Annual Report 2013

Research Institute of Electrical Communication
Tohoku University

RIEC

Annual report of Research Institute of Electrical Communication 2013

Contents

1. Introduction

The RIEC was established in 1935 to research cutting-edge technologies such as Yagi-Uda antennas and magnetrons. Since then, it has made a succession of pioneering achievements in laying the foundations of information communication technology, and has continued to play a world-leading role. To build on this tradition, we are gearing our research towards the development and evolution of science and technology that will allow communications to be implemented in a way that enriches people's lives.

Since 2004, as a framework for this purpose, we have organized ourselves into four Research Divisions (Information Devices, Broadband Engineering, Human Information Systems and Systems & Software), two Laboratories (Laboratory for Nanoelectronics and Spintronics and Laboratory for Brainware Systems), and one Research Center (Research Center for 21st Century Information Technology). These units are engaged in research aimed at achieving fruition over different time scales (Research Divisions: 20 years, Laboratories: 10 years, Research Center: 5 years). We have entered into close cooperation with Tohoku University's graduate schools in subjects relating to electrical engineering (School of Engineering, Graduate School of Information Sciences and Graduate School of Biomedical Engineering) in order to cover a wide range of cutting-edge research fields and foster the development of highly educated researchers and engineers.

In 2010, the RIEC was certified by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) as a Joint Usage/Research Center for collaborative research in information science and technology. To contribute to further community development, we are working on joint research projects with external researchers and engineers from industry, government and academia.

Today, information science and technology is an essential part of the social infrastructure, and there are growing demands for the implementation of faster higher-capacity telecommunications with greater energy savings. Another key attribute

of the social infrastructure is disaster tolerance; a requirement that was demonstrated only too well by the impact of the Great East Japan Earthquake of 2011. We also expect to contribute to a new paradigm of information processing and communication that interconnects people in a fundamentally different way. At the RIEC, we will continue to address these social needs by taking full advantage of our status as a university-affiliated research center. In this way, we hope to play a leading role in the new world of communication, and thereby promote education in the future.

To contribute to the improvement of our research activities and support future developments, we have published this Annual Report every year to make our activities relating to research, education and social contribution widely available for public scrutiny. This edition contains reports on various activities including the research at each of our departments and laboratories, the RIEC symposium, nation-wide cooperative research projects, and the activities of the engineering research association and RIEC lectures. In addition, the bibliography section has been greatly enhanced compared with last year's edition, and now carries the data for various activities over the last five years.

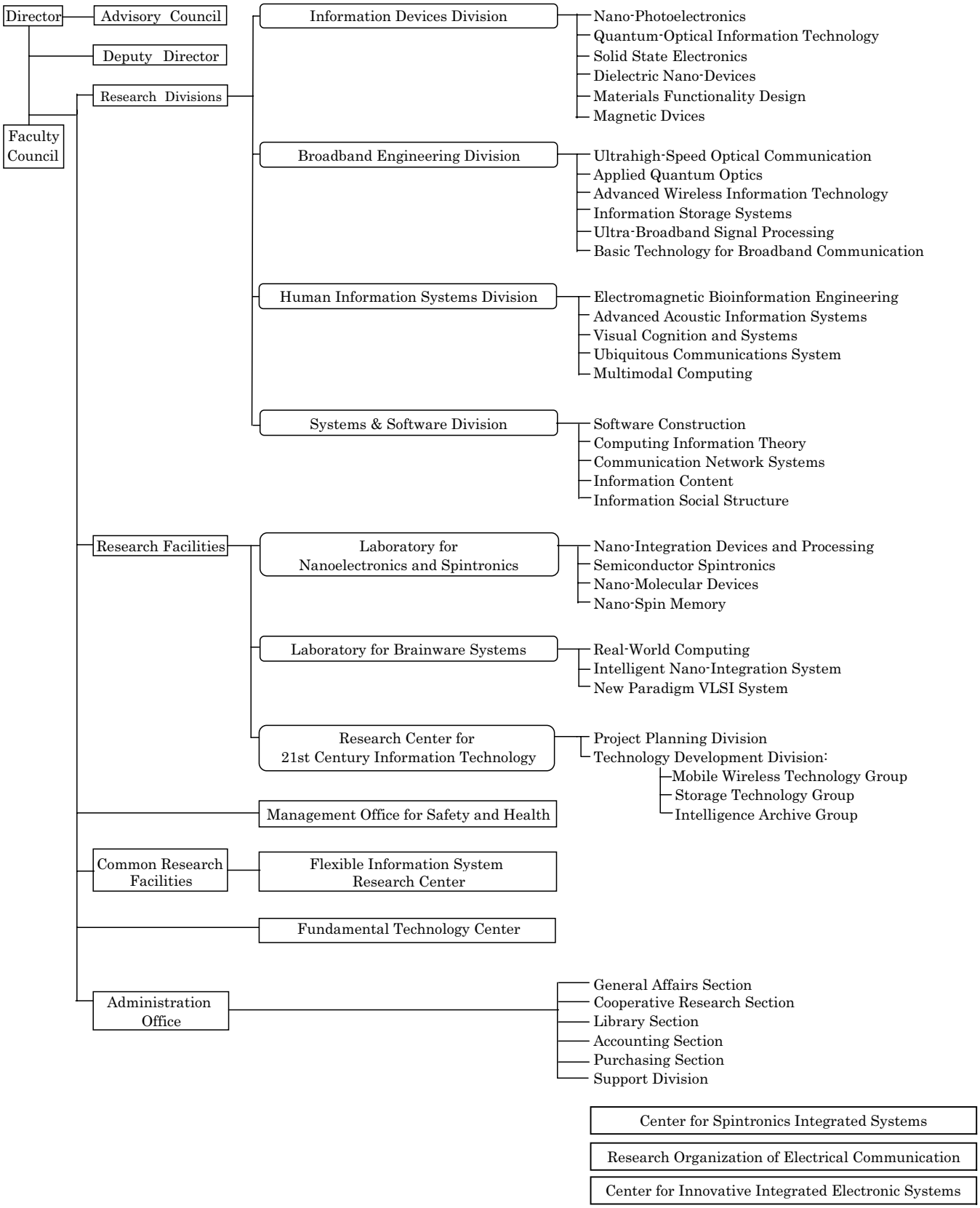
We welcome your frank opinions regarding our research reports, and I sincerely hope we can continue to rely on your guidance and support in the future.

May 1, 2014

Director, Research Institute of Electrical Communication

Hideo Ohno

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 this goal, we have the following 6 sub-divisions. The research fields include nano-scale photoelectronic conversions, quantum-optical information technology, novel transport properties in low-dimensional systems, new dielectrics-based nano-devices for information storage, and design of new materials having exotic functionalities. We also have a partnership with *Nano-Integration Devices and Processing* 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 research target and the summary of activities of each sub-division in 2013 are described in the following pages. The summary of activities of *Nano-Integration Devices and Processing* section is described in the chapter of Laboratory for Nanoelectronics and Spintronics.

Nanophotoelectronics

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

Nanophotoelectronics Yoichi Uehara, Professor
Nano photomolecular electronics Satoshi Katano, Associate Professor

[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.

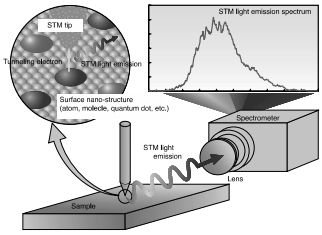


Fig. 1 STM light emission spectroscopy

STM light emission spectroscopy in the THz spectral range is very interesting because the spatial resolution attainable is not limited by the wavelength of light to be detected. Last year, we succeeded in detecting THz STM light emission. Since STM light emission is a kind of dipole radiation, its intensity has the ω^2 term. (Here ω is the frequency of STM light.) Hence, this success of detection is not trivial at all. In this year, we intensively investigated the mechanism that makes the detection possible, and ascertained it.

A metal nanoparticle and its assembled structure have attracted much attention because of their huge potential in the applications of quantum dots and biosensors. In this year, we have studied the spatially-controlled deposition of a single Ag nanoparticle on the Si(111) surface using STM. A clear exponential dependence on the tunneling current was observed for the formation of Ag nanoparticles, suggesting that these are formed by the electric field. An atomically flat Au substrate was also prepared by the evaporation method in order to start the research related to single molecular electronics based on a self-assembled monolayer.

[Staff]

Professor	Yoichi Uehara, Dr.
Associate Professor	Satoshi Katano, 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.

Dr. Satoshi Katano received his D. Sci. degree from Department of Electronic Chemistry, Tokyo Institute of Technology in 2003. He was a postdoctoral research fellow in RIKEN (2003-2006). He joined RIEC, Tohoku University as an Assistant Professor in 2006 and was promoted to an Associate Professor in 2012. His research interests include surface physical chemistry and nano-scale molecular optoelectronics.

[Papers]

[1] Y. Uehara, M. Kuwahara, and S. Katano, "Measurement of Phonon Energy of Sb_2Te_3 by Scanning Tunneling Microscope Light-emission Spectroscopy", *Solid State Commun.*, **177**, 29-32 (2014).
[2] Y. Uehara, "Theory of Attenuated Total Reflection Including Effects of Roughness", *Jpn. J. Appl. Phys.*, **52**, 102001 (2013).
[3] S. Katano, Y. Kim, T. Kitagawa, and M. Kawai, "Tailoring Electronic States of a Single Molecule Using Adamantane-based Molecular Tripods", *Phys. Chem. Chem. Phys.*, **15**, 14229-14233 (2013).

Quantum-Optical Information Technology

Development of optoelectronic devices for quantum information and communication technology

Quantum-Optical Information Technology: Keiichi Edamatsu, Professor
Quantum Solid State Physics: Hideo Kosaka, Associate professor
Quantum Laser Spectroscopy: Yasuyoshi Mitsumori, Associate professor

[Research Target and Activities]

Our goal is to develop the quantum information devices utilizing quantum interaction between photons and electrons in solids. In 2013, we have achieved (1) experimental demonstration of error-disturbance uncertainty relations in photon polarization measurement, (2) fundamental experiment for quantum state transfer from a photon to a nuclear spin using an NV center in diamond, and (3) observation of local-field effects on optical coherent transients of semiconductor quantum dots.

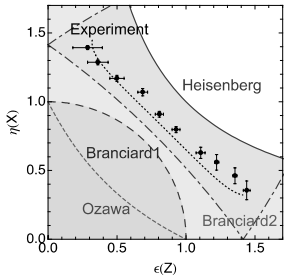


Fig. 1 Experimental results (filled circles) and predicted lower bounds (curves) of error-disturbance uncertainty relations (EDR) in photon polarization measurement. The Heisenberg EDR (blue) is violated while the EDRs proposed by Ozawa (red) and Branciard (purple and green) hold.

[Staff]

Professor: Keiichi Edamatsu, Dr.
Associate Professor: Hideo Kosaka, Dr.
Associate Professor: Yasuyoshi Mitsumori, 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.

Hideo Kosaka received B.S., M.S degrees in Physics from Kyoto University, and PhD degree in Electrical Engineering from Kyoto University. He was a Principal Researcher in NEC Opto-electronics and Basic Research Labs, a Visiting Associate in California University of Los Angeles.

Yasuyoshi Mitsumori received B.S., M.S. and D.S. degrees in Applied Physics from Tokyo Institute of Technology. He was a Research Fellow of the Japan Society for the Promotion of Science, a Researcher in NTT Basic Research Laboratories, a Postdoctoral Fellow in Tokyo Institute of Technology, a Postdoctoral Fellow in Communications Research Laboratory, a Research Associate in Research Institute of Electrical Communication, Tohoku University.

[Papers]

[1] K. Asakura, Y. Mitsumori, H. Kosaka, K. Edamatsu, K. Akahane, N. Yamamoto, M. Sasaki, and N. Ohtani, "Excitonic Rabi oscillations in self-assembled quantum dots in the presence of a local field effect," Phys. Rev. B **87**, 241301(R)/1-4 (2013)

[2] F. Kaneda, S.-Y. Baek, M. Ozawa, and K. Edamatsu, "Experimental test of error-disturbance uncertainty relations by weak measurement," Phys. Rev. Lett. **112**, 020502/1-5 (2014)

[3] T. Inagaki, H. Kosaka, Y. Mitsumori, and K. Edamatsu, "Process tomography of coherent state transfer from light polarization to electron spin polarization in a semiconductor," Phys. Rev. B **89**, 085311/1-7 (2014)

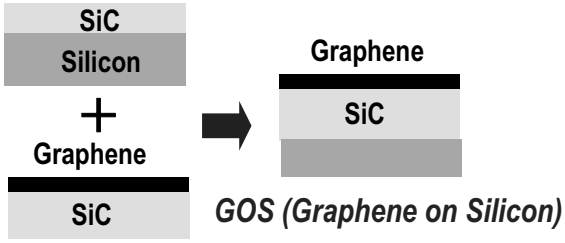
Solid State Electronics Laboratory

Paving a Way for Introducing Graphene into Silicon Technology

Solid State Electroncis　Maki Suemitsu, Professor
Solid State Physics for Electroncis　Hirokazu Fukidome, Associate Professor

[Research Target and Activities]

Graphene is a two-dimensional honeycomb network of carbon atoms. Its extremely high carrier mobility, which is ~100 times as high as that of silicon, makes graphene a dream material. We have developed a method to form an epitaxial graphene onto silicon substrates for the first time, by growing a heteroepitaxial SiC thin film on a Si substrate and by sublimating the surface Si atoms from the SiC film (graphene-on-Si, or GOS, technology). We are currently working on the clarification of the growth kinetics of the epitaxial graphene formation in GOS as well as on the development of graphene devices such as gas sensors, digital and RF field-effect transistors, and optical devices using the GOS structure.



In FY2013, we have clarified that the linear dispersion of electrons does exist in our epitaxial graphene on Si substrate, demonstrated the site-selective formation of graphene on Si wafers, and succeeded in fabrication of high-frequency operation of graphene FET using a self-aligned process.

[Staff]

Professor : Suemitsu, Maki Dr.
Assistant Professor : Fukidome, Hirokazu Dr.
Visiting Professor : Nagasawa, Hiroyuki Dr.
Research Assistant : Sai Jiao Dr.
Technical Assistant : Miura, Akemi

[Profile]

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 (2005) and the Best Paper Award from the Surface Science Society of Japan (2011).

[Papers]

[1] H. Fukidome, Y. Kawai, H. Handa, H. Hibino, H. Miyashita, M. Kotsugi, T. Ohkouchi, M.-H. Jung, T. Suemitsu, T. Kinoshita, T. Otsuji, and M. Suemitsu, "Site Selective Epitaxy of Graphene on Si Wafers," Proceeding of the IEEE, Vol. 101, pp. 1557-1566, 2013. (invited) (DOI: DOI: 10.1109/JPROC.2013.2259131)

[2] M.-H. Jung, G.-H. Park, T. Yoshida, H. Fukidome, T. Suemitsu, T. Otsuji, and M. Suemitsu, "High-Performance Graphene Field-Effect Transistors with Extremely Small Access Length Using Self-Aligned Source and Drain Techniques," Proceeding of the IEEE, Vol. 101, pp. 1603-1608, 2013. (invited) (DOI: 10.1109/JPROC.2013.2258651)

[3] H. Fukidome, M. Kotsug, K. Nagashio, R. Sato, T. Ohkouchi, T. Itoh, A. Toriumi, M. Suemitsu, T. Kinoshita, “Orbital-specific Tunability of Many-Body Effects in Bilayer Graphene by Gate Bias and Metal Contact”, Scientific Reports, Vol. **4**, pp.03713-1-03713-5 (2014).(DOI: 10.1038/srep03713)

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Dielectric Nano-Devices

Research on Dielectric Nano Science and Technology

Dielectric Nano-Devices Yasuo Cho, Professor

[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.

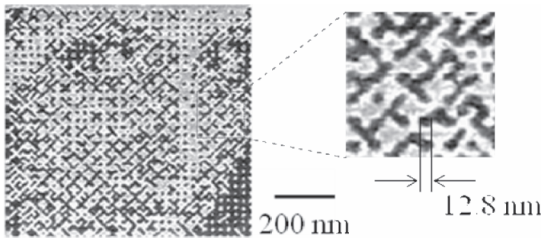

Fig.1 Digital bit data written on ferroelectric single crystal with the areal recording density of 4 Tbit/inch^2.

Major achievements of studies in 2013 are as follows: (1) The interfacial state of graphene was observed using noncontact scanning nonlinear dielectric microscopy (SNDM) with an atomic resolution. Additionally, a novel method for observing the surface potential derived from electric dipoles was developed on a basis of NC-SNDM. (2) SiC MOS devices were characterized using a novel method of super-higher-order nonlinear dielectric microscopy and the visualization of the depletion layer was achieved. (3) In the development of a ferroelectric data storage technology, dot array writing using HDD-type test system was demonstrated. The recording density reached 2.7 Tbit/inch^2. (4) A novel phenomenon concerning the conductivity in the boundary region of nanodomain dots formed on a ferroelectric crystal was found out.

[Staff]

Professor : Yasuo Cho, Dr.
Assistant Professor : Yoshiomi Hiranaga, Dr.
Assistant Professor : Kohei Yamasue, Dr.
Technical Official : Yasuo Wagatsuma

[Profile]

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] D. Mizuno, K. Yamasue and Y. Cho, "Atomic Dipole Moment Distribution on a Hydrogen-Adsorbed Si(111)-(7×7) Surface Observed by Noncontact Scanning Nonlinear Dielectric Microscopy", Appl. Phys. Lett. Vol. 103, p. 101601, 2013
[2] Y. Hiranaga and Y. Cho, "Measurements of Nonlinear Dielectric Constants of $Pb(Zr,Ti)O_3$ Thin Films Using a Dynamic Measuring Method", Jpn. J. Appl. Phys, vol. 52, p. 09KA08, 2013
[3] Y. Cho, "Electrical Conduction in Nanodomains in Congruent Lithium Tantalate Single Crystal", Appl. Phys. Lett., Vol. 104, p. 042905, 2014

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Materials Functionality Design

Computational Design of Functional Materials for Spintornics Devices

Materials Functionality Design: Masafumi Shirai, Professor

[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 2013 are as follows:

(1) Transport in magnetic tunnel junctions

We investigated the spin-dependent transport properties of MgO-based magnetic tunnel junctions (MTJ) with $D0_{22}$-Mn_3Ga or Mn_3Ge electrodes. The tunneling magnetoresistance (TMR) ratios of Mn_3Ga-based MTJ depend remarkably on the interfacial structures; i.e. 600% and 35% for the MnMn and the MnGa termination, respectively. On the other hand, the TMR ratio is over 4,000% for both terminations of Mn_3Ge-based MTJs owing to the fully spin-polarized Δ_1 electrons at the Fermi level in Mn_3Ge (Fig. 1) [2].

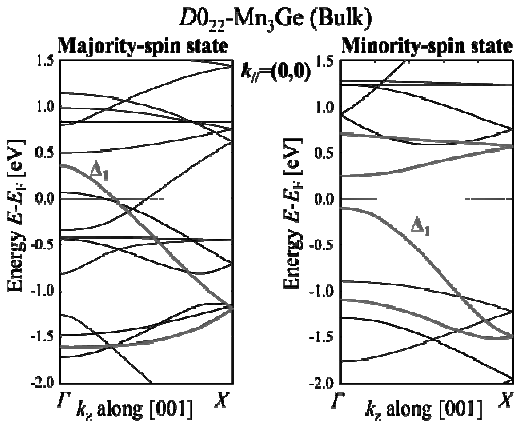

Fig. 1

(2) Perpendicular magnetic anisotropy at interfaces

We investigated the magnetic anisotropy at half-metallic Co-based Heusler alloy/MgO interfaces. High spin polarization and perpendicular magnetic anisotropy are preserved at the MnAl-terminated Co_2MnAl/MgO interfaces. In contrast, the FeAl-terminated Co_2FeAl/MgO interface shows in-plane anisotropy. The Co-terminated or over-oxidized FeAl-terminated interface is responsible for perpendicular magnetic anisotropy observed experimentally in the Co_2FeAl/MgO junction.

[Staff]

Professor : Masafumi Shirai, Dr.
Assistant Professor : Yoshio Miura, Dr.
Assistant Professor : Kazutaka Abe, Dr.
Research Fellow: Masahito Tsujikawa, 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] Y. Miura, M. Tsujikawa and M. Shirai, "A first-principles study on magnetocrystalline anisotropy at interfaces of Fe with non-magnetic metals," J. Appl. Phys., Vol. 113, Article No. 233908, pp. 1-6, 2013
[2] Y. Miura and M. Shirai, "Theoretical study on tunneling magnetoresistance of manetic tunnel junctions with $D0_{22}$-Mn_3Z (Z = Ga, Ge)," IEEE Trans. Magn., Vol. 50, Article No. 1400504, pp. 1-4, 2013
[3] G.-f. Li, Y. Honda, H.-x. Liu, K. Matsuda, M. Arita, T. Uemura, M. Yamamoto, Y. Miura, M. Shirai, T. Saito, F. Shi, and P. M. Voyles, "Effect of non-stoichiometry on the half-metallic character of Co_2MnSi investigated through saturation magnetization and tunneling spin polarization," Phys. Rev. B, Vol. 89, Article No. 014428, pp. 1-14, 2014

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3.2 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, and storage technologies.

(1) Advanced Wireless Information Technology

We are actively engaged in the research work on the dependable wireless information technologies for the next generation wireless systems which include terrestrial / satellite communications. We cover the whole technical fields from the lower to higher layers, i.e., signal processing, RF/Mixed signal device, antenna, MODEM and network technologies. We have developed "Multi-mode Software defined radio (SDR) very small aperture terminal (VSAT)" valid for large scale disaster recovery and have demonstrated the trial VSAT systems in the damaged area of the great east Japan earthquake. We have also developed novel access system for the location & short message communication system via Quasi-Zenith Satellite System (QZSS) and related RF/antenna devices.

