Prefecture. He received his doctoral degree from Tohoku University in 1977. He is currently a Professor at RIEC. Before moving to RIEC in 1993, he was the Professor of Information Engineering at Tohoku University from 1990 to 1993. Prior to that, he served as an Associate Professor and Research Associate at RIEC. He received IEEE Fellow in 1998, IPSJ Fellow in 2000 and IEICE Fellow in 2002. He is the recipient of many awards including, IPSJ Memorial Prize Wining Paper Award in 1985, IPSJ Best Paper Award in 1996, IPSJ Contribution Award in 2007, IEICE Achievement Award in 2001, IEICE Best Paper Award, IEEE ICOIN-11 Best Paper Award in 1997, IEEE ICOIN-12 Best Paper Award in 1998, IEEE ICPADS Best Paper Award in 2000, IEEE 5-th WMSCI Best Paper Award in 2001, UIC-07 Outstanding Paper Award in 2007, Telecommunication Advancement Foundation Incorporation Award in 1991, Tohoku Bureau of Telecommunications Award in 2002, The Commendation for Science and Technology by the MEXT, in 2009, etc. He was the vice president of IPSJ in 2002, IFIP representative from Japan in 2002, an associate member of Science Council of Japan in 2007, and president of IPSJ in 2009. He is working on methodology and technology for symbiosis of human and IT environment.

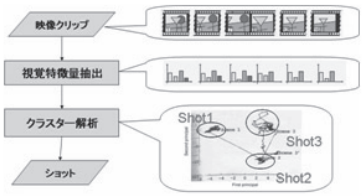
[Papers]

[1] Satoshi Utsumi, S. M. S. Zabir, and Norio Shiratori, "TCP-Cherry for satellite IP networks: Analytical model and performance evaluation," Computer Communications, Vol.32, No.12, pp.1377-1383, 2009.
[2] Satoru Izumi, Kazuhiro Yamanaka, Yoshikazu Tokairin, Hideyuki Takahashi, Takuo Suganuma, and Norio Shiratori, "Ubiquitous supervisory system based on social contexts using ontology," Mobile Information Systems (MIS), Vol.5, No.2, pp.141-163, 2009.
[3] Goutam Chakraborty, Kshirasagar Naik, Debasih Chakraborty, Norio Shiratori, and David Wei, "Analysis of the Bluetooth device discovery protocol," Wireless Networks, Vol.16, pp.421-436, 2010.

Information Contents

Creation, Understanding, Distribution and Consumption of Next-generation Digital Content

DMD



Video Shot Boundary Detection

[Research Target and Activities]

In our laboratory, we developed new technologies this fiscal year.

1, Automatic Character Positioning Method in DMD

We developed automatic character positioning method in DMD (Digital Movie Director), which is innovative and useful because user does not have to think of three dimensional CG space.

2. A Cyclic Broadcasting Method for NVoD for IPTV era

We developed a new broadcast scheduling method for end user to distribute their video content with their PC and network resources. The features of this method is to own network-error resilience.

3. An Intuitive Character Motion Creation System

In general, character motion creation is difficult to generate for most of CG creators. We developed a new system based on arrow-input interface. CG creators can generate new motions more and more easily by this system.

4. High-performance Video shot Boundary Detection Technology

Existing shot boundary detection methods are difficult to detect all of shot boundaries exactly. This is why we proposed a new approach to handle numerous video features based on multivariate statistics. This method showed our proposal to detect most of shot boundaries which existing methods are difficult to detect.

[Staff]

Professor : NUMAZAWA, Junji Dr.
Associate Professor : AOKI, Terumasa Dr.
Secretary : MUTO, Nobuko

[Profile of Professor Numazawa, Junji]

Junji Numazawa received the M.E., and Ph.D degrees in electronics engineering from Hokkaido University, Sapporo, Japan, in 1971, and 1994, respectively. He joined NHK(Japan Broadcasting Corp.) in 1971. He was Director of the Science and Technical Research Laboratories of NHK in June 1996, Director of Engineering Administration Department of NHK in June 1999, Executive Research Engineer of Science and Technical Research Laboratories of NHK in June 2002. Since 2004, he has been a Professor at the RIEC and GSIS of Tohoku University. He received "Suzuki Memorial Incentive Awards" and "Fujio Frontier Awards" of The Institute of Image Information and Television Engineers (ITE) in 1980 and 1995 respectively, "Distinguished Invited Paper Awards" of IUMRS-ICAM-93 in 1993, "Person Who Has Rendered Distinguished Service Awards" of Tokyo Metropolitan Government in 2003. Dr. Numazawa is a Fellow of the Institute of Image Information and Television Engineers (ITE).

[Papers]

[1]Terumasa AOKI, Ryo ASATO and Junji NUMAZAWA, "A Study on Jitter Analysis of Cyclic Broadcasting Schemes and Its Implementation", IEICE Trans. on Commun., Vol.J-93-B, No.1, Jan, 2010. (in Japanese)

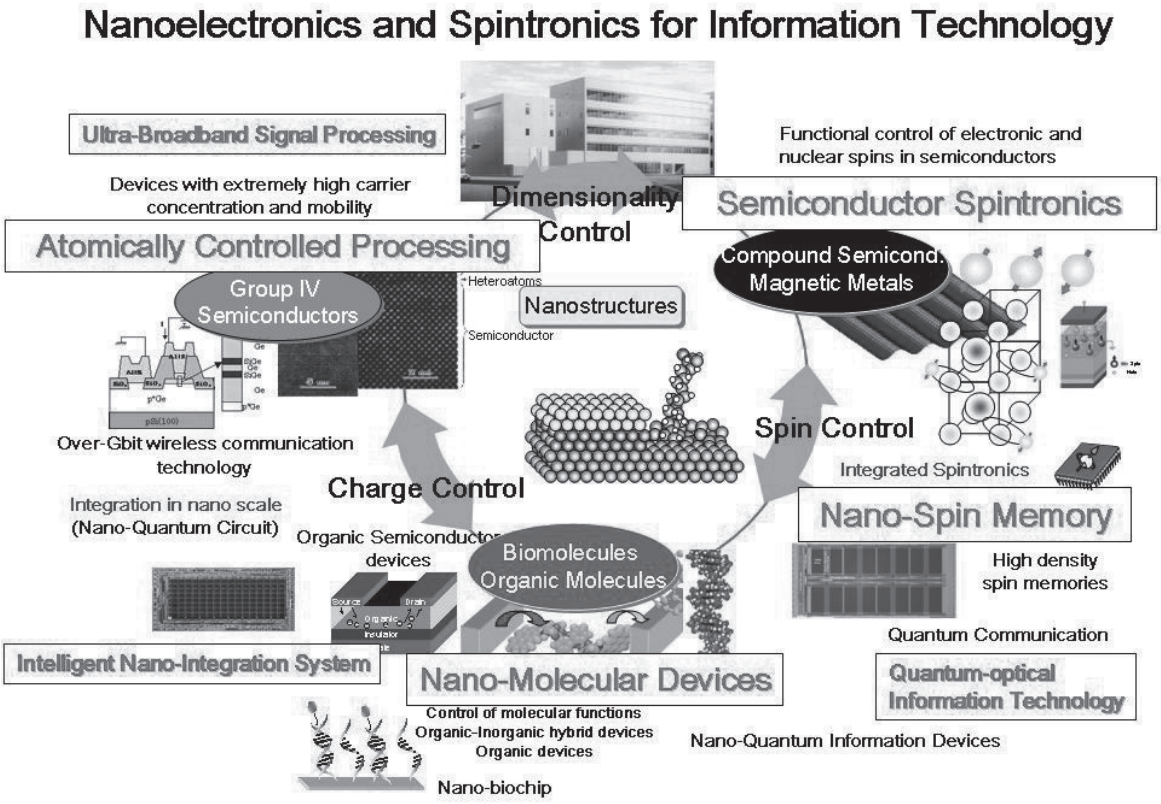
[2]Terumasa AOKI and Uwe Kowalik, "BROAFERENCE – A Prototype of an Emotion-based TV Quality Rating System", Emotional Engineering : Service Development (Chapter 12), Springer, May, 2010 (To be published).

Laboratory for Nanoelectronics and Spintronics

The Laboratory for Nanoelectronics and Spintronics of the Research Institute of Electrical Communication was established in 2004. Its purpose is to develop and establish the science and technology of nanoelectronics and spintronics for information technology, utilizing the facilities installed in the Nanoelectronics-and-Spintronics building having 1300 m^2 of cleanroom area. The Laboratory for Nanoelectronics and Spintronics consists of four Sections:

Atomically Controlled Processing (Junichi Murota, Professor)
Semiconductor Spintronics (Hideo Ohno, Professor)
Nano-Molecular Devices (Michio Niwano, Professor)
Nano-Spin Memory (Shoji Ikeda, Associate Professor)

These Sections cooperatively carry out the research aimed at establishing nanoelectronics and spintronics, together with the groups of Intelligent Nano-Integration System (Koji Nakajima, Professor), Quantum-optical Information Technology (Keiichi Edamatsu, Professor), and Ultra-Broadband Signal Processing (Taiichi Otsuji, Professor) and with the research groups of the Institute, the Graduate School of Engineering, the Graduate School of Information Science, Tohoku University, and nation-wide cooperative research projects in the field.



Highlights of Research Activities in 2009:

Atomically Controlled Processing [Murota Laboratory]

In order to create atomically controlled processing for nanometer-order artificial heterostructures of group IV semiconductors, following experimental results have been obtained: (1) In the research on P atomic-layer doping, low-temperature Si epitaxial growth by reaction of Si_2H_6 as a higher reactivity gas enables higher P concentration. (2) By heavy C atomic-layer doping at heterointerface between a Si cap layer and a $Si_{0.55}Ge_{0.45}$ layer in Si/$Si_{0.55}Ge_{0.45}$/Si(100) heterostructure, the intermixing between Si and Ge at heterointerface is effectively suppressed. (3) In the research on B atomic-layer doping in Si by using a plasma CVD without substrate heating, it is clarified that lowering of the plasma energy effectively suppresses a plasma induced lattice damage and a surface B reduction, and it becomes quite important to achieve heavy B atomic-layer doping in a nanometer-order ultrathin Si film.

Semiconductor Spintronics [Ohno Laboratory]

Our research activities focus on the establishment of the fundamental technologies for future spintronic devices. The outcomes in the last fiscal year are following. (1) We performed the direct magnetometry of electric-field effect on (Ga,Mn)As thin film and observed the modulation of the Curie temperature as well as spontaneous magnetization. (2) Doping concentration dependence of the spin Hall conductivity of semiconductors was quantitatively obtained by systematic studies of the spin Hall effect using scanning Kerr microscope. (3) We demonstrated GaAs THz quantum cascade laser emission with threshold current density of 0.8 kA/cm^2 and maximum operation temperature of 146 K.

Nano-Molecular Devices [Niwano Laboratory]

(1) We have fabricated P3HT organic transistors using an ionic liquid to observe its high operating current as compared to the conventional organic field effect transistors. We monitored *in-situ* the chemical state of the P3HT active layer during FET operation using infrared absorption spectroscopy, and found that the ionic-liquid-based P3HT transistors are operated by electrochemical doping. (2) We have succeeded in fabricating a thin film of TiO_2 nanotubes on a glass substrate by anodizing a metal titanium film deposited on the substrate in an NH_4F-based organic electrolyte. (3) Planar bilayer lipid membranes (BLMs) were formed in microfabricated apertures in Si chips. We have succeeded in preparing BLMs which are stable enough for repetitive solution exchanges and electric stress, and demonstrated that electric noise was suppressed by coating the chip surface with dielectric layers. (4) BLMs with channel proteins were formed in nanoholes of an anodic porous alumina film. We demonstrated that these BLMs exhibited improved mechanical and electric stability compared to BLMs formed in the conventional Teflon films.

Intelligent Nano-Integration System [Nakajima Laboratory]

(1) We proposed a discrete-type inverse function delayed neural network with high-order synapse connections and demonstrated its usability for combinatorial optimization problems by stability analysis on solution states. Moreover, we expanded our new analysis on nonlinear dynamics to a coupled nonlinear system, and burst firing dynamics was successfully generated by using a coupled BVP model. (2) We analyzed the resonant activation property of a Bi-2212 intrinsic Josephson junction and found possible reasons for degradation of the quality factor Q. In order to gain a better Q factor, we designed a filter circuit for suppressing high frequency noise in bias lines and a line for feeding microwave. (3) To improve the performance of high-speed operation for the single flux-quantum fast Fourier transform, a carry look-ahead adder was fabricated using Nb integrated circuits. The high-speed operation of the adder circuit was successfully demonstrated up to 30GHz. A neural network using superconducting quantum interference devices for solving a combinatorial optimization problem was proposed and numerically demonstrated.

Quantum-Optical Information Technology [Edamatsu Laboratory]

1. We have demonstrated that quantum state is transferred from photons to electron spins in a semiconductor. This demonstration opens up an avenue to quantum media conversion between multiple quantum media such as superconducting qubit, nuclear spin qubit, and ion qubit.

2. We have developed the technique of heterodyne Kerr rotation spectroscopy for ultra-high sensitivity measurement of the spin state in semiconductor quantum structures. We have demonstrated the measurement of Kerr rotation induced by an exciton in a single quantum dot.

Nanospin Memory [Ikeda Laboratory]

We are developing technologies to realize advanced spin memory and logic devices using magnetic tunnel junctions (MTJs) consisting of ferromagnetic metal electrodes and insulating barriers. In our group, the following results were obtained: 1) The TMR ratios of 78% at RT were realized in MgO-based MTJs with perpendicular anisotropy CoFe/Pd multilayer electrodes and bottom CoFeB and top Fe insertion layers. 2) For the CoFeB/MgO/CoFeB pseudo spin valve MTJs with *in-situ* annealing, high TMR ratios were observed in the lower resistance area product (*RA*) range. The TMR ratio of 122% at RT with RA=1.0 Ωμm^2 were obtained. 3) Operations of the world's first 32Mb non-volatile random access memory (SPRAM) chip, ternary content-addressable memory (TCAM), Lookup-Table employing the spin-transfer torque MTJs with synthetic ferrimagnetic free layer were verified.

Ultra-Broadband Signal Processing [Otsuji Laboratory]

The goal of our research is to explore the terahertz frequency range by means of novel electron devices and systems. Graphene has mass-less carriers and their peculiar characteristics are expected to be useful as a candidate to realize such systems. We have

theoretically predicted the occurrence of negative dynamic conductivity in the THz range for optically pumped graphene. Using an epitaxial graphene formed on silicon substrates provided by Prof. Suemitsu's group, we have succeeded in observation of amplified stimulated THz emission from femtosecond infrared-laser pumped graphene. We have also achieved the transistor operation in graphene-channel FETs that demonstrate an electron drift mobility by 20 times higher than that for Si MOSFETs. W have also developed a terahertz spectroscopy system using 2D-plasmon resonant terahertz-wave emitters based on compound semiconductor heterostructures.

Wireless Info Tech [Tsubouchi Laboratory]

For realizing radio frequency (RF) filter and oscillator of 5-GHz-band broadband wireless terminal, we have developed bulk acoustic wave (BAW) device. Film AlN was manufactured using metalorganic chemical vapor deposition (MO-CVD) method. Using the manufactured AlN, film bulk acoustic resonator (FBAR) was developed. We have evaluated characteristics of FBAR using computer simulation.

Electromagnetic Bioinformation Engineering [Ishiyama Laboratory]

We have studied successively about a high accuracy strain sensor for detecting the bio-information. In the year 2009, to obtain the higher accuracy, the optimum fabricating conditions of sensor elements for controlling the internal residual stress of the magnetic thin films were examined. In addition, the magnetic domain observation, the magnetization properties, and the impedance properties of the strain sensors were studied in detail. As the result, the strain sensor elements exhibiting the accuracy of 18,000 were successfully realized in result.

