RIEC

# Annual Report 2010

Research Institute of Electrical Communication, Tohoku University

**Annual report of Research Institute of Electrical Communication 2010**

# Contents

# 1. Preface

On behalf of the Research Institute of Electrical Communication (RIEC) of Tohoku University, I would like to express my gratitude for the kind and unfailing support our work receives. I invite you all to read this report of RIEC's research activities in fiscal 2010 and to give us your opinions and comments.

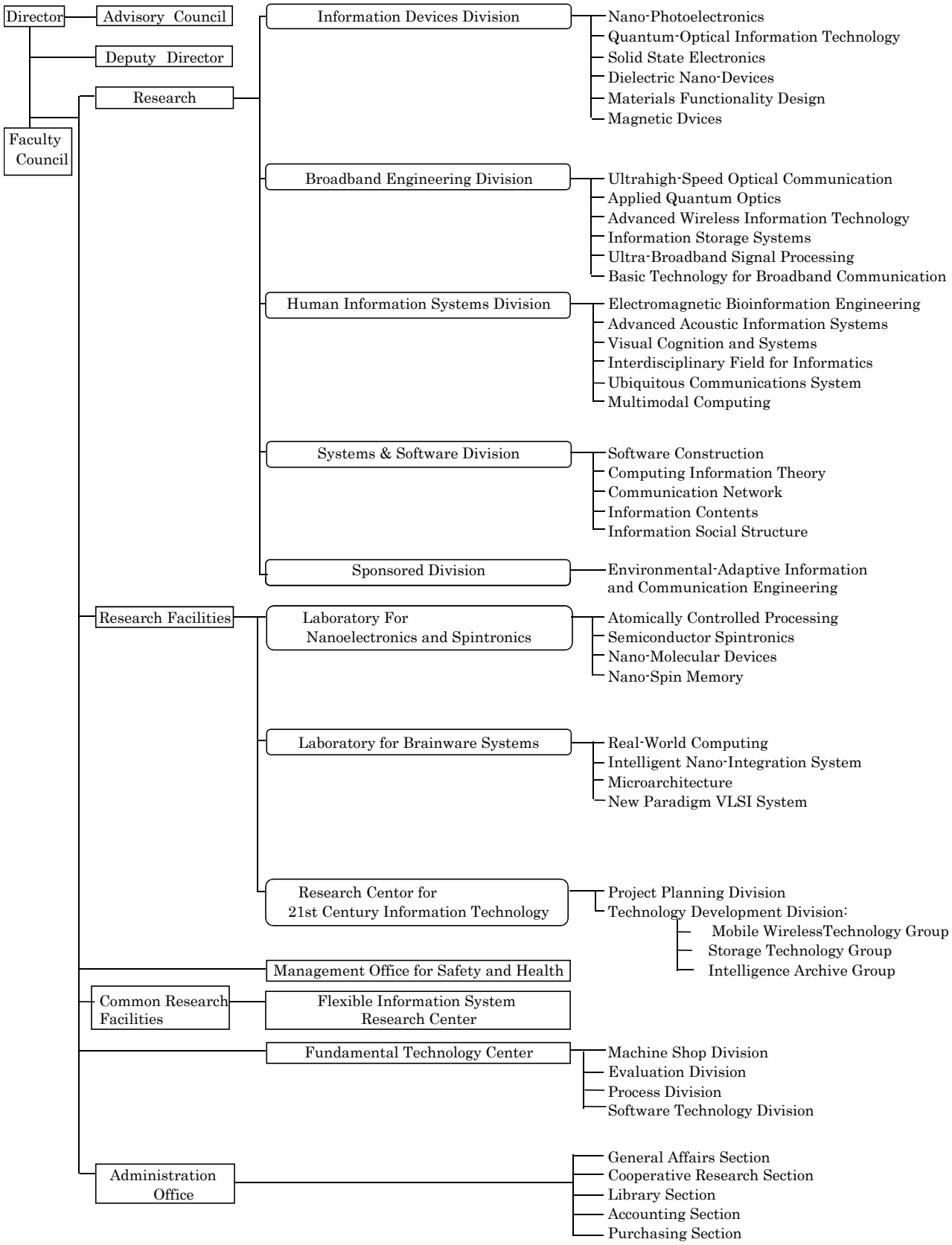
RIEC was established in 1935 as a research institute affiliated with the School of Engineering, where pioneering work in information and communications had already resulted in breakthroughs such as the Yagi-Uda antenna and the split-anode magnetron. Over the years, researchers dedicated to addressing the "theory and applications of intelligent information science and communication Engineering" have given back to society the fruits of their work in these fields. Close and smooth interpersonal communication is fundamental to maintaining and developing a flourishing and humane society, and the technologies that make this possible are taking on ever-increasing importance in the information age. To meet these social needs, RIEC is organized with a three-part structure: four Research Divisions whose programs have a twenty-year horizon; two research facilities working with a ten-year horizon; and the Research Center for 21st Century Information Technology, which aims at the practical application of IT results within a five-year time frame. Furthermore, through close collaboration between RIEC and the six major courses run by the Graduate Schools of Engineering, Information Sciences, and Biomedical Engineering that together make up the Group of Electrical Engineering, Communication Engineering, Electronic Engineering, and Information Engineering, we endeavor to train international researchers and highly skilled engineers while concurrently pursuing cutting-edge research.

Since Tohoku University became a national university corporation, its research institutes have also been undergoing a transformation. In April 2010, RIEC took a further step forward when it was promoted from a National Center for Cooperative Research to a Joint Usage/Research Center. This represents both an opportunity to demonstrate RIEC's important role within the university, and a time of challenge as we question the value of our existence and invite society's evaluation. Through various partnerships within RIEC, and through the management of over 70 nationwide cooperative research projects of Types A, B, and S, and now Type U, whose aim is creative reconstruction after the Great East Japan Earthquake of 3/11, we will expedite technology exchanges and liaisons with industry and government. In these ways, we will do everything in our power to fully realize human communication.

I look forward to your continuing support and encouragement of our endeavors.

Professor Masataka Nakazawa
July 4, 2011
Director, Research Institute of Electrical Communication(RIEC),
Tohoku University

# 2. Organization Chart



# 3.RESEARCH ACTIVITIES

# Targets and achievements of the Information Devices Division

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

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

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

The target and the summary of achievements of the each sub-division in 2010 are described in the following pages. In addition, about the summary of achievement of the atomically controlled processing research section will be written in the chapter of the Laboratory for Nanoelectronics and Spintronics.

## Nanophotoelectronics

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

Nanophotoelectronics Yoichi UEHARA, 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. In this year, we have succeeded in elucidating the mechanism of appearance of vibration-induced structures in STM light emission spectra of a single molecule of benzene adsorbed on Cu(110). Last year, we found that vibrational energies of substrates can be determined from the STM light emission spectra of silver nano-particles placed on their surfaces. This phenomenon has also been elucidated with a mechanism different from that of the benzene-Cu(110) system. STM light emission spectra of alkane-thiol self-assembled single monolayer (SAM) films formed on Au substrates show a strong red shift, unexpected from the dielectric properties of SAM and Au. This shift is found to be caused by electronic transitions induced at the interface of SAM and Au. Surface polaritons are nonradiative in flat surfaces but become radiatiative in nanometer scale structures. We have theoretically investigated radiation by surface phonon poraritons in the THz spectral range, and found that intense emission is expected by optimizing sizes and shapes of the nanostructures. On the basis of this finding, we are planning to develop THz spectroscopy with atomic spatial resolution and THz light sources. Phonons play various critical roles in electronic devices. It is also well known that phonon properties show strong size effects. Thus, measurements of phonon properties of individual nanostructures are important for developing high-density electronic devices. We are developing a novel method for this purpose.

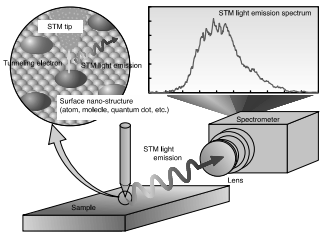



Fig. 1 STM light emission spectroscopy

### [Staff]

| | |
|---|---|
| Professor | Yoichi UEHARA, Dr. |
| Assistant 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.

### [Papers]

[1] S. Katano, S. Ushioda, and Y. Uehara, "Vibrational Excitation of a Single Benzene Molecule Adsorbed on Cu(110) Studied by Scanning Tunneling Microscope Light Emission Spectroscopy", J. Phys. Chem. Lett. **1**, 2763-2768 (2010).

[2] S. Katano, K. Toma, M. Toma, K. Tamada, and Y. Uehara, "Nanoscale coupling of photons to vibrational excitation of Ag nanoparticle 2D array studied by scanning tunneling microscope light emission spectroscopy", Phys. Chem. Chem Phys. **12**, 14749-14753 (2010).

[3] W. Iida, S. Katano, and Y. Uehara, "Finite-Difference Time-Domain Analysis of Scanning Tunneling Microscope Light Emission Spectra", Jpn. J. Appl. Phys., **49**, 095202 (2010).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## 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

### [Research Target and Activities]

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

In 2010, we have achieved (1) development of novel entangled photon sources and heralded, pure single-photon sources using quasi-phase matched devices, (2) quantum media conversion from photons to electron spins in semiconductor quantum structures, and (3) development of heterodyne Kerr-rotation spectroscopy of single quantum dots.

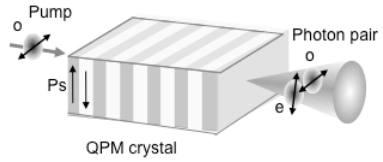



Fig. 1 Entangled photon generation using quasi-phase matching and extended phase matching.

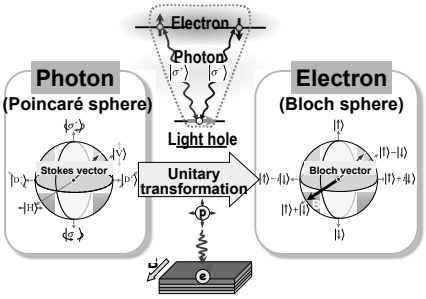



Fig. 2 Quantum media conversion from photon polarization to an electron spin.

### [Staff]

Professor: Keiichi EDAMATSU,Dr.
Associate Professor: Hideo KOSAKA,Dr.
Assistant 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, a Principal Investigator of JST-CREST and MIC-SCOPE projects. He is also a Visiting Associate Professor in National Institute of Informatics.

### [Papers]

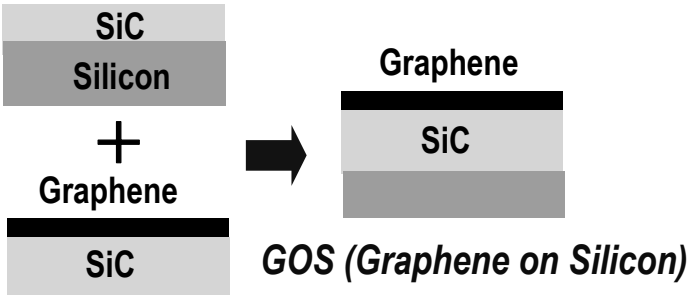
[1] A. Syouji, S. Nagano, R. Shimizu, K. Suizu, and K. Edamatsu, "Efficient up-conversion detection of 1550nm photons using bulk periodically-poled $LiNbO_3$," Jpn. J. Appl. Phys. **49**, 040213/1-3 (2010)
[2] H. Kosaka, H. Shigyou, T. Inagaki, Y. Mitsumori, K. Edamatsu, T. Kutsuwa, M. Kuwahara, K. Ono, Y. Rikitake, N. Yokoshi, H. Imamura, "Coherent spin preparation, manipulation and read-out with light and microwaves in a quantum well and dot", *J. Phys.* **245**, 012001 (2010)
[3] R.-B. Jin, J. Zhang, R. Shimizu, N. Matsuda, Y. Mitsumori, H. Kosaka, and K. Edamatsu, "High-visibility nonclassical interference between intrinsically pure heralded single photons and photons from a weak coherent field," Phys. Rev. A **83**, 031805(R)/1-4 (2011)

## Solid State Electronics Laboratory

# Paving a Way for Introducing Graphene into Silicon Technology

Solid State Electroncis Maki SUEMITSU, 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 FY2009, we discovered by changing the crystallographic orientation of the Si substrate used in the GOS technology that we can control the interfacial structure at the graphene/SiC boundary. This is a property unique to GOS technology, which leads us to possible control of electronic structures of the graphene by simply changing the orientation of the Si face used as the substrate.

### [Staff]

Professor : Maki SUEMITSU, Dr.
Assistant Professor : Hirokazu FUKIDOME, Dr.
Technical Assistant : Akemi MIURA

### [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 surface engineering of semiconductor thin fims. He was awarded the 30 th Kumagai prize of the best paper from the Vacuum Soceity of Japan and the Paper of the Year 2009 from the e-Journal of Surface Science and Nanotechnology.

### [Papers]

[1] M Suemitsu and H Fukidome, “Epitaxial graphene on silicon substrates, ” J.Phys. D: Appl. Phys. 43, p.374012(11pp), 2010
[2] H. Handa, R. Takahashi, S. Abe, K. Imaizumi, M.H. Jung, S. Ito, H. Fukidome and M. Suemitsu, “TEM characterization of epitaxial graphene formed on Si(111), Si(110), Si(100),” 2010 International Conference on Solid State Devices and Materials, pp.125-126, 2010
[3] Arnold Alguno, Sergey N. Filimonov and Maki Suemitsu, “Step bunching and step “rotation” in homoepitaxial growth of Si on Si(110)-16×2,” Surface Science Vol.605, issue 7-8, pp.838-843, 2011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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.

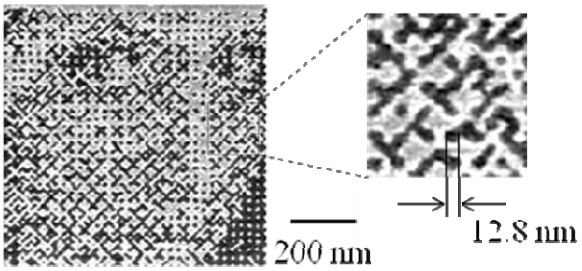


Fig.1 Digital bit data written on ferroelectric single crystal with the areal recording density of 4 Tbit/inch$^2$.

Major achievements of studies in 2010 are as follows: (1) Surfaces of semiconductors were observed with atomic resolution using non-contact SNDM. Especially, dipole moment distributions in domain boundaries on Si (111) surfaces were observed. (2) Single track read/write operations were demonstrated using our HDD-type ferroelectric data storage testing system. (3) A novel label-free biaoaffinity sensing system was developed based on a lumped-constant LC microwave resonator, which is used as a sensing probe of SNDM.

### [Staff]

Professor : Yasuo CHO, Dr.
Assistant Professor : Yoshiomi HIRANAGA, Dr.
Assistant Professor : Kohei YAMASUE, Dr.
Technical Official : Yasuo WAGATSUMA
Research Fellow : Noriaki OKAZAKI, Dr.

### [Profile of Professor Cho]

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

### [Papers]

[1] Nobuhiro Kin and Yasuo Cho, "Imaging of the surface structure of $TiO_2$(110) by non-contact scanning nonlinear dielectric microscopy", J. Appl. Phys., Vol. 107, No.10, pp.104121-1-4, 2010.
[2] Kenkou Tanaka and Yasuo Cho, "Actual information storage with a recording density of 4 Tbit/in.$^2$ in a ferroelectric recording medium", Appl. Phys. Lett., Vol.97, pp.092901-1-3, 2010.
[3] Noriaki Okazaki, Taito Nishino, Toyohiro Chikyow, and Yasuo Cho, "Development of Label-Free Bioaffinity Sensor Using a Lumped-Constant Microwave Resonator Probe", Appl. Phys. Express Vo. 4, pp.017001-1-3, 2011.

## 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 2010 are as follows:

(1) Mechanism of the phase transition in shape memory alloys

We have revealed the underlying mechanism of the phase transition in shape memory alloys $Ni_2Mn_{1+x}Sn_{1-x}$ by hard x-ray photoelectron spectroscopy and first-principles calculations. The Ni 3*d* $e_g$ state in the cubic phase shifts towards the Fermi energy with increasing the Mn contents (Fig. 1), ant its intensity decreases abruptly below the transition temperature. The phase transition is caused by the splitting of the Ni 3*d* $e_g$ state into two levels, i.e. the Jahn-Teller mechanism [1].

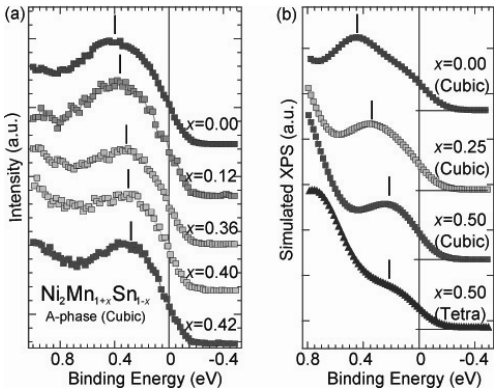


Fig. 1

(2) Tunnel magnetoresistance in perpendicularly magnetized junctions

We have investigated the tunnel magnetoresistance in perpendicularly magnetized $Mn_3Ga$/MgO/$Mn_3Ga$ junctions by using first-principles calculations. Although the $\Delta_1$-band exists in both spin states, the tunneling conductance of the majority-spin electron is two orders of magnitude larger than that of the minority-spin electron, owing to the difference in orbital components of the $\Delta_1$-bands [3].

### [Staff]

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

### [Profile]

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

### [Papers]

[1] M. Ye, A. Kimura, Y. Miura, M. Shirai, Y. Cui, K. Shimada, H. Namatame, M. Taniguchi, S. Ueda, K. Kobayashi, R. Kainuma, T. Shishido, K. Fukushima, and T. Kanomata "Role of electronic structure on martensitic phase transition of $Ni_2Mn_{1+x}Sn_{1-x}$ studied by hard-x-ray photoelectron sprctroscopy and *ab initio* calculation," Phys. Rev. Lett., Vol. 104, No. 17, Article no. 176401, pp. 1-4, 2010.

[2] Y. Sakuraba, K. Izumi, T. Iwase, S. Bosu, K. Saito, K. Takanashi, Y. Miura, K. Futatsukawa, K. Abe, and M. Shirai, "Mechanism of large magnetoresistance in $Co_2MnSi$/Ag/$Co_2MnSi$ devices with current perpendicular to the plane," Phys. Rev. B, Vol. 82, No. 9, Article no. 094444, pp. 1-5, 2010.

[3] T. Kubota, Y. Miura, D. Watanabe, S. Mizukami, F. Wu, H. Naganuma, X. Zhang, M. Oogane, M. Shirai, Y. Ando, and T. Miyazaki, "Magnetoresistance effect in tunnel junctions with perpendicularly magnetized $D0_{22}$-$Mn_{3-\delta}Ga$ electrode and MgO barrier," Appl. Phys. Express, Vol. 4, No. 4, Article no. 043002, pp. 1-3, 2011.


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# Broadband Engineering Division: Research Target and Results

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

(1) Advanced Wireless Information Technology

Since interchange of people and exchanges of information have been world wide, next generation wireless network for ubiquitousness and broadband is one of the most important technology. Especially, a signal processing circuit, RF device and packaging technologies and the modulation/demodulation and network technologies are the two wheels of realizing next generation wireless network.

We are also actively engaged in work on following technologies for broadband, low-power consumption and small-size terminals; RF-CMOS devices for millimeter-wave-band wireless modems and frequency domain equalizer (FDE) for broadband mobile wireless modems.

(2) Ultra-Broadband Signal Processing

We are developing novel, integrated electron devices and circuit systems operating in the terahertz region. One of our major concerns is a new material called “graphene”, a single-layered honeycomb-lattice carbon crystal. We have fabricated a logic gate element utilizing heteroepitaxial graphene-on-silicon (GOS) FETs, demonstrating a complementary logic operation.