(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.

First, we theoretically discovered and experimentally verified the giant THz gain of the surface plasmon polaritons in population-inverted graphene. We also experimentally verified the spontaneous and stimulated THz emission in optically pumped graphene at room temperature. Second, we developed plasmon-resonant THz emitters/detectors, succeeding in world-first coherent monochromatic THz emission and breaking the record sensitivity of 22.7 (6.4) kV/W at 220-GHz (1.5-THz) radiation.

(3) Ultrahigh-Speed Optical Communication

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

This year, we successfully demonstrated 2048 QAM coherent optical transmission for the first time, and achieved an ultrahigh spectral efficiency as high as 15.3 bit/s/Hz.

We also realized ultrahigh-speed and highly spectral-efficient transmission using a coherent optical Nyquist pulse, and achieved a spectral efficiency of 7.5 bit/s/Hz in a single-channel 1.92 Tbit/s, 64 QAM transmission.

(4) Applied Quantum Optics

Novel functional semiconductor photonic devices including photonic integrated circuits are being investigated to explore new-generation photonic network systems.

Ultra-high-speed semiconductor photonic active devices are being investigated. The study on high-speed operation of external cavity semiconductor lasers by injecting high-speed signal light is being continued. It is confirmed that the 3 dB bandwidth of the laser is enlarged to more than 50 GHz by measuring the frequency response of the fabricated device. The study on compact and narrow linewidth semiconductor laser sources is also being proceeded. We try to narrow the spectral linewidth of a semiconductor laser by applying a compact and simple optical negative feedback scheme to the laser. From the numerical simulation, it is confirmed that the spectral linewidth of the laser can be reduced to less than 1 kHz by applying this optical negative feedback scheme to a semiconductor laser.

(5) Information Storage Systems

Research on next-generation perpendicular magnetic recording is carrying out for high density data storage to meet the strong demand of rapid information increase in the Internet, and storage system technology as well.

We unveiled that areal density of 5 Tbit/inch^2, which is tenfold of current density, was difficult only by the bit-patterned media by theoretical approach with a computer simulation. For such high density, we clarified thermal assist recording technique that heats a narrow recording area is indispensable. Storage system technology to enhance the data transfer rate was also developed.

Research Laboratory of Ultrahigh-Speed Optical Communication

Advanced optical communication technologies approaching the Shannon limit

Research Area of Optical Transmission Masataka Nakazawa, Professor
Research Area of Optical Signal Processing Toshihiko Hirooka, Associate Professor
Research Area of High Accuracy Measurements using Optical Fibers
Masato Yoshida, Associate Professor

[Research Target and Activities]

With the vast growth of Internet traffic, it has become increasingly important to realize a high-capacity and high-speed network. This laboratory aims to achieve a global ultrahigh-speed optical network by engaging in the research of ultrashort pulse generation and transmission. This year, we successfully achieved 2048 QAM coherent optical transmission, ultrahigh-speed and highly spectral-efficient transmission of 1.92 Tbit/s, 64 QAM signal using coherent Nyquist pulses, and 16 QAM quantum stream cipher transmission at 10 Gbit/s over 160 km. Figure 1 shows the result of 1.92 Tbit/s/ch, 64 QAM coherent Nyquist pulse transmission over 150 km, where a spectral efficiency reached as high as 7.5 bit/s/Hz.

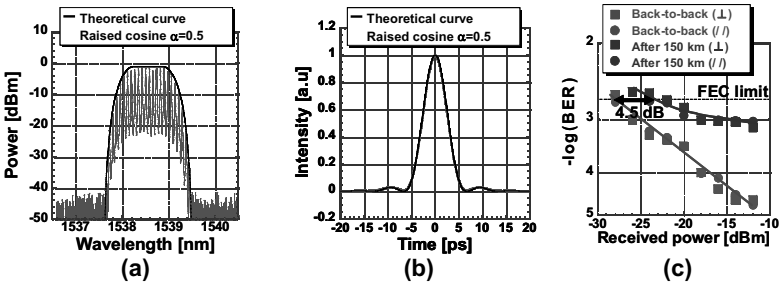

Fig. 1 Waveform (a) and spectrum (b) of a coherent Nyquist pulse and 1.92 Tbit/s, 64 QAM transmission result (c).

[Staff]

Distinguished Professor: Masataka Nakazawa, Dr. Associate Professor: Toshihiko Hirooka, Dr.
Associate Professor: Masato Yoshida, Dr. Assistant Professor: Keisuke Kasai, Dr.

[Profile]

Masataka Nakazawa received the Ph. D. degree from the Tokyo Institute of Technology in 1980. He joined the Ibaraki Electrical Communication Laboratory, Nippon Telegraph & Telephone Public Corporation. He was a visiting scientist at MIT in 1984-1985. In 2001, he became a Professor of the Research Institute of Electrical Communication, Tohoku University, 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 currently the Director of Research Organization of Electrical Communication.

Toshihiko Hirooka received the Ph. D. degree from Osaka University in 2000. From 2000 to 2002, he was a Research Associate at University of Colorado at Boulder. He is currently an Associate Professor at the Research Institute of Electrical Communication, Tohoku University. He has been engaged in research on ultrahigh-speed optical communications and nonlinear fiber optics.

Masato Yoshida received the Ph.D. degree from Tohoku University in 2001. In 2001, he joined the Research Institute of Electrical Communication, Tohoku University, where he is currently an Associate Professor. His research interests include mode-locked fiber lasers, coherent optical communication, and photonic crystal fibers.

[Papers]

[1] K. Harako, D. Seya, T. Hirooka, and M. Nakazawa, "640 Gbaud (1.28 Tbit/s/ch) optical Nyquist pulse transmission over 525 km with substantial PMD tolerance," Opt. Express, vol. 21, no. 18, pp.21063-21076, September (2013).
[2] D. O. Otuya, K. Kasai, M. Yoshida, T. Hirooka, and M. Nakazawa, "A single-channel 1.92 Tbit/s, 64 QAM coherent optical pulse transmission over 150 km using frequency-domain equalization," Opt. Express, vol. 21, no. 19, pp. 22808-22816, September (2013).
[3] M. Nakazawa, M. Yoshida, T. Hirooka, and K. Kasai, "QAM quantum stream cipher using digital coherent optical transmission," Opt. Express vol. 22, no. 4, pp. 4098-4107, February (2014).

Applied Quantum Optics

Research on Innovative Highly Functional Photonic Semiconductor Devices

Highly Functional Photonics Hiroshi Yasaka, Professor

[Research Target and Activities]

Novel functional semiconductor photonic devices including InP-based photonic integrated circuits are being investigated to explore new-generation photonic network systems.

Ultra-high-speed semiconductor photonic active devices are being investigated. The study on high-speed operation of passive feedback semiconductor lasers (PFLs) by injecting high-speed signal light is being continued. It is confirmed experimentally that the 3 dB bandwidth of the PFL is enlarged to more than 50 GHz by measuring the frequency response of the fabricated device.

The study on compact and narrow linewidth semiconductor laser sources is also being proceeded. Narrow linewidth semiconductor lasers are indispensable to realize future digital coherent optical systems and also highly functional optical sensing systems. Usually the spectral linewidth of a single-mode semiconductor laser takes a value of some MHz. We try to narrow the spectral linewidth of a semiconductor laser by applying a compact and simple optical negative feedback scheme to the laser. An optical filter is set at the output end of the laser, which is act as an optical discriminator, and the reflected light from the optical filter is fed back to the laser. From the numerical simulation, it is confirmed that the spectral linewidth of the laser can be reduced to less than 1 kHz by applying this optical negative feedback scheme to a semiconductor laser.

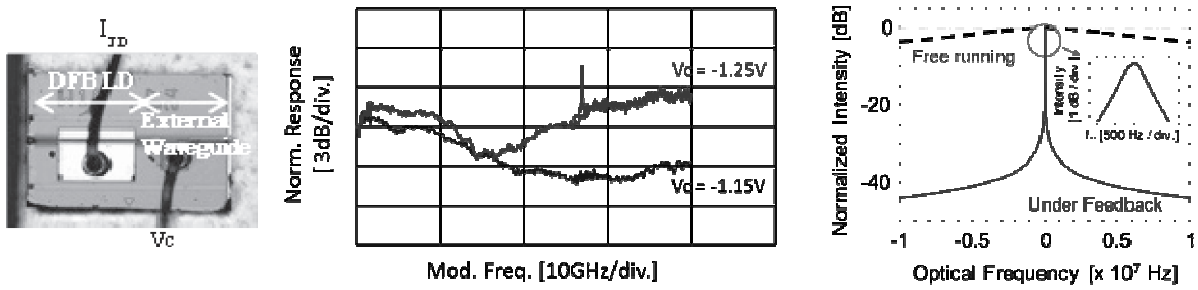

Photo of a fabricated optically controlled passive feedback laser (left), measured small signal response of the fabricated device (middle), and spectral shape of a single-mode semiconductor laser under free running (dashed line) and optical negative feedback (solid blue line) conditions (right).

[Staff]

Professor : Hiroshi Yasaka, Dr.

[Profile]

Hiroshi Yasaka received M.S. degrees in physics from Kyusyu University in 1985, and Ph.D. degree in electronic engineering from Hokkaido University in 1993. In 1985 he joined 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.

[Papers]

[1] T. Saikai, T. Yamamoto, E. Yamada, and H. Yasaka, "Flat-top Optical Frequency Comb Block Generation using InP-based Mach-Zehnder Modulator," The 25th International Conference on Indium Phosphide and Related Materials (IPRM2013), MoD3-3, May 2013.

[2] T. Yamamoto, T. Saikai, E. Yamada, and H. Yasaka, "Tailored Optical Frequency Comb Block Generation using InP-based Mach-Zehnder Modulator," IEICE Transactions on Electronics, vol. E97-C, No. 3, pp. 222-224, 2014.

Advanced Wireless Information Technology

For Realization of the Next Generation Mobile Network

Advanced Wireless Information Technology **Noriharu Suematsu, Professor**
Advanced Wireless Network Technology **Suguru Kameda, Associate Professor**

[Research Target and Activities]

Toward the realization of a ubiquitous and broad-band wireless network, we are actively engaged in the research work on dependable and low power consumption advanced wireless IT. We cover the whole technical fields from the lower to higher layers, i.e., signal processing, RF/Mixed signal device, antenna, MODEM and network technologies.

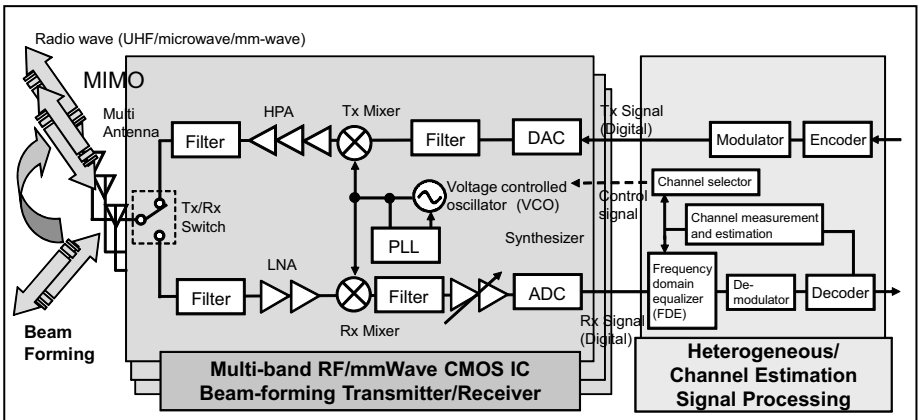

Fig. The target system of
Advanced Wireless Information Technology Laboratory.

We have developed "Multi-mode software defined radio (SDR) very small aperture terminal (VSAT)" valid for large scale disaster recovery and have demonstrated the trial VSAT systems in the damaged area of the great east Japan earthquake. We have also developed novel access system for the location & short message communication system via Quasi-Zenith Satellite System (QZSS) and related RF/antenna devices.

[Staff]

Professor: Noriharu Suematsu, Ph. D
Associate Professor: Suguru Kameda, Ph. D
Research Fellow: Shoichi Tanifuji, Ph. D (until August, 2013)

[Profile]

Noriharu Suematsu received the M.S. and Ph.D. degrees in Electronics and Communication Engineering from Waseda University in 1987 and 2000. From 1987 to 2010, he had been with the R&D center of Mitsubishi Electric, Japan. Since 2010, he has been a professor of Research Institute of Electrical Communication (RIEC), Tohoku University. He received the OHM technology award from the promotion foundation for electrical science and engineering in 2002 and Prize for Science and Technology, the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology in 2009.

Suguru Kameda received the B.S., M.S. and Ph.D. degrees in Electronics Engineering from Tohoku University in 1997, 1999 and 2001, respectively. From 2001, he was an assistant professor of the RIEC. From 2012, he has been currently an associate professor.

[Papers]

[1] S. Yoshida *et al.*, "A 60-GHz band planar dipole array antenna using 3-D SiP structure in small wireless terminals for beamforming applications," IEEE Trans. Antennas and Prop., vol.61, no.7, pp.3502-3510, July 2013.
[2] T. T. Ta *et al.*, "A calibrationless Si-CMOS 5-bit baseband phase shifter using a fixed-gain-amplifier matrix," IEICE Trans. Electron., vol.E96-C, no.10, pp.1322-1329, Oct. 2013.
[3] N. Suematsu *et al.*, "Multi-mode SDR VSAT against big disasters," EuMC 2013, pp.842-845, Nuremberg, Germany, Oct. 2013 (invited).

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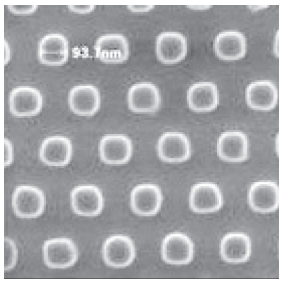
Information Storage System

Research on Large Capacity Information Storage System using High Density Perpendicular Magnetic Recording

Information Storage Systems: Hiroaki Muraoka, Professor
Recording Theory Computation: Simon J. Greaves, Associate Professor

[Research Target and Activities]



The amount of digital information is rapidly growing year by year, and is estimated to reach to Zata-byte in 2020. For such extremely large storage capacity high density magnetic recording is required. Next-generation perpendicular magnetic recording is explored in order to continuously develop the areal density of hard disk drives beyond the conventional density limit, i.e., a near-future target of 1 Tbit/inch^2 and ultimately exceeding 5 Tbit/inch^2. Theoretical studies including a micromagnetic computer simulation in association with an experimental approach are carried out to develop the next generation of high density perpendicular recording devices.

As we have proposed, the magnetic nano-structure of recording media is the most essential parameter to achieve high density perpendicular recording. Bit-patterned medium (Fig 1) is a promising candidate. We have revealed the possibility of an areal density of 5 Tbit/inch^2 in conjunction with heat assisted recording. Disk noise reduction by improving microstructure is in progress.

Research on information storage systems (Fig. 2) is being carried out. High data transfer rate by distributed file system with grouped disk drives was investigated. It was experimentally demonstrated that the data transfer rate of properly designed system was proportional to the number of drives.

[Staff]

Professor: Hiroaki Muraoka, Ph.D. (since 2000)
Associate Professor: Simon J. Greaves, Ph.D. (since 2003)
Secretary: Chie Watanabe

[Profile]

Hiroaki Muraoka joined Tohoku University in 1991. 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.
Simon J. Greaves has been at Tohoku University since 2003. He uses micromagnetic simulations at magnetic recording to investigate the potential of future storage devices. He received his Ph.D in 1993 from Salford University, UK.

[Papers]

[1] Simon John Greaves, Yasushi Kanai, and Hiroaki Muraoka, "Thermally assisted magnetic recording at 4 Tbit/in^2," IEEE Trans. Magn., 49, 6, 2665-2670, 2013. [Invited]
[2] Kenji Miura, Hiroyuki Katada, Makoto Oguma,Yasutaka Nishida, and Hiroaki Muraoka, "Erase Band Noise and Generation Mechanism Due to an Adjacent Track," IEEE Trans. Magn. 49, 7, 3795-3798, 2013.
[3] Simon John Greaves, Yasushi Kanai, Hiroaki Muraoka, "High Frequency Recording With Shielded Planar Type Heads," IEEE Trans. Magn. 49, 7, 3806-3809, 2013.

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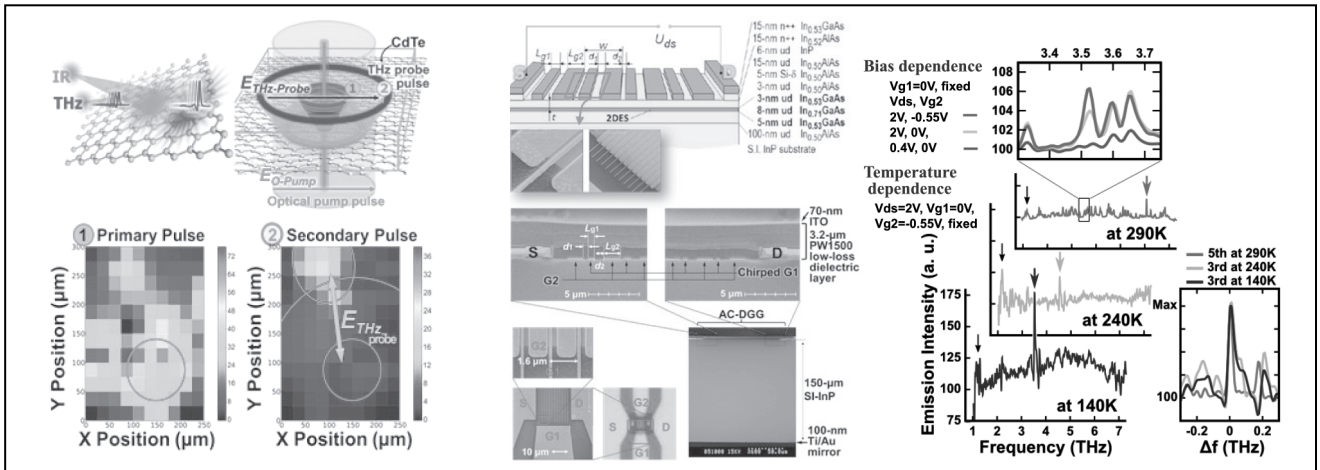
Ultra-broadband Signal Processing

Novel Millimeter-wave and Terahertz Integrated Electron Devices and Systems

Ultra-Broadband Devices and Systems: Taiichi Otsuji, Professor
Ultrafast Electron Devices: Tetsuya Suemitsu, Associate Professor
Ultra-Broadband Device Physics: Stephane Boubanga Tombet, Associate Professor

[Research Target and Activities]



Ultrafast photonic, electronic and plasmonic devices using graphene and III-V semiconductors.

(Left: giant terahertz (THz) gain via surface plasmon-polaritons in optically pumped graphene, center: InP-based asymmetric dual-grating-gate (A-DGG) HEMT, right: coherent, monochromatic THz emission from the A-DGG HEMT.)

We are developing novel, integrated electron devices and circuit systems operating in the terahertz (THz) region. Recent works and achievements are schematically shown in the above figures.

[Staff]

Professor: Taiichi Otsuji, Dr. Eng.
Visiting Professor: Victor Ryhii, Ph.D.
Associate Professor: Tetsuya Suemitsu, Dr. Eng.
Associate Professors: Stephane Boubanga Tombet, Ph.D.
Assistant Professor: Akira Satou, Dr. Comp. Sci.
Assistant Professor: Susumu Takabayashi, Dr. Eng.
Post-Doctoral Research Fellow: Adrian DobroiU, Ph.D. Secretary: Kayo Ueno, Kaori Sugawara

[Profile]

Taiichi Otsuji: received the Dr. Eng. deg. from Tokyo Tech., Japan, in 1994. After working for NTT Labs., Japan, since 1984, he joined Kyutech in 1999, as an Assoc. Prof., being a prof. from 2002. Since 2005, he has been a Prof. at RIEC, Tohoku Univ., Japan. Recipient of the Outstanding Paper Award of the 1997 IEEE GaAs IC Symposium. Member of IEEE(Fellow), OSA (Senior), IEICE, and JSAP.

Tetsuya Suemitsu: received Dr. Eng. from Waseda Univ., Japan, in 2000. Research Scientist, NTT Labs., Japan (1994- 2006); Visiting Scientist, MIT, USA (2002-2003); Assoc. Prof., Tohoku Univ., Japan (2006-). Recipient of the Best Paper Award, IEICE (2003), and the ELEX Best Paper Award, IEICE (2007). Member of IEEE(Senior), APS, JSAP, and PSJ.

Stephane Boubanga Tombet: received Ph.D. from Montpellier 2 Univ., France, in 2008. JSPS Postdoctoral Research Fellow, Tohoku Univ., Japan (2009-2010); Postdoctoral Researcher, Tohoku Univ., Japan (2011); Physics Consultant, University of Rouen, France (2011); Postdoctoral Researcher, Los Alamos National Lab., USA (2012-2013). Associate Professor, Tohoku Univ., Japan (2013-present).

[Papers]

[1] T. Watanabe, T. Fukushima, Y. Yabe, S.A. Boubanga Tombet, A. Satou, A.A. Dubinov, V. Ya Aleshkin, V. Mitin, V. Ryzhii, and T. Otsuji, "Gain enhancement effect of surface plasmon polaritons on terahertz stimulated emission in optically pumped monolayer graphene," New Journal of Physics, Vol. 15, Iss. 7, pp. 075003-1-11, July 2013.
[2] T. Watanabe, A. Satou, T. Suemitsu, W. Knap. V.V. Popov, and T. Otsuji, "Plasmonic Terahertz Monochromatic Coherent Emission from an Asymmetric Chirped Dual-Grating-Gate InP-HEMT with a Photonic Vertical Cavities,"CLEO: Conference on Lasers and Electrooptics Dig., CW3K.7, San Jose, CA, USA, June 12, 2013.
[3] T. Otsuji, V. Popov, and V. Ryzhii, "Active graphene plasmonics for terahertz device applications," J. Phys. D., Vol. 47, Iss. 09, pp. 094006-1-10, Feb. 2014.