Solid State Physics [Takahashi Laboratory]

For low power consumption MRAM (Magnetic Random Access Memory) and high density HDD (Hard Disk Drive), high-efficiency of current induced magnetization switching (CIMS) and high stabilization of magnetization in a pinned layer in tunnel magnetoresistance devices are indispensable. For high-efficiency of the CIMS, in this study, combination of normal- and inverse-CIMS has been demonstrated. As a result, the inverse-CIMS is obtained in the magnetic tunnel junction with Fe_4N layer. And negative anisotropic magnetoresistance (AMR) which arises from -1.5 % to -4% with temperature in a stepwise fashion near 50 K is observed in the Fe_4N single layer. For high stabilization of magnetization, systematic change of the composition of the pinned-ferromagnetic (FM) layer has revealed that body-centered cubic FM layers were more likely to induce stronger exchange anisotropy than face-centered cubic FM layers.

Electromagnetic Theory [Yamaguchi Laboratory]

Magnetically soft amorphous particles and Ni-Fe films have been investigated as seeds of

new materials with high performance in the RF(GHz range) applications. As for the particles, their advantages are their high saturation magnetization and submicron size. In addition to the original synthesizing process, particle precipitation in a magnetic field is studied. In the process of precipitation in the magnetic field the particles are bonded into long chains leading to an appreciable reduction of the demagnetizing field that has generally been an obstacle to the high-permeability performance of soft magnetic particles. The microstructures, magnetic softness of the chains, and significant enhancement of the permeability in the frequency range 0.05~10 GHz are demonstrated.

As for Ni-Fe films, the damping constant(α) of 100-nm-thick Ni_xFe_{1-x} films with various Ni compositions(x) was estimated using a coplanar waveguide (CPW)-FMR system. While α increases from 0.0092 to 0.0099 in the range of x between 0.67-0.76, it tends to decrease from 0.010 to 0.0079 and again increase to 0.011 as x is varied from 0.76 to 0.86, resulting in the minimum α for x=0.78. All these α are larger than that of bulk-Ni-Fe (0.007).

Microelectronics [Sahashi Laboratory]

The microwave oscillation generated by spin transfer torque (STO), which relates to the damping parameter (α) of ferromagnetic material have been studied. In this study, an appropriate electrode structures for the measurement of STO were investigated. We have designed several masks of coplanar wave guide (CPW) electrode structure, which the high frequency can transmit. The CPW transmission line and attenuation characteristics are evaluated by S11 parameter of network analyzer. The CPW transmission line is found to show good noise attenuation characteristics. The magnitude of the reflected signal increases progressively with increasing cross section area. The study on STO including the estimation of α for ferromagnetic thin films will be continued by using the most suitable pattern of electrode for higher frequency of microwave transmission.

Solid State Electronics [Itoh Laboratory]

High-performance TFTs with pseudo-single-crystal silicon has been investigated. A novel laser optical system was introduced to our laser crystallization apparatus, and large elongated silicon grain with the length of over 100 μm was formed. This laser annealing technology was also applied to ferroelectric thin film on glass substrate, and its low temperature annealing method was obtained. As a novel device structure, nanograting MOSFET has been suggested. This device structure was applied to Poly-Si TFT, and its current drivability was enhanced. For RF integrated circuits, above CMOS inductor technology was suggested. Methods for parameter tuning were shown and discussed.

Basic Plasma Engineering [Hatakeyama Laboratory]

Single-walled carbon nanotubes have successfully been grown from nonmagnetic catalysts by plasma chemical vapor deposition (CVD) for the first time. Based on the systematical

investigation for the combination of catalyst type (magnetic or nonmagnetic) and CVD method (plasma CVD or thermal CVD), it is found that a low concentration of hydrogen species during nanotubes growth is the critical factor to realize the SWNTs growth from a nonmagnetic catalyst by the plasma CVD method. This can be explained by the different binding energy between hydrocarbon and catalyst surface. Nano particle fabrication is carried out under the novel reaction phase, where plasma and liquid interface is directly contacted. It is revealed that there is a close correlation between plasma parameters and size distribution of nano particles.

Optical Physics Engineering [Yamada Laboratory]

Our research focus on silicon photonic-wire waveguides, with silicon (Si) core and silica (SiO_2) cladding, with the objective of realizing integrated optical circuits. In this year, we studied an optical input/output interface and an integration method of LDs on Si waveguides. Both, the numerical calculations and the experimental results, showed good properties. In addition, we found an abnormally localized optical mode in 1-D photonic crystals.

Spin Electronics [Ando Laboratory at Department of Applied Physics]

Magnetic tunnel junctions (MTJs) with a half-metallic Co_2MnSi Heusler alloy electrode and a high-quality MgO tunneling barrier have been developed. We have succeeded to observe a very large tunnel magneto resistance (TMR) ratio of 217% at RT and 753% at 2K. The observed large TMR ratio results from both half-metallicity of Co_2MnSi and coherent tunneling through the crystalline MgO barrier. In addition, we succeeded to suppress temperature and bias voltage dependence of TMR ratio by inserting a very thin CoFeB layer into the Co_2MnSi/MgO interface.

Superstructured Thin Film Chemistry [Kawasaki Laboratory at Institute for Materials Research]

One of oxide heterointerfaces, MgZnO/ZnO, can provide an interesting arena for investigation of quantum transport properties with high-mobility two-dimensional electron gas (2DEG). Electron mobility in the 2DEG reaches 180,000 cm^2/Vs by optimization of fabrication conditions. We have also fabricated an FET device with a dielectric layer by atomic layer deposition method and precisely modulate the charge carrier density in the 2DEG. As a result, we firstly observed a fractional quantum Hall effect in oxide heterostructure. The improved controllability will lead to higher performance of transparent field effect transistor.

Co-doped TiO_2 is one of room temperature ferromagnetic oxide semiconductor. In this study, we fabricated electric double layer transistors on Co-doped TiO_2 films, which can modulate high charge carrier density as high as 10^{14} cm^{-2} by a gate electric field. The device shows paramagnetic to ferromagnetic switching by applying external gate bias at room temperature. We will extend this study to device applications in spintronics area.

Materials Quantum Science [Nitta Laboratory at Department of Materials Science]

We have investigated the spin orbit interaction (SOI) in semiconductor heterostructures. (1) We investigated magneto-transport properties in gate fitted narrow wire structures based on InGaAs/InAlAs two dimensional electron gas. Spin relaxation length was enhanced more than 10 times larger than that in the Hall bar structure. From the theoretical analysis, origin of the enhanced spin relaxation length is due to both the one dimensional confinement effect and the Persistent Spin Helix condition, where the strength of Rashba SOI is close to that of Dresselhaus SOI. (2) We investigated the size dependence of spin interference effect in mesoscopic ring structures. With propagating length of electron waves, resistance oscillations observed as Aharanov-Casher effect are systematically changed, which reveals that electrical spin manipulation depends on the diameter of the ring structures.

Nanoscale magnetism and devices [Kitakami Laboratory at Institute of Multidisciplinary Research for Advanced Materials]

Research project on development of high-K_u materials and understanding of magnetization behavior of nanoscale magnets are being carried out, aiming to achieve ultra-high density magnetic memory. Magnetization process under a short pulse field is one of the key issues to increase the operation frequency of magnetic device. Magnetization process of a nanoscale Co/Pt multilayer dot was investigated by detecting anomalous Hall effect of a single dot. It is revealed that the magnetization reversal is initiated by the nucleation process within sub-nanoseconds time scale followed by its growth in nanoseconds.

Medical Nanosystem Engineering [Tanaka Lab at Graduate School of Biomedical Engineering]

The novel SPRAM-based 3-dimensional reconfigurable spin processor has been proposed. This year, two main results below were obtained. As a SPICE model of MTJ was successfully made, it became possible to simulate logic circuit operation including MTJ using SPICE. This leads to a highly efficient analysis of SPRAM circuits. The SPRAM-based reconfigurable logic block circuit is composed of the SRAM for LUT and the SPRAM for configuretion data. As the write circuit design of reconfigurable logic block was improved, 2.4% faster SRAM read-back circuit speed was successfully achieved.

New Paradigm VLSI System [Hanyuu Laboratory]

Our research group has fabricated a nonvolatile LUT (Lookup-Table) circuit in FPGA (Field-Programmable Gate Array) using a MTJ (Magnetic Tunnel Junction) device-based logic technology. The proposed LUT circuit fabricated by a 0.14um CMOS/MTJ-hybrid process achieves area reduction by 2/3 compared to a conventional SRAM-based one, and complete elimination of standby power dissipation. The MOS-transistor part is fabricated by Hitachi Co., Ltd. and the MTJ-device part is fabricated by Laboratory for Nanoelectronics and Spintronics, Research Institute of Electrical Communication, Tohoku University. This is the collaboration of Prof. H. Ohno's, Prof. S. Ikeda's and our laboratories

Technology Development Division Storage Technology Group [Fujimoto Laboratory]

A cooperative research project between industry, academia and government; Development of super high-speed mass storage HDD systems started in August 2007 under the collaborations between RIEC including IT21 storage technology group, major Japanese HDD manufacturers and other laboratories researching related technologies within Tohoku University. Developments of high density patterned media and high sensitivity sensor are research subjects in this project, and we fabricated fine dot arrays of Co based alloy films and spin accumulation devices and studied fundamental properties. We started experimental analysis of magnetization reversal for dot arrays of high-K_u perpendicular films with the dot diameter of 10~15 nm. Moreover, a preliminary study of read/write properties for bit-patterned media (60 nm in dot diameter) using a static tester revealed that the writing margin was 70% to the bit length.

Solid State Electronics [Suemitsu Laboratory]

We have this year made progresses on the establishment of graphene-based field effect transistor (G-FET) and the evaluation of device characteristics of G-FET. As a result, we could have succeeded in fabricating and evaluating of G-FET, which can in principle overwhelm Si-based MOS-FET. Further we have tackled one of the big problems in the application of G-FET, the adequate adoption of the materials for insulator. We have then succeeded in using organic thin films as insulators for the ultra high-speed G-FET.

Researching Section [Endoh Lab at Center for Interdisciplinary Research]

To develop a novel Spin device technology for the Magnetic Tunneling Junction (MTJ) combined with the Si-CMOS circuit, we have systematically studied the Spin device technology, the integration process technology, the circuit design and the measurement.

We fabricated the MTJs on via metal with surface roughness of 0.30nm with 0.14μm CMOS process and 60×180nm^2 MTJ process. The fabricated MTJ on CMOS logic circuit plane achieves a large change in a resistance of 3.63kΩ(anti-parallel) with the TMR ratio of 138% at room temperature. Furthermore, we have successfully demonstrated the DC and AC operation of this MTJ with write transistor. As a result, our MTJ achieves high enough write/read performance with transistors for realizing MTJ-based logic circuits. This is the collaboration of Prof. H. Ohno's, Prof. S. Ikeda's and our laboratories.

Intelligent Nano-Process [Samukawa Laboratory]

We work on the development of quantum dot solar cell and quantum dot laser with ultra-low damage neutral beam etching and sub-10nm bio-template. In the last fiscal year, the outcomes are as follows. (1) We succeeded in controlling the band gap energy (1.4 to 2.2eV) of high density (>7x10^{11} cm^{-2}) 2-dimensional Si-nanodisk (2D Si-ND) array by changing the Si-ND thickness (12-2nm). This characteristic of Si-ND shows great potential to realize all-Si tandem solar cell. PL peak at approximately 630nm was also observed in 2D Si-ND at 100K. (2) Vertical etching profile of GaAs/AlGaAs quantum well (QW) was realized using neutral

beam etching. There is almost no lattice defect on the etched side-wall of GaAs and roughness of etched surface is the same as bare GaAs wafer. The PL intensity of etched GaAs/AlGaAs QW is comparable to unetched one. The result means that ultra low damage etching of GaAs/AlGaAs is realized.

Applied Quantum Optics [Yasaka Laboratory]

Highly functional semiconductor photonic devices and ultra-broadband coherent terahertz (THz) wave sources have been studied to explore new-generation photonic network systems as well as novel science and technology. Novel THz biosensors using surface plasmon resonance were studied to achieve sensitive detection of biomolecules, high-spatial-resolution THz imaging beyond diffraction limit. High-quality THz resonators for local-field enhancement were successfully fabricated on silicon wafers by introducing novel fabrication process using SU-8.

Atomically Controlled Processing

Creation of Atomically Controlled Processing of Group IV Semiconductor and Application to Nano Heterodevices

[Research Target and Activities]

Development of atomically controlled processing technology in deposition and etching is quite important to fabricate future higher-performance ultralarge-scale integrated circuits (ULSIs) as well as quantum devices for new functions and to create new materials with novel properties which are different from that of conventional bulk materials. To overcome the limits of Si material properties and device miniaturization and to achieve on-chip integration of ultimate charge control into Si ULSIs, this laboratory aims to establish atomically controlled processing for nanometer-order artificial heterostructures of group IV semiconductors with atomically controlled surface and interfaces and nanometer-order three-dimensional patterning with molecular control to fabricate nanometer-order heterostructure devices. (**Fig. 1**)

In this year, following experimental results have been obtained: (1) In the research on P atomic-layer doping, low-temperature Si epitaxial growth by reaction of Si_2H_6 as a higher reactivity gas enables higher P concentration. (2) By heavy C atomic-layer doping at heterointerface between a Si cap layer and a $Si_{0.55}Ge_{0.45}$ layer in Si/$Si_{0.55}Ge_{0.45}$/Si(100) heterostructure, the intermixing between Si and Ge at heterointerface is effectively suppressed. (3) In the research on B atomic-layer doping in Si by using a plasma CVD without substrate heating, it is clarified that lowering of the plasma energy effectively suppresses a plasma induced lattice damage and a surface B reduction, and it becomes quite important to achieve heavy B atomic-layer doping in a nanometer-order ultrathin Si film.

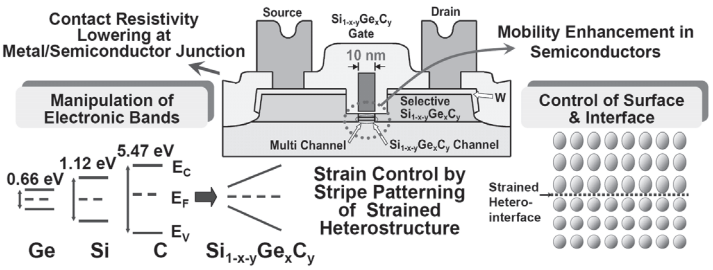


Fig. 1. 10 nm-scale quantum nanodevices with strain controlled nano-scale patterned heterostructure of group IV semiconductors.

[Staff]

Professor: MUROTA, Junichi Dr.
Associate Prof.: SAKURABA, Masao Dr.

[Profile of Prof. J. Murota]

Prof. J. Murota was born in 1948. He received the B.E., M.E. and Ph.D degrees in electronic engineering from Hokkaido University in 1970, 1972 and 1985, respectively. He joined the Musashino Electrical Communication Laboratory, Nippon Telegraph and Telephone Public Corporation (NTT) in 1972. In 1983, he moved to the Atsugi Electrical Communication Laboratory, NTT. In 1985 he became an Associate Professor in the Research Institute of Electrical Communication, Tohoku University and in 1995 became a Professor. He is actively involved in researches on atomically controlled processing of group IV semiconductors. He was awarded the 3rd (2003) Yamazaki-Teiichi Prize and the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology for 2010: The Prizes for Science and Technology in Research Category.

[Papers]

[1] J. Murota, M. Sakuraba and B. Tillack, "Atomically Controlled CVD Processing for Doping of Si-Based Group IV Semiconductors" (**Invited Paper**), Symp. E10: ULSI Process Integration 6 (216th Meeting of the Electrochem. Soc.), Vienna, Austria, Oct. 4-9, 2009, Abs.No.2360: ECS Trans., Vol.25, No.7 (Edited by C. Claeys et al., The Electrochem. Soc., Pennington, NJ, 2009), pp.177-184 (2009).