We also succeeded in observation of the gain profile and pumping threshold behavior of stimulated terahertz emission in femtosecond IR laser-pumped graphene. The result is a manifestation of occurrence of the negative dynamic conductivity that our group has theoretically predicted, leading to realization of a new type of terahertz lasers.

(3) Ultrahigh-Speed Optical Communication

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

As regards the ultrahigh-speed transmission, we successfully demonstrated the first 1.28 Tbit/s/channel − 525 km transmission of single-polarization DQPSK signals by using an ultrafast time-domain optical Fourier transformation technique. In coherent

optical transmission, QAM multiplicity as high as 512 levels was achieved for the first time in optical communications, and a 54 Gbit/s transmission was realized within an optical bandwidth of only 4.1 GHz. This corresponds to a spectral efficiency exceeding 12 bit/s/Hz.

(4) Applied Quantum Optics

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

Ultra-high-speed operation of semiconductor photonic active devices is being investigated. It is confirmed experimentally and numerically that the bandwidth of semiconductor laser sources can be broadened drastically to some tens of GHz by controlling them with high-speed signal light injection. Novel THz biosensors using surface plasmon resonance are also studied. High-quality THz resonators are realized by using novel fabrication process. It is confirmed experimentally that THz wave can transmitted through the resonator successfully.

(5) Information Storage Systems

High density magnetic recording technology to store the tremendous information is crucial to meet the strong demand of information increase. Both high density recording and low power consumption are important for future high capacity storage systems.

A large areal density of 5 Tbit/inch$^2$, which is tenfold of current density, was endeavored by theoretical approach with a computer simulation. This year we showed that cooperative nano-area heating for bit patterned media recording is effective to increase the areal density. Novel storage sub-system to reduce power consumption by 50% was developed and evaluated for petabyte-class large-capacity systems.

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

Development of measurement instruments using the passive millimeter- and terahertz-wave imaging is the research object of this laboratory.

Under the promising results obtained with prototype 77GHz–band passive imaging devices tested in-site at the Narita International Airport in 2009, development of devices with sophisticated performance for practical use has been started.

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

Synthetic aperture radars (SAR) are useful for all-weather surveillance and rescue. In this fiscal year we have developed a real-time image, air-borne SAR under the research contract with Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Hardware of a spotlight-mode SAR system has been successfully completed, with a high resolution (10 cm), small size and light weight (25 kg) at Ku-band. Scientists and

engineers of universities and industries collaborate on the program.

(8) Laboratory for Nanoelectronics and Spintronics: Semiconductor Spintronics

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

We have found a perpendicular magnetic easy axis in thin CoFeB films arising from an interfacial anisotropy at CoFeB/MgO interface, and demonstrated its modulation by the application of electric fields. We have fabricated nano-dot ensemble from a (Ga,Mn)As thin layer by the application of electric fields, where an electric-field effect structure with a meshed gate was employed. We have established the relationship between the magnitude of nuclear quadrupole interaction and spin phase relaxation time in nonmagnetic semiconductor quantum structures.

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

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

CoFeB/MgO based perpendicular anisotropy MTJs (p-MTJs) after annealing at 350°C showed a tunnel magnetoresistance (TMR) ratio > 120%, good thermal stability at dimensions as low as 40 nmϕ, and low $I_{c0}$ < 50 μA, all at the same time. We achieved a TMR ratio of 100% in MgO barrier p-MTJs consisting of CoFe/Pd multilayer electrodes and CoFeB insertions after annealing at 350°C.

## 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 Target and Activities]

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

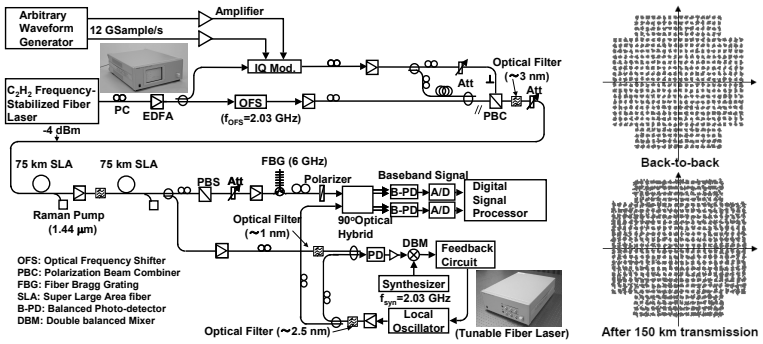


Fig. 1 512 QAM transmission setup and constellations before and after transmission.

As regards ultrahigh-speed transmission, a single-channel 1.28 Tbit/s transmission over 525 km was demonstrated for the first time with a single-polarization DQPSK signal. A time-domain optical Fourier transformation technique was adopted for improving the system tolerance to transmission impairments due to higher-order PMD. As regards multilevel coherent transmission, QAM multiplicity as high as 512 levels was realized for the first time. In this scheme, 54 Gbit/s data were transmitted over 150 km with an optical bandwidth of 4.1 GHz (Fig. 1). The adoption of large area fibers and Raman amplifiers contributed greatly to the realization of this high QAM multiplicity. This result indicates the possibility of achieving a spectral efficiency of more than 12 bit/s/Hz.

### [Staff]

Distinguished Professor: Masataka NAKAZAWA, Dr. Associate Professor: Toshihiko HIROOKA, Dr.
Assistant Professor: Masato YOSHIDA, Dr. JSPS Fellow: 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 was promoted to a Distinguished Professor in 2008. He is currently the Director of the Institute. He is a Fellow of IEEE, OSA, JSAP, and IEICE, and has received various awards including IEEE Daniel E. Noble Award and OSA R. W. Wood Prize.

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, including OTDM transmission, optical solitons, and photonic crystal fibers.

### [Papers]

[1] K. Kasai, T. Omiya, P. Guan, M. Yoshida, T. Hirooka, and M. Nakazawa, "Single-channel 400-Gb/s OTDM-32 RZ/QAM coherent transmission over 225 km using an optical phase-locked loop technique," IEEE Photon. Technol. Lett., vol. 22, no. 8, pp. 562-564, April (2010).
[2] F. Shohda, M. Nakazawa, J. Mata, and J. Tsukamoto, "A 113 fs fiber laser operating at 1.56 μm using a cascadable film-type saturable absorber with P3HT-incorporated single-wall carbon nanotubes coated on polyamide," Opt. Express, vol. 18, no. 9, pp. 9712-9721, April (2010).
[3] P. Guan, H. C. Hansen Mulvad, Y. Tomiyama, T. Hirano, T. Hirooka, and M. Nakazawa, "Single-channel 1.28 Tbit/s-525 km DQPSK transmission using ultrafast time-domain optical Fourier transformation and nonlinear optical loop mirror," IEICE Trans. Comm., vol. E94-B, no. 2, pp. 430-436, February (2011).


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## Applied Quantum Optics

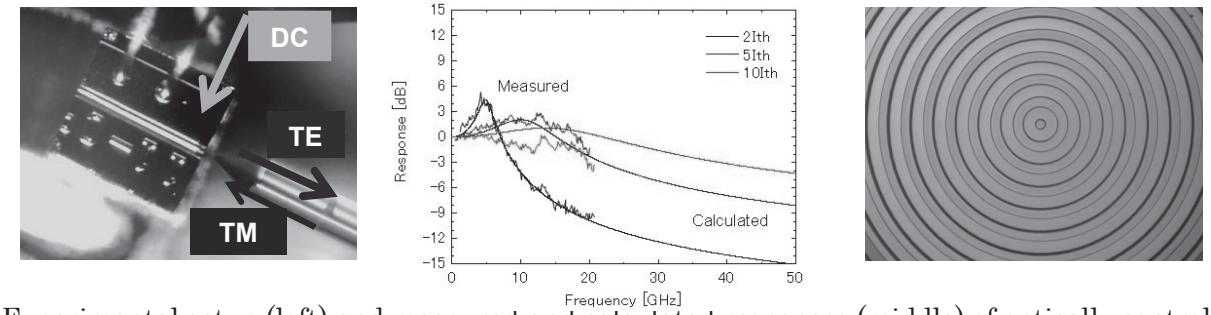
# Research on Innovative Highly Functional Photonic Semiconductor Devices and Ultra-wide band coherent light sources, and their applications

Highly Functional Photonics Hiroshi YASAKA, Professor
Broadband Photonics Jun-ichi SHIKATA, Associate Professor

### [Research Target and Activities]

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

Ultra-high-speed semiconductor photonic active devices is being investigated It is confirmed numerically and experimentally that the bandwidth of semiconductor laser sources can be broadened to some tens of GHz by controlling them with high-speed signal light injection. It is also confirmed that the bandwidth can be broadened drastically by a novel passive feedback laser diode with an external cavity. Novel THz biosensors using surface plasmon resonance are also studied to achieve sensitive detection of biomolecules, high-spatial-resolution THz imaging beyond diffraction limit. High-quality THz resonators for local-field enhancement are realized by using novel fabrication process. It is confirmed experimentally that THz wave can transmitted through the resonator successfully.




Experimental setup (left) and measured and calculated responses (middle) of optically controlled semiconductor laser source, and fabricated surface-plasmon THz-wave resonator (right)

### [Staff]

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

Jun-ichi SHIKATA received his Ph.D. degree in electronic engineering from Tohoku university in 1998. From 1998 to 2003, he was a research associate at the Research Institute of Electrical Communication (RIEC) of the same university. Since 2003, he has been an associate professor. His research interests include lasers, nonlinear optical effects and their applications.

### [Papers]

[1] Hiroki Ishihara, Hiroshi Yasaka and Junichi Shikata, "High-Speed Control of Semiconductor Laser by Gain Modulation," The 3rd Student Organizing International Mini-Conference on Information Electronics Systems (SOIM-GCOE10), F7P-6, 2010.

## Advanced Wireless Information Technology

### For realization of the next generation mobile network

Noriharu SUEMATSU, Professor

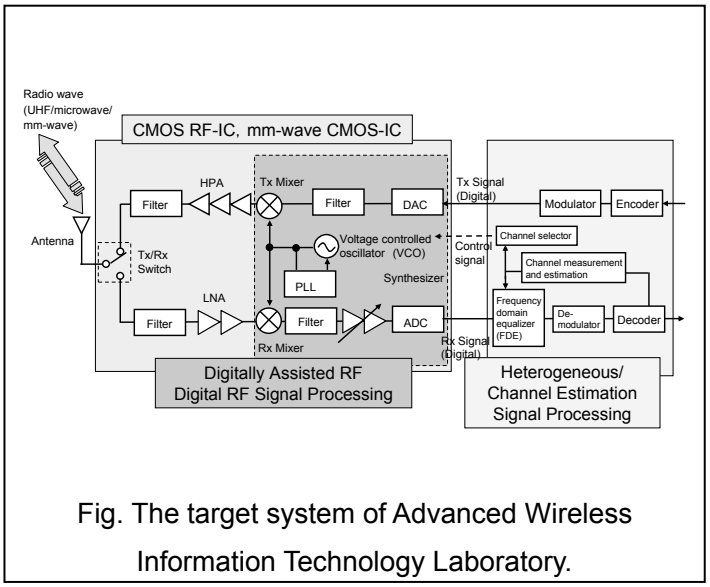



Fig. The target system of Advanced Wireless Information Technology Laboratory.

**[Research Target and Activities]**

In order to realize the next generation mobile network, we concentrate on the developments of following wireless network; (1) next generation mobile broadband wireless access (MBWA), (2) dependable broadband wireless local area network (WLAN), and (3) ultra broadband wireless personal area network (WPAN).

In this year, we have developed following technologies for broadband, low power consumption and small size terminals; (1) RF power amplifier, synthesizer and mixer devices for millimeter wave (mmW) wireless modems, (2) Ultra small antennas for mmW mobile terminals, (3) frequency domain equalizer (FDE) devices on application specific integrated circuit (ASIC). Moreover, we have evaluated the hybrid single-carrier and multi-carrier mobile communication system for wide-area and broadband mobile communication network.

**[Staff]**

Professor: Noriharu SUEMATSU, Ph. D
Assistant Professor: Suguru KAMEDA, Ph. D
Research Fellow: Shoichi TANIFUJI, Ph. D

**[Profile]**

Noriharu SUEMATSU Prof. Suematsu received the M.S. and Dr. 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, 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. He is a member of the IEEE, the IEICE, the Japan Society of Applied Physics, the Institute of Electrical Engineers of Japan and the Japan Institute of Electronics Packaging.

**[Papers]**

[1] S. Yoshida, S. Tanifuji, S. Kameda, N. Suematsu, T. Takagi, and K. Tsubouchi, "Copper Balls Interconnection Technology for 60GHz Band 3-D System-in-Package Modules," 2010 Asia-Pacific Microwave Conference (APMC2010), TH3F-1, Yokohama, Dec. 2010.

[2] T. T. Ta, K. Ando, S. Tanifuji, S. Kameda, N. Suematsu, T. Takagi, and K. Tsubouchi,"5GHz Band Low Phase Noise Si-CMOS Oscillator with Flip-Chip Mounted FBAR," 2010 Asia-Pacific Microwave Conference (APMC2010), TH4F-3, Yokohama, Dec. 2010.

[3] S. Tomita, N. Tran, Y. Miyake, K. Komatsu, H. Oguma, N. Izuka, S. Tanifuji, S. Kameda, N. Suematsu, T. Takagi, and K. Tsubouchi, "Influence of Hand Tremor for 60-GHz-Band Broadband Wireless Communication Terminal Based on Advanced Kiosk Model," 2010 Asia-Pacific Microwave Conference (APMC2010), FR1C-1, Yokohama, Dec. 2010.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## Information Storage System

# Research on Large Capacity Information Storage System Using 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 projected to exceed 1000 Exa-byte in 2010. An extremely large storage capacity by high density magnetic recording is thus required to store this information. Perpendicular magnetic recording was introduced 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.

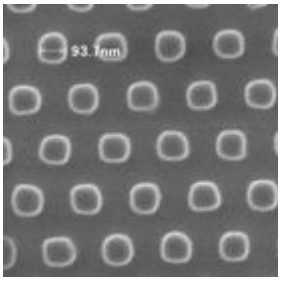

Fig 1 Fabricated bit patterned media

As we have proposed, the magnetic nano-structure of recording media is the most essential parameter to achieve high density perpendicular recording. Bit-patterned media (Fig 1) are one promising candidate. Recently we have clarified the possibility of an areal density of 5 Tbit/inch$^2$ in conjunction with heat assisted recording.

In addition to the studies on magnetic recording, a novel low-power consumption architecture was developed based on tiered operation of hard disk drives. (Fig. 2) A power reduction of 50% was confirmed from our simulation work.


Fig 2 Developed low power consumption storage sub-system.

### [Staff]

Professor: Hiroaki MURAOKA, Ph.D. (since 2000)
Associate Professor: Simon J. GREAVES, Ph.D. (since 2003)
Research Associate: Kenji MIURA, 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 Greaves, Yasushi Kanai, Hiroaki Muraoka, “Shingled Magnetic Recording on Bit Patterned Media,” IEEE Trans. Magn., vol. 46, no. 6, pp. 1460-1463, June 2010.
[2] Yasushi Kanai, Kazuya Koyama, Manabu Ueki, Toshio Tsukamoto, Kazuetsu Yoshida, Simon John Greaves, Hiroaki Muraoka, “Micromagnetic Analysis of Shielded Write Heads Using Symmetric Multiprocessing Systems,” IEEE Trans. Magn., vol. 46, no. 8, pp. 3337-3340, Aug 2010.
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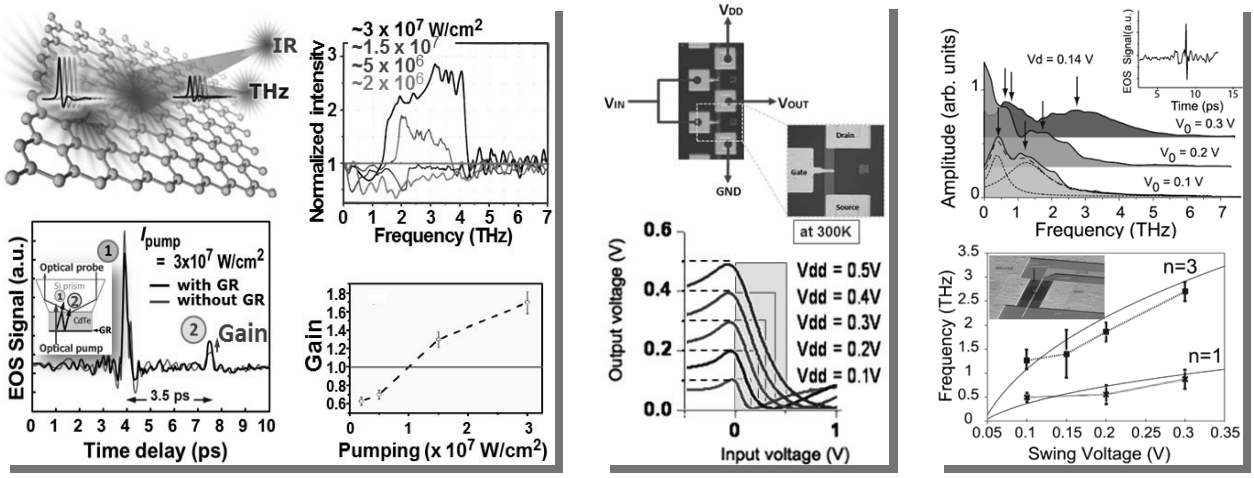
## Ultra-broadband Signal Processing

# 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

### [Research Target and Activities]




Ultrafast photonic, electronic and plasmonic devices using graphene and III-V semiconductors.
(Left: terahertz amplified stimulated emission and its gain profile in optically pumped graphene, center: compliment-ary inverter logic operation using graphene FETs, right: coherent terahertz emission from a plasmon-resonant 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.
Associate Professor: Tetsuya SUEMITSU, Dr. Eng.
Assistant Professor: Akira SATOU, Dr. Eng.
CREST Researcher: Susumu TAKABAYASHI, Dr. Eng.
JSPS Research Fellow: Stephane Albon BOUBANGA TOMBET, Ph.D. Secretary: Kayo UENO

### [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, 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, APS, JSAP, and PSJ.

### [Papers]

[1] V. Ryzhii, M. Ryzhii, A. Satou, T. Otsuji, V. Mitin, **J. Appl. Phys. 109**, 064508 (2011).
[2] S. Boubanga-Tombet et al., **Appl. Phys. Lett. 97**, 262108 (2010).
[3] M. Ryzhii, V. Ryzhii, T. Otsuji, V. Mitin, M.S. Shur, **Phys. Rev. B 82**, 075419 (2010).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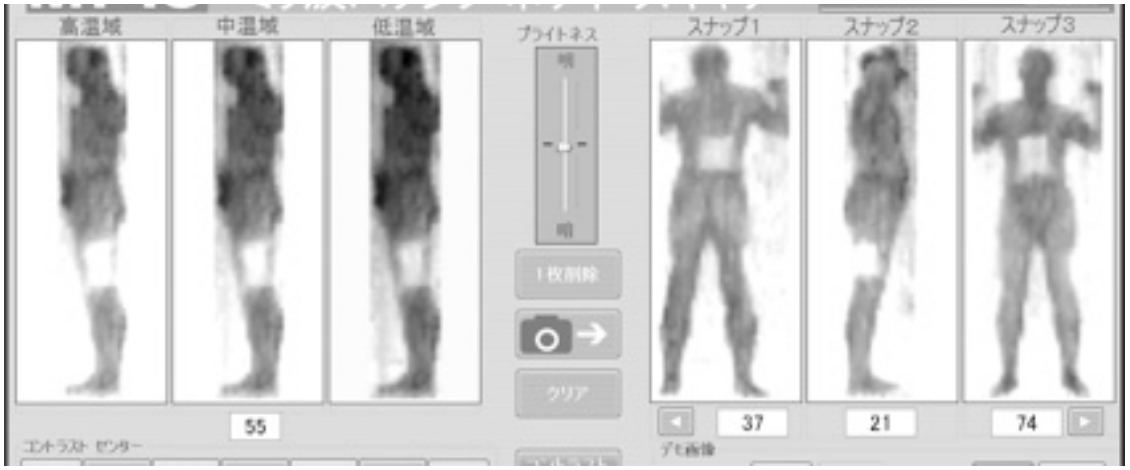
## Basic Technology for Broadband Communication

# Development of Measurement Instrumentation by the Millimeter and THz Wave

### [Research Target and Activities]

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




Simultaneous display of several pictures with different gradation treatments to show objects of low emissivity.