Aims and Achievements of Human Information Systems Division

To realize advanced information communications systems, it is essential to understand and apply sophisticated information processing mechanisms of human being as well as to establish communications environments in that human can communicate anywhere, anytime without recognizing the communications tools. The aim of this division is to research and develop core and system technologies essential to advanced human friendly information and communications systems through understanding biological information generation mechanisms, human information processing mechanisms focusing on acoustic and visual inputs, and optimizing the communications environments.

To achieve the goal of the Division, four laboratories have been carrying out researches and developments in the following areas: (1) Electomagnetic Bioinformation Engineering, (2) Advanced Acoustic Information Systems, (3) Visual Cognition and Systems, and (4) Ubiquitous Communications Systems.

The goals and achievements in the fiscal year 2013 of each laboratory are described in detail below.

(1) Electomagnetic Bioinformation Engineering

(Aims) This laboratory aims at obtaining the high accuracy sensor system for the signals from the human body or electric devices and at obtaining 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 studied high-sensitive magnetic field sensors and strain sensors. We found the most important parameter is the magnetic anisotropy of the thin film materials, and we proposed new technology for controlling the magnetic anisotropy. On the work obtaining very low-loss materials for motor-cores, we proposed new method to decrease an magnetic loss named in-plane eddy current loss which was no way to decrease. The study about the magnetic actuator driven by the external magnetic field was carried out to obtain new medical devices which work implanted in the human body. New material based on fine particles was proposed as which has new functions.

(2)Advanced Acoustic Information Systems

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

(Achievement) In FY2013, we deepen the understanding human spatiotemporal perceptual processes of audio-vestibular information. In particular, we confirmed distortion of auditory space perception in the presence of vestibular information. We also studied how the sense

of presence and verisimilitude is affected by physical factors involved in multimodal content consisting of auditory, visual and vestibular information. These studies are particularly important to realize future multi-modal sensory information processing and communication systems. Moreover, we continued to develop advanced acoustic systems, such as virtual auditory displays based on our accumulated knowledge of human auditory space perception, sensing and reproduction system based on High-order Ambinonics consisting of over 100 channels, 252-ch binaural spatial sound sensing system (SENZI). They are keenly required to realize super-definition audio-visual communications in near future.

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(3) Visual Cognition and Systems

(Aims) This laboratory aims at understanding the mechanisms of human visual perception in our brain to improve the design of visual information display in the information & communication technologies.

(Achievements)

Firstly, we investigated how our body parts successfully interact with objects in the outside world. We found that a motion aftereffect (MAE) has spatial selectivity in hand-centered coordinates. Secondly, we investigated how the eye direction relative to the head influences visual cognition. Using a visual search task in which attention is required, we found that lateral viewing increased the time required to find the target compared with front viewing. Thirdly, we investigated the difference in shape representation between vision and haptics, using the mental rotation task that participants rotate an imagery object in the brain. We found different effects of rotation angle between visual and haptic learning conditions, suggesting that visual and haptic movement representations are processed independently.

(4) Ubiquitous Communications System

(Aims) The goal of ubiquitous communications is to realize communications environments in that everybody can communicate with anybody, anywhere and anytime without recognizing the communications tools. Towards this goal, we have been carrying out research and developments on wide area sensor networks (range: ~ 5 km) and the core technologies to realize Super Broad Band Indoor Wireless Communications with which people can enjoy multiple Gbps transmission freely. Furthermore, we will contribute to IEEE standardization with the developed technologies.

(Achievements) Major achievements in this year include (1) proposal of ISWAN ((Integrated Services Wireless Wide Area Networks) which will work as a wide area sensor network and as an anti-disaster network for emergency case, (2) Technology developments such as (i) 900 MHz propagation measurements in rural, sub-urban and urban areas showing 5 km, 2 km and 1 km transmissions are practically possible respectively, (ii) Interference-resistant performance that is 10- 30 dB better than traditional sensor networks, (iii) Development of 900 MHz small-sized directive base station antenna based on 60 GHz beam forming antenna technology, and (iv) TRX development to verify the long transmission range system

concept as well as each technology. (3) Contribution to IEEE Standardization on wide area sensor networks (4) Continuing 60 GHz beam forming antenna research and developments in addition to automobile wireless harness systems using radio hoses.

Electromagnetic Bioinformation Engineering

Communication with human body

Electromagnetic Bioinformation Engineering, Kazushi Ishiyama, Professor
Electromagnetic Biomaterial Engineering, Shuichiro Hashi, Associate Professor

[Research Target and Activities]

We studied the mechanism of obtaining the magnetic anisotropy of the magnetic thin films for the sensitive magnetic sensors. We obtained a non-metal probe for high frequency magnetic field, and confirmed the probe can measure the high frequency magnetic field with its phase information. In addition, 3D position detecting system using magnetic markers was studied to improve its position accuracy. The study about the magnetic actuator driven by the external magnetic field was carried out for biomimetic robots using the rotational magnetic field, and small wireless pumps were obtained and clarified for their application for an artificial heart-support pump.

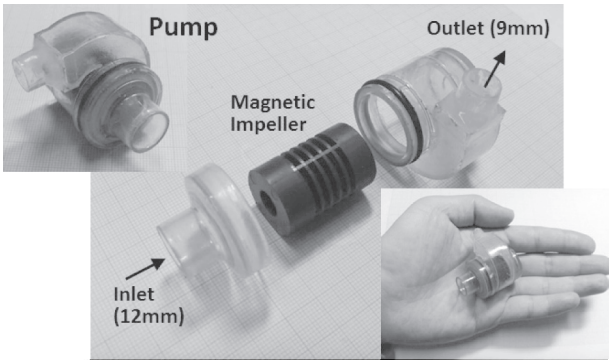

Fig. 1 Prototype of wireless artificial heart assist blood pump[2]

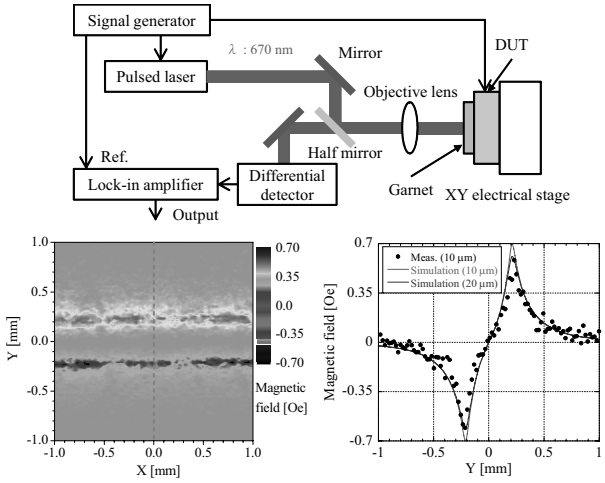

Fig. 2 High frequency magnetic field imaging system using magneto-optical crystal probe[1]

[Staff]

Professor: Kazushi Ishiyama, Dr.
Associate Professor: Shuichiro Hashi, Dr.
Assistant Professor: Sung Hoon Kim, Dr.

[Profile]

Kazushi Ishiyama received his MS and PhD degrees in Electrical Engineering from Tohoku University in 1986 and 1993, respectively. His research interests are in the area of magnetics and magnetic applications.

Shuichiro Hashi received the DE degree in Electrical Engineering from Tohoku University in 1998. His research interests are in the area of magnetic measurement and magnetic materials.

[Papers]

[1] J. Takahashi, S. Hashi, K. Ishiyama, "Measurement for Magnetic-field Distribution Using Pulsed Laser with Magneto-optical Effect," Journal of the Magnetics Society of Japan, Vol. 37, No. 2, pp. 24-28 (2013).
[2] S. H. Kim, S. Hashi, K. Ishiyama, Y. Shiraishi, Y. Hayatus, M. Akiyama, Y. Saiki, T. Yambe, "Preliminary validation of a new magnetic wireless blood pump," Artificial Organs, Vol. 37, Issue 10, pp. 920-926 (2013).
[3] S. Hashi, S. Yabukami, K. Ishiyama, K. I. Arai, "Downsizing of LC Markers for a Wireless Magnetic Position Detection System," Sensor Letters, Vol. 11, No. 1, pp. 98-101 (2013).
[4] J. W. Shin, S. H. Kim, S. Hashi, K. Ishiyama, "Dependence of the magnetic anisotropy on the ratio of the thicknesses of the magnetic and conductive layers," Journal of the Korean Physical Society, Vol. 63, No. 3, pp. 676-680 (2013).

Advanced Acoustic Information Systems

Development of next generation communication systems

Advanced Acoustic Information Systems: Yôiti Suzuki, Professor
Auditory and Multisensory Information Systems: Shuichi Sakamoto, Associate Professor

[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 auditory displays based on the sound image control by simulating transfer functions of sound paths from sound sources to listeners' external ears, and sensing systems of 3D sound field information are two examples. These systems are expected to provide a high-quality virtual sound space, which is keenly required to realize in the multimedia communications, cyberspace systems and visual reality systems. Moreover, in 2013, we put a lot of effort to develop a system to acquire 3D sound-space information that can save, transmit, and reproduce accurate sound-space information to a distant place using a microphone array on a human-head-sized solid sphere with numerous microphones on its surface, and investigate how people perceive sound-space information while their heads are rotating.

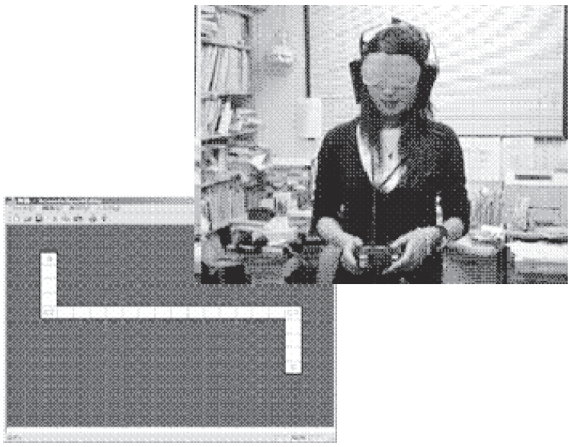

Fig. 1 Application for training spatial cognition based on high-definition virtual auditory display

[Staff]

Professor: Yôiti Suzuki, Dr., Associate Professor: Shuichi Sakamoto, Dr.
Assistant Professor: Tomoko Ohtani, Dr., Research Fellow: Zheng Lie Cui, Dr.
Technical Staff: Fumitaka Saito

[Profile]

Yôiti Suzuki graduated from Tohoku University in 1976 and received his Ph. D. degree in electrical and communication engineering in 1981. His research interests include psychoacoustics and digital signal processing of acoustic signals. He served as a president of the Acoustical Society of Japan from '05 to '07. He is a fellow of the Acoustical Society of America.
Shuichi Sakamoto graduated from Tohoku University in 1997 and received his Ph. D. degree in electrical and communication engineering in 2004. His research interests include human auditory and multisensory information processing and development of advanced multimodal information systems.

[Papers]

[1] Shuichi Sakamoto, Wataru Teramoto, Yôiti Suzuki and Jiro Gyoba, "Auditory space perception during active/passive self-motion (invited lecture)," Proc. 9th International Conference on Intelligent Information Hiding and Multimedia Signal Processing (IIH-MSP 2013), IIHMSP-2013-IS12-10 (4 page manuscript) (2013).
[2] Jorge Trevino, Takuma Okamoto, Yukio Iwaya, Yoiti Suzuki, Junfeng Li, "Extraction of horizontal Ambisonics data from mainstream stereo sources," Proc. 9th International Conference on Intelligent Information Hiding and Multimedia Signal Processing (IIH-MSP 2013), IIHMSP-2013-IS12-07 (4 page manuscript) (2013).

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Visual Cognition and Systems Laboratory

Understanding human visual system for the better communication with visual information

Visual Cognition and Systems Satoshi Shioiri, Professor
Cognitive Brain Functions Ichiro Kuriki, Associate Professor

[Research Target and Activities]

Our target is to understand the vision-related brain functions in order to apply the knowledge to realize human oriented information communication systems. We made achievements in the fields of visuotactile integration, eye-head coordination and haptic mental rotation.

Firstly, we investigated how our body parts successfully interact with objects in the outside world. We found that a motion aftereffect (MAE) has spatial selectivity in hand-centered coordinates. This suggests that seeing one's own body part generates a perceptual representation of the space centered on the body part that is useful for guiding the hand movement. Secondly, we investigated how the eye direction relative to the head influences visual cognition. Using a visual search task in which attention is required, we found that lateral viewing increased the time required to find the target compared with front viewing. This result seems to be consistent with the experience that we move our head to look at an object. Thirdly, we investigated the difference in shape representation between vision and haptics, using the mental rotation task that participants rotate an imagery object in the brain. We found different effects of rotation angle between visual and haptic learning conditions, suggesting that visual and haptic movement representations are processed independently.

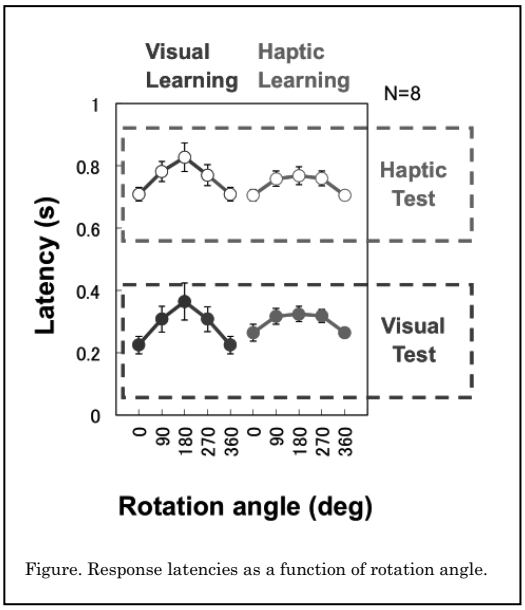

Figure. Response latencies as a function of rotation angle.

[Staff]

Professor : Satoshi Shioiri, Dr.
Associate Professor : Ichiro Kuriki, Dr.

[Profile]

Satoshi Shioiri Professor Shioiri graduated Tokyo Institute of Technology and received Dr. Eng in 1986. Then, he was a postdoctoral researcher at University of Montreal until May of 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.

Ichiro Kuriki Dr. Kuriki received Dr. Eng. degree from Tokyo Institute of Technology in 1996. After then, he worked at Imaging Science and Engineering Laboratory, Tokyo Institute of Technology as a research associate until October, 1999. He worked as a research associate at the Department of Mathematical Engineering and Information Physics, Graduate School of Engineering, the University of Tokyo until March, 2001. He worked as a researcher in Communication Science Laboratories of NTT Corporation until December, 2005. He joined the Research Institute of Electrical Communication, Tohoku University as an Associate Professor in January, 2006.

[Papers]

1. Moving One's Own Body Part Induces a Motion Aftereffect Anchored to the Body Part. Current Biology 24(2), 165-169, 2014. Matsumiya K, Shioiri S
2. Why Do We Move Our Head to Look at an Object in Our Peripheral Region? Lateral Viewing Interferes with Attentive Search. PLoS ONE 9(3): e92284, 2014. Nakashima R, Shioiri S
3. Rotation-independent representations for haptic movements. Scientific Reports 3, 2595; DOI:10.1038/srep02595, 2013. Shioiri S, Yamazaki T, Matsumiya K, Kuriki I

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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 content 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: Technologies for interactive content.
— Structure of Information Society (Visitor Section).

An overview of research results from Apr. 2013 to Mar. 2014 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 developing SML#, a new programming language in the ML family, that embodies some of our research results. The major results of the 2013 academic year include the following. (1) We showed that a parallelization theorems can be clearly explained in terms of a theory of polymorphic types, and moreover, the theory leads to further generalizations of known results. (2) Development of the SML# compiler: We developed a type theoretical framework for compiling polymorphism into a standard instruction set and developed a compilation algorithm from SML# to the LLVM intermediate language. Based on these results, we have successfully completed a new SML# compiler with an LLVM backend.

(2) Computing Information Theory

Rewriting systems are mathematical formalisms which can offer both flexible computing and effective reasoning with equations. Our research focuses on theoretical features of rewriting systems and applications to automated theorem proving, algebraic specifications, and functional and logic programming languages. The main results of this year are as follows. (i) We continued to develop an automated confluence prover ACP for term rewriting systems based on various proof techniques. In the 2nd confluence competition (CoCo 2013), ACP has won first place. (ii) We proposed two criteria for confluence of term rewriting systems based on decreasing diagrams and persistency, which are particular useful for proving confluence of non-linear systems.

(3) Communication Network

In a research project of intelligent management support of disaster-resistant ICT unit based on Active Information Resource, new methods to estimate the logical network and manage the cooperation among multiple ICT units has been developed. In a research on design method of the evolutional agent system, a systematic and effective power control mechanism for portable information devices had been realized and evaluated by using a test bed system. Moreover, in a research on multiagent-based sensor infrastructure, a new autonomous cooperation method for heterogeneous sensors is proposed and evaluated through a prototype system.

(4) Information Content

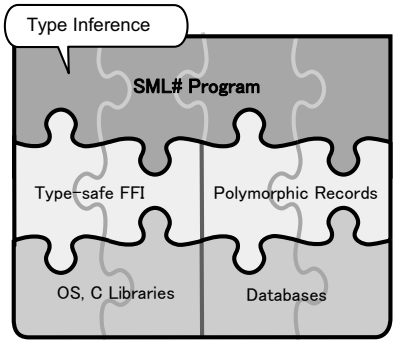
We are conducting comprehensive research on a variety of technologies rerated to interactive content which creates new value through interactions with humans. This year we firstly proposed using a portable projector in order to create a movable new image within a perspectively corrected multi-display environment where a user can seamlessly interact with displayed content across the displays. Secondly, we started a joint research project with industry in terms of the algorithm to interactively, flexibly, and dynamically display a set of digital photographs which we proposed last year. Thirdly, we developed a self-actuated shape-changing digital table named TransformTable, which dynamically changes its shape according to the atmosphere of the conversational space in order to provide comfortable situation with the participants.

Ohori Laboratory

Foundations for Developing High-level and Reliable Programming Languages

Software Construction Atsushi Ohori, Professor

[Research Target and Activities]



SML#: a high-level and reliable language

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, rank-1 polymorphism, and high-degree of inter-operability with existing languages and databases.

The major results of the 2013 academic year include the following. (1) Developments in theoretical foundations: we showed that a sort of parallelization theorems can be clearly explained in terms of a theory of polymorphic types, and moreover, the theory leads to further generalizations of these theorems. (2) Development of the SML# compiler: we replaced our own native code generator of the SML# compiler with the LLVM compiler infrastructure. To establish a compilation scheme from SML# to LLVM IR, we developed a compilation algorithm based on our addtiaional type theoretical analysis on the treatment of polymorphism in native code.

[Staff]

Professor : Atsushi Ohori, Ph.D.
Assistant Professor : Katsuhiro Ueno, Dr.
Assistant Professor : Akimasa Morihata, Dr.

[Profile]

Atsushi Ohori 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] Akimasa Morihata, A Short Cut to Parallelization Theorems, In: ICFP'13: Proceedings of the 18th ACM SIGPLAN International Conference on Functional Programming, pp. 245-256, 2013.
[2] Akimasa Morihata, Masato Koishi and Atsushi Ohori, Dynamic Programming via Thinning and Incrementalization, In: Functional and Logic Programming, 12th International Symposium, FLOPS 2014, Proceedings, Lecture Notes in Computer Science, Vol. 8475, 2014, Accepted.

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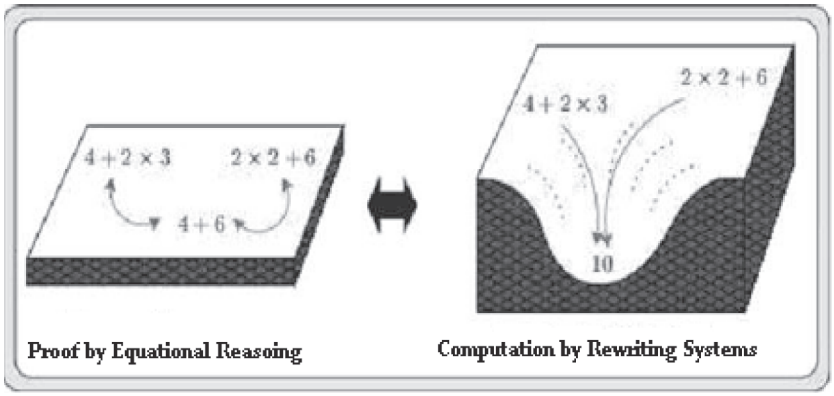
Computing Information Theory

Towards a New Software Paradigm Arising from Computation and Proof

Computing Information Theory **Yoshihito Toyama Professor**
Computing logical system **Takahito Aoto, Associate Professor**

[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 : Yoshihito Toyama, Dr.
Associate Professor : Takahito Aoto, Dr.
Assistant Professor : Kentaro Kikuchi, Dr.

[Profile]

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.

Associate Professor Takahito Aoto　Takahito Aoto was born in 1969. He received his M.S. and Ph.D. from Japan Advanced Institute for Science and Technology (JAIST). He was at JAIST from 1997 to 1998 as an associate, at Gunma University from 1998 to 2002 as an assistant professor, and at Tohoku University from 2003 to 2004 as a lecturer. He has been in Tohoku University from 2004 as an associate professor. His current research interests include rewriting systems, automated theorem proving, and foundation of software.