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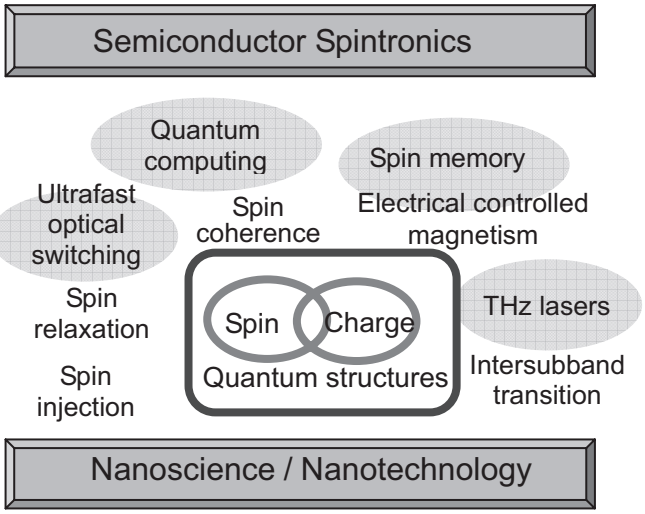
Semiconductor Spintronics

Nanoscience and Nanotechnology for Spintronics and THz Lasers

[Research Target and Activities]

We are working on the nanoscience and nanotechnology to control the quantum states in semiconductors, especially the spin-states and optical transitions in the mid-infrared to THz.

Materials of interest include GaAs/AlAs, InAs/(Al,Ga)Sb, GaN, and ZnO, with and without doping of magnetic elements, all grown by molecular beam epitaxy. We are investigating electrical, optical, magnetic properties of these materials and their application to new functional devices, such as memories and logic devices using spin states as well as quantum cascade lasers (QCL) with THz emission.



The outcomes in the last fiscal year are (1) Direct magnetometry of electric-field control of magnetisim in a (Ga,Mn)As thin film. (2) Determination of spin Hall conductivity in n-type GaAs and its theoretical description (3) Demonstration of GaAs THz quantum cascade laser emission with threshold current density of 0.8 kA/cm^2 and maxumum operation temperature of 146 K.

[Staff]

Professor : OHNO, Hideo
Associate Professor : OHNO, Yuzo
Associate Professor : MATSUKURA, Fumihiro
Assistant Professor : OHTANI, Keita

[Profileof Professor Hideo Ohno]

Hideo Ohno received Ph. D. degree from the University of Tokyo in 1982. He was with the Faculty of Engineering, Hokkaido University as a Lecturer (1982) and then as an Associate Professor (1983). He moved to Tohoku University in 1994 as a Professor. He received the IBM Japan Science Prize (1998), the IUPAP Magnetism Prize (2003), the Japan Academy Prize (2005), and the 2005 Agilent Technologies Europhysics Prize. He is Institute of Physics (IOP) Fellow (2004), Honorable Professor at Institute of Semiconductors, Chinese Academy of Sciences, and JSAP fellow (2007), Distinguished Professor at Tohoku University (2008), and IEEE Magnetic Society Distinguished Lecturer for 2009. He is a member of JSAP, JPS, JACG, IEICE, APS, IOP, IEEE, and AVS.

[Papers]

[1] S. Matsuzaka, Y. Ohno, and H. Ohno, "Electron density dependence of the spin Hall effect in GaAs probed by scanning Kerr rotation microscopy," Physical Review B, Vol. 80, 241305, December 2009.
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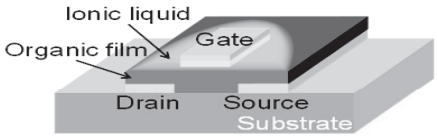
Nano-Molecular Devices

Control of surface and interface of molecular informational devices and development of novel nano-molecular devices

[Research Target and Activities]

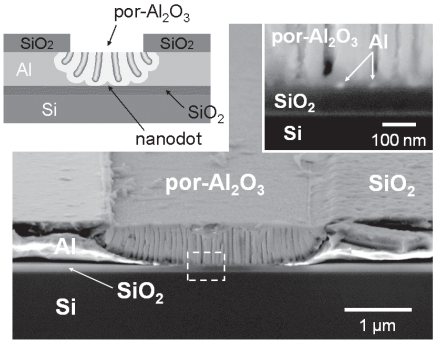
Our research aims at application of the Si technology to organic semiconductor devices or many kinds of biosensors. We have investigated development of 1) an organic transistor using an ionic liquid, 2) an ion channel sensor using a Si technology, and 3) a nanofabrication method using electrochemical processes such as anodization of valve metals. Especially, we have applied TiO_2 nanotubes formed by anodization to dye-sensitized solar cells (DSC).



The schematic of an organic transistor using ionic liquid

1) Fabrication and characterization of an organic transistor using an ionic liquid

We have fabricated P3HT organic transistors using an ionic liquid to observe its high operating current as compared to the conventional organic field effect transistors. We monitored in-situ the chemical state of the P3HT active layer during FET operation using infrared absorption spectroscopy, and found that the ionic-liquid-based P3HT transistors are operated by electrochemical doping.



Anodization of a patterned Al film and Al nanodots formed by it

2) Development of planar bilayer lipid membranes

Planar bilayer lipid membranes (BLMs) were formed in microfabricated apertures in Si chips. We have succeeded in preparing BLMs which are stable enough for repetitive solution exchanges and electric stress, and demonstrated that electric noise was suppressed by coating the chip surface with dielectric layers. BLMs with channel proteins were also formed in nanoholes of an anodic porous alumina films.

3)Direct formation of a titanium oxide nanotube film on a substrate using anodization

A titanium oxide nanotube film was directly formed on a substrate by anodization of a metal titanium film deposited on it in an ammonium fluoride based organic electrolyte.

[Staff]

Professor : NIWANO, Michio Dr.
Assistant professor : KIMURA, Yasuo Dr.

[Profile of Professor NIWANO, Michio]

1998 - present RIEC, Tohoku University, Japan, Professor
Memberships: Electrochemical Society (ECS), Material Research Society (MRS), American Vacuum Society (AVS)
Education: March, 1980 Tohoku University, Japan, Doctorate of Science

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Nano-Spin Memory

Research of spin based device and memory

[Research Target and Activities]

We are developing technologies to realize advanced spin memory and logic devices using magnetic tunnel junctions (MTJs) consisting of ferromagnetic metal electrodes and insulating barriers. In our group, the following results were obtained.

1) TMR properties and film structures of perpendicular MTJs with CoFe/Pd multilayer and different insertion layers such as CoFeB and Fe were investigated. The insertion of 1.8 nm-thick CoFeB layers between CoFe/Pd multilayers and MgO barrier resulted in an increase of TMR ratio from a few percent to up to 43%. By applying combination of bottom CoFeB and top Fe insertion layers, the TMR ratio reached 67%. For the MTJs with *in situ* annealing the TMR ratio of 78% was observed. 2) Operation of a prototype of the world's first 32Mbit non-volatile random access memory (SPRAM) chip employing the spin-transfer torque MTJs with synthetic ferrimagnetic free layer was verified.

[Staff]

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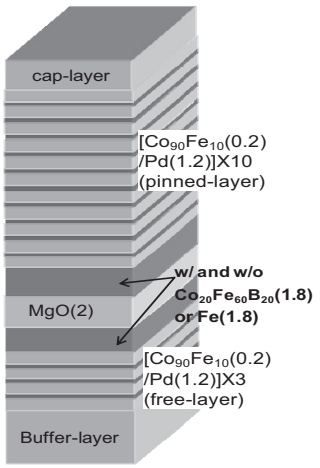
Visiting Professor :HASEGAWA, Haruhiro Ph.D.,
Research Fellow： GAN, Huadong Ph.D.,
Research Fellow： YAMAMOTO, Hiroyuki Ph.D.,
Research Fellow： MIURA, Katsuya Ph.D.,
Research Fellow : YAMAMOTO, Hiroki,

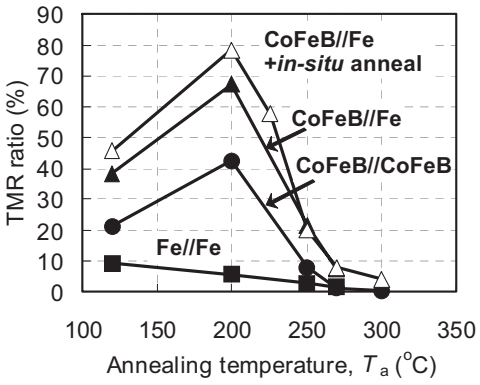
[Papers]

[1] J. H. Park, S. Ikeda, H. Yamamoto, H. Gan, K. Mizunuma, K. Miura, H. Hasegawa, J. Hayakawa, K. Ito, F. Matsukura, and H. Ohno, "Perpendicular magnetic tunnel junctions with CoFe/Pd multilayer electrodes and an MgO barrier", IEEE Transactions on Magnetics, Vol. 45, pp. 3476-3479, September 2009.

[2] K. Mizunuma, S. Ikeda, J. H. Park, H. Yamamoto, H. Gan, K. Miura, H. Hasegawa, J. Hayakawa, F. Matsukura, and H. Ohno, "MgO barrier-perpendicular magnetic tunnel junctions with CoFe/Pd multilayers and ferromagnetic insertion layers", Applied Physics Letters, Vol. 95, pp. 232516, December 2009.

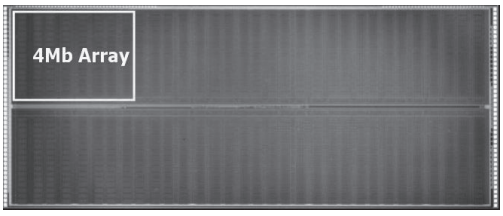
[3] R. Takemura, T. Kawahara, K. Miura, H. Yamamoto, J. Hayakawa, N. Matsuzaki, K. Ono, M. Yamanouchi, K. Ito, H. Takahashi, S. Ikeda, H. Hasegawa, H. Matsuoka, and H. Ohno, "32-Mb 2T1R SPRAM with localized bi-directional write driver and '1'/'0' dual-array equalized reference cell", in Symposium on VLSI Circuits Digest of Technical Papers 2009, pp.84-85, June 2009.





IEEE Trans. Magn. 45 (2009) 3476.
Appl. Phys. Lett., 95 (2009) 232516.

Development of perpendicular MTJs with CoFe/Pd multilayer and different insertion layers such as CoFeB and Fe.



Process	150 nm CMOS
Density	32Mb
Memory cell size	1.0 x 1.0 μm
TMR size	100 x 200 nm
Chip size	15.32 x 6.19 mm
Write	300 μA/cell, 40 ns
Read	32 ns

VLSI Circuits 2009

32Mb Spin-Transfer Torque RAM (SPRAM) chip employing the spin-transfer torque MTJs with synthetic ferrimagnetic CoFeB/MgO/CoFeB free layer.

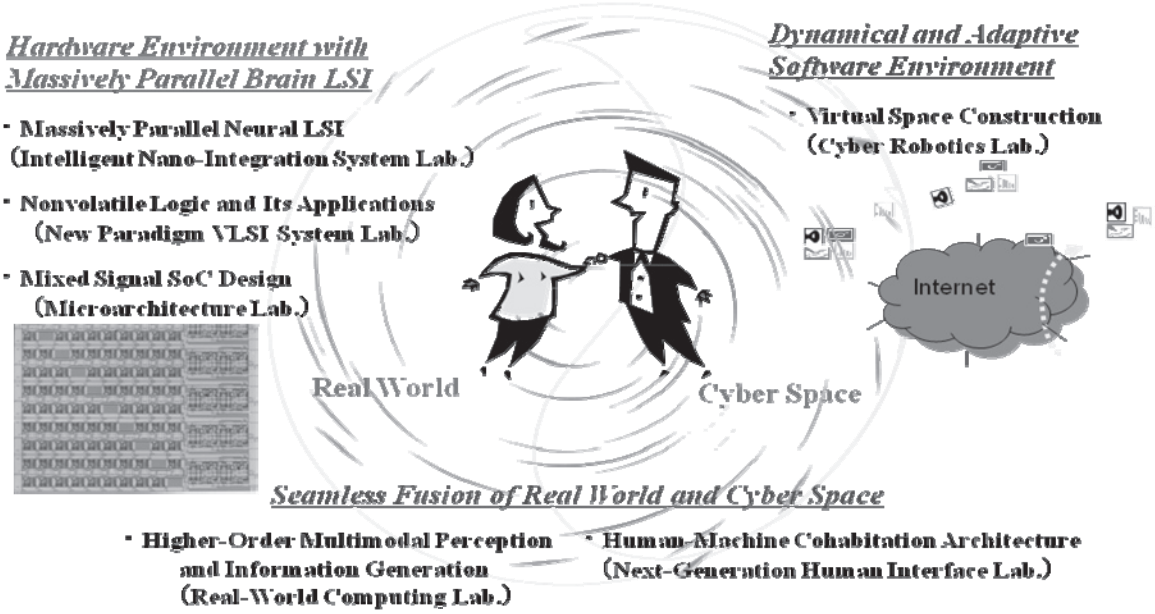
Laboratory for Brainware Systems

Research Targets and Activities of Laboratory for Brainware Systems

The Laboratory for Brainware Systems of the Research Institute of Electrical Communication was established in 2004. Its purpose is to contribute to the research and development of advanced information science and technology for Brainware systems which realize a seamless fusion of the changeable and complex real world and the cyber space.

We aim at establishing scientific and technological foundations for Real-World Computing (section), New Paradigm VLSI System (section), Intelligent Nano-Integration System (section), Microarchitecture (section), Cyber Robotics (planned section), and Next-Generation Human Interface (planned section). The Laboratory for Brainware Systems consists of the above six sections which cooperatively carry out the research. At the same time they serve as a laboratory for nation-wide cooperative research in the field of Brainware systems.

The technology developed in the Laboratory is expected to enhance the research carried out in the four Divisions of the Institute, and the research conducted in the Divisions, in turn, is expected to provide scientific basis for the information technology developed in the Laboratory.



[Research Target]

Real-World Computing Section: Our main aim is to understand highly harmonic and autonomous biological-information systems, and to propose principles for designing new systems. For carrying out any purpose or any function, the biological system must solve inverse problems in the real-world. Since the inverse problem is an ill-posed one, the system has to create an appropriate constraint for solving the ill-posedness by itself, and autonomously satisfies the created constraint in real time. Clarifying logic and basic mechanisms of "Constraint Self-Emergence and Self-Satisfaction", we create artificial systems for pattern recognitions and motion controls that work well in the real-world.

New Paradigm VLSI System Section Section: Performance degradation of SoCs due to wiring complexity, power dissipation and characteristic variation of materials/devices is increasingly getting a serious problem in recent era. Our research activity is to solve the above problem by the following two ways: the use of logic-in-memory architecture based on nonvolatile logic, and the use of asynchronous data-transfer scheme based on multiple-valued current-mode logic, which would open up a novel VLSI chip paradigm, called a "new-paradigm VLSI system."

Intelligent Nano-Integration System Section: Our research activities cover the fields of architectures of Brain computing systems, characterization and application of artificial neural networks, computer aided designs and fabrications of intelligent integrated circuits, and exploitation of new devices for neural circuits. At present research is focused on the large scale integration of Brain computing system and exploitations of new neural devices proposing a neuromorphic quantum computation.

Microarchitecture Section: The research activities in microarchitecture lab. include architecture and circuit design of mixed-signal SoC applicable to sensor network system to explore brain activity research along with mixed-signal topdown design methodology.

[Research Activities]

Real-World Computing Section (Yano Laboratory): We obtained the following three main results. First, we proposed a computational algorithm for odor information representation using time dimension, and clarified how to implement it into a neurobiologically plausible network model. The model accounted for essential features of odor responses of biological networks and emergence of olfactory cognitive functions. Second, concerning arm reaching movement, we computationally demonstrated that the posture and motion of arm can be controlled in autonomous decentralized manner by using "mobility measure" of each joint calculated from its kinematical and dynamical information in real time. We also found that the resulted arm movements of our model have a global optimality with respect to energy consumption during motion. Furthermore, we psychophysically clarified that executing various motion under unpredictable environment would enhance the adaptability of motion control to environmental changes. Third, we examined the psychophysical effects of formant peak and spectral slope on vowel perception, and found that the vowel perception can be generally accounted for by two acoustic features, slope and prominency of band-limited spectrum.