### [Staff]

Visiting Professor: Koji MIZUNO

### [Profile]

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

### [Papers]

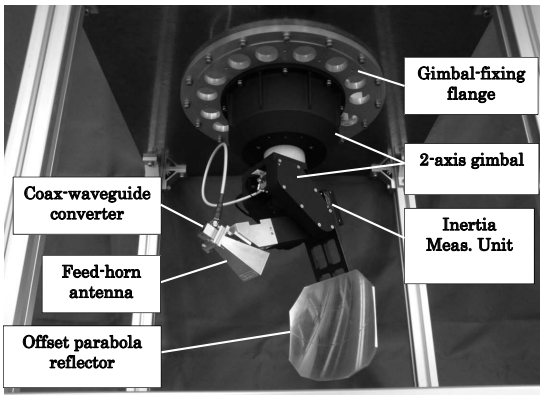
[1] K. Mizuno, "Millimeter-Wave Imaging through a Flame and Smoke," IEEE MTT-S Int. Microw. Symp. Workshop, Ahaheim, CA, WFC-11, May 2010.

[2] K. Mizuno, "Radio Sensing Technologies for Security Use," Instrumentation and Automation (JAPAN INDUSTRIAL PUBLISHING CO. LTD.), Vol.38, No.12, pp. 1 - 5, November 2010 (in Japanese).

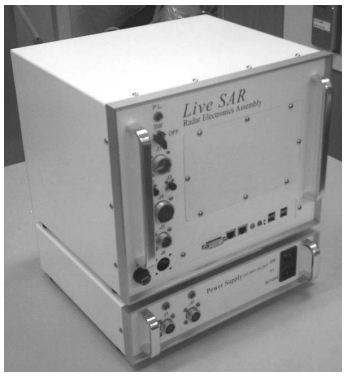
[3] K. Mizuno, "Millimeter-Wave Imaging Technologies," CAMP-Current Advances in Materials and Processes, ISIJ (The Iron and Steel Institute of Japan), 161 Meeting, D1, March 2011 (in Japanese).

## Basic Technology for Broadband Communication

# High Resolution Synthetic Aperture Radar for Civilian Applications




Antenna / Gimbal Assembly : 10 kg




Radar Electronics Assembly : 15 kg

INUTAKE Laboratory: Masaaki INUTAKE, Professor

### [Research Target and Activities]

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

In this fiscal year we have developed a real-time image, air-borne SAR under the research contract with Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Hardware of a spotlight-mode SAR : "Live SAR" has been successfully completed, with a high resolution (10 cm), small size and light weight (25 kg) at Ku-band, as shown in the above figures.

### [Staff]

Visiting Professor : Masaaki INUTAKE,Dr.

### [Profile]

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

### [Papers]

[1] M. Inutake, H. Ikezi,A. Mase, Y. Kogi, M. Sato : Laser Radar and Laser SAR devices, Pat. 2011-015915.
[2] Y. Kogi, S. H. Jeong *et al.*, M. Kwon, and K.,Kawahata: "Calibration of electron cyclotron emission radiometer for KSTAR", Rev. Sci. Instrum. **81**, 10D916 (2010).
[3] S.-W. Chen and M. Sato: "A Novel Method for Polarimetric SAR Image Speckle Filtering and Edge Detection", The 4th Joint PI Symp. ALOS Data Nodes for ALOS Science Program, Tokyo (2010) pp. 55.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# Aims and Achievements of Human Information Systems Division

In order 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 technologies 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, integrating nano-technologies to bio-applications, and optimizing the communications environments.

To achieve the goal of the Division, five 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, (4) Interdisciplinary Field for Informatics, and (5) Ubiquitous Communications Systems. The goals and achievements in the fiscal year 2010 of each laboratory are described in detail below.

## (1) Electomagnetic Bioinformation Engineering

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

**(Achievements)** We studied the relation between the sensitivity of magnetic sensors and the anisotropy of the magnetic thin films. 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 by an animal test.

## (2)Advanced Acoustic Information Systems

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

**(Achievement)** In 2010, we deepen the understanding human spaciotemporal perceptual processes of audio-visual and audio-vestibular information. This is particularly important to realize future multi-modal information processing and communication systems. We clearly demonstrated that the sense of presence and vraisemblance are differently determined by

the foreground information and background information of an audio-visual multi-modal content. We continued to develop methods, 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. Furthermore, we developed new signal processing algorithms of multiple description method for realizing high secrecy in voice over internet protocols (VoIP), advanced digital hearing aids, and high-performance binaural speech enhancement providing proper spatial information.

**(3) Visual Cognition and Systems**

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

(Achievements) We made achievements results in the fields of visual attention and color perception. Firstly, we confirmed that our method to visual attention is useful to estimate extent of visual attention, comparing the results with other typical techniques to measure visual attention. Secondly, we showed experimental results that suggested that attentional states can be estimated objectively functional near-infrared spectroscopy. These subjective and objective methods to measure visual attention is expected to be used for investigate function of visual attention. Thirdly, we achieved a successful modification in a color vision model. With our modification on the color vision model, nonlinear functions of the human color analysis are clearly described in the model.

**(4) Interdisciplinary Field for Informatics**

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

**(Achievements)** This year we have focused on experimental and theoretical approaches to understand the principle of “collective” excitation of localized surface plasmon resonances (LSPR) on Ag nanoparticle 2D crystalline sheet. We found that particles are interacting each other much longer distance than their diameter and excite homogeneous and strong LSPR field in the sheet. The finite difference time domain (FDTD) calculation confirmed the validity of our experimental data. These studies of Ag nanoparticle crystalline sheet is applied to surface plasmon enhanced fluorescence measurements for life-innovation.

**(5) Ubiquitous Communications System**

**(Aims)** The goal of ubiquitous communications is to realize communications environments in that everybody can communicate with anybody, anywhere and anytime without recognizing the communications tools. Towards this goal, the core technologies to realize

Super Broad Band Indoor Wireless Communications have been in research and development with which people can enjoy multiple Gbps transmission freely. Also, this laboratory has been contributing to /leading global standardization at IEEE and will continue this activity.

**(Achievements)** Major achievements in this year include (i) development of commercially applicable 60 GHz beam-forming antennas for portable terminals, (ii) 60 GHz CMOS power amplifiers, and phase shifters research and development close to commercially applicable level, (iii) Improvement of indoor communications interruption probability by the factor of 10 leading to real Super Broad Band Indoor Wireless Communications deployment, (iv) proposing and validating wireless harness systems for automobile applications.

## Electromagnetic Bioinformation Engineering

# Communication with human body

Electromagnetic Bioinformation Engineering　Kazushi ISHIYAMA, Professor
Electromagnetic Bioinformation Materials　Shuichiro HASHI, Associate Professor

### [Research Target and Activities]

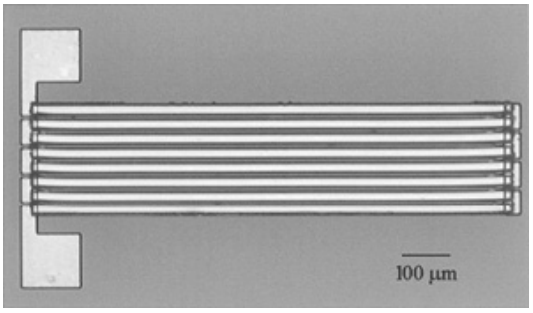


Fig. 1 Sensitive magnetic field sensor

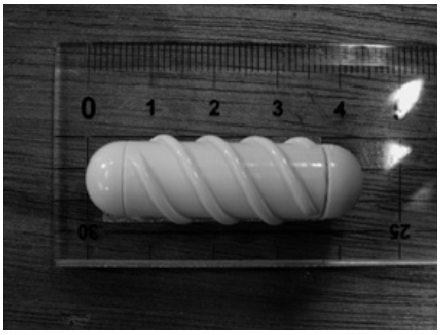


Fig. 2 Magnetic actuator for capsule-endoscope

We studied the relation between the sensitivity of magnetic sensors and the anisotropy of the magnetic thin films. 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 by an animal test.

### [Staff]

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

### [Profile]

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

Shuichiro HASHI　He 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] Y. Suwa, S. Agatsuma, S. Hashi, K. Ishiyama, “Study of Strain Sensor Using FeSiB Magnetostrictive Thin Film,” IEEE Trans. Magn., Vol. 46 , No. 2, pp. 666 – 669, 2010.
[2] H. Nasuno, S. Hashi, K. Ishiyama, N. Adachi, “Magnetic Field Waveform Measurement Using Pulsed Laser,” J. Magn. Soc. Jpn., Vol. 35, No. 3, pp. 273-276, 2011.
[3] S. H. Kim, S. Hashi, K. Ishiyama, “Methodology of Dynamic Actuation for Flexible Magnetic Actuator and Biomimetic Robotics Application,” IEEE Trans. Magn., Vol. 46, No. 6, pp. 1366–1369, 2010.
[4] S. Hashi, K. Ishiyama, S. Yabukami, H. Kanetaka, K. I. Arai, “Analysis and improvement of detection accuracy for a wireless motion sensing system using integrated coil component,” J. Appl. Phys., Vol. 107 , No. 9, pp. 09E701, 2010.


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## Advanced Acoustic Information Systems

# Development of next generation communication systems

Advanced Acoustic Information Systems: Yôiti SUZUKI, Professor
Acoustic Information Communications: Yukio IWAYA, 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 sound image control by high-definition virtual auditory displays based on simulating transfer functions of sound paths from sound sources to listeners' external ears, and a sound field simulator based on precise sound field analysis and control are two examples. These systems are expected to provide a high-quality 3D virtual sound space, which is keenly required to realize in the multimedia communications, cyberspace systems and supre-definition audio-visual display systems. Moreover, in 2010, we put a lot of efforts to investigate the spaciotemporal integration process of multisensory information processing.

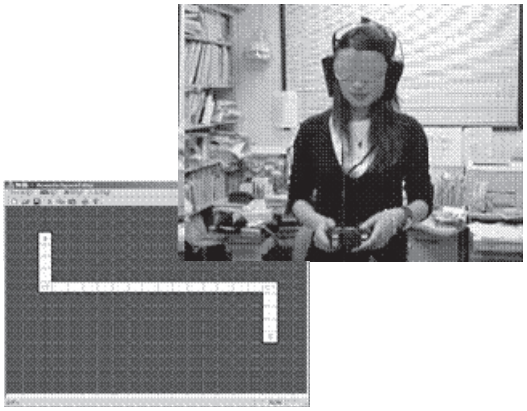


**Fig. 1 Application for training spatial cognition based on high-definition virtual auditory display**

### [Staff]

Professor: Yôiti SUZUKI, Dr., Associate Professor: Yukio IWAYA, Dr.
Assistant Professor: Shuichi SAKAMOTO, Dr.
Technical Official: Fumitaka SAITO, Research Fellow: Zhenglie CUI, Dr., Maori KOBAYASHI, Dr., Takuma OKAMOTO, Dr., Wataru TERAMOTO, Dr., and DaeGee KANG, Dr.

### [Profile ]

SUZUKI Yôiti graduated from Tohoku University in 1976 and received his Ph. D. degree in electrical and communication engineering in 1981. His research interests include psychoacoustics 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.

IWAYA Yukio graduated from Tohoku University in 1991 and received his Ph. D. degree in information sciences in 1999. His research interests include three-dimensional acoustic space perception and development of its communication systems with high sense of presence.

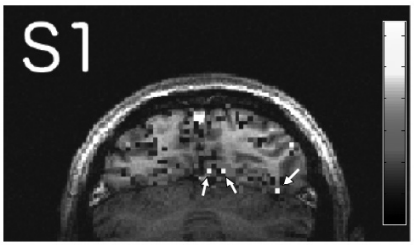
### [Papers]


- Wataru Teramoto et al., "Visual motion perception induced by sounds in vertical plane," Neuroscience Letters, Vol. 479, No. 3, pp. 221-225, 2010.
- Iwaya, Y., et al., "Sound localization in median plane using an avatar robot "TeleHead" with synchronization of a listener's horizontal head rotation," Proc. 20th Intl. Congress on Acoustics (ICA2010), 6-page paper in CD-ROM (2010.8), Sydney, Australia.
- Shuichi S., et al., "SENZI - a 3D sound-space recording system using spherical microphone array with 252-ch microphones -," Proc. 20th Intl. Congress on Acoustics (ICA2010), 4-page paper in CD-ROM (2010.8), Sydney, Australia.

## Visual Cognition and Systems

# Vision sciences for visual communication

Visual Cognition and Systems Satoshi SHIOIRI, Professor
Cognitive Brain Functions Ichiro KURIKI, Associate Professor




A contribution weight map among voxels in the classification analysis

**[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 results in the fields of visual attention and color perception. Firstly, we confirmed that the method we proposed to measure visual attention using the flash lag effec is useful to estimate extent of visual attention. We compared the attention extent measured by the method with those measured by the technique of sensitivity and by saccade eye movements and showed that the estimation of the attention effect is similar. Secondly, we showed experimental results that suggested that attentional states can be estimated objectively functional near-infrared spectroscopy (fNIRS). We succeeded to measure brain activity that is related to visual attention with fNIRS. fNIRS is a useful objective measure of visual attention in terms of less physical constraint of subject movements and the elaboration of the technique is a promising method. Thirdly, we achieved a successful modification in a color vision model. With our modification on the color vision model, nonlinear functions at cone output level and the opponent color level are clearly segregated. This better understanding of color vision will help to use color in communication properly.

**[Staff]**

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

**[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 Ph.D. 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 moved to the Research Institute of Electrical Communication, Tohoku University as an Associate Professor in January, 2006.

**[Papers]**

[1] Inamura, T., Shioiri, S., Tsujimura, S. and Yaguchi, H.: A nonlinear two-stage model for color discrimination. Journal of Optical Society of America A (accepted)

[2] Harasawa,,M. and Shioiri, S.: “Asymmetrical brain activity induced by voluntary spatial attention depends on the visual hemifield: A functional near-infrared spectroscopy study”, Brain and Cognition, 75, 292-298, 2010.

[3] Kuriki, I., Nakamura, S., Sun, P., Ueno, K., Matsumiya, K., Tanaka, K., Shioiri, S., Cheng, K.: “Decoding color responses in human visual cortex”, IEICE TRANSACTIONS on Foundamentals of Electronics, Communications and Computer Sciences E94-A(2), 473-479, 2011.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## Interdisciplinary Field for Informatics

# Fabrication and Application of Plasmonic Ag Nanosheet

Advanced plasmonic system　Kaoru TAMADA, Professor

### [Research Target and Activities]

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

This year we have focused on experimental and theoretical approaches to understand the principle of "collective" excitation of localized surface plasmon resonances (LSPR) on Ag nanoparticle 2D crystalline sheet. We found that particles are interacting each other much longer distance than their diameter and excite homogeneous and strong LSPR field in the sheet. The finite difference time domain (FDTD) calculation confirmed the validity of our experimental data. These studies of Ag nanoparticle crystalline sheet is applied to surface plasmon enhanced fluorescence measurements for life-innovation.

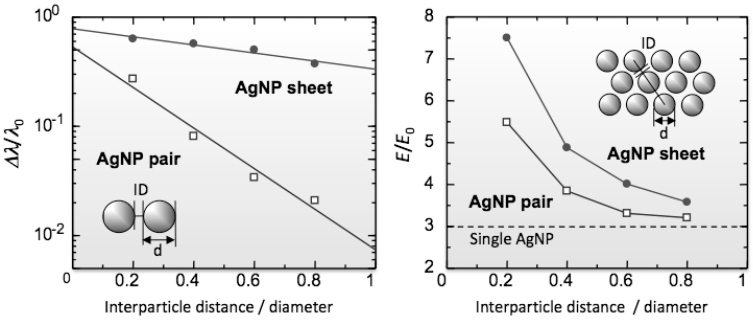



Fig. 1　Collective excitation of LSPR on Ag nanoparticle 2D crystalline sheet fabricated by self-assembly

### [Staff]

Professor　Kaoru TAMADA ,Dr. (from Oct. 2007)
Posdoc　Akihito YOSHIDA ,Dr. (from April. 2010)

### [Profile]

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

### [Papers]

[1] Nanoscale coupling of photons to vibrational excitation of Ag nanoparticle 2D array studied by scanning tunneling microscope light emission spectroscopy, Satoshi Katano, Koji Toma, Mana Toma, Kaoru Tamada and Yoichi Uehara, Phys. Chem. Chem. Phys., 12, 2010, 14749.
[2] Collective plasmon modes excited on a silver nanoparticle 2D crystalline sheet, Mana Toma, Koji Toma, Kanae Michioka, Yasuhiro Ikezoe, Daiki Obara, Koichi Okamoto and Kaoru Tamada, Phys. Chem. Chem. Phys. 2011, 12, 14749-14753.
[3] Gemini-SAMs, K. Tamada, Handbook of Biofunctional Surfaces (Edit. W. Knoll), Pan Stanford publishing, Singapore, 2010.

## Ubiquitous Communications System

# Super Broadband Wireless Communications

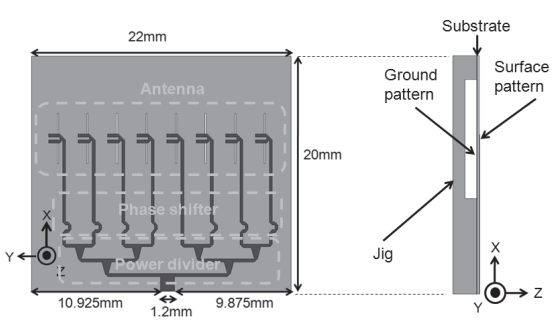
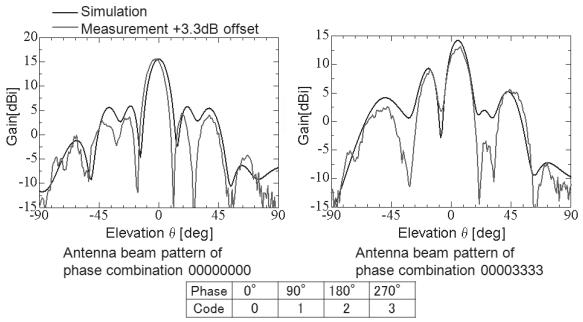



Fig.1 Millimeter-wave double slot array antenna




| Phase | 0° | 90° | 180° | 270° |
|---|---|---|---|---|
| Code | 0 | 1 | 2 | 3 |

Fig. 2 Antenna beam patterns

Ubiquitous Communications Systems: Shuzo Kato, Professor
Ubiquitous Communications RF Device: Hiroyuki Nakase, Associate Professor

**＜Research Target＞**

To realize ubiquitous communications in which everybody can communicate easily without noticing the communications tools much. the laboratory has been working on core technology R&D on Super Broadband Wireless Communications in which people can communicate at multi-Gbps freely.