[Papers]

(1) Takahito Aoto, Disproving confluence of term rewriting systems by interpretation and ordering, In Proceedings of the 9th International Symposium on Frontiers of Combining Systems (FroCoS 2013), Lecture Notes in Artificial Intelligence, Vol.8152, pp.311-326, 2013.

(2) Tsubasa Suzuki, Takahito Aoto and Yoshihito Toyama, Confluence proofs of term rewriting systems based on persistency (in Japanese), Computer Software, Vol.30, No.3, pp.148-162, 2013.

(3) Kentaro Kikuchi, Proving strong normalisation via non-deterministic translations into Klop's extended λ-calculus, In Proceedings of the 22nd Annual Conference of the European Association for Computer Science Logic (CSL 2013), LIPIcs 23, pp.395-414, 2013.

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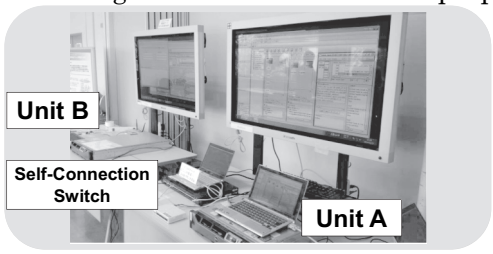
Communication Network

Support for Cooperation and Communication between Human and Systems

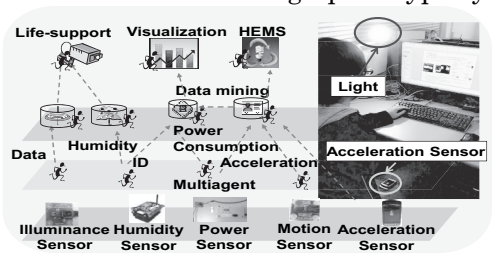
Intelligent Communication Tetsuo Kinoshita, Professor
Intelligent Network Gen Kitagata, Associate Professor

[Research Target and Activities]

In this year, the following studies have been done. (a) Evolutional Agent Systems: A systematic and effective power control for portable information devices had been realized by using a test bed system based on the EAS concept. (b) Knowledge-based Network Management Support System: Methods for estimation of logical network and cooperation among multiple ICT units has been developed. (c) Management Infrastructure of Heterogeneous Sensor: An autonomous cooperation method for heterogeneous sensor has been proposed and evaluated through prototype systems.



Knowledge-based Network Management Support System



Multiagent-based Autonomous Cooperation of Heterogeneous Sensor

Multiagent-based Support for Cooperation and Communication between Human and Systems

[Staff]

Professor : Tetsuo Kinoshita, Dr.
Associate Professor : Gen Kitagata, Dr.
Assistant Professor : Hideyuki Takahashi, Dr.
Assistant Professor : Kazuto Sasai, Dr.

[Profile]

Tetsuo Kinoshita received his B.E. degree in electronic engineering from Ibaraki University, Japan, in 1977, and M.E. and Dr.Eng. degrees in information engineering from Tohoku University, Japan, in 1979 and 1993, respectively. His research interests include agent engineering, knowledge engineering, knowledge-based systems and agent-based systems. He received the IPSJ Research Award, the IPSJ Best Paper Award and the IEICE Achievement Award in 1989, 1997 and 2001, respectively. Dr. Kinoshita is a member of IEEE (SM), ACM, AAAI, IEICE (Fellow), IPSJ (Fellow) and JSAI.

Gen Kitagata is an associate professor of the Research Institute of Electrical Communication of Tohoku University, Japan. He received a doctoral degree from the Graduate School of Information Sciences, Tohoku University in 2002. His research interests include agent-based computing, network middleware design, and symbiotic computing. He is a member of IEICE and IPSJ.

[Papers]

[1] A. Takahashi, T. Kinoshita, "Dynamic Control and Construction Method for Multiagent Systems Based on an Evolutional Agent System," IJEIC, Vol.4, No.2, pp.1-20, 2013.
[2] K. Kalegele, J. Sveholm, H. Takahashi, K. Sasai, G. Kitagata, T. Kinoshita, "Multiagent-based processing and integration of system data," IJISTA, Vol.12, No.2, pp.128-155, 2013.
[3] T. Kato, H. Takahashi, K. Sasai, G. Kitagata, H.-M. Kim, T. Kinoshita, "Priority-Based Hierarchical Operational Management for Multiagent-Based Microgrids," Energies, Vol.7, No.4, pp.2051-2078, 2014.

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Information Content

Technologies for Interactive Content

Interactive Content Design Yoshifumi Kitamura, Professor

[Research Target and Activities]

Good media content has the power to enrich our lives. The effectiveness of content delivery is becoming more and more important in a wide variety of fields, such as industry, education, culture, entertainment, and so on. Expectations of its use in the general public are also increasing. We focus on non-traditional contents other than movies, music and games, conducting comprehensive research on a variety of interactive content which creates new value through interactions with humans. This year we mainly conduct research projects about dynamic and a flexible interactive display method, a shape-changing digital table for enhancing interpersonal communication, and a novel spatial user interface with portable projector, so on.

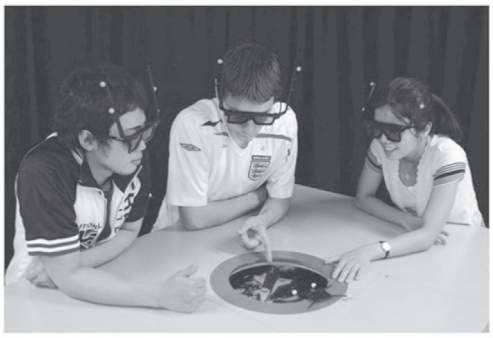

Fig. 1: Direct multi-touch interface on stereoscopic tabletop display

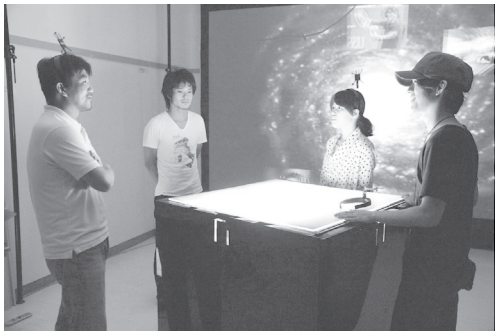

Fig. 2: Media space for enhanced interpersonal communication

[Staff]

Professor: Yoshifumi Kitamura, Dr.
Assistant Professor: Kazuki Takashima, Dr.

[Profile]

Yoshifumi Kitamura received B.Sc., M.Sc. and PhD. degrees in Engineering from Osaka University in 1985, 1987 and 1996, respectively. From 1987 to 1992, he was at the Information Systems Research Center of Canon Inc. From 1992 to 1996, he was a researcher at the ATR Communication Systems Research Laboratories. From 1997 to 2002, he was an Associate Professor at the Graduate School of Engineering and Graduate School of Information Science and Technology, Osaka University. Since April 2010, he has been a Professor at the Research Institute of Electrical Communication, Tohoku University. He is a fellow of the Virtual Reality Society of Japan.

[Papers]

[1] Chi Thanh Vi, Kazuki Takashima, Hitomi Yokoyama, Gengdai Liu, Yuichi Itoh, Sriram Subramanian and Yoshifumi Kitamura, D-FLIP: Dynamic & Flexible Interactive PhotoShow, In Proceedings of Conference on Advances in Computer Entertainment Technology (ACE), pp. 415-427, 2013, Nov.

[2] Kazuki Takashima, Naohiro Aida, Hitomi Yokoyama and Yoshifumi Kitamura, TransformTable: A Self-actuated Shape-changing Digital Table, In Proceedings of Conferece on Interactive Tabletop and Surface (ITS), pp.179-187, 2013, Oct.

[3] Jorge H. dos S. Chernicharo, Kazuki Takashima and Yoshifumi Kitamura, Seamless Interaction Using a Portable Projector in Perspective Corrected Multi Display Environments, In Proceedings of Symposium on Spatial User Interaction (SUI), pp.25-32, 2013, Jul.

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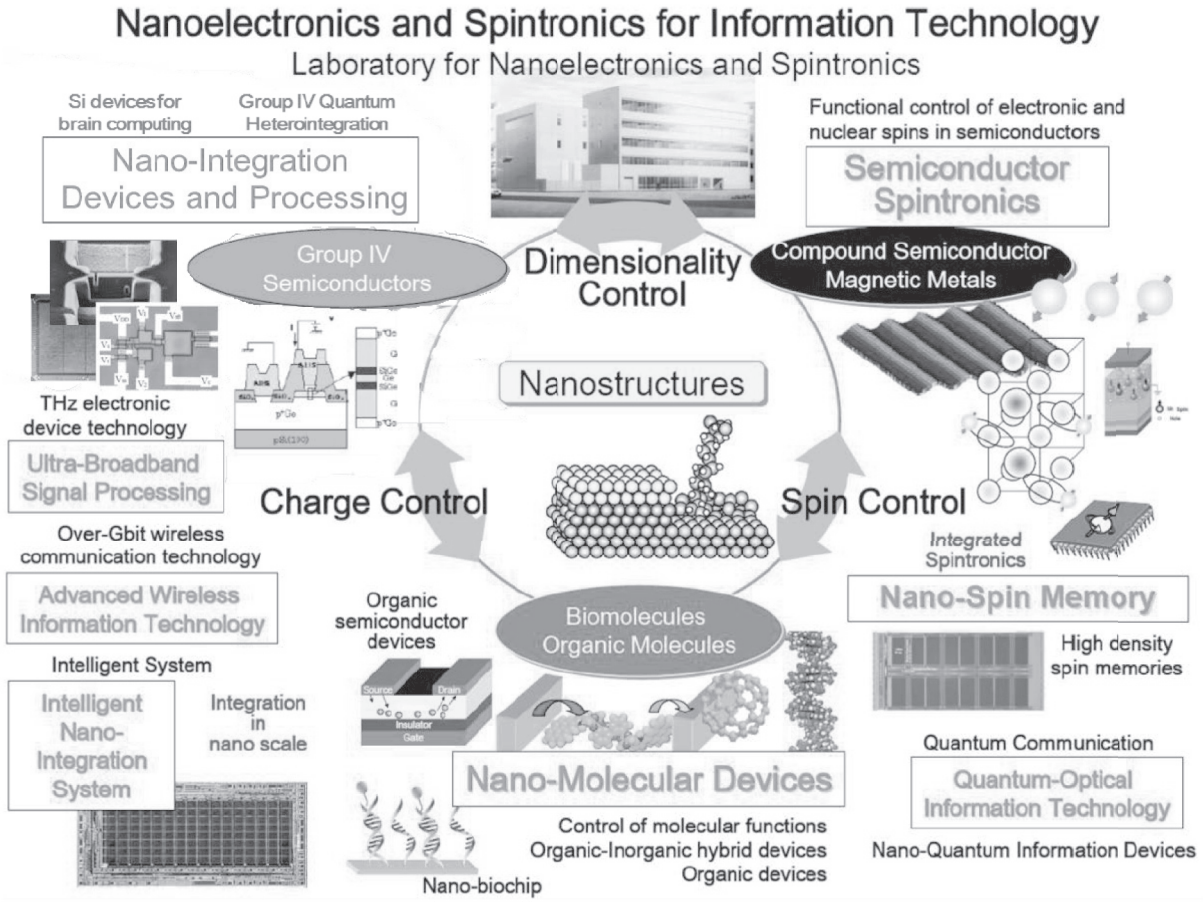
Laboratory for Nanoelectronics and Spintronics

The Laboratory for Nanoelectronics and Spintronics of the Research Institute of Electrical Communication was established on April of 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 and under collaboration between the RIEC and electro-related laboratories of the Graduate Schools of Engineering, Information Sciences, Biomedical Engineering, Tohoku University, R&D of nanotechnologies of materials and devices in Nanoelectronics and Spintronics will be continued extensively. Furthermore, nation-wide and world-wide collaboration research projects will be conducted to build a systematic database in the electrical communication research area.

The Laboratory for Nanoelectronics and Spintronics mainly consists of research groups which promote following sections: Nano-Integration Devices and Processing, Semiconductor Spintronics and Nano-Molecular Devices; together with the groups of Intelligent Nano-Integration System, Quantum-Optical Information Technology, and Ultra-Broadband Signal Processing. These groups cooperatively carry out the research aimed at establishing a world-wide COE in the research area of nanoelectronics and spintronics.



Highlights of Research Activities in 2013

Nano Integration

● Nano-Integration Devices and Processing (S. Sato and M. Sakuraba)

(1) Toward the huge integration of neural networks, we have designed a neuron circuit having large fan-in ability by modifying a majority circuit, which has self-adjusting function to maximize operating margin, and its successful operation has been confirmed together with discrete synapses. We have also implemented a self-oscillating neural network with higher order synapses using an FPGA, and confirmed that dynamic synaptic weight calculation is effective for saving memories.

(2) Epitaxial growth of strained $Si_{1-x}Ge_x$ alloy and Ge films on Si(100) using low-energy ECR plasma CVD without substrate heating has been studied. It is found that reaction rate ratio for SiH_4 and GeH_4 is scarcely dependent on Ge fraction in the films, while the reaction rates tend to increase with increase of the Ge fraction. Moreover, epitaxial growth of highly strained 11 nm-thick $Si_{0.50}Ge_{0.50}$ alloy film lattice-matched to Si(100) substrate has been realized without substrate heating.

● Intelligent Nano-Integration System (K. Nakajima)

(1) By using high-order synapses for an inverse function delayed neural network, we set up an FPGA circuit for traveling salesman and quadratic assignment problems. Furthermore, we proposed an inverse function delay-less model for high speed numerical calculation of artificial neural networks, and we applied the model to some problems in TSP-LIB. (2) We applied ID networks to development of a hetero-associative memory system. In that system we obtained large memory capacity and wide basin size. (3) We demonstrated successfully a 4-bit parallel multiplier using a carry look-ahead adder with niobium integrated circuits to improve the performance of high-speed operation for the SFQ fast Fourier transform, and we fabricated the central part of an 8-bit parallel multiplier of SFQ system. A neural network using superconducting quantum interference devices was fabricated and successfully demonstrated.

Semiconductor Spintronics and Information Technology

● Semiconductor Spintronics and Nano-Spin Memory (H. Ohno and S. Ikeda)

Our research activities focus on realizing low-power functional spintronic devices. The outcomes in the last fiscal year are following. (1) Determination of in-plane magnetic field dependence of electric field-induced magnetization switching probability in a CoFeB-MgO based magnetic tunnel junction (MTJ) with a perpendicular magnetic easy axis. (2) Demonstration of in-plane current induced magnetization switching in Ta/CoFeB/MgO heterostructures. (3) Determination of pulse width and pule amplitude dependence of

current-induced depinning probability of a domain wall in Co/Ni nanowire. (4) Demonstration of bistable states in the world's smallest MTJ with 11 nm in diameter. (5) Demonstration of bistable states, high thermal stability, and high tunnel magnetoresistance (TMR) ratio in MTJ using Co/Pt based synthetic ferrimagnetic reference layer structure. (6) Demonstration of high thermal stability and high TMR ratio in the MTJ using the CoFeB/Ta/CoPt mulitilayer recording layer structure with 17 nm in diameter.

1. Research activities in "Research and Development of Ultra-low power Spintronics-based VLSIs" under granted by JSPS through the FIRST program. (1) Determination of scaling property of MTJ having MgO/CoFeB/Ta/CoFeB/MgO recording layer structure. (2) Determination of magnetic properties in MgO/Fe(B)/MgO structure. (3) Demonstration of reduction of damping constant by inserting CoFe(B) layer in FePd/CoFe(B). (4) Observation of possible existence of a metastable superlattice structure of Co/Ni multilayer. (5) Determination of scaling property of three-terminal device utilizing current-induced domain wall motion.
2. Research activities in "Research and Development of Spintronics Material and Device Science and Technology for a Disaster-Resistant Safe and Secure Society" program under Research and Development for Next-Generation Information Technology of MEXT. (1) Determination of in-plane magnetic field dependence of switching current in CoFeB-MgO MTJ with perpendicular easy axis. (2) Demonstration of high speed domain wall motion in 20-nm wide Co/Ni nanowire.

● **Ultra-Broadband Signal Processing (T. Otsuji, T. Suemitsu, and S. Boubanga-Tombet)**

1. Ultra-Broadband Devices and Systems

   We are developing novel, integrated electron devices and circuit systems operating in the millimeter-wave and terahertz regions. III-V- and graphene-based active plasmonic heterostructures for creating new types of terahertz lasers and ultrafast transistors are major concerns. By making full use of these world-leading device/circuit technologies, we are exploring future ultra-broadband wireless communication systems as well as spectroscopic/imaging systems for safety and security.
2. Ultrafast Electron Devices

   We are focusing on two important material systems for high-speed and high-frequency devices: the indium gallium arsenide (InGaAs) for ultimately high-frequency operation including sub-millimeter-wave regime, the gallium nitride (GaN) for high-power millimeter-wave applications. Our activities include the design, process, and characterization of these devices and their integrated circuits.
3. Ultra-Broadband Device Physics

   We theoretically and experimentally investigate the physics of plasmonics in III-V

semiconductor- and graphene-based heterostructure material systems and their device applications. Our main goal is to develop new and original plasmonic integrated devices operating in the millimeter-wave and terahertz regions for the next generation of imaging, spectroscopy, and ultra-broadband communication systems.

● **Quantum-Optical Information Technology (K. Edamatsu, H. Kosaka and Y. Mitsumori)**

1. We are experimentally investigating error-disturbance uncertainty relations in quantum measurements. We have demonstrated in photon polarization measurement that the Heisenberg error-disturbance uncertainty relation (EDR) is violated while the EDRs proposed by Ozawa and Branciard hold.

2. We are developing a quantum media converter from a photon to an electron spin to realize a quantum repeater, which is expected to extend the transmission distance of quantum info-communication. We have demonstrated that (1) the process of state transfer is quantum like by the measurement of electron spin state tomography, and (2) fundamental experiments for the photonic state transfer to a quantum memory in diamond.

3. We have investigated the excitonic Rabi oscillations in semiconductor quantum dots using four wave mixing spectroscopy for the development of the optical coherent manipulation of the electric states in the quantum dots. We have observed the interesting behavior of the Rabi oscillations arising from the longitudinal electric field effect of the excitonic polarization in the quantum dots.

Nano-Molecular Devices

● **Nano-Molecular Devices (M. Niwano and Y. Kimura)**

1. In-situ monitoring of adipocyte differentiation by infrared spectroscopy (IRAS): We have succeeded in real-time monitoring cell differentiation to adipocytes by using IRAS with the multiple internal reflection (MIR) geometry. We showed that MIR-IRAS has a potential to evaluate antiadipogenic agents in terms of their effects on fat and protein synthesis during adipogenesis.
2. Development of TiO_2 nanotube-based micro-scaled gas-sensor: We have fabricated TiO_2 nanotube-based macro-scaled gas sensors by locally anodizing a thin Ti film on glass substrate. We demonstrated that deposition of metal nanoparticle on the inner wall of nanotubes improves the sensitivity and gas-discrimination function of the gas sensors.
3. Development of organic/TiO_2 hybridized solar cells: We have investigated modification of TiO_2 surfaces used for fabrication of TiO_2/polymer hybrid solar cells. We found that modification of TiO_2 surfaces with [6,6]-phenyl-C61-butyric acid (PCBA) drastically increased the short circuit current of TiO_2/P3HT-based hybrid solar cells. Elucidation of anodization process of titanium.

Nano-Integration Devices and Processing

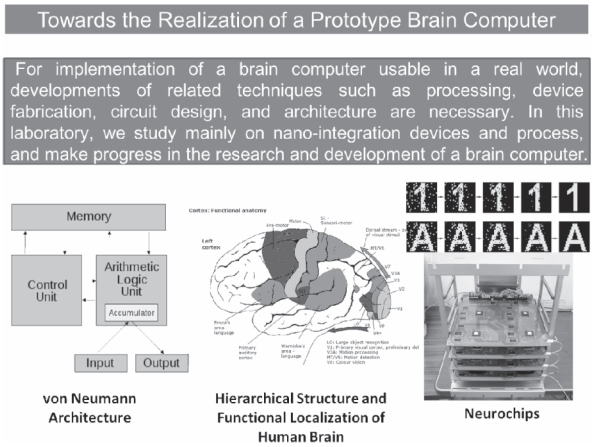
Nano-integration beyond the existing technology

Nano-Integration Devices — Shigeo Sato, Professor
Group IV Quantum Heterointegration — Masao Sakuraba, Associate Professor

[Research Target and Activities]

In addition to the conventional demands such as faster operation and larger throughput, low power operation for low-carbon emission and robust operation not damaged even in a disaster are required for the development of the next generation information technology. To meet these demands, studies on high functional and high performance Si-based semiconductor devices realized by 3-D nano-processing and large scale integration of such devices are important research subjects. We study the subjects such as new transistors and memories using new materials, new devices based on new principles like quantum effects, and required 3-D processing. Moreover, we develop advanced technologies related to 3-D nano-integration, dependable mixed signal LSI, and non von Neumann architecture.

In this year, following experimental results have been obtained: (1) A neuron circuit having large fan-in ability has been designed, and its successful operation in corporation with discrete synapses has been confirmed. (2) By using low-energy ECR plasma CVD, epitaxial growth of highly strained $Si_{1-x}Ge_x$ alloy lattice-matched to Si(100) substrate has been realized without substrate heating.



Towards the Realization of a Prototype Brain Computer

[Staff]

Professor : Shigeo Sato, Dr.
Associate Professor : Masao Sakuraba, Dr.
Assistant Professor: Hisanao Akima, Dr.

[Profile]

Shigeo Sato was received his B.E. and Ph.D. degrees from Tohoku University, in 1989 and 1994, respectively. In 1996, he joined the Research Institute of Electrical Communication, Tohoku University. Now, he studies brain computer and quantum computer as a professor.