New Paradigm VLSI System Section (Hanyu Laboratory): As this-year research results in the nonvolatile logic-in-memory circuit technology, we have succeeded the chip fabrication of an MOS/MTJ-hybrid Lookup-Table (LUT) circuit for a nonvolatile Field-Programmable Gate Array (FPGA) and confirmed its "immediate wake-up" behavior without reloading the configuration data from external nonvolatile devices. We have also succeeded the fine-grained power-gating scheme of the nonvolatile ternary content-addressable memory (TCAM) proposed last year, which results in great reduction of wasted power dissipation in the TCAM. Moreover, we have succeeded the chip fabrication of the single-wire multiple-valued single-track test chip under a 0.13um CMOS process, and confirmed its energy-efficient asynchronous data transmission on the wire length of 5mm.

Intelligent Nano-Integration System Section (Nakajima-Sato Laboratory): (1) We proposed a discrete-type inverse function delayed neural network with high-order synapse connections and demonstrated its usability for combinatorial optimization problems by stability analysis on solution states. Moreover, we expanded our new analysis on nonlinear dynamics to a coupled nonlinear system, and burst firing dynamics was successfully generated by using a coupled BVP model. (2) We analyzed the resonant activation property of a Bi-2212 intrinsic Josephson junction and found possible reasons for degradation of the quality factor Q. In order to gain a better Q factor, we designed a filter circuit for suppressing high frequency noise in bias lines and a line for feeding microwave. (3) To improve the performance of high-speed operation for the single flux-quantum fast Fourier transform, a carry look-ahead adder was fabricated using Nb integrated circuits. The high-speed operation of the adder circuit was successfully demonstrated up to 30GHz. A neural network using superconducting quantum interference devices for solving a combinatorial optimization problem was proposed and numerically demonstrated.

Microarchitecture Section (Masui Laboratory): We have been investigating architecture and circuit techniques for low-power and low-cost CMOS transceiver ICs applicable to wireless sensor network, and high-speed A/D converter applicable to vision sensing. We have been explored a low-power fractional-N PLL synthesizer design with high-speed setup circuit, and a low-power/low-cost bandpass filter implemented with active gm-RC scheme. We start to investigate the hardware optimization technique for time-interleaved A/D converters to achieve one tenth of power consumption and one fifth of area compared with conventional pipeline A/D converters. In terms of design productivity enhancements, we have established a gm/Id lookup table design optimization methodology for low-power OTA (operational transconductance amplifier), and have successfully implemented an optimization flow including a detailed settling time analysis.

Real-world computing

Odor Representation Algorithm: Invariance, Similarity, and Speed-Accuracy Trade-off.

[Research Target and Activities]

Time is a key dimension for sensory information coding in biological networks. In olfactory systems (Fig. 1), an odor-evoked spatial pattern of glomerular activation is transformed into first dense, then sparse spatiotemporal patterns of spikes at Primary olfactory and higher center networks, respectively. Although these spatiotemporal neural representations seem to be useful for concentration invariant odor identification and classification, computational strategy and mechanisms underlying these transformation are still unclear.

We proposed a two-stage algorithm for odor representation that causally and logically relates the neurobiological representations from a computational point of view, and that satisfies computational criteria for usefulness in odor identification and classification. Odor concentration change significantly alters the evoked glomerular activation pattern, but would not affect a ranking of glomeruli in order of their relative response intensity. Implementing the algorithm, a model first extracts the glomerular ranking as a temporal sequence of spike-bursts but its detailed temporal structure still concentration-dependent. In the second-stage, the model evaluates exclusively the activity sequence in the first-stage representation, and acquires the concentration-invariant representation as a sparsely distributed spike sequence (Fig. 2). The represented odor information can predict how odors are grouped. Introduction of plastic connections into the second-stage network enables the system to store odor information as a weighting of network connectivity. The model accounts for essential features of odor responses of biological networks and the emergence of olfactory cognitive functions. The temporal sequence representation predicted by the proposed algorithm is a tool for pattern recognition that warrants further investigation in biological systems and for designing flexible information and communication systems.

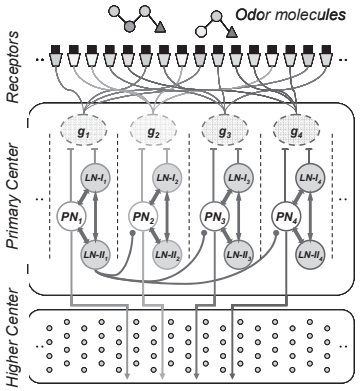


Fig. 1 Schematic illustration of biological olfactory system.

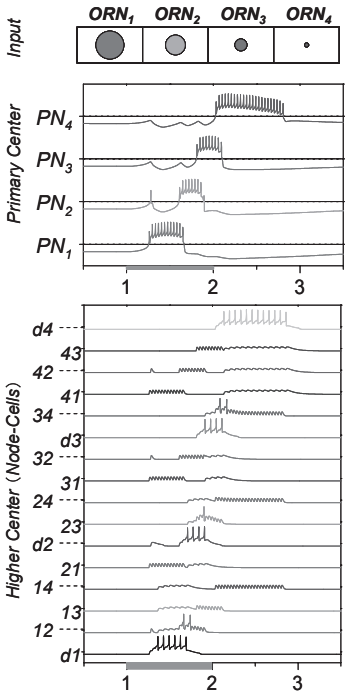


Fig. 2 Network implementation of odor representation algorithm using spatiotemporal neural activity.

[Staff]

Professor: YANO, Masafumi Dr.
Assistant professors: MAKINO, Yoshinari Dr., SAKANOTO, Kazuhiro Dr.
Research associate: TOMITA, Nozomi Dr.

[Profile of Professor Yano]

1992-: Professor, Research Institute of Electrical Communication, Tohoku University.
2007-: Director, Research Institute of Electrical Communication, Tohoku University.

[Papers]

[1] Y. Makino and M. Yano, "Investigating the Underlying Intelligence Mechanisms of the Biological Olfactory System," Advances in Artificial Intelligence, Vol. 2010, Article ID 478107, 2010.
[2] Y. Yoshihara, Y. Makino, N. Tomita, M. Yano, "Can Real-time Optimization of Joint Mobility Generate Globally Optimal Arm Motion?," Keisoku Jidou Seigyo Gakkai, Vol. 45, pp. 570-579, 2009.
[3] K Sakamoto, H Nakajima, T Suzuki and M Yano, "Global closure," ICONIP 2008, Part I, LNCS 5506, pp. 258-265, 2009.

Contact to Professor Masafumi YANO : masafumi@riec.tohoku.ac.jp

Intelligent Nano-Integration System

Basic Technology of Integrated System for Intelligent Processing

[Research Target and Activities]

Our research activities cover the fields of architectures of Brain computing systems, characterization and application of artificial neural networks, computer aided designs and fabrications of intelligent integrated circuits, and exploitation of new devices for neural circuits.

We have constructed a stochastic artificial neural network with one million synaptic units, analyzed the dynamic behaviour of neural networks aiming at a time-dependent data processing, succeeded to propose a system where we are able to get off successfully from any local minima fallen into on the way of data processing in neural networks, and fabricated its prototype hardware system on the silicon microchip by using the CMOS technology. We have also presented an FFT and a neural system operated by using a flux quantum logic in superconducting integrated circuits.

At present research is focused on the large scale integration of Brain computing system and exploitations of new neural devices proposing a neuromorphic quantum computation.

Research Activities in 2009

(1) We proposed a discrete-type inverse function delayed neural network with high-order synapse connections and demonstrated its usability for combinatorial optimization problems by stability analysis on solution states. Moreover, we expanded our new analysis on nonlinear dynamics to a coupled nonlinear system, and burst firing dynamics was successfully generated by using a coupled BVP model. (2) We analyzed the resonant activation property of a Bi-2212 intrinsic Josephson junction and found possible reasons for degradation of the quality factor Q. In order to gain a better Q factor, we designed a filter circuit for suppressing high frequency noise in bias lines and a line for feeding microwave. (3) To improve the performance of high-speed operation for the single flux-quantum fast Fourier transform, a carry look-ahead adder was fabricated using Nb integrated circuits. The high-speed operation of the adder circuit was successfully demonstrated up to 30GHz. A neural network using superconducting quantum interference devices for solving a combinatorial optimization problem was proposed and numerically demonstrated.

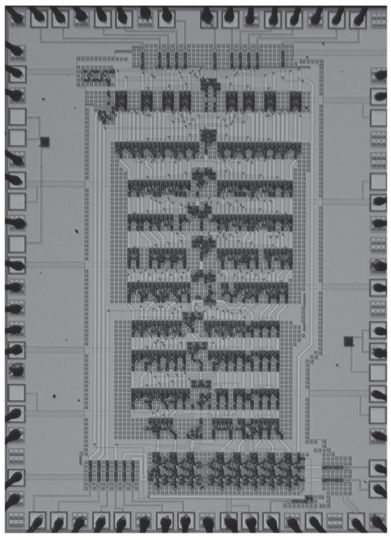


Fig.1 A 4-bit parallel multiplier using SFQ logic

[Staff]

NAKAJIMA, Koji Professor
SATO, Shigeo Associate Professor
ONOMI, Takeshi Assistant Professor

[Profile]

K. Nakajima was received his B.E. M.E. and Dr. Eng. from Tohoku University, Sendai, Japan, in 1972, 1975, and 1978, respectively. Since 1978, he has been working at the Research Institute of Electrical Communication, Tohoku University, except for a ten month period in 1983 when he was a Visiting Assistant Research Engineer at the University of California, Berkeley. He is a professor at the Research Institute of Electrical Communication, Tohoku Univ., and is currently engaged in the study of VLSI implementation of neural network, and Josephson junction devices for digital applications.

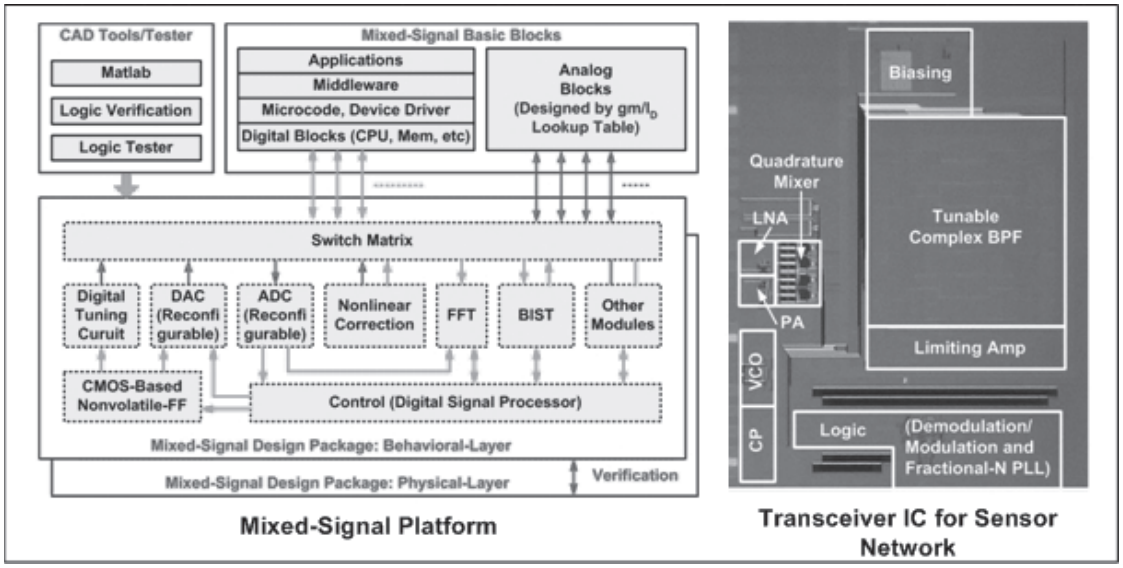
[Papers]

1. T. Onomi, T. Kondo, and K. Nakajima, Implementation of High-Speed Single Flux-Quantum Up/Down Counter for the Neural Computation Using Stochastic Logic, IEEE Trans. Applied Superconductivity, vol.19, no.3, pp.626-629, June 2009.
2. S. Sato, K. Matsushita, K. Inomata, H. Wang, T. Hatano, M. Kinjo, and K. Nakajima, Collective Dynamics of Intrinsic Josephson Junctions, Ext. Abst. 12th International Superconductive Electronics Conf., TD-P35, June 2009.
3. Y. Hayakawa and K. Nakajima, Design of the Inverse Function Delayed Neural Network for Solving Combinatorial Optimization Problems, IEEE Trans. Neural Networks, vol.21, no.2, pp.224-237, Feb. 2010.

Microarchitecture Laboratory

Mixed-Signal Platform Design

[Research Target and Activities]



Ubiquitous society has been established by the deployment of various wireless systems ICs, and it demands advances in mixed-signal (analog and digital) design technique as well as higher integration through SoC (System on a Chip). Our research activities include architecture and circuit design of mixed-signal SoC applicable to sensor network systems for the investigation of brain activities researches as well as design automation of RF/analog circuit. We propose a mixed-signal platform to maximize the design creativity by utilizing IP-based digital design methodology to various RF/analog and mixed-signal circuits. Moreover, we have been researching on the development of RF/analog design optimization flows by using gm/Id based lookup table methodology.

[Staff]

Professor: MASUI Shoichi Dr.

[Profile]

Shoichi Masui received the B. S. and M. S. degrees from Nagoya University, Nagoya, Japan in 1982, and 1984, respectively, and received the Ph. D. degree from Tokyo Institute of Technology in 2006. From 1990 to 1992, he was a Visiting Scholar at Stanford University, Stanford CA, and in 2001, he was a Visiting Scholar at University of Toronto, Toronto ON, Canada. Since 2007, he is a professor in Research Institute of Electrical Communication, Tohoku University. He was the recipient of a commendation by the Minister of Education, Culture, Sports, Science, and Technology, Japan, in 2004 for his research achievements on FeRAM.

[Papers]

[1] D. Su, M. Loinaz, S. Masui, and B. Wooley, "Experimental Results aand Modeling Techniques for Substrate Noise in Mixed Signal Integrated Circuits," Journal of Solid-State Circuits, vol. 28, no. 4, pp. 420-430, 1993.

[2] S. Masui, T. Ninomiya, M. Oura, W. Yokozeki, K. Mukaida, and S. Kawashima, "Ferroelectric Memory Based Secure Dynamically Programmable Gate Array", IEEE J. of Solid-State Circuits, vol. 38, no. 5, pp. 715-725, 2003.

[3] H. Nakamoto, D. Yamazaki, T. Yamamoto, H. Kurata, S. Yamada, K. Mukaida, T. Ninomiya, T. Ohkawa, S. Masui, and K. Gotoh, "A Passive UHF RF Identification Tag LSI with 36.6% Efficiency CMOS-Only Rectifier and Current-Mode Demodulator in 0.35μm FeRAM technology, " IEEE Journal of Solid-State Circuits, vol. 42, no. 1, pp. 101-110, 2007.

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New Paradigm VLSI System Research Group

Realization of a New-paradigm VLSI System

[Research Target and Activities]

Rapid progress in recent deep submicron regime has led the capability to realize giga-scaled embedded systems on a chip (SoC), while performance degradation of SoCs due to wiring complexity, power dissipation and device-characteristic variation is increasingly getting a serious problem in the recent VLSI chip. Our research activity is to solve the above problem primarily by the following two ways: the use of logic-in-memory architecture based on nonvolatile logic, and the use of asynchronous data-transfer scheme based on multiple-valued current-mode logic, which would open up a novel VLSI chip paradigm, called a "new-paradigm VLSI system."

As a this-year research result in nonvolatile-logic area, we have succeeded the chip fabrication of MTJ (Magnetic Tunnel Junction)-based basic logic component, a nonvolatile LUT (look-up table) circuit chip (Fig.1). We have also designed and fabricated a high-throughput asynchronous multiple-valued single-track data-transfer test chip (Fig.3), whose performance is evaluated to be 1.5-times faster than that of a conventional implementation with maintaining less wire counts. Furthermore, we have proposed nonvolatile TCAM based on a fine-grained power-gating scheme which enables to greatly reduce standby power in the TCAM (Fig.2).