**＜FY2010 Major Results＞**

**(1) Successful 60 GHz beam forming antenna development -** 8-element double slot antennas (patent pending) show an antenna gain of 15 dBi that is ready for commercial deployment, (2) **CMOS 60 GHz power amplifier deploying "**Cascode circuit + Class-B source ground circuit" (targeting over 20 % PAE) and 60 GHz phase shifters have been developed, **(3) Indoor communications interruption reduced to 1/10** by deploying intentional reflectors (two), **(4) Millimeter wave wireless harness (**metalized hose) **systems have proven good for practical applications** to reduce automobile weight, **(5)** Continuously **contributed to IEEE 802 Standardization on Millimeter wave systems and others.**

**＜Staff＞**

Prof.: Shuzo Kato, Ph.D, Associ. Prof. : Hiroyuki Nakase, Ph. D. Assist. Prof.: Hirokazu Sawada, Ph. D.Technical staff: Shigeru Yoshimiya, Technical assistant: Yukako Shoji, Naomi Aizawa

**＜Profile＞**

**Shuzo Kato** A Manager, Researcher and Engineer having a successful broad range of experiences from R&D, Manufacturing, Quality management, Product planning, Marketing, Sales, HRs, Establishing & Managing R&D centers, companies in Japan and USA in addition to millimeter wave communications systems global( IEEE) standardization lead. Graduated from Faculty of Engineering, Tohoku University with Ph. D in 1977, Published over 200 technical papers and held over 80 patents (including the one that became Department of Defense (USA) standard in 1998), Fellow of the IEEE and IEICE Japan.

**Hiroyuki Nakase** graduated from Faculty of Engineering, Tohoku University with Ph. D in 1995. From 1995, he worked at NTT Research Laboratories. Since 1999, he has been with RIEC, Tohoku University working on 60GHz CMOS MMICs, super broadband wireless communications and their applications.

**＜Major published papers in FY2010＞**

[1] M. A. Rahmen, C. S. Sum, R. Funada, T. Baykas, J. Wang, S. Sasaki, H Harada, and S. Kato, "Error Rate Analysis of Band-Limited BBPSK with Nakagami/Nakagami ACI Considering Nonlinear Amplifier and Diversity", IEEE VT, Vol. 59, No.3, pp. 1523 – 1529, March 2010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# Research Targets and Activities of Systems & Software Division

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

— Software Construction: Reliable and high-level software.
— Computing Information Theory: Fundamental theory of new software.
— Communication Network: Symbiotic computing.
— Information Content: Technologies for interactive content.
— Structure of Information Society (Visitor Section).

An overview of research results from Apr. 2010 to Mar. 2011 of these fields except the visitor section is described in this section.

## (1) Software Construction

We have been researching on theoretical foundations for flexible yetreliable programming languages, and have been conducting a development project of SML#, a new programming language in the ML family, that embodies some of our research results such as more flexible static typing and high-degree of inter-operability with existing languages and databases. The major results of 2010 academic year include the following. (1) Study on programming languages and systems that mechanically derive efficient programs for solving optimization problems from their natural specifications. In last year, we developed a system for optimal path querying and a library for obtaining optimal sequences for Haskell. Moreover, we extend our theoretical foundations so as to deal with approximation algorithms. (2) Development of the SML# Compiler. The last year's development includes a non-moving bitmap marking GC and so on.

## (2) Computing Information Theory

Aiming at combining program transformation methods and automated theorem proving methods, we continued to pursue the possibility of program transformation by templates based on term rewriting. Based on a notion of natural higher-order inductive theorems, we showed sufficient criteria for applying transformation templates to higher-order programs. Although many automated termination provers have been proposed recently, little work is reported on automated confluence provers. We continued to develop an automated confluence prover ACP for term rewriting systems based on several divide-and-conquer methods. Applying a reduction-preserving completion procedure, we implement a new method for proving confluence of term rewriting systems.

### (3) Communication Network

An autonomic monitoring mechanism of ubiquitous information environment is implemented and evaluated as a basis for realizing an evolutional agent system. Next, a mechanism of using network management heuristics based on the active information resources is designed and implemented, and the situation-adaptive behavior of the mechanism is validated with respect to a network anomaly detection task. On the other hand, a prototype of the multiagent-based microgrid based on a knowledge-based electricity control method and also an extended mechanism for user-centered information retrieval based on active information resources are developed, and the effectiveness of these implemented systems are demonstrated.

### (4) Information Content

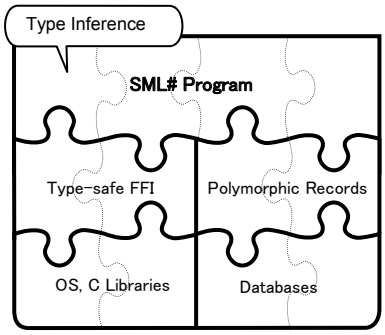
We focus on non-traditional content other than movies, music and games, conducting comprehensive research on a variety of interactive content which creates new value through interactions with humans. This year we mainly conduct research projects on chasing camera movement in interactive 3D environment, interactive video content generated from live video images, efficient and accurate pointing interfaces for graphical user interface on computer monitor, and body-centric interaction techniques for wall-type large displays, and so on.

## Software Construction

# 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, rank1 polymorphism, and high-degree of inter-operability with existing languages and databases.

The major results of 2010 academic year include the following. (1) A system for optimal path querying and a library for obtaining optimal sequences for Haskell, and an extension of our theoretical foundations so as to deal with approximation algorithms. (2) Development of the SML# Compiler. In the last year, we developed the following methods and components. (i) An x86 native code generator for Linux, Windows and Mac OS X. (ii) An efficient non-moving bitmap marking GC for functional languages. (iii) An implementation of lightweight first-class overloading based on polymorphic record compilation. (iv) seamless and polymorphic SQL query integration with ML.

### [Staff]

Professor : Atsushi OHORI, Dr.
Assistant Professor : Katsuhiro UENO, Dr.
Assistant Professor : Akimasa MORIHATA, Dr.

### [Profile]

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

### [Papers]

[1] K. Ueno, A. Ohori, Foreign Function Interface of SML#, Computer Software, May, 2010 (in Japanese).
[2] A. Morihata: A Short Cut to Optimal Sequences. New Generation Computing, 29(1): 31-59, 2011.
[3] A. Morihata, K. Matsuzaki: Automatic Parallelization of Recursive Functions using Quantifier Elimination. In: FLOPS 2010: LNCS, vol. 6009, pp. 321-336, Springer, 2010.

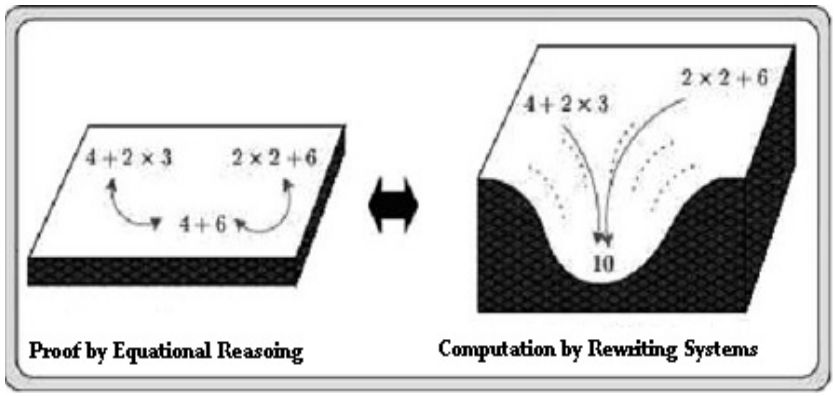
## Computing Information Theory

# 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, Automated confluence proof by decreasing diagrams based on rule-labelling, In Proceedings of the 21st International Conference on Rewriting Techniques and Applications (RTA 2010), Edingburgh, UK, LIPIcs, Vol.6, pp.7-16, 2010.

[2] Yuki Chiba, Takahito Aoto and Yoshihito Toyama, Program transformation templates for tupling based on term rewriting, IEICE Transactions on Information and Systems, Vol.E93-D, No.5, pp.963-973, 2010.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## Communication Network

# Support of Cooperation and Communication between Human and Systems

Intelligent Communication Tetsuo KINOSHITA, Professor
Symbiotic Communication System Takuo SUGANUMA, Associate Professor

### [Research Target and Activities]

It becomes an important problem to develop intelligent systems, which can cooperate with various people as the human-friendly, easy-to-use, intelligent partners, in order to support various creative activities of people in an active and autonomic way. We aim at studying advanced information technologies to realize a new infrastructure of cybersociety based on cooperation and coordination of both people and intelligent systems over the networked environment, using the agent based computing technologies. In this year, the following studies had been done. (a)Evolutional Agent Systems: An autonomic monitoring mechanism of ubiquitous information environment is implemented and evaluated as a basis for realizing an evolutional behavior control mechanism of multiagent organization. (b)Agent-based Network Management Technologies: A mechanism of using network management heuristics based on the active information resources is designed and implemented, and the situation-adaptive behavior of the mechanism is confirmed with respect to a network anomaly detection task. (c)Multiagent applications: A knowledge-based electric power control method for multiagent-based microgrid is proposed, and the effectiveness of the proposed method is validated by the simulation experiment. Moreover, an extended mechanism of user-centered information retrieval based on active information resources is implemented and evaluated. These results had been published as 11 papers of international and domestic journals.

### [Staff]

Professor: Tetsuo KINOSHITA, Dr.
Associate Professor: Takuo SUGANUMA, Dr.
Secretary: Ami KONNO

### [Profile]

Tetsuo Kinoshita received the B.E. degree in electronic engineering from Ibaraki University, Japan, in 1977, and the 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.

Takuo Suganuma recieved the B.E., M.E. and Dr. Eng. degrees in information engineering from Chiba Institute of Technology, Japan, in 1992, 1994 and 1997, respectively. His research interests include flexible network, agent-based computing and symbiotic computing. He received UIC-07 Outstanding Paper Award in 2007. Dr. Suganuma is a member of IEICE, IPSJ, and IEEE.

### [Papers]

[1] Akiko Takahashi, Tetsuo Kinoshita, "A behavioral characteristics model for a flexible distributed system", International Journal of Pervasive Computing and Communications, Vol.6, No.2, pp.192–213, Emerald Group Publishing Limited, 2010.7.
[2] Hak-Man Kim, Tetsuo Kinoshita, Yujin Lim, Tai-Hoon Kim, "A Bankruptcy Problem Approach to Load-shedding in Multiagent-based Microgrid Operation", *Sensors* Vol.10, No.10, pp.8888-8898, MDPI Publishing, 2010.9.
[3] Hak-Man Kim, Tetsuo Kinoshita, Myong-Chul Kim, "A Multiagent System for Autonomous Operation of Islanded Microgrids Based on a Power Market Environment", Energies, vol.3, pp.1972-1990, 2010.12.

## 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 content 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 on camera movement in interactive 3D environment, efficient and accurate interfaces for GUI and wall-type large display, and so on.

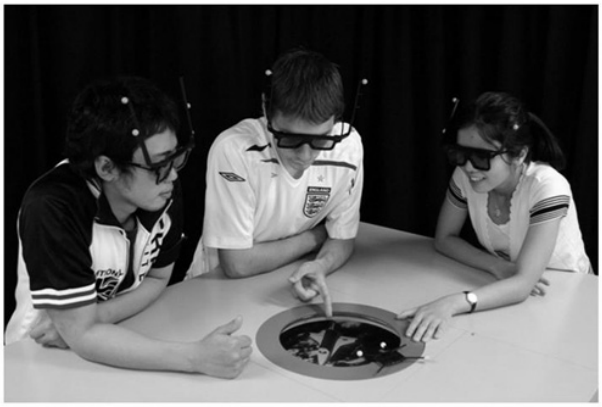

Fig. 1: Interactive stereoscopic display for multiple users

Fig. 2: Interactive video content

### [Staff]

Professor: Yoshifumi KITAMURA, 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] Maya Ozaki, Like Gobeawan, Shinya Kitaoka, Hirofumi Hamazaki, Yoshifumi Kitamura, Robert W. Lindeman: Camera Movement for Chasing a Subject with Unknown Behavior based on Real-time Viewpoint Goodness Evaluation, Visual Computer Vol. 26, No. 6-8, pp. 629-638, Jun. 2010.

[2] Kazuyuki Fujita, Kazuki Takashima, Takayuki Tsukitani, Yuichi Itoh, Yoshifumi Kitamura, Fumio Kishino: Anchored Navigation: Coupling Panning Operation with Zooming and Tilting Based on the Anchor Point on a Map, Proceedings of the Graphics Interface, pp. 233-240, May. 2010

[3] Garth Shoemaker, Takayuki Tsukitani, Yoshifumi Kitamura and Kellogg S. Booth: Body-centric Interaction Technique for Very Large Wall Displays, Proceedings of Nordic Conference on Human-Computer Interaction (NordCHI), pp. 463-472, Oct. 2010.


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## Information Social Structure

# Interdisciplinary Study on Adaptive Bipedal Walking

### [Research Target and Activities]

Life is an intrinsic part of nature. To be both pliant and sturdy in a complex environment requires an autonomy that is capable of creating the information needed to control the self. To "live," a life system must on its own form a harmonious relationship with an unpredictably changing environment. It requires that it be capable of creating the information necessary for its own self-control. It is this autonomy that clearly distinguishes the world of life systems from the physical world, that indicates the necessary for the interdisciplinary studies on the world of life systems.

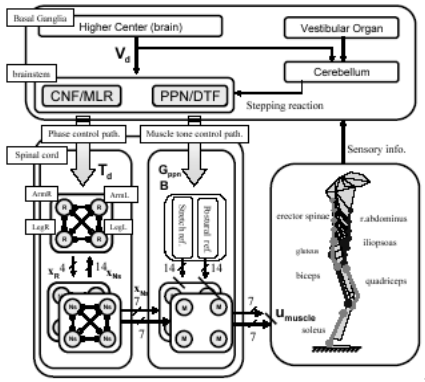
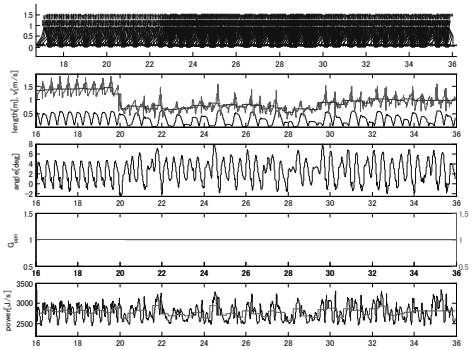



Fig.1 Bipedal Walking Model



Fi.2 Simulation;20kg weight is added during a walk.

Bipedal locomotion is a movement of the body carried out by cyclical and dynamical interactions of the legs with the ground. During the bipedal locomotion in the real world, the body will receive unpredictable forces depending on various actors. To adapt unpredictable changes of the environment, the muscle tone should be appropriately set before the movement depending on an aim supposed by the system-itself, and should be controlled during the movement depending on conditions of the environment. We constructed the model of bipedal walking system shown in Fig. 1. Simulation results indicated that flexible and robust bipedal locomotion can emerge from appropriate control of the muscle-tone depending on the ground reaction force (Fig. 2). Furthermore, it was found that the proposed model is useful for theoretically analyzing various kinds of motor ataxia.

### [Staff]

Visiting Professor: Masafumi YANO, Dr.

### [Profile of Professor Yano]

1992-: Professor, Research Institute of Electrical Communication (RIEC), Tohoku University.
2007-: Director, Research Institute of Electrical Communication (RIEC), Tohoku University.
2010 : Professor Emeritus of Tohoku University and also Research Professor of RIEC

### [Papers]

[1] Y. Makino and M. Yano, "Investigating the Underlying Intelligence Mechanisms of the Biological Olfactory System," Advances in Artificial Intelligence, Vol. 2010, Article ID 478107, 2010.
[2] Y. Yoshihara, Y. Makino, N. Tomita, M. Yano, "Can Real-time Optimization of Joint Mobility Generate Globally Optimal Arm Motion?," Keisoku Jidou Seigyo Gakkai, Vol. 45, pp. 570-579, 2009.

## Information Social Structure

# Disater-oriented Strong Green ICT for Humans' Life and Nature

### [Research Target and Activities]

In 21st century, we are facing with "global environmental changes" including global warming and " social structural changes" such as aging of the population. For absorbing and sublating these changes, we proposed a new computation paradigm, the concept of "Symbiotic computing", in 1992. This idea places on values on harmony between "Agents" (e.g. human, computer, internet, robot, nature, country, culture and etc.). From the engineering point of view, we have been pursuing researches on the "Symbiotic computing" which are its model, design and applications (Fig.1).

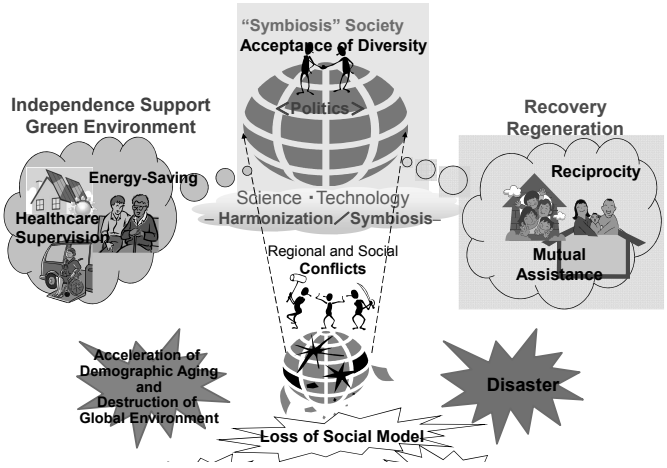



Fig.1: Model of Symbiotic Information Society towards Recovery and Regeneration

In 2010, we have conducted a cooperative project called the "Kurihara Green ICT project" based on the idea of "Symbiotic computing,.

<Kurihara Green ICT Project>: This project, led by Professor Norio Shiratori, aims to create a "Symbiosis between our daily life and nature via information communication technology (ICT)." It is conducted with a budget of 250 million yen for the fiscal year 2010, funded by The Ministry of Internal Affairs and Communications, Japan.

Our project goal is to obtain the technical specification of necessary communication protocol in order to realize network integrated control system. It aims at improving administrative services and reducing environmental burden in the wide-area distributed community. Also, we are considering international standardization of our proposed protocols. Two themes have been discussed, which will be achieved by the symbiosis between natural environment and human through an integration of wide-area distributed community. Details of the experimental results are summarized in the research paper[1] mentioned below.

### [Staff]

Professor: Norio SHIRATORI, Dr. Research Member: Hideyuki TAKAHASHI, Dr.
Visiting Associate Professor: Debasish CHAKRABORTY, Dr. Secretary: Kaori MORIYA

### [Profile]

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

### [Papers]

[1] Norio Shiratori, Kazuo Hashimoto, Debasish Chakraborty, Hideyuki Takahashi, Takuo Suganuma, Naoki Nakamura, and Atushi Takeda, "Kurihara Green ICT Project -- Towards Symbiosis between Human's Lifeand Nature,"Journal of Internet Technology(JIT), Vol. 12, No. 1, pp.1-11, 2011.
[2] Hideyuki Takahashi, Kazuhiro Yamanaka, Satoru Izumi, Yoshikazu Tokairin, Takuo Suganuma, Norio Shiratori, "Gentle supervisory system based on integration of environmental information and social knowledge," International Journal of Pervasive Computing and Communications, Vol. 6, No. 2, pp. 229 - 247, 2010.
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## 3-5. Environmental-Adaptive Information and Communication Engineering: goals and achievements in 2010

To embody a humanity-rich-communication by innovating information-and-communication technology (ICT) in the sustainable global society, we have to create human-friendly low-environmental-impact ICT devices and systems by using electronic materials and device-technology in the research fields of Nanotechnology, Spintronics and Information technology. Our aim is that the embodiment of low-environmental-impact information devices and electronic equipments based on fundamental theory of spin and electron; these are designed by systematic survey of the rapidly-changing industry needs and R&D trends. We report the summary of our activities in 2010.