Masao Sakuraba received his B.E. and Ph.D. degrees from Tohoku University in 1990 and 1995, respectively. In 1995, he joined the Research Institute of Electrical Communication, Tohoku University. Now, he studies group IV quantum heterointegration as an associate professor.

[Papers]

[1] "Epitaxial Growth of B-Doped Si on Si(100) by Electron-Cyclotron-Resonance Ar Plasma Chemical Vapor Deposition in a SiH4-B2H6-H2 Gas Mixture without Substrate", Y. Abe, M. Sakuraba and J. Murota, Thin Solid Films, 557, (2014), 10-13.
[2] "Epitaxial Growth of Si1-xGex Alloys and Ge on Si(100) by Electron-Cyclotron-Resonance Ar Plasma Chemical Vapor Deposition without Substrate Heating", N. Ueno, M. Sakuraba, S. Sato and J. Murota, Thin Solid Films, 557, (2014), 31-35.
[3] "Nitrogen Doping Effect upon Hole Tunneling Characteristics of Si Barriers in Si1-xGex/Si Resonant Tunneling Diode", T. Kawashima, M. Sakuraba and J. Murota, Thin Solid Films, 557, (2014), 302-306.

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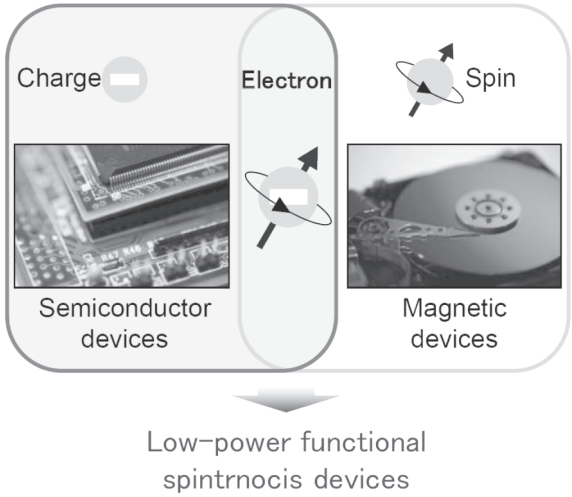
Semiconductor Spintronics

Advanced technology for spintronics-based devices

Functional Spintronics: Hideo Ohno, Professor

[Research Target and Activities]

We are working on spin-related phenomena in semiconductors, magnetic semiconductors, and magnetic metals as well as novel functional spin materials and devices, in order to realize low-power functional spintronic devices. In particular, we are tackling the following challenges; development of functional spin materials and structures by using molecular beam epitaxy and sputtering, understanding and characterization of spin-related phenomena such as electric field-induced and current-induced magnetization reversal, development of new spintronic devices utilizing them, and fabrication of various prototype integrated circuits employing spintronic devices.



The outcomes in the last fiscal year are determination of (1) in-plane magnetic field dependence of electric field-induced magnetization switching probability in a CoFeB/MgO based magnetic tunnel junction with a perpendicular magnetic easy axis, (2) in-plane current induced effective fields in Ta/CoFeB/MgO heterostructures, (3) pulse width and pule amplitude dependence of current-induced depinning probability of a domain wall in Co/Ni nanowire.

[Staff]

Professor: Hideo Ohno, Dr.
Assistant Professor: Michihiko Yamanouchi, Dr.
Research Fellow: Norikazu Ohshima, Dr.
Research Fellow: Hiroyasu Nakayama, Dr.

[Profile of 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), the 2005 Agilent Technologies Europhysics Prize, Thomson Reuters Citation Laureates (2011), JSAP Outstanding Achievement Award (2011), and IEEE David Sarnoff Award (2012). He is Institute of Physics (IOP) Fellow (2004), Honorable Professor at Institute of Semiconductors, Chinese Academy of Sciences, JSAP fellow (2007), and APS fellow (2012), Distinguished Professor at Tohoku University (2008), and IEEE Magnetic Society Distinguished Lecturer for 2009.

[Papers]

[1] S. Kanai, Y. Nakatani, M. Yamanouchi, S. Ikeda, F. Matsukura, H. Ohno, "In-plane magnetic field dependence of electric field-induced magnetization switching", Applied Physics Letters, Vol. 103, 072408 (4 pages), August 2013.
[2] C. Zhang, M. Yamanouchi, H. Sato, S. Fukami, S. Ikeda, F. Matsukura, and H. Ohno, "Magnetotransport measurements of current induced effective fields in Ta/CoFeB/MgO", Applied Physics Express, Vol. 103, 262407 (3 pages), December 2013.
[3] S. Fukami, M. Yamanouchi, S. Ikeda, and H. Ohno, "Depinning probability of a magnetic domain wall in nanowires by spin-polarized currents", Nature Communications, Vol. 4, 2293 (6 pages), August 2013.

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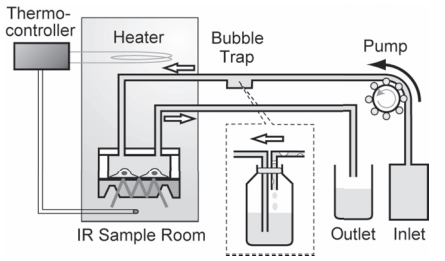
Nano-Molecular Devices

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

Nano-Molecular Devices: Michio Niwano, Professor
Nano-Electron Devices: Yasuo Kimura, Associate Professor

[Research Target and Activities]

Development of the semiconductor nanofabrication technology as typified by photolithography has miniaturized and sophisticated electronic devices. On the other hand, the progress of nanotechnology and biotechnology enables us to synthesize and use biological molecules, supramolecules, and nanostructures with electrically and optically unique features. By combining these technologies, we are aiming to develop molecular scale devices which allow advanced information processes.



Bio-sensing system for *in-situ* monitoring of cell activities by infrared spectroscopy

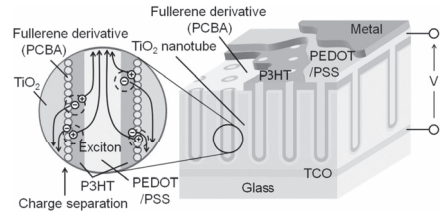
1) *In-situ* monitoring of adipocyte differentiation by infrared spectroscopy (IRAS)

We have succeeded in real-time monitoring cell differentiation to adipocytes by using IRAS with the multiple internal reflection (MIR) geometry. We showed that MIR-IRAS has a potential to evaluate antiadipogenic agents in terms of their effects on fat and protein synthesis during adipogenesis.

2) Development of TiO_2 nanotube-based micro-scaled gas-sensor

We have fabricated TiO_2 nanotube-based macro-scaled gas sensors by locally anodizing a thin Ti film on glass substrate. We demonstrated that deposition of metal nanoparticle on the inner wall of nanotubes improves the sensitivity and gas-discrimination function of the gas sensors.

3) Development of organic/TiO_2 hybridized solar cells



Organic/TiO_2 hybridized solar cells with TiO_2 nanotube.

We have investigated modification of TiO_2 surfaces used for fabrication of TiO_2/polymer hybrid solar cells. We found that modification of TiO_2 surfaces with [6,6]-phenyl-C61-butyric acid (PCBA) drastically increased the short circuit current of TiO_2/P3HT-based hybrid solar cells.

[Staff]

Professor: Niwano, Michio Dr.
Associate Professor: Kimura, Yasuo Dr.

[Profile]

Michio Niwano 1998 – present RIEC, Tohoku University, Japan, Professor, Doctorate of Science. Memberships: The Electrochemical Society (ECS), The Japan Society of Applied Physics (JSAP), The Surface Science Society of Japan (SSSJ).

Yasuo Kimura 2010 – present RIEC, Tohoku University, Japan, Associate Professor, Ph. D. Eng. Memberships: ECS, JSAP, SSSJ.

[Papers]

[1] Y. Aonuma, Y. Kondo, A. Hirano-Iwata, *et al*., "Label-free and real time monitoring of adipocyte differentiation by surface infrared spectroscopy", Sens. Actuators B **176** (2013) 1176-1182.

[2] Y. Kimura, S. Kimura, R. Kojima, M. Bitoh, M. Abe, and M. Niwano, "Micro-scaled hydrogen gas sensors with patterned anodic titanium oxide nanotube film", Sens. Actuators B **177** (2013) 1156-1160.

[3] Ma, Teng; Zhang, Jinyu; Kojima, Ryota; *et al*., "Investigation of TiO_2 Surface Modification with [6,6]-Phenyl-C-61-butyric Acid for Titania/Polymer Hybrid Solar Cells", Japanese J. of Appl. Phys. **52**(2013) 112301.

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Nano-Spin Memory

Research of spin based device and memory

Nano-Spin Memory Shoji Ikeda, Associate Professor

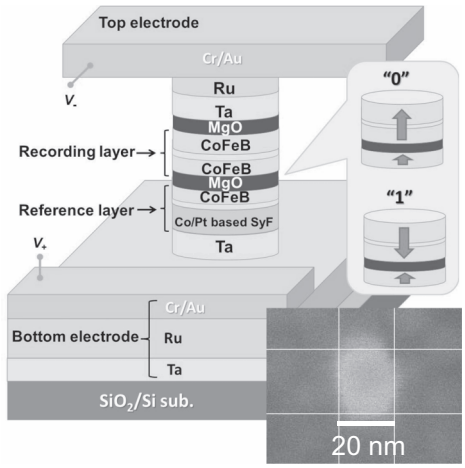
[Research Target and Activities]

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

1) We developed p-MTJs with a double interface MgO/CoFeB/Ta/CoFeB/MgO recording layer. The thermal stability of the p-MTJ with 20 nmϕ can satisfy application requirements while maintaining an intrinsic critical current for spin transfer torque switching. In addition, we successfully demonstrated bistable states in the world's smallest MTJ with 11 nmϕ.

2) We verified bi-stable states of parallel and antiparallel magnetization configurations in addition to the higher thermal stability of antiparallel magnetization configuration owing to reduction of the shift field by adjusting the number of Co/Pt bilayers in the synthetic ferrimagnetic (SyF) reference layer.

3) We demonstrated thermal stability Δ = 92 and TMR ratio = 91% at the same time in the MTJ using the CoFeB(1.6)/Ta(0.4)/[Co(0.4)/ Pt(0.6)]$_6$ recording layer structure with 17 nm in diameter.



Schematic diagram and SEM image of perpendicular anisotropy magnetic tunnel junction (p-MTJ) with double interface MgO/CoFeB/Ta/CoFeB/MgO recording layer.

[Staff]

Associate Professor : Shoji Ikeda, Ph.D.
Research Fellow : Tadashi Yamamoto
Research Fellow : Norikazu Ohshima, Ph.D.
Research Fellow : Christopher Eli Enobio, Ph.D.

[Profile]

Shoji IKEDA received the B.S., M.S., and Ph. D degrees from Muroran Institute of Technology, Muroran, Japan, in 1991, 1993 and 1996, respectively. He was a Research Associate with the Department of Electrical and Electronic Engineering at the Muroran Institute of Technology from 1996 to 1999. He was with Fujitsu Limited, Atsugi/Nagano, Japan, from 1999 to 2003. He joined Tohoku University, Sendai, Japan, in 2003, where he is currently an Associate Professor. His current research interests include magnetic metal devices with nanostructures and their application. He received the Magnetics Society of Japan Distinguished Paper Award in 2003, the APEX/JJAP Paper Award in 2009, DPS Best Paper Award in 2011, and SSDM Paper Award in 2012.

[Papers]

[1] S. Ishikawa, H. Sato, M. Yamanouchi, S. Ikeda, S. Fukami, F. Matsukura, and H. Ohno, "Magnetic properties of MgO-[Co/Pt] multilayers with a CoFeB insertion layer", Journal of Applied Physics, 113, 17C721 (2013).

[2] H. Sato, T. Yamamoto, M. Yamanouchi, S. Ikeda, S. Fukami, K. Kinoshita, F. Matsukura, N. Kasai, and H. Ohno, "Comprehensive study of CoFeB-MgO magnetic tunnel junction characteristics with single- and double-interface scaling down to 1X nm", 2013 IEEE International Electron Devices Meeting (IEDM), Washington, DC, USA.

[3] Hideo Sato, Shoji Ikeda, Shunsuke Fukami, Hiroaki Honjo, Shinya Ishikawa, Michihiko Yamanouchi, Kotaro Mizunuma, Fumihiro Matsukura, and Hideo Ohno, "Co/Pt multilayer based reference layers in magnetic tunnel junctions for nonvolatile spintronics VLSIs", Japanese Journal of Applied Physics, 53, 04EM02 (2014).

Laboratory for Brainware Systems

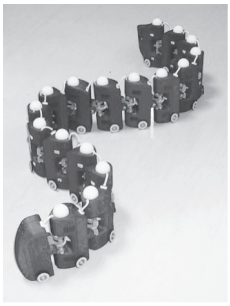
Research Targets and Activities of Laboratory for Brainware Systems

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.

Physical and Adaptive Hardware Environment

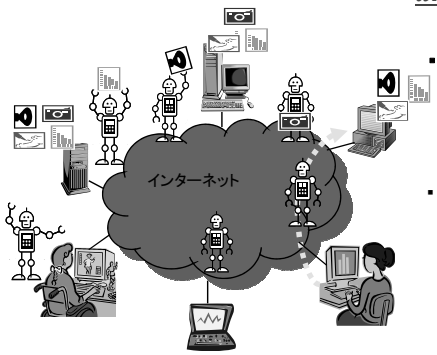


・**Real-World Dynamical Intelligence**

（Real-World Computing）

・**Virtual Space Construction**

（Cyber Robotics）



Seamless Fusion of Real World and Multi-Modal Computing

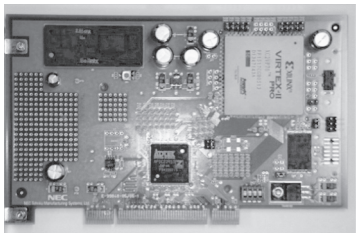
・**Human-Machine Cohabitation Architecture**

（Next-Generation Human Interface）

・**Higher-Order Multimodal Perception and Information Generation**

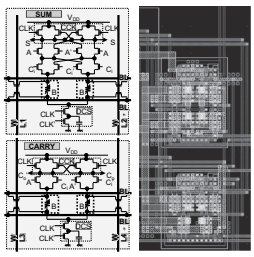
（Multi-Modal Computing）

Hardware Environment with Massively Parallel Brain LSI



・**Massively Parallel Neural LSI**

（Intelligent Nano-Integration System）



・**Nonvolatile Logic and Its Applications**

（New Paradigm VLSI System）

[Research Target]

Real-World Computing Section: Living organisms exhibit surprisingly adaptive and versatile behavior in real time under unpredictable and unstructured real world constraints via spatiotemporal coordination of a significantly large number of bodily degrees of freedom. Clarifying these remarkable abilities enable us to understand life-like complex adaptive systems as well as to construct truly intelligent artificial systems. A prominent concept for addressing this issue is “autonomous decentralized control”, in which non-trivial macroscopic functionalities are emerged via spatiotemporal coordination among vast amount of autonomous components that cannot be explained solely in terms of individual functionality. We investigate the design principle of autonomous decentralized systems that exhibit life-like resilient behaviors from the viewpoints of robotics, mathematics, nonlinear science, and physics.

New Paradigm VLSI System Section: Performance degradation of System on a Chip (SoC) or Network on Chip (NoC) due to wiring complexity, power dissipation and characteristic variation of materials/devices is increasingly getting a serious problem in recent VLSI 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 storage elements combined with CMOS 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.

[Research Activities]

Real-World Computing Section (Ishiguro Laboratory): The main contributions achieved in 2013 are summarized as follows: (1) we have successfully reproduced the versatile gait patterns of quadrupeds and the gait transition between them, e.g., from walk to trot to bound, with real physical robots. To our knowledge, this is the first successful robotic case study that achieves the gait transition ranging from walk to bound gait; (2) we have developed a decentralized-controlled snake-like robot that exhibits omni-directional locomotion. We have also constructed a decentralized control rule that enables concertina locomotion observed in narrow spaces; (3) we have discussed the applicability of our CPG model for quadruped locomotion to bipedal and hexapod locomotion; (4) we have modeled a decentralized control rule that can well reproduce the inter-limb coordination of Ophiuroids. This result could be helpful for realizing resilient robotic systems.

New Paradigm VLSI System Section (Hanyu Laboratory): The major contributions achieved in 2013 are summarized as follows: (1) a ternary content-addressable memory (TCAM)-based hardware called nonvolatile "multi-functional CAM (MF-CAM)" is designed and fabricated for an ultra-low-energy "full-text search" system in recent data centers. The proposed nonvolatile MF-CAM-based full-text search engine can perform parallel comparison while eliminating leakage energy by hierarchical power gating. By the massively parallel comparison with the hierarchical power gating, energy consumption of the proposed search engine is reduced within 1% in comparison with the conventional CPU-based full-text search system, where repetitive comparisons between the CPU and a memory consume much energy; (2) a nonvolatile field-programmable gate array (NVFPGA) test chip with 240 tiles (basic components) in a 12x20 2D-array is designed and fabricated by using 90nm-CMOS and 70nm-magnetic tunnel junction (MTJ) technologies. As a result, both the write-operation power and the total power in the proposed NVFPGA are reduced to 77% and 70%, respectively, in comparison with that of a conventional MTJ-based NVFPGA, and with that of a conventional SRAM-based FPGA; (3) a new asynchronous delay-insensitive data- transmission method based on level-encoded dual-rail encoding with novel packet-structure restriction is proposed to realize a high-throughput network-on-chip (NoC) router together with a compact hardware. As a result, the proposed asynchronous NoC router on a 0.13um CMOS technology has a 90% increase in throughput and a 34% decrease in energy dissipation with 25% area overhead in comparison with a conventional four-phase asynchronous NoC router under a post-layout simulation.

Intelligent Nano-Integration System Section (Nakajima-Sato Laboratory): (1) By using high-order synapses for an inverse function delayed neural network, we set up an FPGA circuit for traveling salesman and quadratic assignment problems. Furthermore, we proposed an inverse function delay-less model for high speed numerical calculation of artificial neural networks, and we applied the model to some problems in TSP-LIB. (2) We applied ID networks to development of a hetero-associative memory system. In that system we obtained large memory capacity and wide basin size. (3) We demonstrated successfully a 4-bit parallel multiplier using a carry look-ahead adder with niobium integrated circuits to improve the performance of high-speed operation for the SFQ fast Fourier transform, and we fabricated the central part of an 8-bit parallel multiplier of SFQ system. A neural network using superconducting quantum interference devices was fabricated and successfully demonstrated.

Real-world Computing

Toward Understanding Design Principle for Life-like Resilient Systems

Real-world Computing Akio Ishiguro, Professor

[Research Target and Activities]

Living organisms exhibit surprisingly adaptive and versatile behavior in real time under unpredictable and unstructured real world constraints. Such behaviors are achieved via spatiotemporal coordination of a significantly large number of bodily degrees of freedom. Clarifying these remarkable abilities enable us to understand life-like complex adaptive systems as well as to construct truly intelligent artificial systems. A prominent concept for addressing this issue is "autonomous decentralized control", in which non-trivial macroscopic functionalities are emerged via spatiotemporal coordination among vast amount of autonomous components that cannot be explained solely in terms of individual functionality. We study the design principle of autonomous decentralized systems that exhibit life-like resilient behaviors from the viewpoints of robotics, mathematics, nonlinear science, and physics.

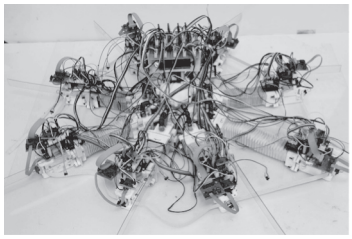


Fig.1: Soft-bodied amoeboid robot driven by a fully decentralized control scheme extracted from true slime mold

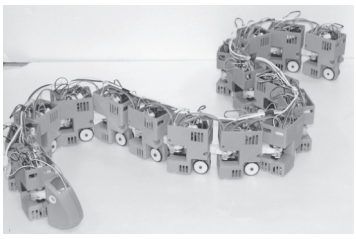


Fig.2: Snake-like robot driven by a decentralized control that exhibits omni-directional locomotion

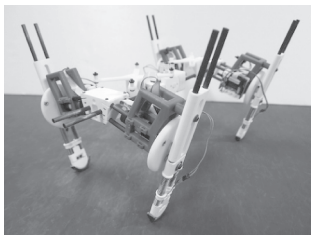


Fig.3: Quadruped robot that exhibits highly adaptive inter-limb coordination.

[Staff]

Professor: Akio Ishiguro, Dr.
Assistant Professor: Dai Owaki, Dr., Takeshi Kano, Dr., Kazuhiro Sakamoto, Dr.

[Profile]

Akio Ishiguro received B.E., M.E., and Ph.D. degrees from Nagoya University in 1987, 1989, and 1991, respectively. From 1991 to 1997, he was with Nagoya University as an assistant professor. From May 1997 to 2006, he was an associate professor, Nagoya University. From 2006 to 2011, he was a professor of the Graduate School of Engineering, Tohoku University. Since April 2011, he has been a professor of Research Institute of Electrical Communication, Tohoku University. His main research interests are in bio-inspired robotics, nonlinear dynamics. He received 2003 IROS Best Paper Award Nomination Finalist, 2004 IROS Best Paper Award, 2008 Ig Nobel Prize (Cognitive Science Prize), 2009 IROS Best Paper Award Nomination Finalist, 2011 IEEE/RSJ NTF Award Finalist for Entertainment Robots and Systems, Living Machines 2012 Best Paper Award.