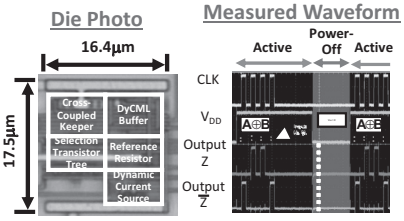


Fig. 1: MTJ-based nonvolatile LUT circuit chip

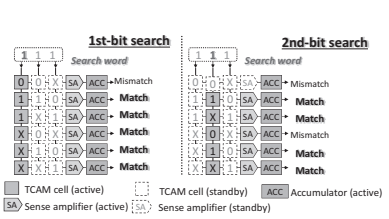
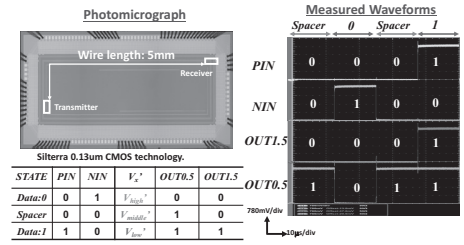


Fig. 2 Nonvolatile TCAM based on fine-grained power-gating scheme



STATE	PIN	NIN	V_x'	OUT0.5	OUT1.5
Data:0	0	1	V_{high}'	0	0
Spacer	0	0	V_{middle}'	1	0
Data:1	1	0	V_{low}'	1	1

Fig. 3 High-speed asynchronous data-transfer chip based on multiple-valued signle-track scheme and its waveforms

[Staffs]

Professor	HANYU, Takahiro Dr.,
Assistant Professor	NATSUI, Masanori Dr., MATSUMOTO, Atsushi Dr.
Research Fellow	MATSUNAGA, Shoun Dr., ONIZAWA, Naoya Dr., SUZUKI, Daisuke Dr.

[Profile]

Takahiro Hanyu received the B.E., M.E. and D.E. degrees in Electronic engineering from Tohoku University, Sendai, Japan, in 1984, 1986, 1989, respectively. He is currently a Professor in the Research Institute of Electrical Communication, Tohoku University. His general research interests include multiple-valued current-mode logic and its application to high performance and low-power arithmetic VLSIs.

[Papers]

(1) Naoya Onizawa, Takahiro Hanyu, and Vincent C. Gaudet, Design of High-Throughput Fully-Parallel LDPC Decoders Based on Wire Partitioning, IEEE Trans. on VLSI Systems, Vol.18, No.3, pp.482 - 489, 2010.

(2) Daisuke Suzuki, Masanori Natsui, Shoji Ikeda, Haruhiro Hasegawa, Katsuya Miura, Jun Hayakawa,Fabrication of a Nonvolatile Lookup-Table Circuit Chip Using Magneto/Semiconductor-Hybrid Structure for an Immediate-Power-Up Field Programmable Gate Array, Tetsuo Endoh, Hideo Ohno and Takahiro Hanyu, IEEE 2009 Symposia on VLSI Circuits, Dig. Tech. Papers, pp.80-81, 2009.

(3) Shoun Matsunaga, Atsushi Matsumoto, Masanori Natsui, Tetsuo Endoh, Hideo Ohno, and Takahiro Hanyu, Fine-Grain Power-Gating Scheme of a CMOS/MTJ-Hybrid Bit-Serial Ternary Content-Addressable Memory, International Conference on Solid State Devices and Materials (SSDM), K-6-6, pp. 1382-1383, 2009.

IT-21 center

Research and Development of the IT-Based Practical Technology by the Industry-Academia-Government Collaboration

[Research Target and Activities]

The purpose of the IT-21 center is development of practical technologies for IT based on the advanced technologies of RIEC with the partnership among Industry, Government and University. The term of development is limited less than 5 years. The projects are planed on matching with both basic technologies in the University and application in the Industry. Combination of the technologies of the University and Industry makes practical technologies with availability for the commercial products. The center actively accelerates to obtain the intellectual properties generated from the development of practical technology to the Industry. From 2007, the new 2 projects were started.

1. Development of Dependable Wireless System and Devices

Our new project "Development of Dependable Wireless System and Devices" was accepted in 2007 as the Japan Science and Technology Agency (JST) CREST type research program "Fundamental Technology for Dependable VLSI System." The project has been executed by the collaborations between RIEC including IT21 mobile wireless technology group, major Japanese mobile terminal manufacturers and other universities. In this project, concept of Dependable Air, which is multi-mode and multi-band dependable wireless network, is proposed. The targets of this project are (1) all IP dependable wireless network which can realize a communication speed of 1Mbit/s~10Gbit/s, (2) all Si CMOS mixed signal LSI with frequency range of 500MHz~70GHz, (3) LSI development of frequency domain equalizer technology, and (4) scalable AD converter.

2. Development of Low Power Consumption Mass Storage HDD Systems

A new project "Development of super high-speed mass storage HDD systems" started in 2007 under the collaborations between RIEC including IT21 storage technology group, major Japanese HDD manufacturers and other laboratories within Tohoku University. The goals of this project are to develop the perpendicular recording technologies required for higher than 2 Tbits/inch^2 recording density and, based on these technologies, to develop the system architecture for realizing large capacity, high performance and low power consumption storage systems; (1) Development of fundamental technologies for the recording densities over 2 Tb/inch^2; high sensitivity sensors, high recording resolution SPT writers and high-density media including patterned media, (2) Development of a system architecture for high performance and low power consumption storage systems.

[Staff]

Director: Kazuo TSUBOUCHI, Professor
Katsumi SAGAE, Technical Official

Project Planning Division
Makoto FURUNISHI, Professor

Technology Development Division (Mobile Wireless Technology Group)
Tadashi TAKAGI, Professor
Makoto IWATA, Visiting Professor

Technology Development Division (Storage Technology Group)
Kazuhisa FUJIMOTO, Professor
Hajime AOI, Visiting Professor
Takehito SHIMATSU, Associate Professor
Kiyoshi YAMAKAWA, Visiting Associate Professor

The IT-21 Center Project Planning Division

Planning and Encouraging of R&D Projects

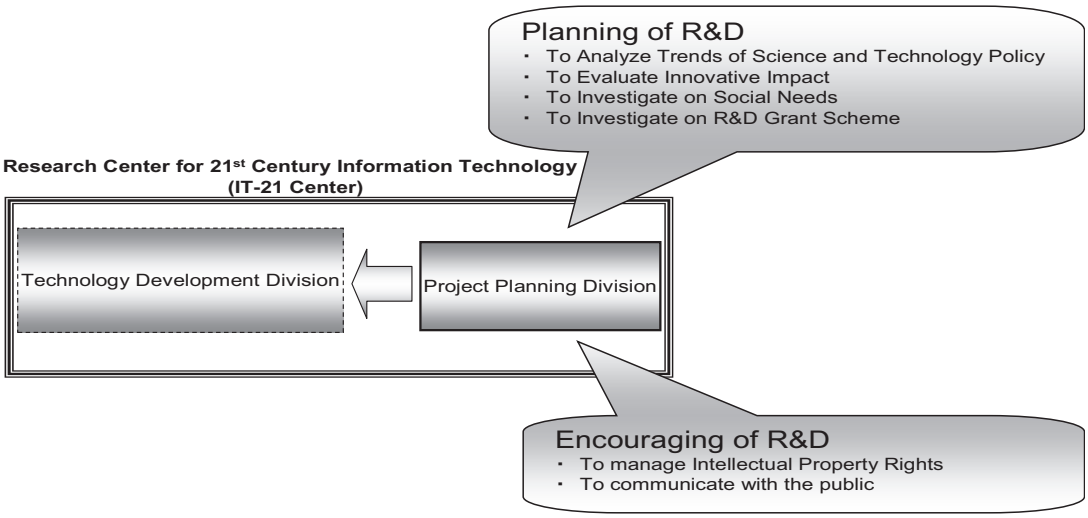
[Research Target and Activities]

Study on trends of science and technology policy, etc. to launch R&D projects with industries. Study on schemes to support R&D projects.

We have successfully launched two new projects since 2007FY, "the development of super high-speed mass storage HDD systems" and "the development of CMOS wireless LAN by 3D SiP". We issued a final report on the IT Project which was entrusted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) from 2002FY to 2007FY. Planning of a new project is underway to utilize the internationally standardized outcome of the IT Project.

We have proposed the roles that the Research Institute of Electrical Communication (RIEC) would play in the management of intellectual property rights, and have arranged a new scheme to handle intellectual property rights with industries in order to carry out the projects mentioned above.

We hold meetings with institutes with which RIEC has concluded the cooperation agreements to start R&D projects.



[Staff]

Professor : FURUNISHI, Makoto

Secretary : KAGAMITANI, Machiko

[Profile]

1986.3 got master's degree from Department of Mechanical Engineering, Faculty of Engineering, the University of Tokyo

1986.4 joined Science and Technology Agency (Ministry of Education, Culture, Sports, Science and Technology (MEXT) at present)

2005.1- 2004.7 Director of Nuclear Fuel Cycle Regulation Division, NISA, METI

2006.8- 2009.9 Professor, IT-21 Center, RIEC, Tohoku University, 2006.11-2008.3 Special Advisor to President

2009.9- Councilor, Secretariat of Science Council of Japan

2009.12- Visiting Professor, RIEC, Tohoku University

[Article]

Effective Management of Intellectual Property Rights at National Universities for the Advancement of Industry-University Collaboration, Intellectual Property Management, Vol.59, No.11, 2009

IT21 Center Mobile Wireless Technology Group

Development of Dependable Wireless System (DWS) Technology for Dependable Air

[Research Target and Activities]

"Development of Dependable Wireless System and Devices" project was accepted in 2007 as the Japan Science and Technology Agency (JST) CREST type research program "Fundamental Technology for Dependable VLSI System." In this project, concept of Dependable Air, which is multi-mode and multi-band dependable wireless network, has been proposed. The targets of this project are (1) all IP dependable wireless network which can realize a communication speed of 1Mbit/s-10Gbit/s, (2) all Si CMOS mixed signal LSI with frequency range of 500MHz-70GHz, (3) LSI development of frequency domain equalizer technology, and (4) scalable AD converter.

1. All Si CMOS RFIC
   For realizing DWS, we have developed a 5GHz- and 60GHz-band RF circuits using 90nm Si-CMOS technology.
2. Digitally Assisted Compensation Technology
   We have developed a novel frequency domain equalizer (FDE) technology implemented to an application specific integrated circuit (ASIC). We have demonstrated a transmission test under multipass fading environments. Due to the FDE, we have realized to improve bit error rate (BER) characteristics. Conventionally, FDE technology has been evaluated by simulation. Here, we have been able to realize it by experiment.
3. Adaptive and Scalable ADC/DAC (Analog-to-Digital Converter/ Digital-to-Analog Converter)
   We have devised a current mode pipeline ADC, which is suitable for process miniaturization and low supply voltage. We have designed several core circuits of the ADC and have realized static characteristics.

[Staff]

Professor: TAKAGI, Tadashi, Dr. (since 2005)

Guest Professor: IWATA, Iwata, Dr. (since 2003)

[Profile of Professor TAKAGI, Tadashi]

Professor TAKAGI Tadashi received the B.S. degree in physics from Tokyo Institute of Technology, Tokyo, Japan and Ph.D. degree in electronic engineering from Shizuoka University, Shizuoka, Japan, in 1973 and 1995, respectively. In 1973, he joined the Mitsubishi Electric Corporation, where he was engaged in development on microwave and millimeter-wave circuits technology. Since 2005, he has been with Tohoku University, where he is now a professor. Now, his main area of research interest is mobile wireless broadband communication circuits and systems technology. He is a senior member of the IEEE and a member of IEICE of Japan.

[Papers]

[1] S. Tanifuji, T. T. Thanh, S. Kameda, T. Takagi, and K. Tsubouchi, "5GHz band low phase noise Si-CMOS oscillator using FBAR", IEICE Electron. Express, vol.7, no.3, pp.165-169, 2010.
[2] S. Yoshida, H. Oguma, S. Kameda, T. Takagi, and K. Tsubouchi, "60 GHz Band Planar Monopole Antenna Using Organic Substrates for Ultra-Small WPAN Modules," Global Symposium on Millimeter Waves 2009 (GSMM2009), April 2009.
[3] S. Kameda, H. Oguma, T. Takagi, K. Tsubouchi, N. Izuka, Y. Asano, and Y. Yamazaki, "Feasibility Study of Downlink Transmission with 256 QAM Based on Results of MBWA System Field Trial," European Wireless 2009, pp.140-144, May 2009.

Contact to Professor Tadashi TAKAGI : t-takagi@riec.tohoku.ac.jp

IT-21 center, Technology Development Division, Storage Technology Group

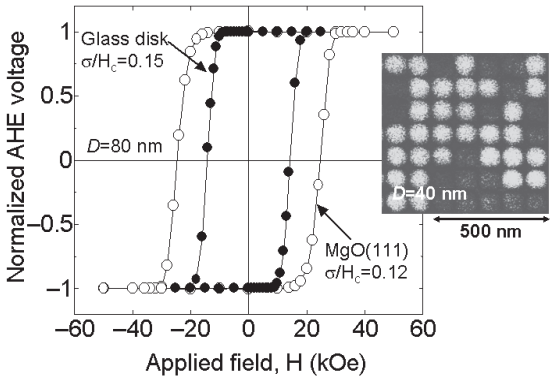
Development of low power consumption mass storage HDD systems

[Research Target and Activities]

A new project ;Development of super high-speed mass storage HDD systems started in August 2007 under the collaborations between RIEC including IT21 storage technology group, major Japanese HDD manufacturers. The goals of this project are to develop the perpendicular recording technologies required for higher than 2 Tbits/inch^2 recording density and, to develop the system architecture for realizing large capacity, high performance and low power consumption storage systems.

This year we continued fundamental studies and obtained the following achievements.

1) High density recording media: $L1_1$-type CoPtM (M: Fe, Ni, Cr, Mn, Pd) ordered alloy films with a large uniaxial magnetic anisotropy were fabricated using UHV sputter film deposition, and magnetic properties were examined. Moreover, we started experimental analysis of magnetization reversal for dot arrays of high-K_u perpendicular films with the dot diameter of 10~15 nm.
2) High sensitivity sensor technology: It was experimentally shown for high sensitivity spin accumulation sensor that an introduction of MgO barrier structure resulted in an enhancement of output signal.
3) Single pole type writer with a high recording resolution: Multiple tapered main-pole structure was further improved utilizing simulation. Preliminary study of head element fabrication was started.
4) New recording algorithm for over terabits per square inch densities: Possibility of attaining 2Tb/in^2 using hard/soft stacked structure bit patterned media (BPM) was confirmed using LLG simulation. Moreover, a preliminary study of read/write properties for bit-patterned media (60 nm in dot diameter) using a static tester revealed that the writing margin was 70% to the bit length.
5) A 64-TB testbed with "2-dimension data allocation method with an access prediction" was developed to evaluate the energy savings with minimum loss of speed and could obtain an energy-saving of 16% compared with current tiered-storage without loss of data-throughput. The energy savings in 1-PB capacity system, estimated from the measured data, corresponded to a saving of 55%.



AHE curves and MFM image for the dot arrays of $L1_1$-CoPt alloy films.

[Staff]

Kazuhisa FUJIMOTO, Professor. Hajime AOI, Visiting Professor. Takehito SHIMATSU, Associate Professor. Kiyoshi YAMAKAWA, Visiting Associate Professor.

[Profile]

Kazuhisa Fujimoto received the Dr. of Engineering degree from Kyushu University in 1997. He joined Central Research Laboratory, Hitachi, Ltd., in 1987. He joined RIEC, Tohoku University in 2007. He has been engaged in research on storage system architectures.

[Papers]

[1] K. Fujimoto, H. Akaike, N. Okada, K. Miura, and H. Muraoka, "Power-aware Proactive Storage-tiering Management for High-speed Tiered-storage Systems," *SustainIT '10 (online proceedings)* (2010).

[2] T Shimatsu, H Sato, H Kataoka, S Okamoto, O Kitakami, and H Aoi, "Magnetic and structural properties of $L1_1$ type CoPt-C ordered alloy perpendicular films as a function of C content," ICM2009, Th-C-10-10 (*J. Phys.: Conf. Ser., in press*).