### Research

We have focused on the development of stabilizing technology for thermally unstable triangle silver nanoparticles for the device application. We succeeded in maintaining the particle shape for 90 minutes even in 0.9wt% NaCl solution. By applying this technology, an environmental-adaptive device recording a history of environmental change as color have been developed; that records the changes in plasmonic absorption wavelength of particles, which is due to exposure to environmental radiation and chemicals.

### Open-innovation

The first technical meeting between RIEC and Fuji electric group was held at 14 Oct. The number of participant was 35. The presentations by RIEC professors were concerning with magnetic materials for sensing devices, optoelectronic device applications of graphene and plasmonic crystalline for a nano-antenna structure. Those by researchers from Fuji electric group were introduction of Fuji electric R&D, sensing and MEMS technology and R&D of graphene in Fuji electric. These meetings will clarify the differences between R&D processes in University and company. This helps us promote the discovery of seeds in University for industrial applications.

## Environmental-Adaptive Information and Communication Engineering

# Does it contain Wisdom?

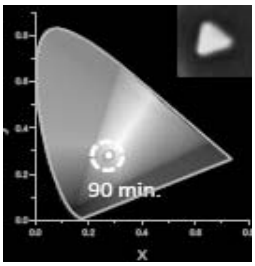
Environmental-Adaptive Information and Communication Engineering Eiki ADACHI, Professor

### [Research Target and Activities]

To embody a humanity-rich-communication by innovating information-and-communication technology (ICT) in the sustainable global society, we have to create human-friendly low-environmental-impact ICT devices and systems by using electronic materials and device-technology in the research fields of Nanotechnology, Spintronics and Information technology. Our aim is that the embodiment of low-environmental-impact information devices and electronic equipments based on fundamental theory of spin and electron; these are designed by systematic survey of the rapidly-changing industry needs and R&D trends.

1. Research

We have focused on the development of stabilizing technology for thermally unstable triangle silver nanoparticles for the device application. We succeeded in maintaining the particle shape for 90 minutes even in 0.9wt% NaCl solution. By applying this technology, an environmental-adaptive device recording a history of environmental change as color have been developed; that records the changes in plasmonic absorption wavelength of particles, which is due to exposure to environmental radiation and chemicals.




Color stability shown on CIE color chart. Its lifetime is almost 90 min that is 10 times longer than the ordinary one.

2. Open innovation

The first technical meeting between RIEC and Fuji electric group was held at 14 Oct. The number of participant was 35. The presentations by RIEC professors were concerning with magnetic materials for sensing devices, optoelectronic device applications of graphene and plasmonic crystalline for a nano-antenna structure. Those by researchers from Fuji electric group were introduction of Fuji electric R&D, sensing and MEMS technology and R&D of graphene in Fuji electric. These meetings will clarify the differences between R&D processes in University and company. This helps us promote the discovery of seeds in University for industrial applications.

### [Staff]

Professor: Eiki ADACHI, PhD.

### [Profile]

Eiki ADACHI, Education: B.S. in Physics (Saitama University, May 1989), M.S. in Physics (Tokyo Institute of Technology, May 1991), Ph.D. (Tokyo University, May 1996). History of employment: ERATO project, National institute of physiological sciences, L'ORÉAL Tsukuba center, Fuji electric advanced technology Co., Ltd., Fuji electric holdings Co., Ltd., Professor, Research Institute of Electrical Communication (Tohoku University, May 2010~). Research field: Synthesis of nanomaterials and its application for communication technology.

### [Papers]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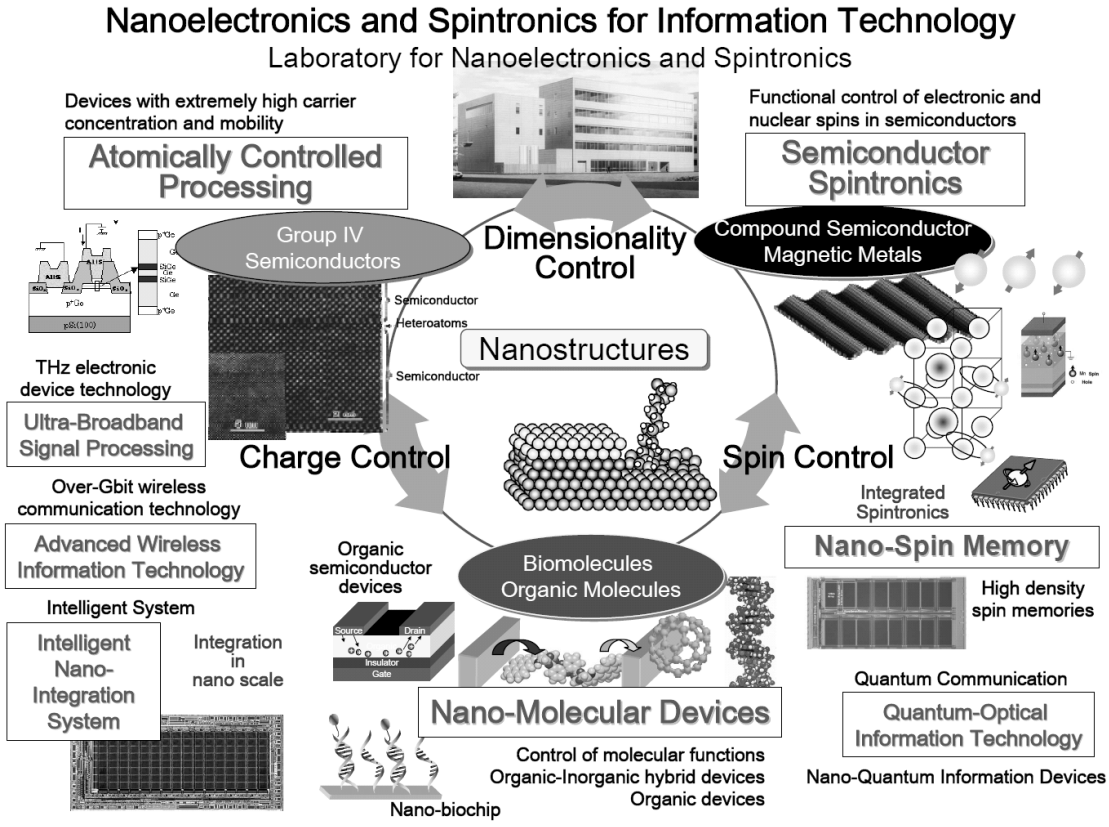
# Laboratory for Nanoelectronics and Spintronics

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: Atomically Controlled 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 2010

### Atomically Controlled Processing and Nano Integration

#### ● Atomically Controlled Processing (J. Murota and M. Sakuraba)

In order to create atomically controlled processing for nanometer-order artificial heterostructures of group IV semiconductors, following experimental results have been obtained: (1) In P atomic layer doping, P segregation at a Si cap surface becomes more significant in the case with tensile strain in Si than that without strain. Solid solubility of P at the heterointerface becomes smaller with tensile strain. (2) Deposition rate of $Si_{0.55}Ge_{0.45}$ on Si(100) is reduced by tensile strain in Si(100) and increased by compressive strain in Si(100). Moreover, electrical activity of B atoms in Si with tensile strain is reduced. (3) By using $Si_2H_6$ in Si epitaxial growth on nanometer-order $Si_{0.42}Ge_{0.58}$ film, roughness generation and mixing at the heterointerface are suppressed. Additionally by applying the growth condition to resonant tunneling diode, room-temperature negative differential conductance was clearly demonstrated.

#### ● Intelligent Nano-Integration System (K.Nakajima and S.Sato)

(1) We have analyzed behavior of a connected neural system by using a new concept virtual particle dynamics, and we have designed and measured a hardware neuro-system based on this concept. Furthermore, we have proposed a stochastic logic neuron for an inverse function delayed model with high-order synapse connections, and we have discussed the possibilities of it. (2) We measured switching current distributions of stacked Nb/AlOx/Nb Josephson junctions, and studied the experimental technique for evaluating coupling strength between Josephson junctions from switching current distributions. It has been confirmed that large difference is found between samples with and without capacitive couplings, and the crossover temperature region between quantum and classical regions becomes large in comparison with a conventional theory. (3) We designed an 8-bit parallel multiplier for the large scale superconducting digital signal processor. The operation of the designed multiplier up to 40GHz was confirmed by the numerical simulation. The estimated power dissipation was 6.33mW. A neural network using superconducting quantum interference devices for solving N-Queens problem was designed and numerically demonstrated.

### Semiconductor Spintronics and Information Technology

#### ● Semiconductor Spintronics and Nano-Spin Memory

(H. Ohno, Y. Ohno, F. Matsukura, and S. Ikeda)

Our research activities focus on the establishment of fundamental technologies for future spintronics devices. The outcomes in the last fiscal year are following. (1) Fabrication of magnetic nano-dot ensemble from a (Ga,Mn)As thin layer by the application of electric field. (2) Establishment of the relationship between the magnitude of nuclear quadrupole interaction and spin phase relaxation time in nonmagnetic semiconductor quantum structures. (3) Discovery of CoFeB/MgO interfacial magnetic anisotropy and its control by the application of electric-fields. (4) Fabrication of CoFeB/MgO based perpendicular anisotropy MTJs (p-MTJs) with TMR ratio over 120%, high thermal stability at dimensions as low as 40 nmϕ, and low $I_{c0}$ < 50 μA, after annealing at 350°C. (5) Achievement of a TMR ratio of 100% in p-MTJs consisting of MgO barrier and CoFe/Pd multilayer electrodes with CoFeB insertions after annealing at 350°C.

Research activities in "Research and development of ultra-low power spintronics-based VLSIs" under "Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program)," initiated by CSTP. (1) $L1_0$-ordered MnAl films showed perpendicular anisotropy with a very large anisotropy constant of ~$1\times10^7$ erg/cc. (2) Very large TMR ratio of 350% at RT and 947% at 2 K was observed in MTJs with $Co_2MnSi$/MgO interface and 0.8 nm-thick CoFe insertion. (3) Operation of 2T-2MTJ bit-serial TCAM cell and a 1T-1MTJ binary CAM (BCAM) cell fabricated by a 0.14 μm and 90 nm CMOS/MTJ process and a 90-nm CMOS/MTJ process was verified. (4) Using prototype reconfigurable spin processor, the data writing operation from the working memory (SRAM) to the configuration memory (SPRAM) with the reconfigurable spin logic block was demonstrated.

## ● Ultra-Broadband Signal Processing (T.Otsuji and T.Suemitsu)

The goal of our research is to explore the terahertz frequency range by means of novel electron devices and systems. Graphene has massless carriers and their peculiar characteristics are expected to be useful as a candidate to realize such systems. Using an epitaxial graphene formed on silicon substrates provided by Prof. Suemitsu's group, we have fabricated graphene-channel FET's to integrate a complimentary logic inverter gate and confirmed its normal operation at room temperature. We have also succeeded in observation of stimulated emission of terahertz radiation from optically pumped graphene, which proved our theoretical discovery of the possibility of the negative dynamic conductivity and population inversion in optically pumped graphene.

## ● Quantum-Optical Information Technology (K.Edamatsu and H.Kosaka)

1. Investigation of optical nonlinearities at a single-photon level is essential in realizing quantum info-communication technology. We have succeeded in measuring the optical Kerr nonlinearity at the single-photon level in photonic crystal fibers and Si wire

waveguides.

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 polarization transfer from a photon to an electron spin and manipulation of an electron spin in a gate-defined quantum dot. We have also theoretically shown that we can read out two-spin coherence and perform the complete Bell state measurement of two electrons in a g-factor engineered double quantum dot.

## Nano-Molecular Devices

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

①Fabrication of a P3HT organic transistor using ionic liquid and its characterization

We fabricated a P3HT organic transistor using ionic liquid and demonstrated that it drived high output current at low voltage. Infrared spectra of the P3HT layer were in-situ observed during operation. The infrared spectra of the P3HT indicated that the P3HT organic transistor using ionic liquid was dominantly controlled by the electrochemical doping to the P3HT active layer.

②Direct formation of titanium oxide nanotube film on a substrate by anodization

The metallic titanium film was deposited on a glass substrate by the DC magnetron method. The titanium oxide nanotube film was directly formed on a glass substrate by anodizing the metallic titanium film in an ammonium fluoride based organic electrolyte. The diameter of the titanium oxide nanotubes was controlled by the applied anodic potential.

③Reconstitution of free-standing bilayer lipid membranes in Si substrates

Free-standing bilayer lipid membranes (BLMs) were reconstituted in micro apertures fabricated in Si substrates. The mechanical and electrical stability of the BLMs was remarkably improved compared with BLMs prepared by a conventional method. Background current noise was reduced by coating the Si substrate with insulating layers.

④ Reconstitution of free-standing bilayer lipid membranes in nanoporous anodic alumina films

Free-standing BLMs were formed in nanoporous anodic alumina films. The use of porous anodic alumina reduced individual membrane size to improve the BLM stability compared with conventional BLMs. On the other hand, total BLM area is still large to facilitate protein incorporation. This approach is useful for designing highly sensitive biosensors.

## Atomically Controlled Processing

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

Atomically Controlled Processing Junichi MUROTA, Professor
Group IV Quantum Heterointegration Masao SAKURABA, Associate Professor

### [Research Target and Activities]

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

In this year, following experimental results have been obtained: (1) In P atomic layer doping, P segregation at a Si cap surface becomes more significant in the case with tensile strain in Si than that without strain. Solid solubility of P at the heterointerface becomes smaller with tensile strain. (2) Deposition rate of $Si_{0.55}Ge_{0.45}$ on Si(100) is reduced by tensile strain in Si(100) and increased by compressive strain in Si(100). Moreover, electrical activity of B atoms in Si with tensile strain is reduced. (3) By using $Si_2H_6$ in Si epitaxial growth on nanometer-order $Si_{0.42}Ge_{0.58}$ film, roughness generation and mixing at the heterointerface are suppressed. Additionally by applying the growth condition to resonant tunneling diode, room-temperature negative differential conductance was clearly demonstrated.

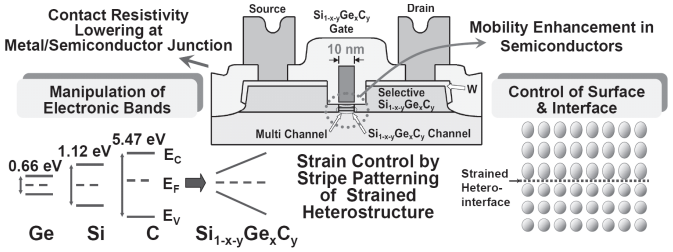



**Fig. 1.** 10 nm-scale quantum nanodevices with strain controlled nano-scale patterned heterostructure of group IV semiconductors.

### [Staff]

Professor : MUROTA, Junichi Ph.D.
Associate Prof. : SAKURABA, Masao Ph.D.
Research Fellow : CHIBA Yohei Ph.D.

### [Profile]

Junichi MUROTA received the B.E., M.E. and Ph.D degrees in electronic engineering from Hokkaido University in 1970, 1972 and 1985, respectively. He joined the Electrical Communication Laboratory, Nippon Telegraph and Telephone Public Corporation in 1972. In 1985 and 1995 he became an Associate Professor and a Professor, respectively, in the RIEC, Tohoku University. He was awarded the 3rd Yamazaki-Teiichi Prize (2003), the JSAP Fellow (2009) and the Commendation for Science and Technology by the MEXT (2010).

Masao SAKURABA received the B.E. degree in electrical engineering in 1990 and M.E. and Ph.D degrees in electrical and communication engineering in 1992 and 1995, respectively from Tohoku University. In 2002 he became an Associate Professor in the RIEC. He was awarded Young Researcher Award of Int. Conf. SSDM (1992) and 12th Research Encouragement Award of Tokin Foundation for Advancement of Science and Technology (2001).

### [Papers]

[1] K. Takahashi, M. Sakuraba and J. Murota, "Fabrication of High-Ge-Fraction Strained $Si_{1-x}Ge_x$/Si Hole Resonant Tunneling Diode Using Low-Temperature $Si_2H_6$ Reaction for Nanometer-Order Ultrathin Si Barriers", Solid-State Electron., Vol.60, pp.112-115, (2011).
[2] J. Murota, M. Sakuraba and B. Tillack, "Atomically Controlled Processing in Strained Si-Based CVD Epitaxial Growth" (Invited Paper), 10th IEEE Int. Conf. on Solid-State and Integrated Circuit Technology (ICSICT-2010), Shanghai, China, Nov. 1-4, 2010, Proc.No.I12_05.
[3] M. Sakuraba and J. Murota, "Atomically Controlled Plasma Processing for Epitaxial Growth of Group IV Semiconductors" (Invited Paper), 10th IEEE Int. Conf. on Solid-State and Integrated Circuit Technology (ICSICT-2010), Shanghai, China, Nov. 1-4, 2010, Proc.No.I12_07.

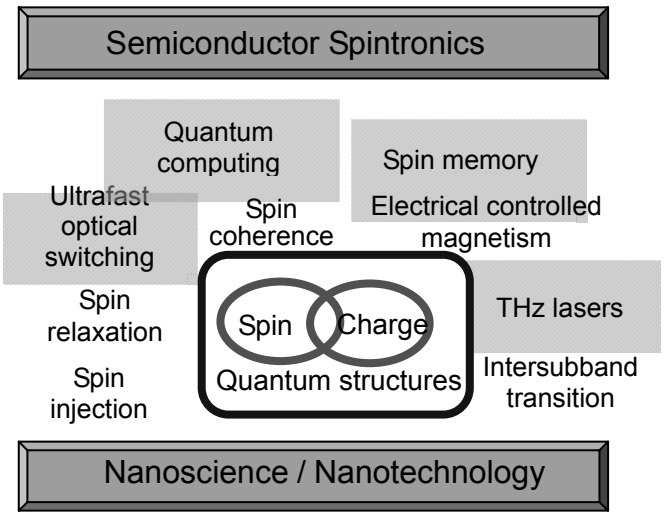
## Semiconductor Spintronics

# Nanoscience and Nanotechnology for Spintronics and THz Lasers

### [Research Target and Activities]

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

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




The outcomes in the last fiscal year are (1) Discovery of CoFeB/MgO interfacial magnetic anisotropy and its control by the application of electric-fields. (2) Fabrication of magnetic nano-dot ensemble from a (Ga,Mn)As thin layer by the application of electric field. (3) Establishment of the relationship between the magnitude of nuclear quadrupole interaction and spin phase relaxation time in nonmagnetic semiconductor quantum structures.

### [Staff]

Hideo Ohno, Professor
Yuzo Ohno, Associate Professor
Fumihiro Matsukura, Associate Professor
Keita Ohtani, Assistant Professor

### [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), and the 2005 Agilent Technologies Europhysics Prize. He is Institute of Physics (IOP) Fellow (2004), Honorable Professor at Institute of Semiconductors, Chinese Academy of Sciences, and JSAP fellow (2007), Distinguished Professor at Tohoku University (2008), and IEEE Magnetic Society Distinguished Lecturer for 2009. He is a member of JSAP, JPS, JACG, IEICE, APS, IOP, IEEE, and AVS.