[Papers]

[1] T. Kano, R. Kobayashi, and A. Ishiguro, "Decentralized Control Scheme for Adaptive Earthworm Locomotion Using Continuum-Model-Based Analysis", Advanced Robotics, 28-3, pp. 197-202 (2014) DOI:10.1080/01691864.2013.861770

[2] T. Kano, T. Kawakatsu, and A. Ishiguro, "*Generating Situation-dependent Behavior*: Decentralized Control of Multi-functional Intestine-like Robot That Can Transport and Mix Contents", Jounral of Robotics and Mechatronics, 25-4, pp. 871-876 (2013)

[3] D. Owaki, K. Osuka, and A. Ishiguro, "Stabilization Mechanism underlying Passive Dynamic Running", Advanced Robotics, 27-18, pp. 1399-1407 (2013) doi: 10.1080/01691864.2013.839087

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Intelligent Nano-Integration System

Basic Technology of Integrated System for Intelligent Processing

Intelligent Nano-Integration System, Koji Nakajima, Professor

[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 also presented a neural system and an FFT 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.

Research Activities in 2013：(1)The active area of Inverse function Delayed (ID) models make the state of network escape from local minima by their destabilization. In computer simulation and theoretical estimation, we showed that the ID network was capable of converging on optimal solutions only. We fabricated a prototype chip of the burst ID model and successfully demonstrated operations for solving combinatorial optimization problems. By using Higher-order Connections for an ID neural network (HC-ID), we theoretically obtained the parameter values that presented only optimal solutions for traveling salesman and quadratic assignment problems. Furthermore, we proposed a generalized energy function for scheduling problems and an Inverse function Delay-Less (IDL) model for high speed numerical calculation of artificial neural networks.
(2) We applied ID networks to development of an auto- and hetero-associative memory system. In that system we obtained large memory capacity and wide basin size.
(3) We fabricated a neuron circuit using SQUIDs with niobium integrated circuits and successfully demonstrated. Furthermore, we demonstrated a 4-bit parallel multiplier using a carry look-ahead adder to improve the performance of high-speed operation for fast Fourier transform based on single flux-quantum circuits and designed an 8-bit parallel multiplier.

[Staff]

Professor：Koji Nakajima, Dr.
Assistant Professor：Takeshi Onomi, Dr.

[Profile]

Koji 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. He is a professor at the same institute of Tohoku Univ., and is currently engaged in the study of VLSI implementation of neural network, and Josephson junction devices for digital applications.

[Papers]

[1] Y. Tsuji, T. Onomi, and K. Nakajima, “Characteristics of rf-SQUID Ladder Circuits,” Proceedings of Superconducting SFQ VLSI Workshop SSV 2013, pp.60-63, Tsukuba, Japan, Nov. 2013.
[2] Takeshi Onomi and Koji Nakajima, "Neuron Circuit Using Coupled SQUIDs Gate with Flat Output Characteristics for Superconducting Neural Network", IEICE Trans. Electron., E97-C, 3, pp.173-177(2014)
[3] A. Yamada, T. Onomi, and K. Nakajima, “Comparative Study of SFQ Parallel Multipliers,” Proceedings of Superconducting SFQ VLSI Workshop SSV 2013, pp.78-81, Tsukuba, Japan, Nov. 2013.
[4] K. Nakajima, “Superconducting Multipliers Based on Single Flux-Quantum Circuits,” CNSE and JSPS Core-to-Core Program Joint Seminar “Atomically Controlled Processing/Nanotechnology for Ultralarge Scale Integration,” Frankfurt Germany, Oct. 2013.

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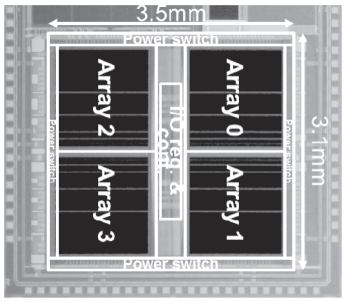
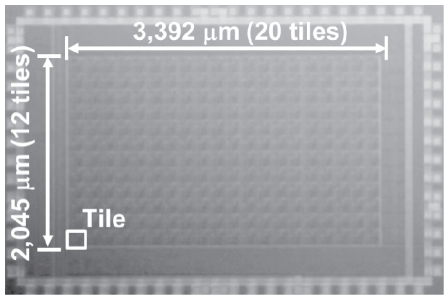
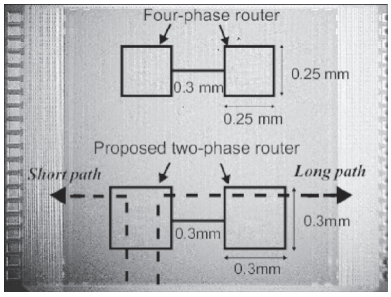
New Paradigm VLSI System Research Group

Realization of a New-Paradigm VLSI-Computing World







90nm CMOS/70nm p-MTJ technologies

0.13-um CMOS technology

Fig. 1. Nonvolatile TCAM Chip: Power supply at unmatched modules using perpendicular MTJ devices can be turned off. The search energy becomes 1/100 in comparison with that of the CPU implementation.

Fig. 2. Nonvolatile FPGA Chip: Zero standby power capability is realized since all the configuration data and temporal data are stored in perpendicular MTJ devices.

Fig. 3. Asynchronous NoC Router Chip: High-throughput compact delay-insensitive NoC router is fabricated based on an asynchronous-circuit aware packet structure.

New Paradigm VLSI System: Takahiro Hanyu, Professor

[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 are increasingly getting serious problems in the recent VLSI chip. Our research activity is to solve the above problems primarily by the following two ways: the use of logic-in-memory architecture based on nonvolatile logic, and the use of asynchronous data-transfer schemes based on multiple-valued current-mode logic, which would open up a novel VLSI chip paradigm, called a "new-paradigm VLSI system."

This year, we have succeeded the fabrication of MTJ (Magnetic Tunnel Junction)-based ternary content-addressable memory (TCAM) chip (Fig.1), reducing the search energy by 99% and the zero-standby power 240-tile FPGA (Fig.2). Furthermore, we have also fabricated the delay-insensitive asynchronous Network-on-Chip (NoC) router (Fig. 3).

[Staff]

Professor : Takahiro Hanyu, Dr. Assistant Professor : Masanori Natsui, Dr.
Assistant Professor : Naoya Onizawa, 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, Shoun Matsunaga, Vincent C. Gaudet, Warren J. Gross and Takahiro Hanyu, "High-Throughput Low-Energy Self-Timed CAM Based on Reordered Overlapped Search Mechanism," IEEE Trans. on Circuits and Syst. I, Reg. Papers, vol. 61, no. 3, pp. 865-876, 2014.
[2] Naoya Onizawa, Tomoyoshi Funazaki, Atsushi Matumoto, and Takahiro Hanyu, "High-Throughput Compact Delay-Insensitive Asynchronous NoC Router," IEEE Transactions on Computers, vol. 63, no. 3, pp. 637-649, 2014.
[3] Noboru Sakimura, Yukihide Tsuji, Ryusuke Nebashi, Hiroaki Honjo, Ayuka Morioka, Kunihiko Ishihara, Keizo Kinoshita, Shunsuke Fukami, Sadahiko Miura, Naoki Kasai, Tetsuo Endoh, Hideo Ohno, Takahiro Hanyu, Tadahiko Sugibayashi, "A 90nm 20MHz Fully Nonvolatile Microcontroller for Standby-Power-Critical Applications," 2014 IEEE ISSCC, Dig. Tech. Papers, pp.184-185, Feb. 2014.

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. Presently, two projects for mobile and storage technologies are being carried out.

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. Within the term until 2014, the project aims at DWS (Dependable Wireless System) wireless terminal, in which transmission distance, communication speed, power consumption, and QoS are all optimized. In 2013 the project attained (1) Proposal of the evaluation concept of 'wireless dependability' for wireless communication network, (2) Design and prototyping of the 60GHz beam-forming antenna for millimeter wide-band communication.

2. Development of High Availability Information Storage Systems

Severe information loss took place due to damage of storage servers at the Tohoku Earthquake. We started research on reliable information storage with smart file backup and restoration, which contributes to anti-disaster information storage technology. A project "Research and Development on highly-functional and highly-available information storage technology" supported by MEXT started in 2012 under the collaborations of RIEC including IT21 storage technology group, Hitachi, a major Japanese Storage manufacturer, and Hitachi Solutions East Japan. The goal of the project is the development of highly functional and highly available storage system. In 2013, (1) From computer simulations, it was shown that 90 % of information can be available even when a half (50%) servers are lost or damaged, (2) High-speed data-transfer for urgent file backup was investigated by parallel-transfer storage devices and smart-routing network systems, (3) Highly functional programing frame-work that can access both established relational data-base and key-value store methods for cloud servers.

[Staff]

Director: Hiroaki Muraoka, Professor

Project Planning Division

Makoto Furunishi, Visiting Professor

Technology Development Division (Mobile Wireless Technology Group)

Kazuo Tsubouchi, Visiting Professor
Tadashi Takagi, Visiting Professor

Technology Development Division (Storage Technology Group)

Takaki Nakamura, Associate Professor

IT21 Center Mobile Wireless Technology Group

For Realizing Dependable Air

Kazuo Tsubouchi, Visiting Professor (Project Leader)
Tadashi Takagi, Visiting Professor
Akinori Taira, Associate Professor

[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.

1. All Si CMOS RFIC: For realizing DWS, we have developed a 5GHz- and 60GHz-band RF circuits using 90nm 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).
3. Adaptive and Scalable ADC/DAC: We have devised a current mode pipeline ADC, which is suitable for process miniaturization and low supply voltage.

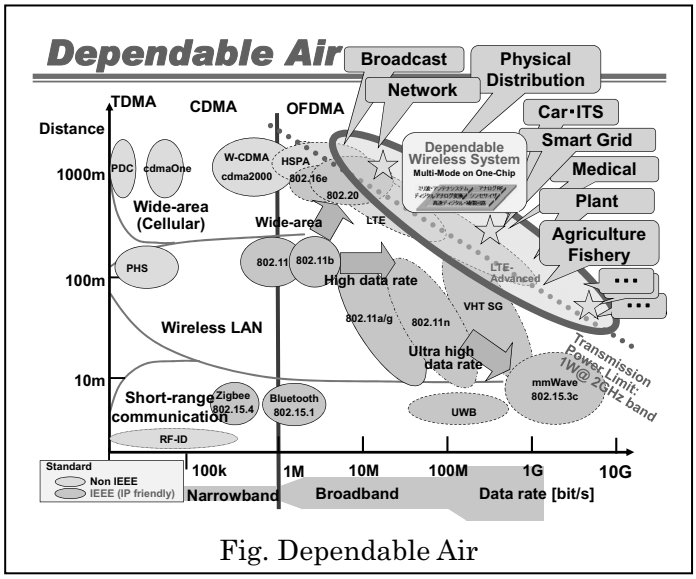


Fig. Dependable Air

[Staff]

Visiting Professor: Kazuo Tsubouchi, Ph. D, Tadashi Takagi, Ph. D
Associate Professor: Akinori Taira, Ph. D

[Profile]

Kazuo Tsubouchi received the Ph.D. degree in Electronics Engineering from Nagoya University in 1974. In 1974, he joined the RIEC. In 1982, he spent at Purdue University as a visiting associate professor. From 1993 to 2010, he has been a professor of RIEC. From 2002 to 2010, he has been the director of IT-21 Center. He is currently a visiting professor. He is a member of the IEEE, the IEICE, the Physical Society of Japan, the Japan Society of Applied Physics, et al.

Tadashi Takagi received the B.S. degree in physics from Tokyo Institute of Technology and Ph.D. degree in electronic engineering from Shizuoka University 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. From 2005 to 2010, he has been a professor of IT-21 Center. He is currently a visiting professor. He is a fellow of IEICE and a senior member of the IEEE.

Akinori Taira received the B.S., M.S., and Ph.D. degrees in electronics and communication engineering from Waseda University in 1994, 1996 and 2008, respectively. In 1996, he entered the Mitsubishi Electric Corporation, where he had been engaged in research and development of broadband wireless communication system. He is currently an associate professor of IT-21 Center.

[Papers]

[1] O. Wada *et al.*, "5 GHz-band CMOS direct digital RF modulator using current-mode DAC with idle current," IWS2013, WE3B-1, April 2013.
[2] T. Takagi *et al.*, "Dependable air and wireless dependability," GSMM2013, April 2013 (invited).
[3] Y. Suzuki *et al.*, "Hetero-plane beam synthesis using 60 GHz band 3-D phased array antenna module," IEEE RWS2014, MO3A-4, Newport Beach, USA, Jan. 2014.

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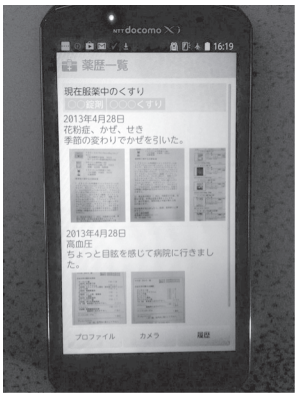
IT21 Center Storage Technology Group

Realization of Highly-available Storage System

Takaki Nakamura, Associate Professor

Highly-Available Storage System



Application under development for Storage System

[Research Target and Activities]

The Storage Technology Group continue to be engaged in the research and development of storage technology in a collaboration between industry, academia, and government. Our group successfully completed two national projects commissioned by the Ministry of Education, Culture, Sports, Science and Technology from FY2002 to FY2011.

Recently, as social and information systems become more complicated, one of the urgent research areas in storage, in addition to “devices” and “drives”, is the “system”. Because of this our group started a new national project “Research and Development on Highly-functional and Highly-available Information Storage Technology” in FY2012. The project will continue until FY2016. Furthermore, in collaboration with the storage system industry, we will focus on bringing the results of our research into practical use within five years, which is the prime mission of the IT-21 center.

[Staff]

Associate Professor: Takaki Nakamura, Ph.D.
Research Fellow: Masachika Harada

[Profile]

Takaki Nakamura received B.E, M.E, and Ph.D. in information science from Osaka University in 1996, 1998, and 2011 respectively. He joined Central Research Laboratory, Hitachi, Ltd. in 1998. He is currently an associate professor at RIEC, Tohoku University. He has been engaged in research on storage system.

[Papers]

[1] T. Fukatani, K. Matsuzawa, H. Kamei, M. Agetsuma, and T. Nakamura, “A Method for Eliminating Metadata Cache De-allocation Latency in Enterprise File Servers,” IEEE Trans. Magn. Vol. 49, No. 6, pp.2504-2509, 2013
[2] H. Kamei, T. Nakamura, and N. Komoda, “SDD: Selective De-duplication with Index by File Size for Primary File Servers,” 2013 Int. Conf. on Computer Design (CDES'13), 2013
[3] S. Matsumoto, T. Nakamura, and H. Muraoka, “Risk-aware Data Replication to Massively Multi-sites against Widespread Disasters (Best Paper Award),” The 2nd Asian Conference on Information Systems, 2013

Contact to Associate Professor Takaki Nakamura : takaki@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 Safety and Health is established to maintain the safety and health 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 Safety and Health provides support for safety and health 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 safety and health at the office, the Safety and Health Committee first presents the basic policies of safety management at the institute, and the Management Office for Safety and Health 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 Safety and Health 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 safety and health. 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 safety and health management system and working environment within the institute
- ○ Holding first-aid training course
- ○ Investigation of laws related to safety and health and collection of information regarding safety and health management
- ○ Providing advice and information to safety and health personnel in each department

[Staff]

Manager: Michio NIWANO, Professor

Deputy Manager: Yoichi UEHARA, Professor

Nobuyuki SATO, Assistant Professor

Maho ABE, Technical staff　　Ayako CHIBA, Clerk

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 advanced information processing with respect to the human intention and situation of its environment.

Our goal is to investigate the design principles of flexible information system through the theories and the experiments, and establish their system construction methodology. Moreover, we also study the flexible distributed systems to use/reuse, organize, and manage scientific information. Developing 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 research themes:

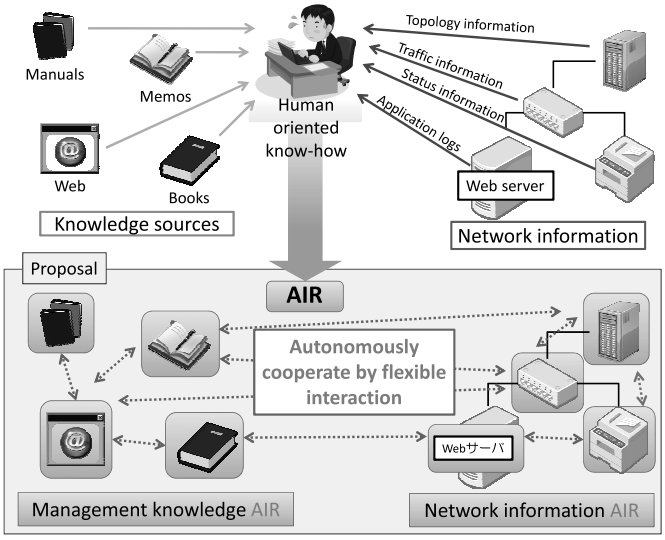


Fig.1 Knowledge based Network Management System.

(1) development of knowledge based network management system (Fig.1),
(2) development of an autonomous service management system in emergency situations and
(3) flexible computing mechanism in biological system.

[Staff]

(1) Steering Committee
Professor: Tetsuo Kinoshita, Dr., Yôiti Suzuki, Dr., Yoshihito Toyama, Dr., Masafumi Shirai Dr., Atsushi Ohori, Dr., Takuo Suganuma, Dr.
(2) FIR Committee
Professor: Yoshihito Toyama, Dr., Takuo Suganuma, Dr.
Associate Professor: Masato Yoshida, Dr., Gen Kitagata, Dr.
Assistant Professor: Takeshi Onomi, Dr., Dai Owaki, Dr., Katsuhiro Ueno, Dr., Kazuto Sasai, Dr.
Technical Official: Masahiko Sato
Research Fellow: Johan Sveholm Dr.
Technical Support Member: Midori Suzuki, Sachiko Nagase, Yuki Ohashi, Keiko Taniguchi
(3) Regular Staff
Associate Professor: Gen Kitagata, Dr.
Assistant Professor: Kazuto Sasai, Dr.
Technical Official: Masahiko Sato
Research Fellow: Johan Sveholm Dr.
Technical Support Member: Midori Suzuki, Sachiko Nagase, Yuki Ohashi, Keiko Taniguchi

[Profile]

Refer to the Communication Network Laboratory for the profile of Prof. Tetsuo Kinoshita.
Refer to the Computing Information Theory Laboratory for the profile of Prof. Yoshihito Toyama.

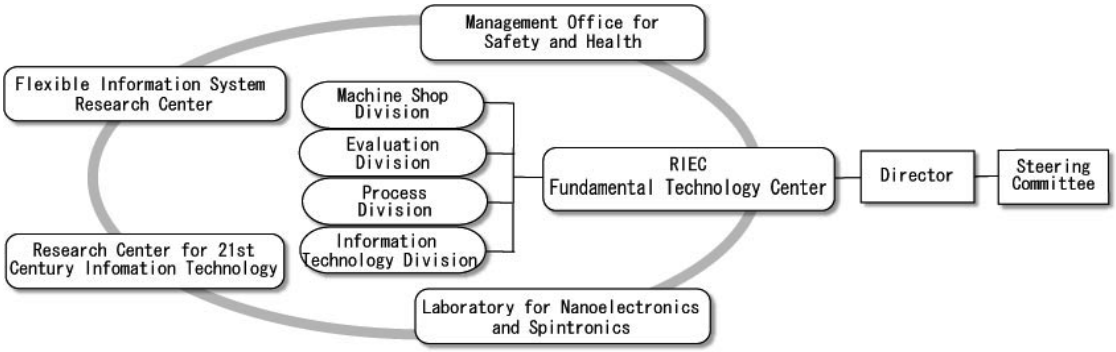
[Papers]

1. Kazuto Sasai, Yuki-Pegio Gunji, Tetsuo Kinoshita, "A Model of Market Behavior based on Time and Space Uncertainty," Proc. of The Nineteenth International Symposium on Artificial Life and Robotics (AROB 19th 2014), Jan. 2014.

Contact to Associate Professor Gen Kitagata : minatsu@riec.tohoku.ac.jp

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 a wide range of technical supports for research and development (R & D) through the following four divisions; machine shop, evaluation, process, and information technology. The activities of the present year are summarized as follows except for those of Technical Official F. Saito and Y. Wagatsuma, which are separately described in the sections of Advanced Acoustic Information Systems and Dielectric Nano-devices, respectively.

1. Machine Shop Division

The Machine Shop Division supplied machining products of 190, following requests from researchers. About 10 % of the requests were from the outside of the institute.

2. Evaluation Division

23 laboratories utilized evaluation and measurement apparatuses for shared usage (the utilization time was 4483 hours in total). Glass processing products of 8 were supplied. Several services relating to supply of cryogenic liquids were provided. 8 laboratories used the project clean room (PCR), a clean room for shared usage, which is operated by this division.

3. Process Division

This division supplied electron-beam lithographic products of 139, in cooperation with technical office, Laboratory for Nanoelectronics and Spintronics. Technical supports were provided for operating and maintain clean rooms of Laboratory for Nanoelectronics and Spintronics. Customized optical elements were supplied to 1 laboratories.

4. Software Technology Division.

This division operated the in-house network at the institute and maintained shared-use-information-equipment, in cooperation with Flexible Information System Research Center. This division also engaged in contracting affairs of collaborative research based on intellectual-property rights and in giving advices to researchers who tried to apply patents.

[Staff]

Director (Professor): Yoichi Uehara

Assistant Professor: Nobuyuki Sato

Technical Officials : Koichi Shoji, Tamotsu Suenaga, Maho Abe, Keisuke Sato, Kento Abe, Masahiko Sato, Yuko Maruyama, Yurika Iwami, Iori Morita, Takenori Tanno, Yasuo Wagatsuma, Shigeto Agatsuma, Fumitaka Saito, Katsumi Sagae, Hiroshi Watanabe, Munetomo Sugawara, Choichi Takyu, Setsuko Odagiri, Midori Suzuki, Keiko Taniguchi,

Center for Spintronics Integrated Systems (CSIS)

＜About the Center＞

Establishment：CSIS was established on March 10th 2010 in order to implement the FIRST Program, "Research and Development of Ultra-low Power Spintronics-based VLSIs".