Contact to Professor Kazuhisa FUJIMOTO : fujimoto@riec.tohoku.ac.jp

Management Office for Safety and Health

Realizing and Maintaining a Safe and Comfortable Environment to Support Research

[Research Target and Activities]

Safety and health seminar

First aid training course

1. Outline of the Management Office for Safety and Health

The Management Office for Health and Safety is established to maintain the health and safety of students and staff working at the institute. The use of chemicals, high-pressure gas and radiation in research activities at the institute entails many risks. The Management Office for Health and Safety provides support for health and safety management in research laboratories, experimental facilities and the Fundamental Technology Center through various activities to ensure safe and smooth research activities within the institute.

2. Activities by the Management Office for Safety and Health

For the actual management of health and safety at the office, the Health and Safety Committee first presents the basic policies of safety management at the institute, and the Management Office for Health and Safety then plans and executes activities based on them. At the institute, laboratories and other individual sections are highly independent of each other; unlike a general corporate organization, top-down safety management is not suitable and measures appropriate for independent sections need to be taken., Various considerations are also necessary for students, researchers, and other members engaged in research activities as well as faculty staff. At this institute, extremely hazardous materials and facilities are used, including chemicals, high-pressure gas, and X-ray devices. Since there is also a clean room and other special workplaces, safety management should be extended by considering them. In these circumstances, the Management Office for Health and Safety will monitor situations and characteristics in each section at the institute, plan and recommend practical management methods and improvement measures, and support their implementation for the efficient and effective management of health and safety. The main activities in this fiscal year are as follows:

- ○ Holding safety and health seminar and high-pressure gas seminar for staff and students at the institute
- ○ Inspection of and assistance in improving the health and safety management system and working environment within the institute
- ○ Holding first-aid training course
- ○ Investigation of laws related to health and safety and collection of information regarding health and safety management
- ○ Providing advice and information to health and safety personnel in each department

[Staff]

Manager: Michio NIWANO Dr., Professor

Deputy Manager: Yoichi UEHARA Dr., Professor

Nobuyuki SATO Dr., Assistant Professor

Ayako CHIBA, Clerk

Contact to anzen@riec.tohoku.ac.jp

Flexible Information System Research Center

Development of Flexible Information Systems and Management of Network

[Research Target and Activities]

The present information systems such as computers are inflexible systems, because their purpose is predefined and they provide only the fixed procedures and functions. On the other hand the flexible information system can perform the flexible information processing adapted to the human intention and situation of its environment.

Our goal is to investigate principles of the flexible information processing through the theories and experiments, and establish their system construction methodology. Moreover, we also study the flexible distributed systems for advanced organization, utilization, administration, operation and putting out scientific information. Through practical applications of above results to the real network in RIEC, we confirm effectiveness of our methods. To achieve the above goal, this year we have conducted the following researches:

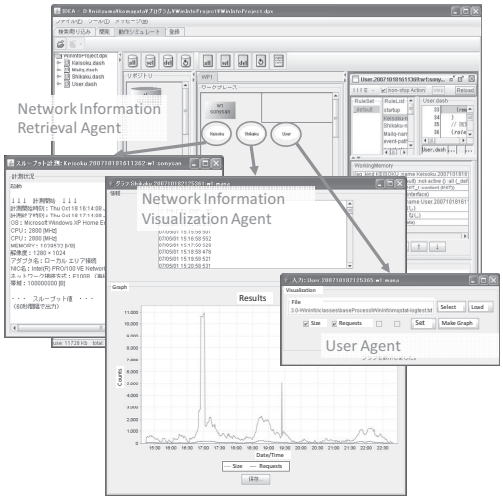


Fig. 1 Agent based Network Management System.

(1) development of distributed and scalable authentication method for large scale overlay network,
(2) development of an agent based network management system (Fig.1) and
(3) flexible computing mechanism in biological system.

[Staff]

(1) Steering Committee
Professor: SUZUKI Yôiti Dr., SHIRATORI Norio Dr., TOYAMA Yoshihito Dr., KINOSHITA Tetsuo Dr., SHIRAI Masafumi Dr., OHORI Atsushi Dr.
(2) FIR Committee
Professor: TOYAMA Yoshihito Dr., KINOSHITA Tetsuo Dr.
Associate Professor: AOTO Takahito Dr., AOKI Terumasa Dr., KITAGATA Gen Dr.
Assistant Professor: YOSHIDA Masato Dr., ONOMI Takeshi Dr., SASAI Kazuto Dr.
Research Fellow: OSADA Toshiaki Dr.
Technical Support Member: SUZUKI Midori, NIITSUMA Sachiko
(3) Regular Staff
Associate Professor: KITAGATA Gen Dr.
Assistant Professor: SASAI Kazuto Dr.
Research Fellow: OSADA Toshiaki Dr.
Technical Support Member: SUZUKI Midori, NIITSUMA Sachiko

[Profile]

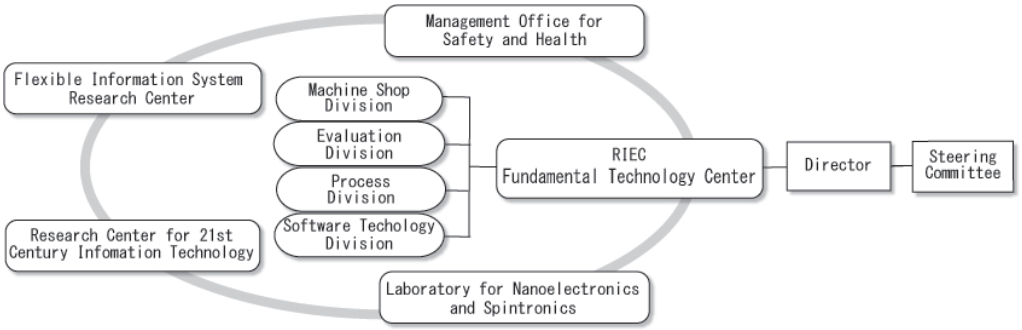
Refer to the Advanced Acoustic Information Systems Laboratory for the profile Prof. Yôiti Suzuki.
Refer to the Computing Information Theory Laboratory for the profile Prof. Yoshihito Toyama.

[Papers]

1. J. Makishi, D. Chakraborty, T. Osada, G. Kitagata, A. Takeda, K. Hashimoto, N. Shiratori, "A Fair Load Sharing Scheme for Multi-source Multimedia Overlay Application Layer Multicast," Proc. of the 4th International Conference on Complex, Intelligent and Software Intensive Systems (CISIS 2010), Krakow, Polland, Feb. 15-18, 2010.
2. Akihiro Satoh, Toshiaki Osada, Toru Abe, Gen Kitagata, Norio Shiratori, Tetsuo Kinoshita, "Traffic Classification in Mobile IP Network," Proc. of the 4th International Conference on Ubiquitous Information Technologies & Applications (ICUT 2009), 2009.12.
3. Akira Sakatoku, Akifumi Kawato, Toshiaki Osada, Gen Kitagata, Norio Shiratori, Tetsuo Kinoshita, "3D Symbiotic Environment for Collaborative Work," Proc. of the 4th International Conference on Ubiquitous Information Technologies & Applications (ICUT 2009), 2009.12..

Fundamental Technology Center

Supporting research with high-level specialized knowledge and technology



Overview of Fundamental Technology Center

[Research Target and Activities]

The Fundamental Technology Center provides research support, closely linked with research activities at the Institute, based on its high-level specialized knowledge and technology. We must maintain and improve our organization to develop and pass on high-level knowledge and technology. Based on this philosophy, the Center provides research support through its four Divisions.

1. Machine Shop Division

The Machine Shop Division has previously pioneered a number of new machining methods, and contributed to research on high-density magnetic recording and many other types of research relating to advanced information and communications. This year, there were 129 fabrication requests from laboratories (114 from inside the Institute, 15 from outside).

2. Evaluation Division

The Evaluation Division provides the following as measurement equipment for shared use:
atomic force microscope, scanning electron microscope, X-ray diffractometer, electron spin resonance spectrometer, scanning transmission electron microscope, electron probe micro analyzer, X-ray fluorescence analyzer, fourier transform infrared spectrophotometer, infrared-visible spectroscope, liquid chromatograph, optical characteristic measurement equipment, in-air photoelectron measurement equipment, dicing saw

3. Process Division

The Process Division provides the following as measurement equipment for shared use:
Focused ion beam system, mask aligner, X-ray diffractometer for thin films, electron beam exposure equipment, sputtering equipment, scanning electron microscope, optical microscope, scanning probe microscope, spectrophotometer, digital microscope, dicing saw, UV & ozone dry stripper

4. Software Technology Division

The Software Technology Division manages, operates and develops information systems for the Institute. To support research in each field, the Division handles tasks like disseminating information on research results and providing services for gathering/organizing/utilizing academic information, such as space collaboration systems and a database of RIEC researchers.

[Staff]

Director (Professor): Michio NIWANO Dr., Assistant Professor: Nobuyuki SATO Dr.
Technical Official : Yasuo WAGATSUMA, Shigeto AGATSUMA, Koichi SHOJI, Tamotsu SUENAGA, Takeshi YAMASHITA, Maho ABE, Keisuke SATO, Kento ABE, Hiroshi WATANABE, Munetomo SUGAWARA, Yuji KONNO, Ryuji YONEZAWA, Choichi TAKYU,

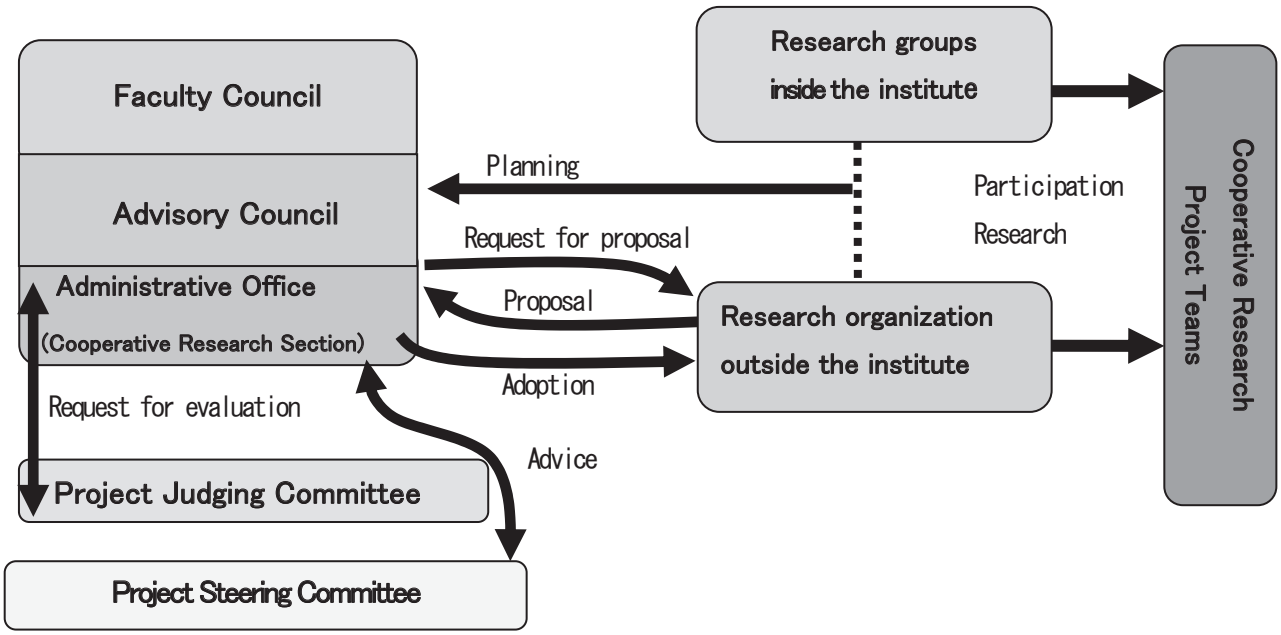
4. Nation-wide Cooperative Research Projects

The Institute has a long history of fundamental contributions in many fields of engineering and science that include the fields of semiconductor materials and devices, magnetic recording, optical communication, electromagnetic technology, applications of ultrasonic, acoustic communication, non-linear physics and engineering, and computer software. On the basis of this rich historical background the Institute was designated as National Center for Cooperative Research in 1994. Accompanying Tohoku University's transformation to "a national university juridical entity" in April,2004, this institution plays a leading role on the world stage, as its researchers, both domestic and foreign, continue the task of "investigating the theory and application of universal science and technology to realize communication, to the enrichment of humanity."

In such background, the Institute organizes Nation-wide Cooperative Research Projects by coordinating its activities with research workers. The main themes for Cooperative Research are selected annually by the Committee for Cooperative Research. Then invitations for project proposals and participation are extended to university faculties and government laboratories as well as industrial research groups. Each project approved by the Faculty Council of the Institute is carried out by a team of researchers that include members of the Institute as well as outside participants.

The advisory Council which includes members from other institutions has an advisory function to the Director in defining the general direction of the research at the Institute and its Nation-wide Cooperative Research Projects.

The Project Judging Committee that includes members from the outside of Tohoku University has a judging function for project proposals. The purpose of the Project Steering Committee is the proper operation of approved projects.



Nation-wide cooperative research projects list 2009

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H19／A01 Development of magnetic-dielectric material using magnetic nanoparticle assembly for ultra-high frequency devices	**Migaku TAKAHASHI** School of Engineering Tohoku University	**Yasuo CHO**
H19／A02 A basic research for gaining IP network aspect	**Hiroshi UEDA** Library and Information Technology Center,Gunma University	**Yukio IWAYA**
H19／A03 Theoretical Design and Fabrication of Multi-functional Spintronics Materials	**Akio KIMURA** Hiroshima University, The Graduate School of Science	**Masafumi SHIRAI**
H19／A04 Valency Control of Group IV Semiconductor Quantum Dots and Its Application of MOS Memories	**Seiichi MIYAZAKI** Hiroshima University, Advanced Sciences of Matter	**Junichi MUROTA**
H19／A05 Study of Orientation and Mobility Training for the Persons with Visual Impairment by using Wide-Range Three Dimensional Acoustical Technologies	**Yoshikazu SEKI** National Institute of Advanced Industrial Science and Technology	**Yukio IWAYA**
H19／A06 Research on accurate HRTF measurement systems	**Tatsuya HIRAHARA** Toyama Prefectural University Faculty of Engineering	**Yôiti SUZUKI**
H19／A07 A study on the basic representation of color (color alphabets) in visual cortex	**Ichiro KURIKI** Research Institute of Electrical Communication, Tohoku University	**Ichiro KURIKI**
H19／A08 Development of new measurement techniques with nanometer scale spatial resolution and exploration of the electronic and optical properties of surface nanostructures	**Yoichi UEHARA** Research Institute of Electrical Communication, Tohoku University	**Yoichi UEHARA**

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H19／A10 On application of frequency domain binaural model for hearing aids	Tsuyoshi USAGAWA Kumamoto University, Graduate School of Science and Technology	Yôiti SUZUKI
H19／A13 Physiological Evaluation and Development of a Distributed Multi-display System Adapting to User's situation	Atsumi IMAMIYA University of Yamanashi, Interdisciplinary Graduate School of Medicine and Engineering	Takuo SUGANUMA
H19／A14 Next Generation Wireless Hot-Spot Network	Kazuo TSUBOUCHI Research Institute of Electrical Communication, Tohoku University	Kazuo TSUBOUCHI
H20／A01 Basic Studies in Plasma Nanobiotronics	Rikizo HATAKEYAMA School of Engineering Tohoku University	Michio NIWANO
H20／A02 The Frontier of Photonic Crystal and Nano-Photonic Applications	Shojiro KAWAKAMI Sendai Foundation for Applied Information Sciences	Masataka NAKAZAWA
H20／A03 Investigation of interface trap density for an MIS structures using an ECR sputter-deposited high-k gate-oxides	Toshiro ONO Graduate School of Science and Technology Hirosaki University	Junichi MUROTA
H20／A04 Three-DimensionalNanostructure Formation of Strain-Controlled Group-IV Semiconductors and Its Device Application	Junichi MUROTA Research Institute of Electrical Communication, Tohoku University	Junichi MUROTA
H20／A05 Fabrication of high mobility two-dimensional hole gas	Seigo TARUCHA School of Engineering The University of Tokyo	Yuzo OHNO
H20／A06 Intelligent nano-integration system and its application	Koji NAKAJIMA Research Institute of Electrical Communication, Tohoku University	Koji NAKAJIMA