### [Papers]

[1] M. Endo, S. Kanai, S. Ikeda, F. Matsukura, and H. Ohno, "Electric-field effects on thickness dependent magnetic anisotropy of sputtered MgO/$Co_{40}Fe_{40}B_{20}$/Ta structures," Applied Physics Letters, Vol. 96, 212503 (3 pages), May 2010.
[2] D. Chiba, F. Matsukura, and H. Ohno, "Electrically Defined Ferromagnetic Nanodots," Nano Letters, Vol. 10, 4505-4508, November 2010.
[3] H. Ohno, "A window on the future of spintronics," Nature Materials, Vol. 9, pp. 952-954, November 2010.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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]

Our research aims at application of semiconductor micro/nano-fabrication to semiconductor devices or many kinds of biosensors. We have investigated development of 1) a biomolecular sensing system using Si fabrication technologies and 2) a nanofabrication method using electrochemical processes such as anodization of valve metals.

1) Application of Titanium nanotubes to counter electrode for dye-sensitized solar cells (DSC)

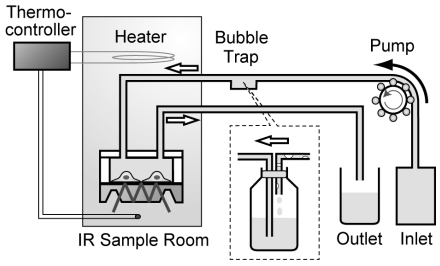
We have fabricated a porous titanium composite counter electrode for a DSC. The counter electrode increased the fill factor and short-circuit current, resulted in improvement of the performance of the DSC.

2) Characterization of Organic Field Effect Transistor (OFET)

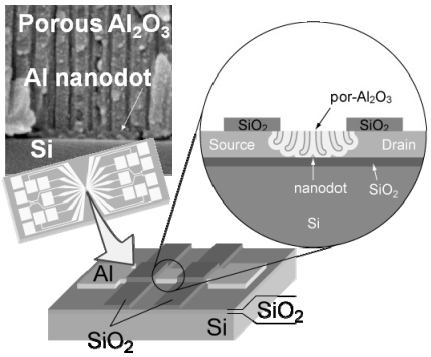
We have investigated the influence of carrier injection on the characteristics of an OFET using a rubrene single crystal.

3) In situ monitoring of ATP synthesis in mitochondria by surface infrared spectroscopy

A real-time and label free method for monitoring of ATP synthesis and hydrolysis in mitochondria has been developed.




Experimental system for *in situ* monitoring of cell activity by surface infrared spectroscopy




Nanodots formation by anodization and its application to a transistor

### [Staff]

Professor: Michio NIWANO, Dr.
Associate Professor: Yasuo KIMURA, Dr.
Assistant Professor: Yuki AONUMA, Dr.

### [Profile]

Michio NIWANO 1998 – present RIEC, Tohoku University, Japan, Professor, Doctorate of Science
Memberships: The Electrochemical Society (ECS), The Material Research Society (MRS), American Vacuum Society (AVS), The Japan Society of Applied Physics (JSAP)

Yasuo KIMURA 2010 – present RIEC, Tohoku University, Japan, Associate Professor, Ph. D. Eng.
Memberships: The Electrochemical Society (ECS), The Japan Society of Applied Physics (JSAP), The Surface Science Society of Japan

### [Papers]

[1] M. M. Rahman, R. Kojima, M. El Fassy Fihry, Y. Kimura and M. Niwano. "Formation of Porous Titanium Film and Its Application to Counter Electrode for Dye-Sensitized Solar Cell." Japanese Applied Physics Letter, Vol. 49, No. 12, (2010) 122302.

[2] Y. Kimura, T. Oba, T. Shimakura and M. Niwano. "Influence of Carrier Injection on Characteristics of an Organic Field Effect Transfer." Journal of the Surface Science Society of Japan, Vol. 32, No. 1 (2011) pp. 21-26.

[3] R. Yamaguchi, A.Hirano-Iwata, Y. Aonuma, Y. Yoshimura, Y. Kimura, Y. Shinohara and M. Niwano. "Real-time monitoring of mitochondrial adenosine 5'-triphosphate synthesis and hydrolysis by surface infrared spectroscopy." Applied Physics Letter, Vol. 98, No. 13 (2011) 133703.

## Nano-Spin Memory

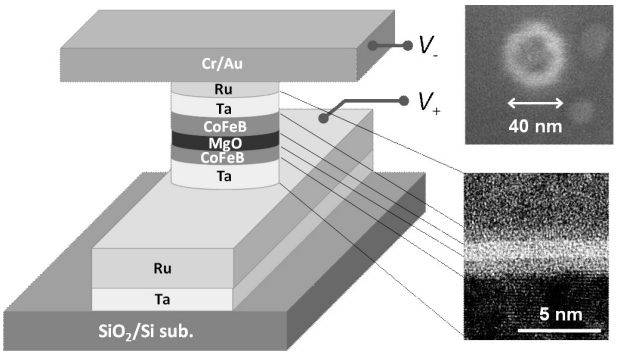
# Research of spin based device and memory

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 found that perpendicular magnetic anisotropy resulting from interfacial anisotropy between CoFeB and MgO is large enough to enable high-performance perpendicular anisotropy MTJs (p-MTJs) at reduced dimensions. The p-MTJs annealed at 350°C show a tunnel magnetoresistance (TMR) ratio > 120%, good thermal stability at dimensions as low as 40 nmϕ, and low $I_{c0}$ < 50 μA, all at the same time. This approach promises to become an essential building block for future spintronics-based nonvolatile VLSIs.




Schematic of perpendicular anisotropy CoFeB/MgO-based magnetic tunnel junction (MTJ).

2) By reducing the Pd layer thickness, we achieved a TMR ratio of 100% in the p-MTJs after 350°C annealing. The resulting solid solubility of B in the layer adjacent to CoFeB is the key factor for the high annealing stability.

### [Staff]

Associate Professor : Shoji IKEDA, Ph.D.
Research Fellow : Katsuya MIURA, Ph.D.
Research Fellow : Hiroki YAMAMOTO

### [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 and the APEX/JJAP Paper Award in 2009.

### [Papers]

[1] K. Mizunuma, S. Ikeda, H. Yamamoto, H. D. Gan, K. Miura, H. Hasegawa, J. Hayakawa, K. Ito, F. Matsukura, H. Ohno, "CoFeB Inserted Perpendicular Magnetic Tunnel Junctions with CoFe/Pd Multilayers for High Tunnel Magnetoresistance Ratio," Japanese Journal of Applied Physics, Vol.49, No. 4, 04DM04 (4 pages), April 2010.

[2] S. Ikeda, K. Miura, H. Yamamoto, K. Mizunuma, H. D. Gan, M. Endo, S. Kanai, J. Hayakawa, F. Matsukura and H. Ohno, "A perpendicular-anisotropy CoFeB–MgO magnetic tunnel junction ," Nature Materials, Vol. 9 No.9 pp.721-724, September 2010

[3] K. Mizunuma, M. Yamanouchi, S. Ikeda, H. Sato, H. Yamamoto, H. D. Gan, K. Miura, J. Hayakawa, F. Matsukura, and H. Ohno, "Pd Layer Thickness Dependence of Tunnel Magnetoresistance Properties in CoFeB/MgO-Based Magnetic Tunnel Junctions with Perpendicular Anisotropy CoFe/Pd Multilayers," Applied Physics Express, Vol. 4, No. 2, 023002 (3pages), February 2011.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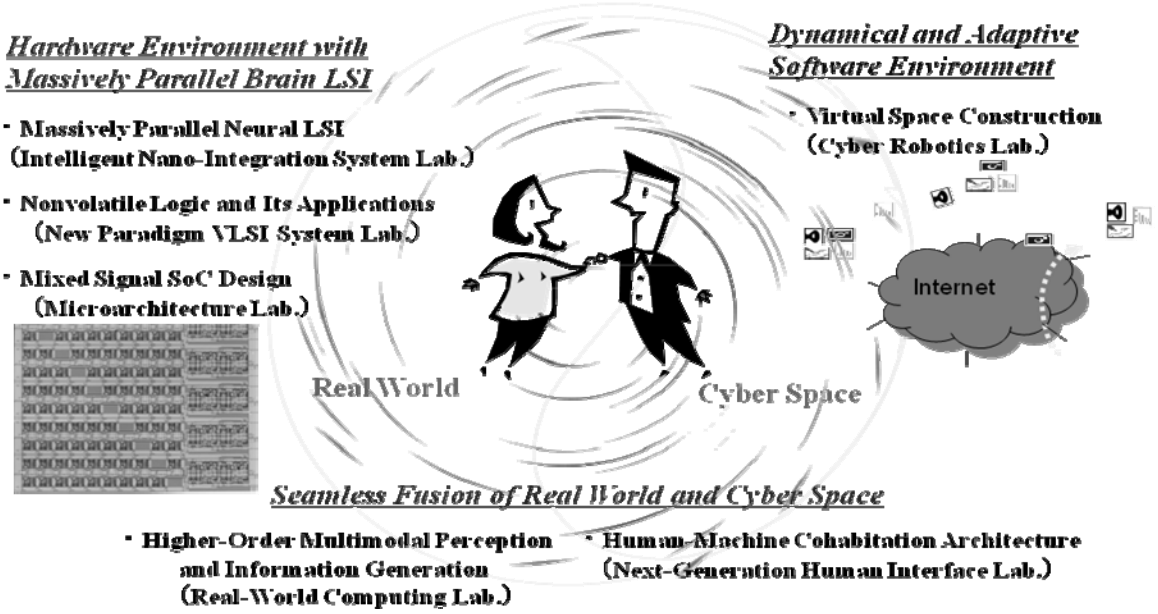
## Laboratory for Brainware Systems

# Research Targets and Activities of Laboratory for Brainware Systems

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

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

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




### [Research Target]

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

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

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

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

**[Research Activities]**

Real-World Computing Section (Yano Laboratory): We obtained the following two main results. In natural scenes, objects are often partially occluded. Nonetheless, our visual system can readily complete an object shape from available information and perceive it as a whole, a process known as amodal completion. Although implementation of this completion process is an important issue, visual computation for completion, based on both the local continuity of contours and on global regularities, such as symmetry, has received little attention. We showed a novel neurocomputational model based on recent physiological findings, in particular those in visual area V4. The model enables amodal completion through the evaluation of a global constellation of features describing a shape's contours. Complex behavior of animal is organized by complex neuronal networks in the brain. Recent theoretical studies suggest that such networks can exhibit many dynamical states, and have a capability to switch from one state to another. Increase in fluctuations of available measures in many complex systems serve as symptoms for such state transitions. We analyzed the firing variability of the prefrontal neurons of monkeys, and revealed that it was enhanced right before the neurons showed a switching of neuronal coding for behavioral goals.

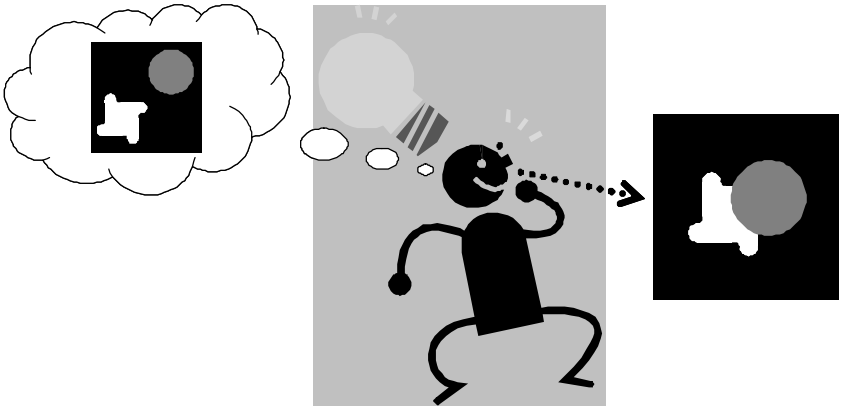
New Paradigm VLSI System Section (Hanyu Laboratory): As this-year research results in nonvolatile-logic area, we have succeeded the chip fabrication of MTJ (Magnetic Tunnel Junction)-based typical logic components, such as a nonvolatile LUT (look-up table) circuit chip with PVT-variation resilience and a nonvolatile binary bit-serial CAM cell array chip with a 1T-1MTJ structure. We have also developed a highly reliable link for asynchronous Network-on-Chip (NoC), which enables open-fault detection, link recovery and QDI with less energy and less wire counts in comparison with those of a conventional approach.

Intelligent Nano-Integration System Section (Nakajima-Sato Laboratory): (1) We have analyzed behavior of a connected neural system by using a new concept virtual particle dynamics, and we have designed and measured a hardware neuro-system based on this concept. Furthermore, we have proposed a stochastic logic neuron for an inverse function delayed model with high-order synapse connections, and we have discussed the possibilities of it. (2) We measured switching current distributions of stacked Nb/AlOx/Nb Josephson junctions, and studied the experimental technique for evaluating coupling strength between Josephson junctions from switching current distributions. It has been confirmed that large difference is found between samples with and without capacitive couplings, and the crossover temperature region between quantum and classical regions becomes large in comparison with a conventional theory. (3) We designed an 8-bit parallel multiplier for the large scale superconducting digital signal processor. The operation of the designed multiplier up to 40GHz was confirmed by the numerical simulation. The estimated power dissipation was 6.33mW. A neural network using superconducting quantum interference devices for solving N-Queens problem was designed and numerically demonstrated.

Microarchitecture Section (Masui Laboratory): We have been investigating architecture and circuit techniques for low-power and low-cost CMOS transceiver ICs applicable to wireless sensor network, and high-speed A/D converter applicable to vision sensing. We have been explored a low-power fractional-N PLL synthesizer design with a proposed self-dithering scheme, which can minimize the fractional spurious without hardware overhead, and a high-speed setup circuit supported by CMOS-compatible nonvolatile memory. In terms of design productivity enhancements, we have established a $g_m/I_D$ lookup table design methodology for low-power OTAs (operational transconductance amplifier), and have successfully implemented a low-power bandpass filter with an active gm-RC architecture to reduce the power consumption from 23.5mW to 2.7mW.

## Real-world computing

### Toward principles for adaptation in indefinite real-world ~Studies on flexible information processing in the brain and body~



Koji NAKAJIMA Professor

**[Research Target and Activities]**

It is unclear how biological systems behave adaptively in the real world, even though the environment is inherently indefinite and unpredictable. To clarify the adaptive mechanism underlying the brain, we study it in various fields including vision, audition, motor control and memory.

We made progresses in two directions as follows in 2010.

In natural scenes, objects are often partially occluded. Nonetheless, our visual system can readily complete an object shape from available information and perceive it as a whole, a process known as amodal completion. Although implementation of this completion process is an important issue, visual computation for completion, based on both the local continuity of contours and on global regularities, such as symmetry, has received little attention. We showed a novel neurocomputational model based on recent physiological findings, in particular those in visual area V4. The model enables amodal completion through the evaluation of a global constellation of features describing a shape's contours.

Complex behavior of animal is organized by complex neuronal networks in the brain. Recent theoretical studies suggest that such networks can exhibit many dynamical states, and have a capability to switch from one state to another. Increase in fluctuations of available measures in many complex systems serve as symptoms for such state transitions. We analyzed the firing variability of the prefrontal neurons of monkeys, and revealed that it was enhanced right before the neurons showed a switching of neuronal coding for behavioral goals.

**[Staff]**

Professor: Koji NAKAJIMA, Dr.
Assistant professor: Yoshinari MAKINO, Dr., Kazuhiro SAKAMOTO, Dr.

**[Profile]**

**[Papers]**

[1] K. Sakamoto, T. Kumada and M. Yano, "A computational model that enables global amodal completion based on V4 neurons," ICONIP 2010, Part I, LNCS (Lecture Notes in Computer Science), Vol. 6443, pp. 9-16, 2010
[2] K. Sakamoto, T. Kumada and M. Yano, "A neurocomputational model for amodal completion in ambiguous figures," Neurosci. Res., Vol. 68, sppl1, p. e217, 2010
[3] Y. Katori, K. Sakamoto, H. Mushiake, K. Aihara, "Representational transition in a multi-stable attractor model of the prefrontal cortex," J. Phyisiol. Sci., Vol. 60 sppl1 p. S64, 2010

## Intelligent Nano-Integration System

# Basic Technology of Integrated System for Intelligent Processing

Intelligent Nano-Integration System, Koji NAKAJIMA, Professor
Integrated Superconducting Quantum System, Shigeo SATO, Associate 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 have presented an FFT and a neural system operated by using a flux quantum logic in superconducting integrated circuits. At present research is focused on the large scale integration of Brain computing system and exploitations of new neural devices proposing a neuromorphic quantum computation.

Research Activities in 2010 : (1) We have analyzed behavior of a connected neural system by using a new concept virtual particle dynamics, and we have designed and measured a hardware neuro-system based on this concept. Furthermore, we have proposed a stochastic logic neuron for an inverse function delayed model with high-order synapse connections, and we have discussed the possibilities of it.

(2) We measured switching current distributions of stacked Nb/AlOx/Nb Josephson junctions, and studied the experimental technique for evaluating coupling strength between Josephson junctions from switching current distributions. It has been confirmed that large difference is found between samples with and without capacitive couplings, and the crossover temperature region between quantum and classical regions becomes large in comparison with a conventional theory.

(3) We designed an 8-bit parallel multiplier for the large scale superconducting digital signal processor. The operation of the designed multiplier up to 40GHz was confirmed by the numerical simulation. The estimated power dissipation was 6.33mW. A neural network using superconducting quantum interference devices for solving N-Queens problem was designed and numerically demonstrated.

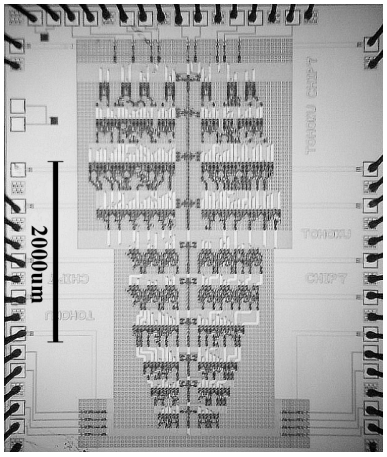



Figure A 4-bit parallel multiplier using SFQ logic

### [Staff]

Professor : Koji NAKAJIMA, Dr. Associate Professor : Shigeo SATO, 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.

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 an associate professor.

### [Papers]

[1] S. Sato, A. Ono, M. Kinjo, and K. Nakajima, "Performance of Adiabatic Quantum Computation using Neuron-like Interconnections," Proc. 2010 Int. Symp. Nonlinear Theory and its Applications, pp. 39-42, Sep. 2010.

[2] T. Sota, Y. Hayakawa, S. Sato, and K. Nakajima, "Discrete Higher Order Inverse Function Delayed Network," Proc. 2010 Int. Symp. Nonlinear Theory and its Applications, pp. 615-618, Sep. 2010.