Organization：

・Director : Hideo Ohno (Professor and Director of RIEC)

・FIRST Program Operational Support Institution : Tohoku University

・Number of Researchers : 30 （including 17 concurrent appointments）

Research Target：CSIS has been assuming a leading role in innovative change by demonstrating the fusion of spintronics devices and logic integrated circuits, thus aiming at playing a pivotal role in the global innovation cycle of logic VLSIs.

Research Activities: Demonstration of ultra-low power and high performance spintronics logic VLSIs by research and development of spintronics material, device, integration processing, circuit design, and design tools coherently.

＜Major Achievements in 2013＞

In 2013, spintronics-based logic VLSIs composed of millions of transistors and MTJs were designed using our developed design environment, and fabricated, using 90 nm CMOS technology and the perpendicular easy-axis MTJs, in order to demonstrate superior performance (chip area ratio × delay time ratio × power consumption ratio ≦ 1/64) compared with conventional CMOS technology. The high performance of spintronics-based VLSIs have been reported in world-leading international conferences such as IEEE ISSCC, VLSI Symposia and IEDM; the reported VLSIs are the following logic embedded STT-MRAM, non-volatile logic VLSIs general purpose application, and special purpose application with the Logic-in-Memory (LIM).

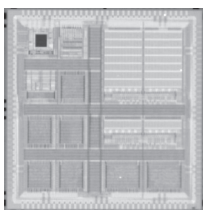
・Non-volatile 1-Mbit STT-MRAM with high access speed,

・Non-volatile microcontroller with 64-KByte non-volatile RAM,

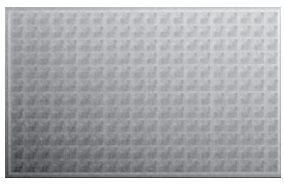
・Non-volatile Field Programmable Gate Array (FPGA) with LIM architecture,

・Non-volatile 1-Mbit Content -Addressable Memory (TCAM) with LIM architecture for big-data search.

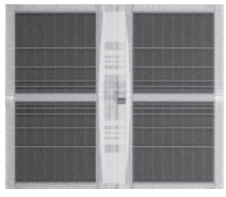
STT-MRAM



Microcontroller



FPGA



TCAM

CSIS is the world's first and only spintronics research center with open collaboration. We lead spintronics technology to apply ultra-low power and high performance logic integrated circuits. Our research achievements in FY2013 (from April 1st of 2013 through March 31st of 2014) include 52 papers in authoritative academic journals, 223 papers in conferences, 18 and 11 patent applications in Japan and abroad, respectively.

Research Organization of Electrical Communication (ROEC)

Towards Construction of Disaster-Resistant Information Communication Network

[Purpose of our establishment]

Many serious problems have become clear as a result of the Great East Japan Earthquake, which exposed the weaknesses of the most advanced information communications network in the world by severing the mobile phone and optical fiber lines thus cutting off essential telecommunications services. To solve these problems, Tohoku University's Disaster Reconstruction and Regeneration Research Project includes an ICT Reconstruction Project for restoring information communication. The mission given to the researchers in the Electrical Engineering and Information Sciences group after the disaster was to achieve a disaster-resistant information communication network through the ICT Reconstruction Project, taking the needs of the disaster areas into consideration.

To realize this network, we needed to employ the combined strength of our problem-solving abilities by linking researchers in electrical engineering and the information sciences across multiple faculties, including the School of Engineering, the Graduate School of Information Sciences, the Graduate School of Biomedical Engineering, the Cyberscience Center, and the Research Institute of Electrical Communication. These faculties and schools came together to form a new organization that could create close and flexible links between researchers and organizations, and on October 1, 2011 we established the Research Organization of Electrical Communication (ROEC) (Fig.1). The ROEC intends to take an all-Japan approach based on collaboration between industry, academia and government, and assemble expertise from the university with the participation of related local governments, private companies, public research organizations, and other universities with the goal of developing the most advanced disaster-resistant information communication network in the world (Fig.2).

[Main Activities]

Since 2012, we have been promoting 11 disaster-resilient ICT projects supported by the Ministry of Internal Affairs and Communications. In 2013, four ongoing projects were promoted. In addition, we demonstrated the feasibility of the research results produced by these projects at Yamamoto-cho and Kakuta-shi in Miyagi. We have also been engaged in a disaster management project supported by RISTEX, JST, to realize a database of disaster information and response records, and to utilize effectively the information and accumulated lessons in the future by analyzing this huge database. The research results produced by the promoted projects were presented at the ROEC symposium held on July 23, 2013, and our activities were described in ROEC Newsletters published in 2013.

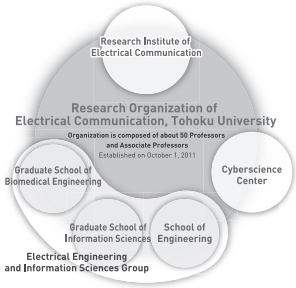


Fig.1 Research Organization of Electrical Communication.

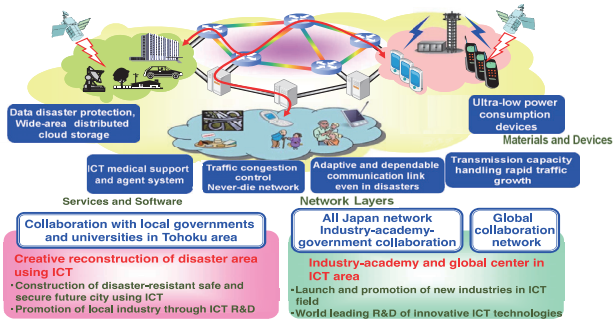


Fig.2 Overview of ICT Reconstruction Project.

[Staff]

Prof. Masataka Nakazawa (Executive Director)
Prof. Fumiyuki Adachi (Vice Executive Director)
Specially Appointed Prof. Naomichi Numata (Vice Executive Director)
Specially Appointed Prof. Katsumi Iwatsuki (Research Administrator)
Mr. Yasuharu Ito (Office Manager)
Ms. Izumi Ishikawa (Secretary)

[Papers]

[1] M. Nakazawa, "Disaster-resilient networks and optical communication technologies", Proceedings of IEICE, Vol. 96, No. 10, pp. 748-751 (2013) in Japanese.
[2] F. Adachi, "Disaster-resilient Multilayered Communications Network", Invited talk, ETPSC'2013 (2013).
[3] Y. Kawamoto, H. Nishiyama, and N. Kato, "Toward Terminal-to-Terminal Communication Networks: A Hybrid MANET and DTN Approach", Invited paper, ETPSC'2013 (2013).
[4] N. Suematsu, S. Kameda, et al., "Satellite Communication Networks Valid for Disaster Recovery," IEEE Satellite and Space Communications (SSC) Newsletter, pp. 8-12 (2013).
[5] K. Iwatsuki, "The projects of Disaster-Resistant Information Communication Network at the Research Organization of Electrical Communication, Tohoku University", Invited paper, Photonics West, 8646-9 (2013).

Center for Innovative Integrated Electronics Systems

＜Overview＞

Establishment: October 1, 2012 at Aobayama New Campus, Tohoku University

Organization : -Director: Tetsuo Endoh (Professor, Graduate School of Eng.)
-Staff: about 50 people

Mission: Contribute to the enhancement of global competitiveness in the field of next-generation integrated electronics systems, and further, work toward the creation of practical applications and new industries, through the research and development of innovative devices and its integrated electronic systems and constructing a consortium for this field under the international collaboration among industries, universities and government.

Research topics: Research and development by industry-university joint research projects, national research projects and so on in a wide variety of integrated electronics fields such as for next-generation semiconductor memory, high-performance printed-circuit board, packaging, and image processing technologies.

＜Major activities in 2013＞

In April 2013, the Center for Innovative Integrated Electronic Systems (established in October 2012) was completed at the Aobayama New Campus, which was funded wholly by the private sector. This center has already started industry-university joint research projects in a wide variety of integrated electronics fields such as for next-generation semiconductor memory, high-performance printed-circuit board, packaging, and image processing technologies. In the field of next-generation semiconductor memory, the center has a program for R&D of spin-transfer torque magnetic random access memory (STT-MRAM) where Tohoku University leads the world. The center was the first among Japanese universities to develop a trial 300 mm-wafer process line and is working on R&D together with domestic and oversea semiconductor device/equipment companies, universities and research institutions.

It is expected that the center will become a worldwide R&D base for integrated electronic technologies, and play a leading role in the “Renaissance of Tohoku and Rebirth of Japan” through various industry-university joint research projects and cultivation of highly talented human resources in such an environment. Consequently, the center will contribute to enhancing the international competitive power of Japan in this field and create new industries which will lead to the realization of an energy-saving society in the future.

The center has received official supports from Miyagi Prefecture and Sendai City.

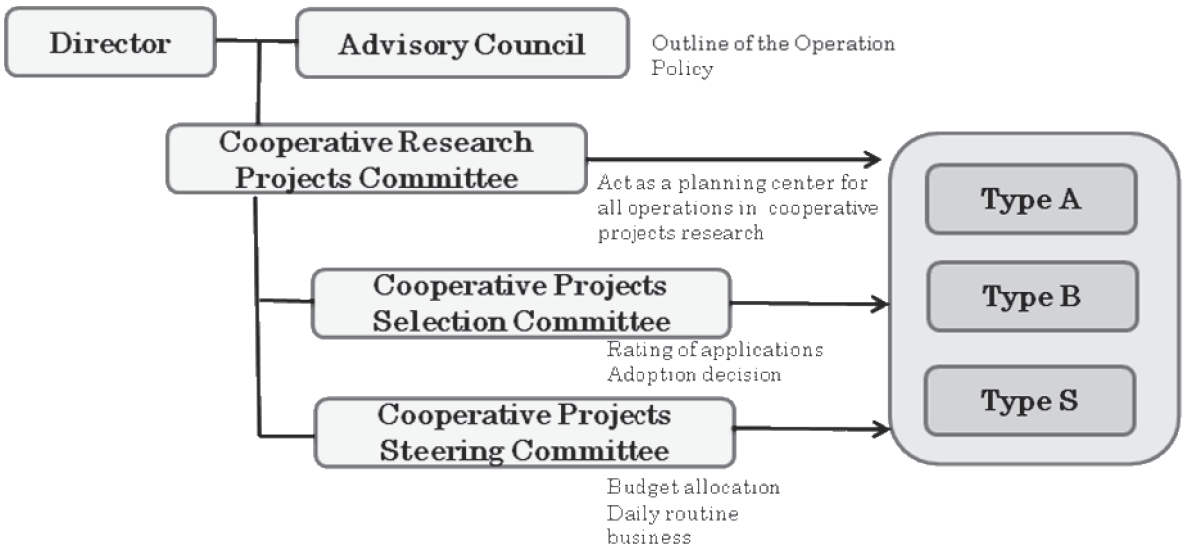
4. Nation-wide Cooperative Research Projects

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 Cooperative Research Projects. Committee 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 Selection 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 2013

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H23／A02 Optoelectronic devices using carbon-based nanomaterials	**Takashi Uchino** Tohoku Institute of Technology	**Taiich Otsuji**
H23／A03 Development of the fabrication technique for atomically-controlled Si- and Ge-MIS structures and the evaluation technique of their interfaces	**Hiroshi Okamoto** Hirosaki University	**Michio Niwano**
H23／A04 Highly-Strained and Atomically-Controlled Heterostructure Formation of Group-IV Semiconductors and Nanodevice Application	**Masao Sakuraba** Research Institute of Electrical Communication, Tohoku University	**Michio Niwano**
H23／A06 Heterogeneous Network Roaming Technology for Dependable Air	**Noriharu Suematsu** Research Institute of Electrical Communication, Tohoku University	**Noriharu Suematsu**
H23／A08 Signal transduction of the artificial neuronal network	**Haruyuki Kamiya** Graduate School of Medicine, Hokkaido University	**Michio Niwano**
H23／A09 A research on flexible, printable organic heterojunction photovoltaic devices	**Fumihiko Hirose** Graduate School of Engineering, Yamagata University	**Michio Niwano**
H23／A10 Development of magnetic devices using thin film element with inchlined stripe magnetic domain and its applications	**Hiroaki Kikuchi** Iwate University	**Kazushi Ishiyama**
H23／A11 Research on Infrastructure System for Cyber-Physical Integrated Society	**Hiroshi Shigeno** Science and Technology, Keio Univercity	**Gen Kitagata**

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H23／A12 Two-dimensional sound localization based on a monaural input signal	Masashi Itoh Tohoku Institute of Technology	Yôiti Suzuki
H24／A01 Development of ultra-bright entangled photon sources	Ryousuke shimizu The University of Electro-Communications	Keiichi Edamatsu
H24／A02 Development of Solid Oxide Fuel Cells with thin film electrolyte	Kiyoshi Uchiyama Tsuruoka National College of Technology	Yasuo Cho
H24／A03 Precise Interface Control of Graphene and Nano Device Applications	Maki Suemitsu Research Institute of Electrical Communication, Tohoku University	Maki Suemitsu
H24／A04 Basic Study of Plasma Nanobio-Medicine	Toshiro Kaneko Graduate School of Engineering, Tohoku University	Michio Niwano
H24／A05 Development of Highly Sensitive Sensors Using Surface Plasmons Excited on Periodic Structure	Hiroyuki Odagawa Kumamoto National College of Technology	Yasuo Cho
H24／A06 Development of Atomically-Controlled Plasma CVD Process for Quantum Heterointegration of Group-IV Semiconductors	Masao Sakuraba Research Institute of Electrical Communication, Tohoku University	Michio Niwano
H24／A07 Device Design, Evaluation and Preparation of Langasite Family Piezoelectric Single Crystals for High-Temperature Acoustic Sensors at 1000℃	Yuji Ohashi Graduate School of Engineering, Tohoku University	Yasuo Cho
H24／A08 Study on Electron and Nuclear spins in semiconductor nanostructures	Yuzo Ohno Graduate School of Pure and Applied Sciences, University of Tsukuba	Hideo Ohno

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H24／A10 THz wave generation and detection systems using resonant tunneling devices	Koichi Maezawa Graduate School of Science and Engineering for Research, University of Toyama	Taiichi Otsuji
H24／A11 Distortion of auditory space caused by vestibular information	Wataru Teramoto Muroran Institute of Technology	Shuichi Sakamoto
H24／A12 A Fundamental Study on an Affective Networking System	Masaki Omata University of Yamanashi	Gen Kitagata
H24／A13 Fabrication of artificial lipid bilayers and their application to bio-information devices	Ayumi Hirano Graduate School of Biomedical, Tohoku University	Michio Niwano
H24／A15 Contents-Oriented Computing in Super-distributed Environment	Jun Munemori Faculty of Systems Engineering, Wakayama University	Tetsuo Kinoshita
H24／A16 Research of Coordination Mechanism of Repository-based Multiagent Framework for Symbiotic Computing	Takahiro Uchiya Graduate School of Engineering, Nagoya Institute of Technology	Tetsuo Kinoshita
H25／A01 Fabrication and characterization of nanometer-scale chalcogenide structures, and their application to memory devices	Masashi Kuwahara National Institute of Advanced Industrial Science and Technology	Yoichi Uehara
H25／A02 Study on High-Power Terahertz Signal Source with InGaAs HEMTs	Yohtaro Umeda Faculty of Science and Technology Electrical Engineering, Tokyo University of Science	Tetsuya Suemitsu
H25／A03 Self-assembling formation of high density ferromagnetic nanodots by controlled alloying of group IV semiconductors with metals and its magnetic properties	Seiichi Miyazaki Graduate School of Engineering, Nagoya University	Michio Niwano

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H25／A04 Electronic structure and properties of ferromagnetic shape memory and other functional magnetic materials	**Shin Imada** College of Science and Engineering, Ritsumeikan University	**Masafumi Shirai**
H25／A05 Implementation of Large Scale Superconducting Quantum Detectors for Practical Applications	**Satoshi Kohjiro** National Institute of Advanced Industrial Science and Technology	**Shigeo Sato**
H25／A06 High-precision communication system for kansei information of speech	**Akihiro Tanaka** Tokyo Woman's Christian University	**Sakamoto Shuichi**
H25／A07 Multi-channel color representation in human brain	**Ichiro Kuriki** Research Institute of Electrical Communication, Tohoku University	**Ichiro Kuriki**
H25／A08 Development of speech processing technology by nonlinear time-varying auditory representation	**Masanori Morise** Interdisciplinary Graduate School of medicine and Engineering, University of Yamanashi	**Yôiti Suzuki**
H25／A09 Study of the cooperative environment for building visual cognition models	**Ko Sakai** Faculty of Engineering, Information and Systems, University of Tsukuba	**Satoshi Shioiri**
H25／A10 Evaluation of sound field rendering using a surrounding loudspeaker array system	**Takao Tsuchiya** Faculty of Science and Engineering, Doshisha University	**Yôiti Suzuki**
H25／A11 Study of Information Principle of Brainware and its applications	**Toshiyuki Kanoh** NEC Corporation	**Koji Nakajima**
H25／A12 Heterarchical analysis of adaptability under indeterminacy and its technological applications	**Tatsuji Takahashi** School of Science and Engineering, Tokyo Denki University	**Kazuto Sasai**
H25／A13 Interpersonal Communications in a Media Space	**Ikuo Daibo** Motivation and Behavioral Sciences, Tokyo Future University	**Yoshifumi Kitamura**

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H25／A14 An Intelligent Sensing Environment for Smart Aging	Zixue Cheng School of Computer Science and Engineering, The University of Aizu	Gen Kitagata
H25／A15 Study on knowledge acquirement in information networks for agent-based management system	Yukio Iwaya Faculty of Engineering, Tohoku Gakuin Univercity	Gen Kitagata
H23／B02 Research on the new concept large scale memory and its system with integration of nano materials on silicon technology	Heiji Watanabe Graduate School of Engineering, Osaka University	Hideo Ohno
H23／B03 Research on nano semiconductor materials and nano structured devices required for future electronic systems	Kikuo Yamabe Graduate School of Pure and Applied Sciences, Tsukuba University	Hideo Ohno
H23／B04 New Technologies for Reducing Iron Loss of Electrical Steels	Kazushi Ishiyama Research Institute of Electrical Communication, Tohoku University	Kazushi Ishiyama
H23／B05 Study of functional piezoelectric materials and applications to advanced communication devices	Shin-ichiro Umemura Graduate School of Engineering, Tohoku University	Yôiti Suzuki
H23／B06 Ultrafast Coherent Lightwave Control Technologies for Ultimate Communication and Measurement Systems	Hidemi Tsuchida National Institute of Advanced Industrial Science and Technology	Masataka Nakazawa
H23／B08 Passive/Active Circuit Technologies and Their Applications for Next Generation RFIC	Toshio Ishizaki Faculty of Science And Technology, Ryokoku University	Noriharu Suematsu
H23／B09 Multisensory integration involving self-body motion	Kenzo Sakurai Faculty of liberal arts, Tohoku Gakuin University	Yôiti Suzuki

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H23／B11 Foundation of Dependable Cloud System with a Highly Reliable Programming Language System	Kazuhiko Kato Graduate School of Systems and Information Engineering, Tsukuba University	Atsushi Ohori
H24／B01 Fundamental characteristics and applications in innovative functional and reactive field generated with various plasma flow	Akira Ando Graduate School of Engineering, Tohoku University	Maki Suemitsu
H24／B02 Unlicensed Band Wireless Communications	Shuzo Kato Research Institute of Electrical Communication, Tohoku University	Shuzo Kato
H24／B03 Problems and perspectives of intelligent nano integrated system	Yoshihiro Hayakawa Sendai National College of Technology	Koji Nakajima
H24／B05 Entertainment Computing for Creative Rejuvenation	Yoshifumi Kitamura Research Institute of Electrical Communication, Tohoku University	Yoshifumi Kitamura
H24／B06 A New Academic Association for HCI in the Asia-Pacific Region	Yoshifumi Kitamura Research Institute of Electrical Communication, Tohoku University	Yoshifumi Kitamura
H24／B07 Functionalization of oxide surfaces and its application to nanodevices	Toshio Ogino Yokohama National University, Graduate School of Engineering	Michio Niwano
H24／B08 Research on planar measurement techniques for earthquake, tsunami, and crustal deformation using optical-fiber networks	Masato Araya Earthquake Research Institute, The University of Tokyo	Masataka Nakazawa
H24／B09 Control of Large Degree-of -Freedom System Inspired from Animal Locomotion	Ryo Kobayashi Graduate School of Science, Hiroshima University	Akio Ishiguro
H24／B10 Computational Ability of High-Dimensional Neural Network	Akira Hirose Graduate School of Engineering, The University of Tokyo	Shigeo Sato

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H24／B11 Study of human perceptual/cognitive and decision processes	Ken-ichiro Tsutsui Graduate School of Life Sciences, Tohoku University	Satoshi Shioiri
H24／B12 Evolution of elementary technologies of high performance Computing for national security needs	Yoshihiko Orita Japan Marine Science Fundation	Takahiro Hanyu
H24／B13 Studies on enrichment technologies for digital contents	Akira Nishimura Tokyo University of Information Sciences	Yôiti Suzuki
H25／B01 New Principle Nano Devices Based on Precision Control and Observation of Spin Fluctuation and Correlations	Shintaro Nomura Graduate School of Pure and Applied Sciences, University of Tsukuba	Hideo Ohno
H25／B02 Fabrication of novel nano-materials based on fine particle plasma physics	Masaharu Shiratani Graduate School and Faculty of Information Science and Electrical Engineering, Kyushu University	Michio Niwano
H25／B03 Research in magnetic materials and magnetic devices for advanced communications equipment	Takeshi Yanai Graduate School of Engineering, Nagasaki University	Kazushi Ishiyama
H25／B04 Physics and applications of electric-field control of magnetism	Masafumi Shirai Research Institute of Electrical Communication, Tohoku University	Masafumi Shirai
H25／B05 Novel photonics and nano photonic informatic	Takashige Omatsu Graduate School of Advanced Integration Science, Chiba University	Keiichi Edamatsu
H25／B06 Research on Electromagnetic Wave Technologies for Low-Carbon Energy Society	Takashi Ohira Toyohashi Univercity of Technology	Noriharu Suematsu