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H20／A07 A research on organic heterojunction photovoltaic devices	**Fumihiko HIROSE** Yamagata University Graduate School of Science and Engineering	**Michio NIWANO**
H20／A08 Development of Ion-Channel Chips	**Masao SUGAWARA** Nihon University College of Humanities and Sciences	**Michio NIWANO**
H20／A09 Study of human visual stability during eye movements	**Masayuki SATO** Faculty of Environmental Engineering, Kitakyushu University	**Satoshi SHIOIRI**
H20／A10 Learning effects of sound localization in the binaural technology	**Kenji OZAWA** University of Yamanashi, Interdisciplinary Graduate School of Medicine and Engineering	**Yôiti SUZUKI**
H20／A11 Cell-based chips using infrared spectroscopy	**Yasuo SHINOHARA** Institute for Genome Research, The University of Tokushima	**Michio NIWANO**
H20／A13 Study of magnetic devices with application of the thin film element with inclined stripe magnetic domain	**Tomoo NAKAI** Industrial Technology Institute, Miyagi Prefectural Government	**Kazushi ISHIYAMA**
H20／A14 A study on advanced video content retrieval technology	**Junji NUMAZAWA** Research Institute of Electrical Communication, Tohoku University	**Junji NUMAZAWA**
H21／A01 Superconducting Computer Technology toward Reduction of Environmental Burden	**Yoshinao MIZUGAKI** The University of Electro-Communications	**Shigeo SATO**
H21／A02 Nanophotonics and Nanoelectronics Devices with Metallic Nanomaterials	**Kaoru TAMADA** Research Institute of Electrical Communication Tohoku University	**Kaoru TAMADA**
H21／A03 Study on the heterointerface for the improvement of performance and reliability of group-Ⅳ hetero-devices	**Toshiaki TSUCHIYA** Shimane University Interdisciplinary Faculty of Science and Engineering	**Junichi MUROTA**

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H21／A04 Evaluation of Piezoelectric Langasite Family Compounds by the Ultrasonic Microspectroscopy and Piezoelectric Resonant-Antiresonant Frequencies Methods and their Applications to High-Temperature Sensors	Jun-ichi KUSHIBIKI School of Engineering Tohoku University	Yasuo CHO
H21／A05 Study on spintronic application of the oxide thin films with Magneto-Electric effect	Seiji SAHASHI School of Engineering Tohoku University	Kazushi ISHIYAMA
H21／A06 STT microwave oscillation of self-organized multi-nano-pillar structure and its application	Masaaki DOI School of Engineering Tohoku University	Kazushi ISHIYAMA
H21／A07 Synchronization in dynamics of oscillating pulse edges in switch lines	Koichi NARAHARA Yamagata University Graduate School of Science and Engineering	Taiichi OTSUJI
H21／A08 High performance THz wave sources based on resonant tunneling diode pairs	Koichi MAESAWA Faculity of Engineering, University of Toyama	Taiichi OTSUJI
H21／A09 Development of measuring method for speech recognition performance under various sound field	Hiroshi SATO National Institute of Advanced Industrial Science and Technology	Yôiti SUZUKI
H21／A10 A Study on Higher Realistic Communication in Three Dimensional Sound Space	Kazuhiro KONDO Yamagata University Graduate School of Science and Engineering	Yukio IWAYA
H21／A11 The cooperative system to built a model of visual cognition	Satoshi SHIOIRI Research Institute of Electrical Communication Tohoku University	Satoshi SHIOIRI

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H21／A12 A study on SAT(Scenario To Anime) technology	Terumasa AOKI Research Institute of Electrical Communication Tohoku University	Terumasa AOKI
H21／A13 Creation of Platform for Sustainable Information Society by Sensor-Cloud Systems	Osamu TAKAHASHI The School of Systems Information Science Future University-HAKODATE	Norio SHIRATORI
H19／B01 Subject and View of Synthetic Aperture Radar Development for Civilian Use	Atsushi MASE Art,Science and Technology Center for Cooperative Research,Kyushu University	Kazuo TSUBOUCHI
H19／B02 Research on optical measurements of earthquakes and their networking	Akito ARAYA Earthquake Research Institite, University of Tokyo	Masataka NAKAZAWA
H19／B04 Development of Science of Fine-Particle Plasmas	Yasuaki HAYASHI Kyoto Institute of Technology	Michio NIWANO
H19／B09 A proof theoretical approach to principles of program construction	Masahiko SATO Graduate School of Informatics, Kyoto University	Yoshihito TOYAMA
H20／B02 Development of high performance piezoelectric materials and application to information and communication devices	Jun-ichi KUSHIBIKI School of Engineering Tohoku University	Yasuo CHO
H20／B03 Research on Ultra High Density Semiconductor Memories based on New Conceptual Material and Storage Principle	Heiji WATANABE Graduate School of Engineering Osaka University	Tetsuo ENDOH
H20／B04 Research on Nano Semiconductor Materials and its Application to Nano Devices	Kikuo YAMABE Graduate School of Pure and Applied Sciences University of Tsukuba	Tetsuo ENDOH

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H20／B05 Cooperation of Semiconductor Science and Technologies Toward Science Driven Semiconductor Technologies-	Kenji SHIRAISHI Center for Computational Sciences University of Tsukuba	Hideo OHNO
H20／B06 Development of high-performance quantum cascade lasers and their applications to high-sensitive sensing	Keita OHTANI Research Institute of Electrical Communication, Tohoku University	Keita OHTANI
H20／B08 Advanced communication and measurement technologies using phase-controlled lightwaves	Hidemi TSUCHIDA National Institute of Advanced Industrial Science and Technology	Masataka NAKAZAWA
H20／B09 Research on Next-Generation Peta-byte Information Storage	Hiroaki MURAOKA Research Institute of Electrical Communication, Tohoku University	Hiroaki MURAOKA
H20／B10 Development of Dependable System Software with a Highly Reliable Programming Language System	Kazuhiko KATO University of Tsukuba, Graduate School of Systems and Information Engineering	Atsushi OHORI
H20／B11 Automatic program verification based on deduction engines	Mizuhito OGAWA School of Information Science,Japan Advanced Institute of Science and Technology	Atsushi OHORI
H21／B01 Fundamental characteristics and applications of innovative functional field generated by various plasma flow	Akira ANDOH School of Engineering Tohoku University	Maki SUEMITSU
H21／B02 Control and Elucidation of Growth Mechanism of Graphene for device applications in the next generation	Maki SUEMITSU Research Institute of Electrical Communication Tohoku University	Maki SUEMITSU

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H21／B03 Small Power Wireless Communications	Shuzo KATO Research Institute of Electrical Communication Tohoku University	Shuzo KATO
H21／B04 Complex Valued Neural Network for Real Applications	Akira HIROSE School of Engineering The University of Tokyo	Shigeo SATO
H21／B05 Study on human performance with a view to designing human-friendly information systems	Hirofumi YANAI College of Engineering. Ibaraki University	Koji NAKAJIMA
H21／B06 Toward an interdisciplinary approach of vision sciences	Kenichiro TSUTSUI Tohoku University, Graduate School of Life Science	Satoshi SHIOIRI
H21／B07 Novel Bioelectronic Devices Based on Combination of Nano and Bio-technology	Toshio OGINO Yokohama National University, Graduate School of Engineering	Michio NIWANO
H21／B08 Constructivist approach to mechanism of adaptive locomotion of biological system	Ko HOSODA Graduate School of Engineering Osaka University	Masafumi YANO
H21／B09 Evolution of high performance computing by non-volatile bits-operation technologies	Hiroshi MATSUOKA RIKEN Advanced Institute for Computational Science	Takahiro HANYU
H21／B10 Research on Next-Generation Models of Digital Content Distribution	Isao ECHIZEN National Institute of Informatics	Yôiti SUZUKI

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H21／B11 New Paradigm VLSI System and Its System Integration Technology	**Takahiro HANYU** Research Institute of Electrical Communication Tohoku University	**Takahiro HANYU**
H20／S01 Development of essential technologies for superhivision	**Hidenori MIMURA** Shizuoka University Research Institute of Electronics	**Yôiti SUZUKI**
H20／S02 Spintronics Initiative Network	**Kouhei ITOH** Keio University Science and Technology	**Hideo OHNO**
H21／S01 Information processing and communication system based on an innovative new concept associated with human functions	**Yasushi YAGI** The Institute of Scientific and Industrial Research, Osaka University	**Koji NAKAJIMA**

5. Symposium organized by the Institute

This Symposium is planned to exchange relevant information on current important topics concerning Electrical Eng., Electrical Communications, Electronic Eng., and Information Eng. Many related researchers inside and outside Tohoku University participate the Symposium and stimulate discussion.

Symposium In Past

	Title	Date
1	Quantum Electronics of Liglht Waves and Micro Waves	Feb. 6- 8, 1964
	Magnetic Recording	Feb.14-15, 1964
2	Ultra-High Frequency Acoustelectronics	Feb.11-12, 1965
3	Artificial lntelligence	Mar. 8- 9, 1966
4	Thin Film Electronics	Jan.26-27, 1967
5	Crystal Growth	Dec. 19-20, 1967
6	1968 Sendai Svmoosium on Acoustelectronics	Aug.19-20, 1968
7	Current Status and Future Trends of Superconductivitv	Jan.22-24, 1970
8	Soeech Information Processing	Feb.24-26, 1971
9	Surface Acoustic Wave Technology	May.25-26, 1972
10	Liquid Crystals · Their Molecular Orientations and Application to Display Devices	Dec.13-14, 1974
11	Computer Network	Mar.17-18, 1975
12	The Memorial Symposium on the 40th Anniversarv of the Foundation of RIEC	Sep.25-26, 1975
13	Application of Amorphous Ferromagnetic Materials	Mar.10-11, 1977
14	Stoichiometry of Compound Crystals	Nov.24-25, 1977
15	Submillimeter Waves	Nov.16-17, 1978
16	Solid State Chemical Sensors	Feb. 1- 2, 1980
17	Graph Theory and Algorithms	Oct.24-25, 1980
18	Perpendicular Magnetic Recording	Mar.11-12, 1982
19	Approach to Optical Computer	Mar.10-11, 1983
20	Plasma Non-Linear Phenomena - Basic Problems for Fusion Plasmas	Mar. 8- 9, 1984
21	New Computer Architecture	Jul.25-26, 1985
22	Guided Wave Technology and Its Application at Mid-Infrared	Mar.13-14,1986
23	Physics and Applications of Tunnelling Phenomena	Mar.12-14, 1987
24	Biomagnetics and Bioelectronics	Feb.26-27, 1988
25	Ultrasonic Electronics - New Applications of Piezoelectricity	Feb. 2- 3, 1989
26	Boundaries between Light and Electromagnetic Wave	Feb. 1-2, 1990

27	Issues and Realization of Pattern Recognition and Understanding	Feb.28-Mar.1,1991
28	Discrete Algorithms	Oct.17-18, 1991
29	Perspective for New Computing Paradigm	Feb. 4- 5, 1993
	Current Status and Future Prospects of System Control	Mar. 3- 4, 1993
30	Future Prospects of Electron Beam Devices	Nov. 1- 2, 1993
31	Discharge and EMC	Dec.20-21, 1994
32	Statistical Physics and Information Science	Mar.22-23,1995
33	Photo-and Plasma-Excited Processes on Surfaces	Nov.30-Dec.1,1995
34	Nano Spinics and Power Electronics	Feb.15-16, 1996
35	Potential Formation and Related Nonlinear Phenomena in Plasmas	Sep.17-19, 1996
36	New Trend in Ultrasonic Measurements	Feb. 3- 4, 1997
37	Toward the Realization of the High-Definition Multi-Media Communication	Nov. 4- 6, 1997

International Symposium Organized by the Institute

	Title	Date
1	Intrinsic Josephson Effect and THz Plasma Oscillation in High T_c Superconductors	Feb.23-25, 1997
2	Design and Architecture of Information Processing Systems Based on The Brain Information Principle	Mar.16-18, 1998
3	Novel Techniques and Applications of Millimeter-Waves	Dec.14-16, 1998
4	The International Joint Conference on Silicon Epitaxy and Heterostructures	Sep.13-17, 1999
5	International Workshop on Photonic and Electromagnetic Crystal Structures	Mar.8-10, 2000
6	Physics and Application Spin Related Phenomena in Semiconductors	Sep.13-15, 2000
7	Rewriting in Proof and Computation	Oct.25-27, 2001
8	Nonlinear Theory and its Applications	Oct.28-Nov.1, 2001
9	New Paradigm VLSI Computing	Dec.12-14, 2002
10	Ultra High Density Spinic Storage System	Oct.23-24, 2003
11	3rd International Workshop on New Group IV (Si-Ge-C) Semiconductors	Oct.12-13, 2004
12	3rd International Workshop on High Freaqency Micromagnetic Devices and Materials (MMDM3)	Apr.11-12, 2005
13	4th International Conference on Silicon Epitaxy and Heterostructures (lCSl-4)	May.23-26, 2005
14	1st International WorkShop on New Group IV Semiconductor Nanoelectronics	May.27-28. 2005

15	GSIS International Symposium on Information Sciences of New Era: Brain, Mind and Society	Sep.26-27, 2005
16	The 1st RIEC International Workshop on Spintronics -Spin Transfer Phenomena-	Feb.8-9, 2006
17	4th International Workshop on High Frequency Micromagnetic Devices and Materials (MMDM4)	May 8,2006
18	4th International Conference on Physics and Applications of Spin-Related Phenomena in Semiconductors (PASPS-lV)	Aug.15-18,2006
19	2nd International Workshop on New Group IV Semiconductor Nanoelectronics	Oct.2-3,2006
20	2nd RIEC International Workshop on Spintronics	Feb.15-16,2007
21	Japan-China Joint Conference on acoustics, JCA2007	Jun.4-6,2007
22	International Conference on Discovery Science/ International Conference on Algorithmic Learning Theory	Oct.1-4,2007
23	The 3rd RIEC International Workshop on Spintronics	Oct. 31-Nov.1,2007
24	3rd International Workshop on New Group ⅣSemiconductor Nanoelectronics	Nov.8-9,2007
25	International Workshop on Nanostructures & Nanoelectronics	Nov.21-22,2007
26	The 18th International Symposium on Algorithms and Computation(ISAAC2007)	Dec.17-19,2007
27	International Interdisciplinary-Symposium on Gaseous and Liquid Plasmas (ISGLP 2008)	Sep.5-6,2008
28	4th International Workshop on New Group IV Semiconductor Nanoelectronics	Sep.25-27,2008
29	The 4th RIEC International Workshop on Spintronics	Oct.9-10,2008
30	GSMM2009 (Global Symposium on Millimeter Waves 2009)	Apr.20-22,2009
31	Mini R.I.E.C. workshop on multimodal perception	Apr.24-25,2009
32	The 4th International Symposium on Ultrafast Photonic Technologies	Aug.4-5,2009
33	PIMRC2009 (Personal Indoor and Mobile Radio Communications Symposium 2009)	Sep.13-16,2009
34	2nd RIEC-CNSI Workshop on Nanoelectronics,Spintronics and Photonics (5th RIEC Symposium on Spintronics)	Oct.22-23,2009
35	International Workshop on the principles and applications of spatial hearing (IWPASH2009)	Nov.11-13,2009
36	5th International Workshop on New Group IV Semiconductor Nanoelectronics	Jan.29-30,2010
37	6th RIEC International Workshop on Spintronics	Feb.5-6,2010
38	2nd International Workshop on Nanostructure & Nanoelectronics	Mar.11-12,2010

6. Study groups on Electrical Communication

Study Groups on Electrical Communication are organized to solve scientific and technological problems and to promote research and development through the collaboration of the Research Institute of Electrical Communication, Depts. of Electrical Eng., Electrical Communications, Electronic Eng., Information Eng., and related scientists and engineers inside and outside Tohoku University. The Study Groups on Electrical Communication consist of 14 Sub-Groups as listed below, to deal with specific subjects. Each Sub-Group holds workshops. The abstracts of the workshops are published annually in *The Record of Electrical and Communication Engineering Conversazione Tohoku University*.