[3] R. Nakamoto, S. Sakuraba, T. Onomi, A. Martins, S. Sato, and K. Nakajima, "High Throughput Parallel Arithmetic Circuits for Fast Fourier Transform," IEICE Trans. Electron., vol.E94-C, pp.280-287, Mar. 2011.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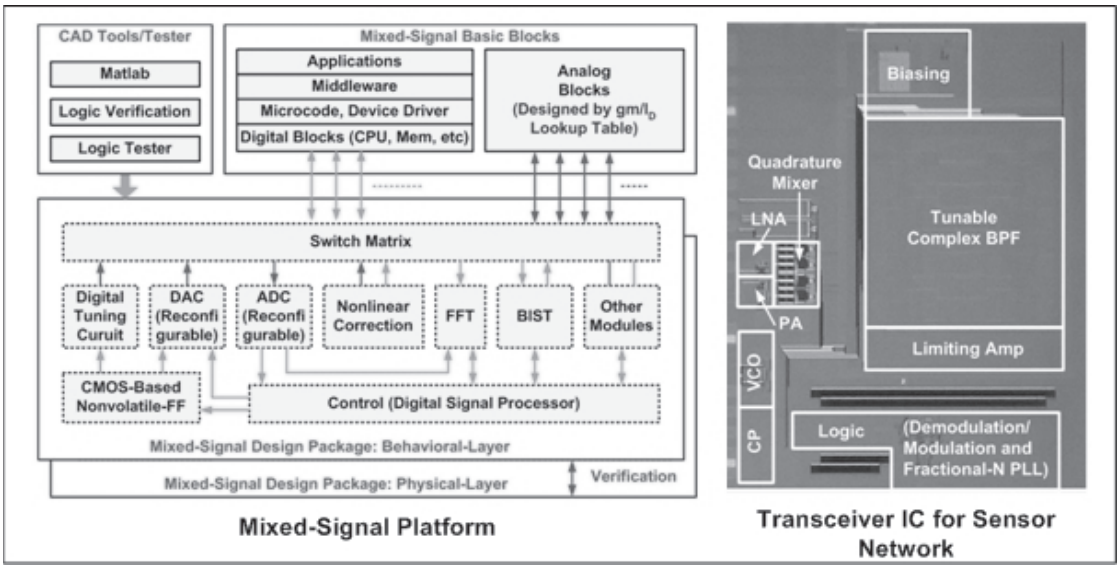
## Microarchitecture Laboratory

# Mixed-Signal Platform Design

Microarchitecture Shoichi MASUI, Professor

### [Research Target and Activities]




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

### [Staff]

Professor: Shoichi MASUI, Dr.

Visiting Associate Professor: Takana KAHO, Dr., Research Fellow: Illani Mohd NAWI

### [Profile]

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

### [Papers]

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

[2] S. Masui, et al., “Ferroelectric Memory Based Secure Dynamically Programmable Gate Array”, IEEE J. of Solid-State Circuits, vol. 38, no. 5, pp. 715-725, 2003.

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

## New Paradigm VLSI System Research Group

# Realization of a New-Paradigm VLSI-Computing World

New Paradigm VLSI Computing: Takahiro HANYU, Professor

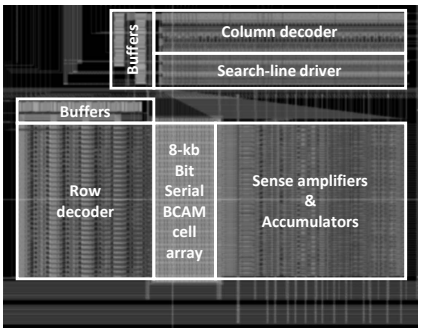



Fig.1: Nonvolatile binary bit-serial CAM cell array chip with a 1T-1MTJ structure

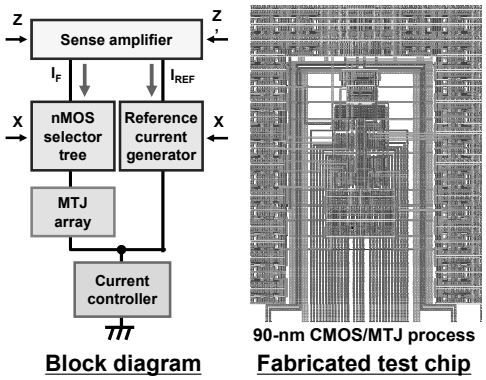



Fig.2: Nonvolatile look-up table circuit chip with PVT-variation resilience

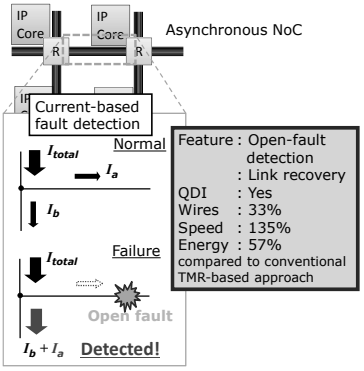



Fig.3: Highly reliable asynchronous transmission link.

### [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."

As this-year research results in nonvolatile-logic area, we have succeeded the chip fabrication of MTJ (Magnetic Tunnel Junction)-based typical logic components, such as a nonvolatile binary bit-serial CAM cell array chip (Fig.1) with a 1T-1MTJ structure and a nonvolatile LUT (look-up table) circuit chip (Fig.2) with PVT-variation resilience. We have also developed a highly reliable link for asynchronous Network-on-Chip (NoC) (Fig.3), which enables open-fault detection, link recovery and QDI with less energy and less wire counts in comparison with those of a conventional approach.

### [Staff]

Professor: Takahiro HANYU, Dr.
Assistant Professor: Atsushi MATSUMOTO, Dr.
Assistant Professor: Masanori NATSUI, Dr.
Research Fellow: 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 nonvolatile logic and its application to high-performance and low-power SoCs.

### [Papers]

[1] S. Matsunaga, M. Natsui, K. Hiyama, T. Endoh, H. Ohno and T. Hanyu, "Fine-Grained Power-Gating Scheme of a Metal-Oxide-Semiconductor and Magnetic-Tunnel-Junction-Hybrid Bit-Serial Ternary Content-Addressable Memory," Japanese Journal of Applied Physics, Vol.49, No.2, 04DM05-1--04DM05-5, 2010.
[2] N. Onizawa, T. Hanyu, "Highly Reliable Multiple-Valued One-Phase Signaling for an Asynchronous On-Chip Communication Link," IEICE Trans. on Information and Systems, Vol.E93-D, No.8, pp.2089-2099, 2010.
[3] N. Onizawa, A. Matsumoto, and T. Hanyu, "Interconnect-Fault-Resilient Delay-Insensitive Asynchronous Communication Link Based on Current-Flow Monitoring," Design, Automation & Test in Europe (DATE'11), 2011.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## IT-21 center

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

### [Research Target and Activities]

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

### 1. Development of Dependable Wireless System and Devices

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

### 2. Development of Low Power Consumption Mass Storage HDD Systems

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

### [Staff]

Director: 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)

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

## IT21 Center Mobile Wireless Technology Group

# For Realizing Dependable Air

Kazuo TSUBOUCHI, Visiting Professor (Project Leader)
Tadashi TAKAGI, Visiting 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 Si-CMOS technology.
2. Digitally Assisted Compensation Technology: We have developed a novel frequency domain equalizer (FDE) technology implemented to an application specific integrated circuit (ASIC). We have demonstrated a transmission test under multipass fading environments. Due to the FDE, we have realized to improve bit error rate (BER) characteristics. Conventionally, FDE technology has been evaluated by simulation. Here, we have been able to realize it by experiment.
3. Adaptive and Scalable ADC/DAC (Analog-to-Digital Converter/ Digital-to-Analog Converter): We have devised a current mode pipeline ADC, which is suitable for process miniaturization and low supply voltage. We have designed several core circuits of the ADC and have realized static characteristics.

### [Staff]

Visiting Professor: Kazuo TSUBOUCHI, Ph.D (since 2010)
Visiting Professor: Tadashi TAKAGI, Ph.D (since 2010)

### [Profile]

Kazuo TSUBOUCHI Prof. Tsubouchi received the Ph.D. degree in Electronics Engineering from Nagoya University in 1974. In 1974, he joined the Research Institute of Electrical Communication, Tohoku University. In 1982, he spent at Purdue University as a Visiting Associate Professor. From 1993 to 2010, he has been a professor of RIEC, Tohoku University. From 2002 to 2010, he has been the director of IT-21 Center. He is currently a visiting professor. He received the 2005 Achievement Award from the IEICE, and "Minister of Education, Culture, Sports, Science and Technology, Award" in the Award for Persons of Merit in Industry-Academia-Government Collaboration in FY2007, et al. He is a member of the IEEE, the IEICE, the Physical Society of Japan, the Japan Society of Applied Physics, and the Institute of Electrical Engineers of Japan.

Tadashi TAKAGI Prof. Takagi received the B.S. degree in physics from Tokyo Institute of Technology, Tokyo, Japan and Ph.D. degree in electronic engineering from Shizuoka University, Shizuoka, Japan, in 1973 and 1995, respectively. In 1973, he joined the Mitsubishi Electric Corporation, where he was engaged in development on microwave and millimeter-wave circuits technology. From 2005 to 2010, he has been a professor of IT-21, Tohoku University. He is currently a visiting professor. He is a senior member of the IEEE and a member of IEICE of Japan.

### [Papers]

[1] S. Kameda, H. Oguma, N. Izuka, Y. Asano, Y. Yamazaki, T. Takagi, K. Tsubouchi, "Issue of IEEE 802.20 Vehicular-A Delay Profile Model on Estimating Received Signal Level Variation of Wideband Signal," 4th European Conference on Antennas and Propagation, EuCAP 2010, Mo-55, April 2010.
[2] H. Oguma, S. Kameda. N. Izuka, Y. Asano, Y. Yamazaki, T. Takagi, K. Tsubouchi, "Coverage Estimation of Uplink 16 QAM Signal up to 20 MHz Bandwidth Based on Field Trial Results of FH-OFDMA System," IEEE Wireless Communications and Networking Conference 2010 (WCNC2010), Sydney, Australia, April 2010.
[3] T. T. Ta, S. Kameda, T. Takagi, K. Tsubouchi, "A 5 GHz Band Low Noise and Wide Tuning Range Si-CMOS VCO with a Novel Varactors Pair Circuit," IEICE Trans. on Electronics, Vol.E93-C, No.6, pp.755-762, June 2010.


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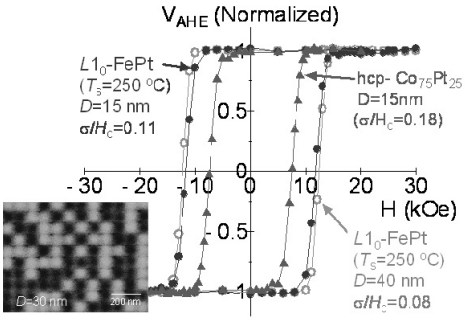
**IT-21 center, Technology Development Division, Storage Technology Group**

# Development of low power consumption mass storage HDD systems

Kazuhisa FUJIMOTO, Professor
Takehito SHIMATSU, Associate Professor

## [Research Target and Activities]

A new project ;Development of super high-speed mass storage HDD systems started in August 2007 under the collaborations between RIEC including IT21 storage technology group and major Japanese HDD manufacturers. The goals of this project are to develop the perpendicular recording technologies in the order of Tbits/inch$^2$ recording density and, to develop the system architecture for realizing large capacity, high performance and low power consumption storage systems. Last year, we fabricated bit-patterned media samples consisted of hard/soft-stacked dot arrays, and the write margin of synchronous recording was evaluated using a static tester. Our results indicated that a reduction of the large margin loss arising from the multi-domain dots and a resultant improvement in the write error rate is expected when the recording dots become smaller than 30 nm. Moreover, we succeeded in fabricating $L1_0$-type FePt ordered alloy perpendicular films at low substrate temperatures of 200–350 °C, and demonstrated the potential of the films for use in data storage applications. In the development of high performance and low power consumption storage systems, we studied the algorithm for the power-aware data allocation method to get higher data transfer rate with scale-out of storage nodes. We have proposed the improved algorithm to alleviate degradation of data transfer rate due to file-access skew.




AHE curves and MFM image for the dot arrays of $L1_0$-FePt alloy films.

## [Staff]

Professor: FUJIMOTO Kazuhisa Dr., Visiting Professor: AOI Hajime Dr., Associate Professor: SHIMATSU Takehito Dr., Visiting Associate Professor: YAMAKAWA Kiyoshi Dr., Visiting Researchers: OGAWA Susumu Dr., SAGA Hideki, YAMADA Masaki Dr., AKAIKE Hirotoshi, OSAWA Yuichi Dr., KATAOKA Hiroyasu, INOUE Daisuke, KUDO Koji, NAKATA Hitoshi Dr., OBA Kenji, MATSUSHITA Koji, Technical Assistant: UOMOTO Miyuki, Secretaries: SATO Ayumi, ANAZAWA Tomomi

## [Profile]

Kazuhisa FUJIMOTO received the Dr. of Engineering degree from Kyushu University in 1997. He joined Central Research Laboratory, Hitachi, Ltd., in 1987. He joined RIEC, Tohoku University in 2007. He has been engaged in research on storage system architectures.
Takehito SHIMATSU received the Dr. of Engineering degree from Tohoku University. He joined RIEC in 1998. He has been engaged in research on magnetic materials and storage devices.

## [Papers]

[1] H. Akaike, K. Fujimoto, K. Miura, and H. Muraoka, “Performance evaluation of energy-efficient high-speed tiered-storage system,” Proceedings of INDIN 2010, 663-670 (2010).
[2] T. Shimatsu, Y. Inaba, H. Kataoka, J. Sayama, H. Aoi, S. Okamoto, and O. Kitakami, “Dot arrays of $L1_0$ type FePt ordered alloy perpendicular films fabricated using low-temperature sputter film deposition,” *Journal of Applied Physics*, vol. 109, 07B726(1-3) (2011).
[3] H. Saga, K. Shirahata, K. Mitsuzuka, T. Shimatsu, H. Aoi, and H. Muraoka, “Experimental write margin analysis of bit patterned media,” *Journal of Applied Physics*, vol. 109, 07B721(1-3) (2011).

## Management Office for Health and Safety

# 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 Health and Safety

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

### 2. Activities by the Management Office for Health and Safety

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

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

### [Staff]

Manager: Michio NIWANO, Professor

Deputy Manager: Yoichi UEHARA, Professor

Nobuyuki SATO, Assistant Professor

Ayako CHIBA, Clerk


Contact to anzen@riec.tohoku.ac.jp

## Flexible Information System Research Center

# Development of Flexible Information Systems and Management of Network

### [Research Target and Activities]

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

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

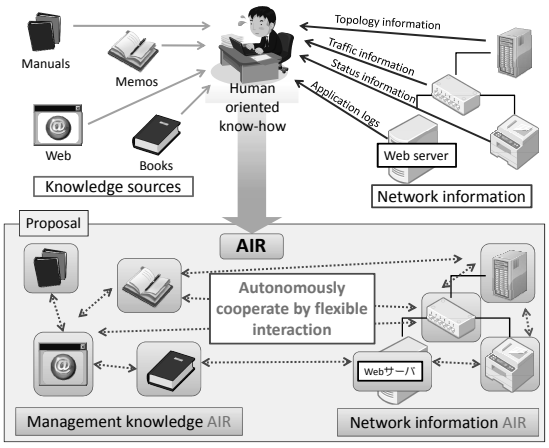



**Fig.1 Knowledge based Network Management System.**

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

### [Staff]

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

### [Profile]

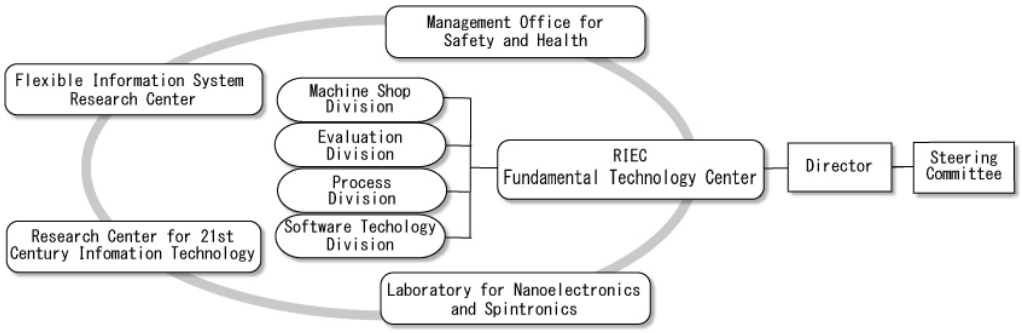
Refer to the Advanced Acoustic Information Systems Laboratory for the profile Prof. Yôiti Suzuki.
Refer to the Computing Information Theory Laboratory for the profile Prof. Yoshihito Toyama.

### [Papers]

1. K. Hashimoto, G. Kitagata, H. Takahashi, A. Takeda, D. Chakraborty and N. Shiratori, "Socio-familiar Personalized Service and its Application –Towards a New Network Software for Next Generation Ubiquitous Service-", Proc. of the 10th International Symposium on Autonomous Decentralized Systems (ISAD2011), 2011. **(Invited)**, (to be published)
2. K. Sasai, N. Tanji, Y. Takahashi, G. Kitagata, T. Kinoshita, "An Architecture of Extended Network Management System: Autonomous Cooperation between Knowledge Resource and Network Equipments", Proc. of IEEE/ACIS 9th International Conference on Computer and Information Science (ICIS2010), pp. 617-622, 2010.
3. Akira Sakatoku, Akifumi Kawato, Toshiaki Osada, Gen Kitagata, Norio Shiratori, Tetsuo Kinoshita, "3D Symbiotic Environment for Agent-aided Collaborative Work", Journal of Internet Technology, 2011. (to be published)

## 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 research support, closely linked with research activities at the institute, through the following four divisions, machine shop, evaluation, process, and software technology. One of the important missions of the university is to accumulate novel knowledge and to create advanced technology, and to return them to society continuously. On this philosophy, this center is operated with the intention of not only advancing skills of each staff but also transferring them to the next generation.

**1. Machine Shop Division**

The Machine Shop Division has being pioneering a number of new machining methods and contributing to research and development with the advanced techniques. In this year, there were 162 fabrication requests, in which 153 was in house.

**2. Evaluation Division**

The evaluation division provides various evaluation and measurement apparatuses for shared usage. In this year, 17 laboratories utilized them and the utilization time was 3462 hours in total. Glass machining and supply of liquid helium and nitrogen are also covered by this division. There were eight requests for the Glass machining. 3400 litters of liquid nitrogen were supplied.

**3. Process Division**

The processing division is, in cooperation with the evaluation division, responsible for operating and maintaining the project clean room (PCR), a clean room for shared usage. Various apparatuses for processing are also equipped in the clean room. The clean room was utilized by 10 laboratories. Customized optical filters for the visible and infrared spectral range were supplied to three laboratories. A nanometer-scale electron beam lithography service has been prepared.

**4. Software Technology Division**

The Software Technology Division operated and maintained, in cooperation with Flexible Information System Research Center, the computer networks in the institute.