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H25／B07 Studies on cortical mechanisms for visual perception of object-surface attributes	Katsunori Okajima Graduate School of Environment and Information Sciences, Yokohama National University	Ichiro Kuriki
H25／B08 Understanding of human adaptive motor function based on the concept of embodiment	Toshiyuki Kondo Tokyo University of Agriculture and Technology	Akio Ishiguro
H25／B09 Development and Civilian Use of Microwave and Laser Aided Synthetic Aperture Radar	Atsushi Mase Art, Science and technology Center for Cooperative Research, Kyushu University	Hiroshi Yasaka
H25／B10 Logical Approach to Metaprogramming	Yukiyoshi Kameyama Graduate School of Systems and Information Engineering, University of Tsukuba	Yoshihito Toyama
H23／S01 Development of essential technologies directed to systematization of superhivision	Hidenori Mimura Shizuoka University Research Institute of Electronics	Yôiti Suzuki
H23／S02 Spintronics International Alliance	Kohei Itoh Keio University Science and Technology	Hideo Ohno
H23／S03 Collaborative Research on Nano-electronics	Tetsuya Osaka Waseda University. Institute for Nanoscience & Nanotechnology	Michio Niwano
H24／S01 Empathic Computing System based on an innovative new concept associated with human functions	Takashi Washio The Institute of Scientific and Industrial Research (ISIR) Osaka University	Yoshifumi Kitamura

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. 1- Nov.1,2007
24	3rd International Workshop on New Group Ⅳ Semiconductor 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	Global Symposium on Millimeter Waves 2009 (GSMM2009)	Apr.20-22,2009
31	Mini R.I.E.C. workshop on multimodal perception	Apr.24,2009
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 2009 (IWPASH2009)	Nov.11-13,2009
36	5th International Workshop on New Group IV Semiconductor Nanoelectronics	Jan.29-30,2010
37	6th RIEC International on Spintronics	Feb.5-6,2010
38	2nd International Workshop on Nanostructure & Nanoelectronics	Mar.11-12,2010
39	2nd RIEC International Symposium on Graphene Devices (ISGD2010)	Oct.27-29,2010
40	9th Japan-Korea Symposium on Surface Nanostructures	Nov.15-16,2010
41	The 7th RIEC International Workshop on Spintronics	Feb.3-4,2011
42	The 42nd RIEC International Symposium 12th International Multisensory Research Forum (IMRF2011)	Oct.17-20,2011
43	The 8th RIEC International Workshop on Spintronics	Feb.2-3,2012
44	The Sixth International Symposium on Medical, Bio- and Nano-Electronics	Mar.8,2012
45	3rd International Workshop on Nanostructures & Nanoelectronics	Mar.21-22,2012
46	9th RIEC International Workshop on Spintronics	May 31- Jun.2,2012
47	The 1st International Workshop on Smart Technologies for Energy, Information and Communication (STEIC2012)	Oct.18-19,2012
48	Technical University of Dresden and Tohoku University Symposium 2012	Nov.2,2012

49	The 1st RIEC International Symposium on Brain Functions and Brain Computer	Nov.15-16,2012
50	Tohoku – Harvard Joint Workshop New Directions in Materials for anoelectronics,Spintronics and Photonics （10th RIEC International Workshop on Spintronics）	Jan.15-16,2013
51	11th RIEC International Workshop on Spintronics & 3rd CSIS International Symposium on Spintronics-based VLSIs	Jan.31-Feb.1,2013
52	7th International Symposium on Medical, Bio- and Nano-Electronics	Mar.7,2013
53	6th Global Symposium on Millimeter Wave 2013	Apr.22-23,2013
54	The 2nd RIEC International Symposium on Brain Functions and Brain Computer	Feb.21-22,2014
55	8th International Symposium on Medical,Bio- and Nano-Electronics	Mar.6-7,2014
56	5th International Workshop on Nanostructures and Nanoelectronics	Mar.6-7,2014

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 15 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	Associate Prof. Takashi Katagiri

Acoustic Engineering	
Chair	Prof. Akinori Ito
Manager	Associate Prof. Shuichi Sakamoto

Sendai "Plasma Forum"	
Chair	Prof. Akira Ando
Manager	Prof. Toshiro Kaneko

Sendai Seminar on EMC	
Chair	Prof. Hideaki Sone
Manager	Prof. Masahiro Yamaguchi

Computer Science	
Chair	Prof. Ayumi Shinohara
Manager	Associate Prof. Eijiro Sumii

Systems Control	
Chair	Prof. Makoto Yoshizawa
Manager	Associate Prof. Noriyasu Homma

Information-biotronics	
Chair	Prof. Michio Niwano
Manager	Prof. Tatsuo Yoshinobu

Spinics	
Chair	Prof. Masahiro Yamaguchi
Manager	Associate Prof. Fumihiro Sato
Manager	Assistant Prof. Yohei Shiokawa

New Paradigm Computing	
Chair	Prof. Takahiro Hanyu
Manager	Associate Prof. Naofumi Homma

Ultrasonic Electronics	
Chair	Prof. Shin-ichiro Umemura
Manager	Associate Prof. Shin Yoshizawa

Brainware	
Chair	Prof. Koji Nakajima
Manager	Assistant Prof. Takeshi Onomi

Mathematical Physics and its Application to Information Sciences	
Chair	Prof. Kazuyuki Tanaka
Manager	Associate Prof. Yuji Waizumi

Biocybernetics and Bioinformatics	
Chair	Prof. Satoshi Shioiri
Manager	Associate Prof. Takeshi Obayashi

Nanoelectronics and Spintronics	
Chair	Prof. Shigeo Sato
Manager	Associate Prof. Yasuo Kimura

Advenced Information Communication Engineering	
Chair	Prof. Tetsuo Kinoshita
Manager	Prof. Takuo Suganuma

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)
- The Interdisciplinary Center on Nanoscience of Marseille, National Center of 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 Vigo (Spain)
- State University of New Nork (U.S.A)
- Department of Physics, National Sun Yat-Sen Univesity (Taiwan)

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

1	Acoustical Science and Technology
2	ACTA ACUSTICA (Chinese version)
3	Applied Intelligence: International Journal of Artificial Intelligence, Neural Networks, andComplex Problem-Solving Technologies
4	Asian Journal of Computer Sciences
5	Frontiers in Virtual Environments (a section of Frontiers in Robotics and AI)
6	Higher-order and symbolic computation
7	IEICE Electronics Express
8	International Journal of Energy, Information and Communication
9	International Journal of Information Sciences and Computer Engineering
10	International Journal of Computer Science and Network Security
11	Japanese Journal of Applied Physics
12	Journal of Magnetics, Korean Magnetics Society
13	Journal of SPIN
14	Nature Communications
15	Neural Networks

16	NPG Asia Materials
17	Optical Fiber Technology
18	Optical Review
19	The Journal of Computer Animation and Virtual Worlds (John Wiley & Sons, Inc.)
20	Virtual Journal of Nanoscale Science and Technology

Recent international conferences programmed by a staff in RIEC:

1	12th International Conference on Atomically Controlled Surfaces, Interfaces and Nanostructures (ACSIN)
2	13th International Ceramics Congress, 6th Forum on New Materials, and 5th International Conference Novel Functional Carbon Nanomaterials (CIMTEC2014)
3	18th International Conference on Electron Dynamics in Semiconductors, Optoelectronics and Nanostructures (EDISON)
4	2013 Spintronics Workshop on LSI
5	2014 International Topical Meeting on Microwave Photonics/The 9th Asia-Pasific Microwave Photonics Conference(NWP/APMA2014)
6	20th International Conference on Electronic Properties of Two-Dimensional Systems (EP2DS-20) and 16th Modulated Semiconductor Structures (MSS-16)
7	24th MAGNETIC RECORDING CONFERENCE (TMRC2013)
8	25th International Conference on Indium Phosphide and Related Materials (IPRM)
9	32nd Electronic Materials Symposium (EMS)
10	3DUI 2013 International Symposium on 3D User Interface
11	3rd Berkeley Symposium on Energy Efficient Electronic Systems
12	5th International Conference on Recent Progress in Graphene Research (RPGR)
13	6th Global Symposium on Milli-Meter Waves (GSMM)
14	7th International School and Conference on Spintronics and Quantum Information Technology (SPINTECH VII)
15	7th Terahertz Days/GDR-I Workshop
16	8th International Symposium on Metallic Multilayers (MML2013)
17	ACM SIGGRAPH Asia
18	ACM SIGGRAPH Asia 2013: The 6th SIGGRAPH Conference and Exhibition on Computer Graphics and Interactive Techniques in Asia 2013
19	ACM SIGGRAPH Asia 2014: The 7th SIGGRAPH Conference and Exhibition on Computer Graphics and Interactive Techniques in Asia 2014
20	ACM Symposium on Virtual Reality Software and Technology (VRST)
21	Asia-Pacific Conference on Vision (APCV) 2014
22	Asia-Pacific Microwave Conference (APMC)
23	Asia-Pacific Workshop on Fundamentals and Applications of Advanced Semiconductor Devices (AWAD)
24	Eurographics Workshop on Virtual Environment (EGVE)
25	European Conference on Optical Communication (ECOC)
26	European Solid-State Device Research Conference (ESSDERC)
27	IEEE International Symposium on Asynchronous Circuits and Systems
28	IEEE International Symposium on Multiple-Valued Logic
29	IEEE 3rd Global Conference on Consumer Electronics (GCCE2014)

30	IEEE Computer Society
31	IEEE International Symposium on Asynchronous Circuits and Systems
32	IEEE International Symposium on Multiple-Valued Logic
33	IEEE Symposium on 3D User Interfaces(3DUI)
34	International Federation for Information Processing (IFIP)Human-Computer Interaction (TC-13)
35	International Conference on Optical Terahertz Science and Technology (OTST)
36	International Conference on Artificial Reality and Tele-existence (ICAT)
37	International Conference on Indium Phosphide and Related Materials (IPRM)
38	International Conference on Optical, Optoelectronic and Photonic Materials and Applications (ICOOPMA)
39	International Electron Device Meeting (IEDM)
40	International Quantum Electronics Conference (IQEC), Program Subcommittee Member for Quantum Information
41	International SiGe, Ge, & Related Compounds: Materials, Processing, and Devices Symposium
42	International Symposium on Advanced and Applied Convergence
43	International Symposium on Compound Semiconductors (ISCS)
44	International Symposium on Nonlinear Theory and Its Applications
45	SPIE International Conference on Defense, Security, and Sensing
46	SPIE Photonics West, Physics and Simulation of Optoelectronic Devices
47	Technical Committee of Multiple-Valued Logic, IEEE Computer Society
48	The IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT2014)
49	The International Conference Industrial & Engineering Applications of Artif. Intell. & Exp. Systems (IEA/AIE2014)
50	The International Conference on Smart Technology for Energy, Information and Communication (IC-STEIC2014)
51	The International Multisensory Research Forum
52	Topical Workshop on Heterostructure Microelectronics (TWHM)

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.

3. RIEC News

As a part of RIEC's publication service, "RIEC News" is published.

With the 75th anniversary of the establishment of RIEC, RIEC News introduces cutting-edge's

research and the vision of the future from RIEC's contributions to the progression of science and technology in Japan. RIEC News was first launched in March 2011, In fiscal year 2014, 8th, 9th and 10th issues were published. Every issue introduces special topics such as large scale projects and Specially-Promoted Research, etc. RIEC News also includes current information about each laboratory and center, all kinds of RIEC events, research exchange meetings, laboratories open to the public (RIEC Open Day), etc. English version is also published in March 2014. Further, RIEC News offers a notification service by mail whenever a new issue is released and an electronic version of every issue published so far can be downloaded by following the link below.

http://www.riec.tohoku.ac.jp/riecnews/

9. Staff, Budget

1.Faculty & Staff

as of May 1, 2013

Professors	24
Associate Professors	20
Assistant Professors	24
Research Fellows	25
Specially Appointed Professors	3
Administrative Staff	17
Technical Staff	10
Total	123

2.Researchers (FY2013)

Foreign Researchers	Visiting Professors	1
	Visiting Associate Professors	6
Cooperative Researchers of Private Company etc		4
JSPS Postdoctoral Fellows		5
Contract Researchers		6
Contract Trainees		1
Total		23

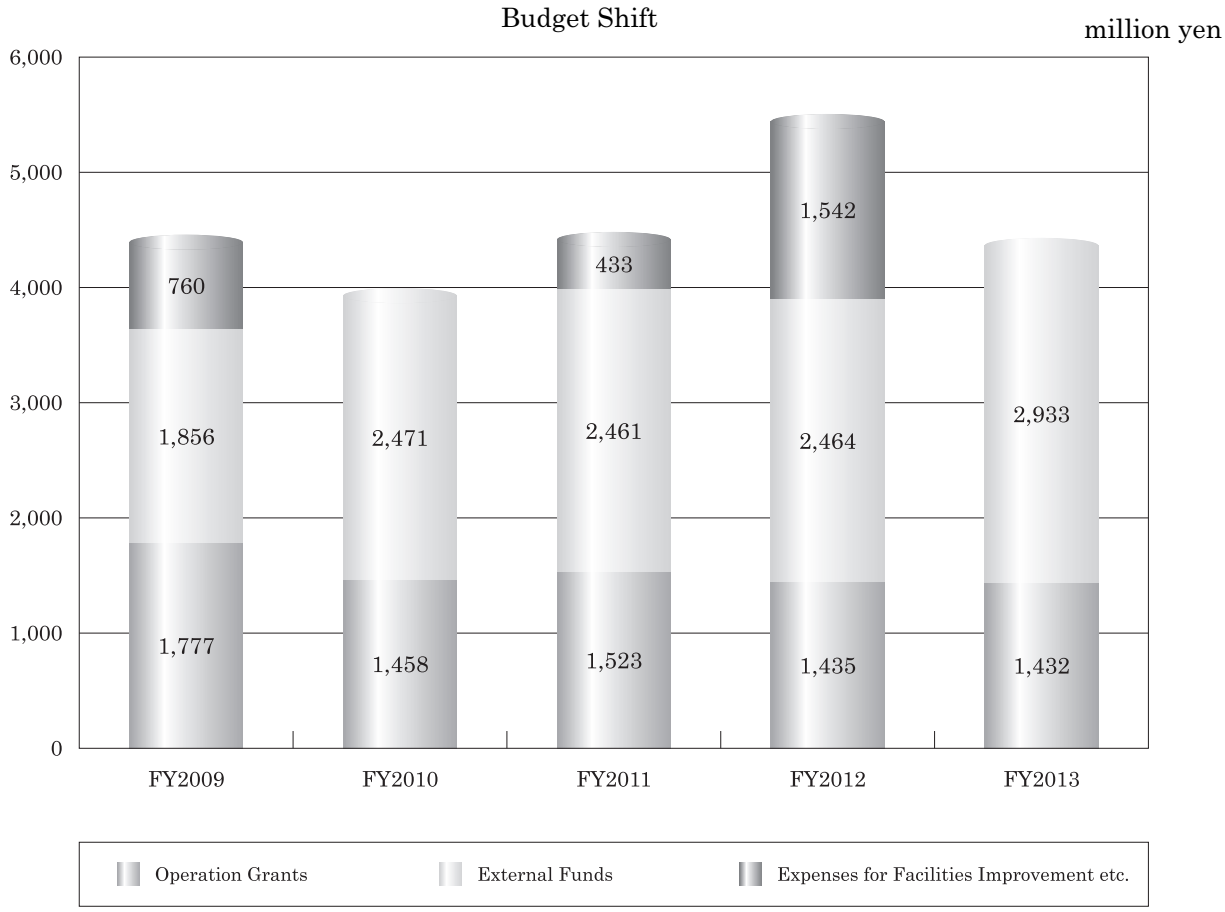
3.Students

as of May 1, 2013

	School of Engineering	Graduate School of Information Science	RIEC	Total
Undergraduate Students	67 (1)			67 (1)
Master Course Students	76 (8)	49 (9)		125 (17)
Doctor Course Students	28 (7)	10 (7)		38 (14)
Research Students			5 (4)	5 (4)
Total	171 (16)	59 (16)	5 (4)	235 (36)

※( ) Foreigner

5.Budget



Budget Summary

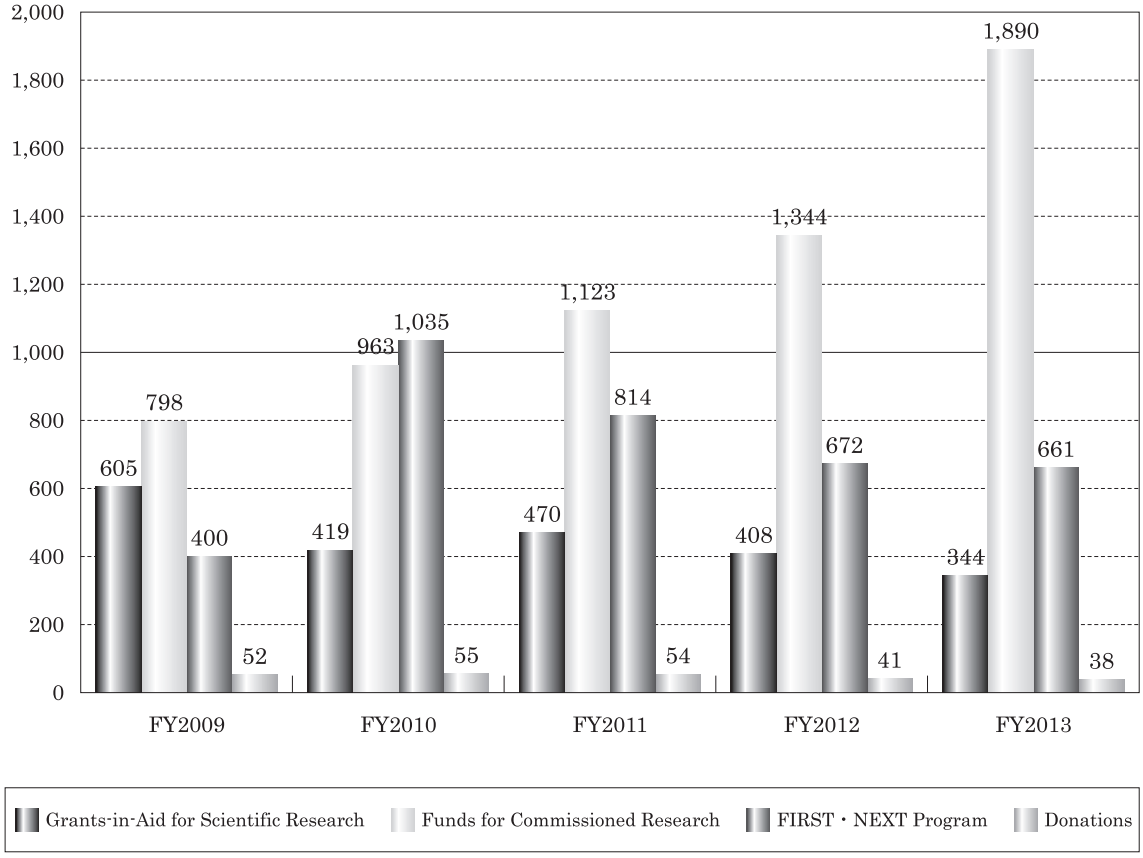
thousand yen

Categories		FY2009	FY2010	FY2011	FY2012	FY2013
Operation Grants	Personnel Expenses	1,026,511	777,776	835,898	770,443	723,507
	Non-Personnel Expenses	750,364	680,411	687,253	665,038	708,222
Operation Grants Total		1,776,875	1,458,187	1,523,151	1,435,481	1,431,729
External Funds	Grants-in-Aid for Scientific Research	605,100	418,680	469,840	407,629	343,824
	Funds for Commissioned Research	798,053	962,712	1,122,944	1,344,071	1,890,012
	FIRST Program ※1・NEXT Program ※2	400,440	1,034,827	813,777	671,668	660,578
	Donations	51,954	55,085	54,167	40,714	38,100
External Funds Total		1,855,547	2,471,304	2,460,728	2,464,082	2,932,514
Expenses for Reconstruction				432,607	4,993	0
Expenses for Facilities Improvement		760,000	0	0	1,536,530	0
Expenses for Facilities Improvement etc. Total		760,000	0	432,607	1,541,523	0
Total		4,392,422	3,929,491	4,416,486	5,441,086	4,364,243

※1 FIRST Program…Funding Program for World-Leading Innovative R&D on Science and Technology (JSPS)
※2 NEXT Program…Funding Program for Next Generation World-Leading Researchers (JSPS)

External Funds

million yen



External Funds

thousand yen

Categories	FY2009	FY2010	FY2011	FY2012	FY2013
Grants-in-Aid for Scientific Research	605,100	418,680	469,840	407,629	343,824
Funds for Commissioned Research	798,053	962,712	1,122,944	1,344,071	1,890,012
FIRST Program ※1・NEXT Program ※2	400,440	1,034,827	813,777	671,668	660,578
Donations	51,954	55,085	54,167	40,714	38,100
Total	1,855,547	2,471,304	2,460,728	2,464,082	2,932,514

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※2 NEXT Program…Funding Program for Next Generation World-Leading Researchers (JSPS)

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