Many scientists and engineers—not only from universities but also from government laboratories and industries—attend the workshops, present papers, and discuss issues actively. We are pleased to provide information on these activities upon request. Please contact each Sub-Group Chairman or manager for general information or more specific questions.

Electromagnetic and Optical Waves Engineering	
Chair	Prof. Yuji MATSUURA
Manager	Assistant Prof. Takashi KATAGIRI

Acoustic Engineering	
Chair	Prof. Yôiti SUZUKI
Manager	Associate Prof. Yukio IWAYA
Manager	Assistant Prof. Masashi ITO

Sendai "Plasma Forum"	
Chair	Prof. Rikizo HATAKEYAMA
Manager	Associate Prof. Satoshi IIZUKA

Sendai Seminar on EMC	
Chair	Prof. Hideaki SONE
Manager	Prof. Masahiro YAMAGUCHI

Computer Science	
Chair	Prof. Naoki KOBAYASHI
Manager	Associate Prof. Takahito AOTO

Systems Control	
Chair	Prof. Makoto YOSHIZAWA
Manager	Associate Prof. Noriyasu HOMMA

Information-biotronics	
Chair	Prof. Michio NIWANO
Manager	Prof. Tatsuo YOSHINOBU

Spinics	
Chair	Prof. Migaku TAKAHASHI
Manager	Associate Prof. Simon GREAVES
Manager	Associate Prof. Yasushi ENDO

New Paradigm Computing	
Chair	Prof. Michitaka KAMEYAMA
Manager	Associate Prof. Masahide ABE

Ultrasonic Electronics	
Chair	Prof. Shinichirou UMEMURA
Manager	Assistant Prof. Yuji OHASHI

Integration of Brain Functions	
Chair	Prof. Koji NAKAJIMA
Manager	Associate Prof. Shigeo SATO

Mathematical Physics and its Application to Information Sciences	
Chair	Prof. Kazuyuki TANAKA
Manager	Prof. Kazuyuki TANAKA

Biocybernetics and Bioinformatics	
Chair	Prof. Mitsuyuki NAKAO
Manager	Assistant Prof. Kazumichi MATSUMIYA

Nanoelectronics and Spintronics	
Chair	Prof. Hideo OHNO
Manager	Associate Prof. Yuzo OHNO

7. International activities

Many of the staff in RIEC contribute to the development of technology and science in the world by serving as editors of referees of international journals or by chairing or programming international conferences. In some fields in electronics, electrical communications, or information engineering RIEC serves as a Center of Excellence (COE), which attracts many visiting researchers and students from all over the world every year. Several academic exchange programs with foreign colleges or institutes are in operation.

International academic exchange programs:

- The Institute of Physics, Polish Academy of Sciences (Poland)
- The Faculty of Science, Chulalongkorm University (Thailand)
- Harbin Institute of Technology (China)
- The James Frank Institute, The University of Chicago (U.S.A.)
- Queen Mary and Westfield College, University of London (U.K.)
- Scientific Research Department, Shenzhen University (China)
- Institute of Information and Communication Technology, Sung-Kyun-Kwan University (Korea)
- Institute of Materials Science, Faculty of Applied Physics, University of Twente (Netherlands)
- The Institute of Radioengineering and Electronics Russian Academy of Sciences (Russia)
- Department of Electronics Science and Engineering, University of Nanjing (China)
- School of Computer and Communication Engineering, Taegu University (Korea)
- Research Center of Condensed Materials and Nanosciences, National Center for Scientific Research (France)
- IHP-Innovations for High Performance microelectronics (Germany)
- Institute of Semiconductors Chinese Academy of Sciences (China)
- WINLAB, Rutgers University (U.S.A.)
- University of California, Santa Barbara (U.S.A.)
- King Mongkut's Institute of Technology Ladkrabang (Thailand)
- The University of York (U.K.)
- The Dresden University of Technology (Germany)
- Berlin Institute of Technology (Germany)
- National Tsing Hua University (Taiwan)
- Universite de Technologie de Compiegne (France)

International journals in which a staff in RIEC participates as an editor:

1.	Acoustical Science and Technology
2.	Applied Acoustics
3.	Applied Physics Express (APEX)
4.	Higher-Order and Symbolic Computation
5.	IEICE Electronics Express
6.	IEICE Transactions on Electronics
7.	Institution of Engineering and Technology (IET)

8.	International journal of Artificial Intelligence, Neural Networks, and Complex Problem Solving Technologies
9.	International Journal of Computer Science and Network Seculity
10.	International Journal of Information Sciences and Computer Engineering (IJSCE)
11.	Journal of Infrared, Millimeter and Terahertz Waves
12.	Journal of Ambient Intelligence and Humanized Computing
13.	Journal of Communications and Networks
14.	Japanese Journal of Applied Physics
15.	Japanese Journal of Applied Physics (JJAP)
16.	NPG Asia Materials
17.	Nonlinear Theory and Its Applications, IEICE
18.	Optical Fiber Technology
19.	Optics Communications
20.	The Journal of Computer Animation and Virtual Worlds
21.	Virtual Journal of Nanoscale Science and Technology

Recent international conferences programmed by a staff in RIEC:

1.	European Solid-State Device Research Conference (ESDERC)
2.	Asia-Pacific Radio Science Conference (AP-RASC)
3.	Asia-Pacific Microwave Conference (APMC)
4.	Asia-Pacific Workshop on Fundamentals and Applications of Advanced Semiconductor Devices (AWAD)
5.	International Conference on Infrared, Millimeter, and Terahertz Waves
6.	International Conference on Magnetics (ICM)
7.	IEEE International Magnetic Conference (INTERMAG)
8.	Conference on Magnnetism & Magnetic Materials (MMM)
9.	International Symposium on Advanced Magnetic and Applications (ISAMMA)
10.	International Symposium on Surface Science (ISSS-6)
11.	6th International Conference on Molecalar Electronics and Bioelectronics (M&BE5)

12.	Europian Conference on optical Communication (ECOC)
13.	ACM Symposium on Virtual Reality Software and Technology
14.	IEEE Symposium on 3D User Interfaces
15.	International Symposium on Graphene Devices:technology, Physics and Modeling (ISGD)
16.	SPIE International Conference on Defence, Security, and Sensing
17.	International Symposium on Compound Semiconductors (ISCS)
18.	The 7th International Conference on Ubiquitous Intelligence and Computing
19.	Topical Workshop on Heterostructure Microelectronics(TWHM)
20.	4th SiGe, Ge, and Related Compounds: Materials, Processing, and Devices Symposium (The Electrochemical Society)
21.	International Symposium on Technology Evolution for Silicon Nano-Electronics (ISTESNE)
22.	4th International Workshop on spin Currents and 2nd International Workshop on Spin caloritronics
23.	6th RIEC International Workshop on Spintronics
24.	5th RIEC International Workshop on Spintronics, RIEC-CNSI Workshop on Nanoelectronics, Spintronics, and Photonics
25.	Engineering Conference International (ECI)
26.	International Conference of Magnetism (ICM)
27.	The 14th International Conference on Modulated Semiconductor Structures (MSS14)
28.	20th International Colloquium on Magnetic Films and Surfaces (ICMFS)
29.	5th International School and Conference on Spintronics and Quantum Information Technology (SPINTECH V)
30.	38th International School & Conference on the Physics of Semiconductors (Jaszowiec)
31.	The 6th International Conference on the Physics and Applications of Spin Related Phenomena in Semiconductors (PASPS-VI)
32.	The 37th International Symposium on Compound Semiconductors
33.	ISMVL Technical Committee
34.	International Workshop on the Principles and the Applications of Spatial Hearing 2009

35.	The 10th western pacific acoustics conference (WESPAC) 2009
36.	The 3rd International Universal Communication Symposium (IUCS2009)
37.	The Fifth International Conference on Intelligent Information Hiding and Mutimedia Signal Processing (IIHMSP2009)
38.	International Conference on Functional Programming 2009
39.	ACE 2009: 5th Advances in Computer Entertainment Technology Conference
40.	2009 International Advisory Board, Korean Magnetic Society
41.	ISMVL (International Symposium of Multiple-Valued Logic) 2009
42.	VRST 2009: 16th ACM Symposium on Virtual Reality Software and Technology
43.	22nd International Conference on Indium Phosphide and Related Material (IPRM2010)
44.	The 22nd IEEE International Semiconductor Laser Conference (ISLC2010)
45.	Asia-Pacific microwave Conference (APMC) 2010
46.	Joint MMM-Intermag Conference 2010
47.	The 9th Perpendicular Magnetic Recording Conference (PMRC 2010)
48.	The 3rd International Symposium on Organic and Inorganic Electronic Materials and Related Nanotechnologies (EM-NANO2010)
49.	The 9th International Conference on Auditory-Visual Speech Processing (AVSP2010)
50.	International Multisensory Research Forum (IMRF) 2010
51.	The Sixth International Conference on Intelligent Information Hiding and Mutimedia Signal Processing (IIHMSP2010)
52.	The 4th International Universal Communication Symposium (IUCS2010)
53.	Asia Pacific Vision Conference 2010
54.	International Conference Nanoscopio Colloidand Surface Science (NCSS2010)
55.	ACM SIGPLAN-SIGACT Symposium on Principles of Programming Language 2010
56.	ACM SIGPLAN Workshop on pertial Eualation and Program Manipulation 2010
57.	The 5th International Conference on broadband, Wireless Computing, Communication and Applications (BWCCA-2010)
58.	The 25th International Conference on Advanced Information Networking and Applications (AINA-2010)
59.	The 1st International Workshop on Symbiotic and Multiagent Systems (SCMAS-2010)

60.	IEEE Virtual Reality Conference 2010
61.	ACE 2010: 6th Advances in Computer Entertainment Technology Conference
62.	3DUI 2010: 5th IEEE Symposium on 3D User Interfaces
63.	2nd International Symposium on Aware Computing (ISAC2010)
64.	5th International SiGe Technology and Device Meeting (ISTDM2010)
65.	2010 International Symposium on Nonlinear Theory and Its Applications (NOLTA 2010)
66.	International Workshop on Human and Information Space Symbiosis (IWHISS2010)
67.	First International Workshop on Symbiotic Computing and Multiagent Systems (SCMAS2010)
68.	The 9th perpendicular Magnetic Recording Conference (PMRC 2010)
69.	International Multisensory Research Forum (IMRF) 2011

8. Periodicals Published by the Institute

The Institute publishes the following two periodicals to inform readers on recent research results of the Institute.

1. The Record of Electrical and Communication Engineering Conversazione Tohoku University

This journal aims at providing an opportunity to publish research results of the Institute as well as the result of the Departments of Electrical Engineering, Communication Engineering, Electronics Engineering, and Information Engineering of the Faculty of Engineering. Since the journal also aims at publishing general research activities of the Institute and of the Departments such as records of the final lectures of retiring professors, records of the Institute Symposium, and reviews.

The name of the Journal 'Conversazione' is attributable to the 'Tuesday Conversazione' at the Department of Electrical Engineering, which had been held once a week on Tuesday since around 1920. Minutes of the meetings had been distributed to researchers outside of the University via various routes and therefore some of them had been referred to as 'Records of Tuesday Electrical Engineering Conversazione Tohoku University' with the result that they came to be treated as official publications.

Though the meeting was once interrupted by World War Two, it was restarted in 1947. In 1952, the publication of the records was succeeded by the Institute and the records have been published as periodicals, two or three times a year recently, since No. 1 Vol. 21 was published in July, 1952.

2. The Annual Report of Research Activity at the Research Institute of Electrical Communication, Tohoku University

Published annually since 1995. This report details the activities of each research division and research facility. Also included are reports on nation-wide co-operative research projects, international symposium and seminars organized by members of RIEC, and the reports and evaluation on the RIEC advisory board members. English edition(digest version of Japanese edition) has been published since 2007.

9. Staff,Land and Buildings,Budget

1. Staff

(2009.7.1)

Classification	Division	Laboratory for Nanoelectronics and Spintronics	Laboratory for Brainware sysystems	Research Center for 21st century Information Technology	Fundamental Technology Center	Administration Office			Total
						Head Official	General Affairs Group	Accounting Group	
Professors	19	3	4	3					29
Associate Professors	12	4	1	1					18
Assistant Professors	17	3	5						25
Research Fellows	8	4	3	1					16
Technical Officials					17		1	1	19
Administrative Officials						1	6	7	14
Total	56	14	13	5	17	1	7	8	121

2.Land and Buildings

Site: Katahira 2-1-1, Aoba-ku, Sendai 980-8577, Japan
Total building area: 12,913m^2
Total floor area: 28,776m^2

(2009.7.1)

Name of Buildings	Structure	Year of Completion	Floor Area
Building No.1	Reinforced Concrete, 4 floors	Building-S:1962,1963	7,772m^2
		Building-N:1959,1960	
Building No.2	Reinforced Concrete, 4 floors	1962, 1963	7,085m^2
Laboratory for Nanoelectronics and Spintronics	Steel-flame, 5 floors	2004	7,375m^2
Laboratory for Brainware sysystems	Reinforced Concrete, 1 floor	1967, 1968, 1972	525m^2
	Reinforced Concrete(partly steel-flame), 2 floors	1986	1,553m^2
	Steel-frame 1 floor	1996	598m^2
	Light-weight steel-frame, 2 floors	1999	147m^2
Research Center for 21st century Information Technology	Reinforced Concrete, 3 floors	1930	1,343m^2
	Steel-frame 1 floor	2002	435m^2
Evaluation and Analysis Center	Reinforced Concrete, 2 floors	1981	790m^2
Helium Sub-Center	Reinforced Concrete(partly light-weight steel-flame), 1 floor	1972	166m^2
Machine Shop	Reinforced Concrete(partly light-weight steel-flame), 1 floor	1965, 1966, 1978	479m^2
Others			508m^2
Total			28,776m^2

3.Budget

(Unit:1,000yen)

Financial Year	Personnel Expenditure	Supplies Expenditure	Research Grant		total
			Ministry of Education,Science and Culture	Partnership Between Universities and Industry	
2005	984,113	1,050,647	554,680	1,303,028	3,892,468
2006	971,482	927,090	599,040	937,441	3,435,053
2007	970,961	813,724	700,615	888,833	3,374,133
2008	879,481	953,000	694,883	1,069,832	3,597,196
2009	1,026,511	1,562,318	605,100	798,053	3,991,982

10. Afterword

Although it has often been said that "we are just one national university affiliated research institute for a given subject in Japan," the expression "just one" does not sound very forceful. Because, from the start, university affiliated research institutes were established as organizations without overlapping research fields. However, there are many outside competitors when we take account of the research institutes of companies, national and private university research institutes, etc., and so it is hard for us to rise to the real top. Nevertheless, I think it is very important for a university affiliated research institute to establish an industrial infrastructure for the next generation by efficiently exploiting tradition and culture, rooted in the deep knowledge peculiar to that university, which other organizations cannot imitate.

The Research Institute of Electrical Communication (RIEC) of Tohoku University began life by undertaking research on weak-current electricity, and devices are our strength. Nowadays, we have expanded our research scope from devices to software.

In the autumn of last year, we held the Tokyo Forum whose theme was "Brain Science and Communications". There were many participants, and the event was very successful. If we are to process images received by the eye or realize a realistic sound field space, we need new DSPs and LSIs adapted for these special purposes. We want to propose a new system in a form that includes these functionalities. Without question, the integration of such devices and software is easier said than done. However, we plan to attack these difficult themes from various angles with new strategies. Although we may sometimes fail, I strongly hope that we can eventually find a new direction that will prove globally useful 20 years from now. We are now looking for ways to merge different fields into a new form that goes beyond the four major research divisions with their more than 20 constituent laboratories. I expect to make the Laboratory for Nanoelectronics and Spintronics and the Laboratory for Brainware Systems, agile and flexible organizations capable of making systems. Moreover, we have begun to consider a program for young researchers, such as assistant professors and associate professors, to help them progress rapidly.

After reading this report please send us any opinions or proposals that you may have; for example "The new direction remains unclear," or "I think this is interesting." We shall be very happy to hear from you. We will all greatly appreciate your further help and encouragement in the years to come.

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