**[Staff]**

Director (Professor): Yoichi UEHARA

Assistant Professor: Nobuyuki SATO

Technical Official: Fumitaka SAITO, Katsumi SAGAE, Koichi SHOJI, Tamotsu SUENAGA, Ryutaro SASAKI, Maho ABE, Keisuke SATO, Kento ABE, Hiroshi WATANABE, Munetomo SUGAWARA, Ryuji YONEZAWA, Yuji KONNO, Sadao TSUCHIDA, Choichi TAKYU, Shigeto AGATSUMA

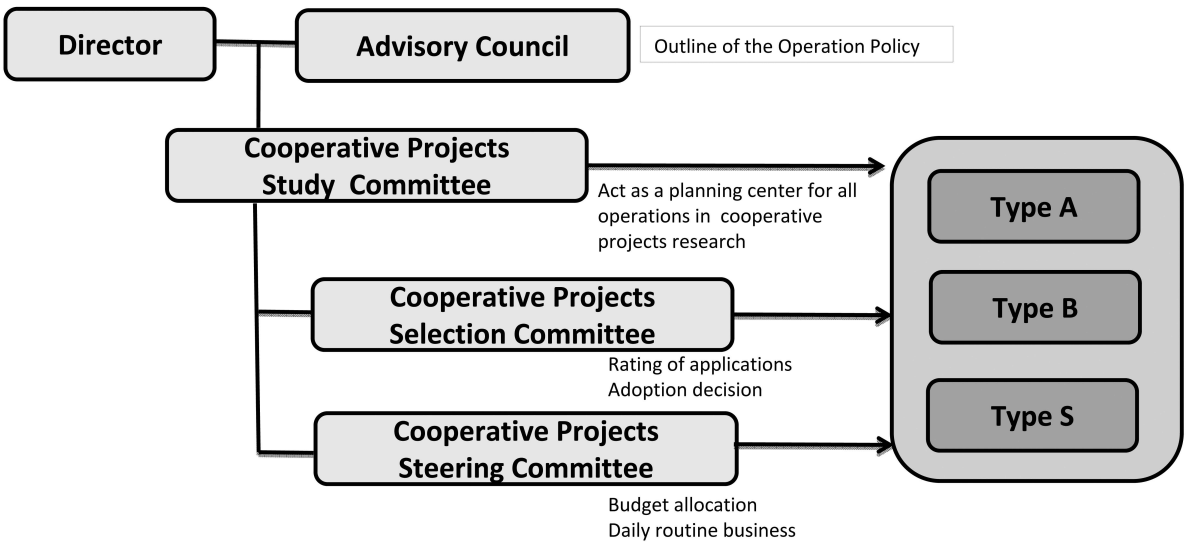
# 4. Nation-wide Cooperative Research Projects

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

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

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

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



# Nation-wide cooperative research projects list 2010

| Project Number<br>Research Project Theme | Project Leader | Facilitator in RIEC |
|---|---|---|
| H20／A01<br>Basic Studies in Plasma Nanobiotronics | **Rikizo HATAKEYAMA**<br>School of Engineering Tohoku University | **Michio NIWANO** |
| H20／A03<br>Investigation of interface trap density for an MIS structure using ECR sputter-deposited high-k gate-oxides | **Toshiro ONO**<br>Graduate School of Science and Technology Hirosaki University | **Junichi MUROTA** |
| H20／A04<br>Three-DimensionalNanostructure Formation of Strain-Controlled Group-IV Semiconductors and Its Device Application | **Junichi MUROTA**<br>Research Institute of Electrical Communication, Tohoku University | **Junichi MUROTA** |
| H20／A05<br>Fabrication of high mobility two-dimensional hole gas | **Seigo TARUCHA**<br>School of Engineering The University of Tokyo | **Yuzo OHNO** |
| H20／A06<br>Implementation of intelligent nano-integrated system and its application | **Yoshihiro HAYAKAWA**<br>Sendai National College of Technology | **Koji NAKAJIMA** |
| H20／A07<br>A research on organic heterojunction photovoltaic devices | **Fumihiko HIROSE**<br>Yamagata University Graduate School of Science and Engineering | **Michio NIWANO** |
| H20／A08<br>Development of Ion-Channel Chips | **Masao SUGAWARA**<br>Nihon University College of Humanities and Sciences | **Michio NIWANO** |
| H20／A09<br>Study of human visual stability during eye movements | **Masayuki SATO**<br>Faculty of Environmental Engineering, Kitakyushu University | **Satoshi SHIOIRI** |

| Project Number<br>Research Project Theme | Project Leader | Facilitator in RIEC |
|---|---|---|
| H20／A10<br>Learning effects of sound localization in the binaural technology | **Kenji OZAWA**<br>University of Yamanashi, Interdisciplinary Graduate School of Medicine and Engineering | **Yôiti SUZUKI** |
| H20／A11<br>Cell-based chips using infrared spectroscopy | **Yasuo SHINOHARA**<br>Institute for Genome Research, The University of Tokushima | **Michio NIWANO** |
| H20／A13<br>Study of magnetic devices with application of the thin film element with inclined stripe magnetic domain | **Tomoo NAKAI**<br>Industrial Technology Institute, Miyagi Prefectural Government | **Kazushi ISHIYAMA** |
| H20／A14<br>A study on advanced video content retrieval technology | **Terumasa AOKI**<br>Research Institute of Electrical Communication, Tohoku University | **Terumasa AOKI** |
| H21／A01<br>Superconducting Computer Technology toward Reduction of Environmental Burden | **Yoshinao MIZUGAKI**<br>The University of Electro-Communications | **Shigeo SATO** |
| H21／A02<br>Nanophotonics and Nanoelectronics Devices with Metallic Nanomaterials | **Kaoru TAMADA**<br>Research Institute of Electrical Communication Tohoku University | **Kaoru TAMADA** |
| H21／A04<br>Evaluation of Piezoelectric Langasite Family Compounds by the Ultrasonic Microspectroscopy and Piezoelectric Resonant-Antiresonant Frequencies Measurement Methods and their Applications to High-Temperature Sensor | **Jun-ichi KUSHIBIKI**<br>School of Engineering Tohoku University | **Yasuo CHO** |
| H21／A05<br>Study on spintronic application of the oxide thin films with Magneto-Electric effect | **Seiji SAHASHI**<br>School of Engineering Tohoku University | **Kazushi ISHIYAMA** |
| H21／A06<br>STT microwave oscillation of self-organized multi-nano-pillar structure and its application | **Masaaki DOI**<br>School of Engineering Tohoku University | **Kazushi ISHIYAMA** |

| Project Number<br>Research Project Theme | Project Leader | Facilitator in RIEC |
|---|---|---|
| H21／A08<br>High performance THz wave sources based on resonant tunneling diode pairs | **Koichi MAESAWA**<br>Faculity of Engineering, University of Toyama | **Taiichi OTSUJI** |
| H21／A09<br>Development of measuring method for speech recognition performance under various sound field | **Hiroshi SATO**<br>National Institute of Advanced Industrial Science and Technology | **Yôiti SUZUKI** |
| H21／A10<br>A Study on Higher Realistic Communication in Three Dimensional Sound Space | **Kazuhiro KONDO**<br>Yamagata University Graduate School of Science and Engineering | **Yukio IWAYA** |
| H21／A11<br>The cooperative system to built a model of visual cognition | **Satoshi SHIOIRI**<br>Research Institute of Electrical Communication Tohoku University | **Satoshi SHIOIRI** |
| H21／A12<br>A study on STA(Scenario To Anime) technology | **Terumasa AOKI**<br>Research Institute of Electrical Communication Tohoku University | **Terumasa AOKI** |
| H21／A13<br>Creation of Platform for Sustainable Information Society by Sensor-Cloud Systems | **Osamu TAKAHASHI**<br>The School of Systems Information Science Future University-HAKODATE | **Takuo SUGANUMA** |
| H22／A01<br>Study on terahertz optoelectronic devices using graphene | **Victor RYZHII**<br>University of AIZU | **Taiichi OTSUJI** |
| H22／A02<br>Formation and Valency Control of Ge-based Quantum Dots and Their Application to Nanoscale Functional Memories | **Seiichi MIYAZAKI**<br>Nagoya University | **Junichi MUROTA** |
| H22／A03<br>Computational Materials Design and Device Applications of Magneto-electric and Magneto-elastic Effects | **Tatsuki ODA**<br>Kanazawa University College of Science and Engineering | **Masafumi SHIRAI** |

| Project Number<br>Research Project Theme | Project Leader | Facilitator in RIEC |
|---|---|---|
| H22／A04<br>Study on High-Efficiency Switching-Mode Power Amplifier with InGaAs HEMTs | **Yohtaro UMEDA**<br>**Tokyo University of Science** | **Tetsuya SUEMITSU** |
| H22／A05<br>Broadband light generation and detection using electron tunneling | **Yoichi UEHARA**<br>Research Institute of Electrical Communication Tohoku University | **Yoichi UEHARA** |
| H22／A06<br>Research of spintronics devices with negative spin-polarization materials | **Masakiyo TSUNODA**<br>School of Engineering Tohoku University | **Masafumi SHIRAI** |
| H22／A07<br>Chemical synthesis of pure Fe nanoparticle assembly with high saturation magnetization and its soft magnetic properties | **Migaku TAKAHASHI**<br>School of Engineering Tohoku University | **Kazushi ISHIYAMA** |
| H22／A08<br>Research on personal acoustic telepresence system | **Tatsuya HIRAHARA**<br>TOYAMA Prefectual University | **Yôiti SUZUKI** |
| H22／A09<br>Multimodal speech communication system based on human perceptual property | **Akihiro TANAKA**<br>Waseda Institute for Advanced Study | **Shuichi SAKAMOTO** |
| H22／A10<br>Effect of Natural Sound on Stress Response | **Shin FUKUDO**<br>Tohoku University School of Medical | **Yôiti SUZUKI** |
| H22／A11<br>Development of universal training system using acoustic virtual reality technique | **Makoto OH-UCHI**<br>Tohoku Fukushi University | **Yukio IWAYA** |
| H22／A12<br>Directivity control on frequency domain binaural model | **Yoshifumi CHISAKI**<br>KUMAMOTO University | **Yôiti SUZUKI** |
| H22／A13<br>Study of Brainware Systems | **Toshiyuki KANOH**<br>NEC Corporation | **Junji TADA** |

| Project Number<br>Research Project Theme | Project Leader | Facilitator in RIEC |
|---|---|---|
| H22／A14<br>Fundamental Study to Obtain Understanding on Working Network to Fully Make Use of the Knowledge | **Ryuji IGARASHI**<br>AKITA University | **Gen KITAGATA** |
| H22／A15<br>Establishment of User's Attention and Emotion Model for User-Adaptable Communication Technologies and Its Applications | **Atsumi IMAMIYA**<br>University of YAMANASHI | **Takuo SUGANUMA** |
| H22／A16<br>Advanced study on a real-world oriented computing application based on the symbiotic computing | **Shigeru FUJITA**<br>**Chiba Institute of Technology** | **Takuo SUGANUMA** |
| H20／B02<br>Development of high performance piezoelectric materials and application to information and communication devices | **Jun-ichi KUSHIBIKI**<br>School of Engineering Tohoku University | **Yasuo CHO** |
| H20／B03<br>Research on Ultra High Density Semiconductor Memories based on New Conceptual Material and Storage Principle | **Heiji WATANABE**<br>Graduate School of Engineering Osaka University | **Tetsuo ENDOH** |
| H20／B04<br>Research on Nano Semiconductor Materials and its Application to Nano Devices | **Kikuo YAMABE**<br>Graduate School of Pure and Applied Sciences University of Tsukuba | **Tetsuo ENDOH** |
| H20／B08<br>Advanced communication and measurement technologies using phase-controlled lightwaves | **Hidemi TSUCHIDA**<br>National Institute of Advanced Industrial Science and Technology | **Masataka NAKAZAWA** |
| H20／B09<br>Research on Next-Generation Peta-byte Information Storage | **Hiroaki MURAOKA**<br>Research Institute of Electrical Communication, Tohoku University | **Hiroaki MURAOKA** |
| H20／B10<br>Development of Dependable System Software with a Highly Reliable Programming Language System | **Kazuhiko KATO**<br>University of Tsukuba, Graduate School of Systems and Information Engineering | **Atsushi OHORI** |

| Project Number<br>Research Project Theme | Project Leader | Facilitator in RIEC |
|---|---|---|
| H21／B01<br>Fundamental characteristics and applications of innovative functional field generated by various plasma flow | **Akira ANDOH**<br>School of Engineering Tohoku University | **Maki SUEMITSU** |
| H21／B02<br>Elucidation and Control of Graphene Growth for its applications in the next generation devices | **Maki SUEMITSU**<br>Research Institute of Electrical Communication Tohoku University | **Maki SUEMITSU** |
| H21／B03<br>Small Power Wireless Communications | **Shuzo KATO**<br>Research Institute of Electrical Communication Tohoku University | **Shuzo KATO** |
| H21／B04<br>Complex Valued Neural Network for Real Applications | **Akira HIROSE**<br>School of Engineering The University of Tokyo | **Shigeo SATO** |
| H21／B05<br>Study on human performance with a view to designing human-friendly information systems | **Hirofumi YANAI**<br>College of Engineering. Ibaraki University | **Koji NAKAJIMA** |
| H21／B06<br>Toward an interdisciplinary approach of vision sciences | **Kenichiro TSUTSUI**<br>Tohoku University, Graduate School of Life Science | **Satoshi SHIOIRI** |
| H21／B07<br>Novel Bioelectronic Devices Based on Combination of Nano and Bio-technology | **Toshio OGINO**<br>Yokohama National University, Graduate School of Engineering | **Michio NIWANO** |
| H21／B08<br>Understanding of adaptive locomotion mechanism of biological system and its application to engineering | **Ko HOSODA**<br>Graduate School of Engineering Osaka University | **Satoshi SHIOIRI** |
| H21／B09<br>Evolution of high performance computing by non-volatile bits-operation technologies | **Hiroshi MATSUOKA**<br>Japan Atomic Energy Agency, Center for Computational Science & E-systems | **Takahiro HANYU** |

| Project Number<br>Research Project Theme | Project Leader | Facilitator in RIEC |
|---|---|---|
| H21／B10<br>Research on Next-Generation Models of Digital Content Distribution | **Isao ECHIZEN**<br>National Institute of Informatics | **Yôiti SUZUKI** |
| H21／B11<br>New Paradigm VLSI System and Its System Integration Technology | **Takahiro HANYU**<br>Research Institute of Electrical Communication Tohoku University | **Takahiro HANYU** |
| H22／B01<br>Development and applications of next-generation first-principles computational methods | **Kazunori SATO**<br>OSAKA University | **Masafumi SHIRAI** |
| H22／B02<br>Application and Basic Study of Fine Particle Plasmas | **Tetsu MIENO**<br>National University Corporation SHIZUOKA University | **Michio NIWANO** |
| H22／B03<br>Nano-structured magnetic materials and their application to MEMS | **Masaki NAKANO**<br>NAGASAKI University | **Kazushi ISHIYAMA** |
| H22／B04<br>Photonics for novel interface of bioinformation | **Jun-ichi SHIKATA**<br>Research Institute of Electrical Communication Tohoku University | **Jun-ichi SHIKATA** |
| H22／B05<br>New Principle Nano Devices Based on Nano-Scale Control of Fluctuation and Electron Correlations | **Kenji SHIRAISHI**<br>Center for Computational Sciences, TSUKUBA University | **Hideo OHNO** |
| H22／B06<br>Research of large-format quantum detector arrays with High-Q microwave superconducting resonators | **Toshiyuki MIYAZAKI**<br>RIKEN | **Shigeo SATO** |
| H22／B07<br>Challenge and Perspective for Millimeter Wave Applications | **Koji MIZUNO**<br>Research Institute of Electrical Communication Tohoku University | **Taiichi OTSUJI** |

| Project Number<br>Research Project Theme | Project Leader | Facilitator in RIEC |
|---|---|---|
| H22／B08<br>Investigation of Bio-inspired Information Theory and its Technological Application | **Daisuke URAGAMI**<br>Tokyo University of Technology | **Kazuto SASAI** |
| H22／B09<br>Study on visual information of material surface properties | **Katsunori OKAJIMA**<br>Yokohama National University | **Ichiro KURIKI** |
| H22／B10<br>Program Verification with Mathematical Logic | **Masahiko SATO**<br>KYOTO University | **Yoshihito TOYAMA** |
| H22／B11<br>Development and Application of Synthetic Aperture Radar System for Civilian Use | **Atsushi MASE**<br>Art, Science and technology Center for Cooperative Research, Kyushu University | **Hiroshi YASAKA** |
| H20／S 01<br>Development of essential technologies for superhivision | **Hidenori MIMURA**<br>Shizuoka University Research Institute of Electronics | **Yôiti SUZUKI** |
| H20／S 02<br>Spintronics Initiative Network | **Kouhei ITOH**<br>Keio University Science and Technology | **Hideo OHNO** |
| H21 ／ S 01<br>Information processing and communication system based on an innovative new concept associated with human functions | **Hidekazu TANAKA**<br>The Institute of Scientific and Industrial Research, Osaka University | **Masafumi SHIRAI** |

# 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 Tc Superconductors | Feb.23-25, 1997 |
| 2 | Design and Architecture of Information Processing Systems Based on The Brain Information Principle | Mar.16-18, 1998 |
| 3 | Novel Techniques and Applications of Millimeter-Waves | Dec.14-16, 1998 |
| 4 | The International Joint Conference on Silicon Epitaxy and Heterostructures | Sep.13-17, 1999 |
| 5 | International Workshop on Photonic and Electromagnetic Crystal Structures | Mar.8-10, 2000 |
| 6 | Physics and Application Spin Related Phenomena in Semiconductors | Sep.13-15, 2000 |
| 7 | Rewriting in Proof and Computation | Oct.25-27, 2001 |
| 8 | Nonlinear Theory and its Applications | Oct.28-Nov.1, 2001 |
| 9 | New Paradigm VLSI Computing | Dec.12-14, 2002 |
| 10 | Ultra High Density Spinic Storage System | Oct.23-24, 2003 |
| 11 | 3rd International Workshop on New Group IV (Si-Ge-C) Semiconductors | Oct.12-13, 2004 |
| 12 | 3rd International Workshop on High Freaqency Micromagnetic Devices and Materials (MMDM3) | Apr.11-12, 2005 |
| 13 | 4th International Conference on Silicon Epitaxy and Heterostructures (lCSl-4) | May.23-26, 2005 |
| 14 | 1st International WorkShop on New Group IV Semiconductor Nanoelectronics | May.27-28. 2005 |
| 15 | GSIS International Symposium on Information Sciences of New Era: Brain, Mind and Society | Sep.26-27, 2005 |
| 16 | The 1st RIEC International Workshop on Spintronics -Spin Transfer Phenomena- | Feb.8-9, 2006 |
| 17 | 4th International Workshop on High Frequency Micromagnetic Devices and Materials (MMDM4) | May 8,2006 |
| 18 | 4th International Conference on Physics and Applications of Spin-Related Phenomena in Semiconductors (PASPS-lV) | Aug.15-18,2006 |
| 19 | 2nd International Workshop on New Group IV Semiconductor Nanoelectronics | Oct.2-3,2006 |
| 20 | 2nd RIEC International Workshop on Spintronics | Feb.15-16,2007 |
| 21 | Japan-China Joint Conference on acoustics, JCA2007 | Jun.4-6,2007 |
| 22 | International Conference on Discovery Science/ International Conference on Algorithmic Learning Theory | Oct.1-4,2007 |

| | | |
|---|---|---|
| 23 | The 3rd RIEC International Workshop on Spintronics | Oct. 31-Nov.1,2007 |
| 24 | 3rd International Workshop on New Group 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 |

# 6. Study groups on Electrical Communication

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

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

| ***Electromagnetic and Optical Waves Engineering*** | |
|---|---|
| Chair | Prof. Fumiyuki ADACHI |
| Manager | Assistant Prof. Haris GACANIN |

| ***Acoustic Engineering*** | |
|---|---|
| Chair | Prof. Yôiti SUZUKI |
| Manager | Assistant Prof. Shuichi SAKAMOTO |

| ***Sendai "Plasma Forum"*** | |
|---|---|
| Chair | Prof. Rikizo HATAKEYAMA |
| Manager | Prof. Akira ANDO |

| ***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. Osamu ICHINOKURA |
| Manager | Associate Prof. Shin SAITO |
| Manager | Assistant Prof. Kenji MIURA |

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

| *Ultrasonic Electronics* | |
|---|---|
| Chair | Prof. Junichi KUSHIBIKI |
| Manager | Assistant Prof. Yuji OHASHI |

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

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

| *Biocybernetics and Bioinformatics* | |
|---|---|
| Chair | Prof. Satoshi SHIOIRI |
| Manager | Assistant Prof. Kazumichi MATSUMIYA |

| *Nanoelectronics and Spintronics* | |
|---|---|
| Chair | Prof. Junichi MUROTA |
| Manager | Associate Prof. Masao SAKURABA |

# 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)

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

| | |
|---|---|
| 1. | Higher-order and symbolic computation |
| 2. | International Journal of Energy, Information and Communications |
| 3. | International Journal of Artificial Intelligence, Neural Networks, and Complex Problem Solving technologies |
| 4. | International Journal of Computer Science and Network Security |
| 5. | International Journal of Information Sciences and Computer Engineering (IJISCE) |
| 6. | SICE Journal of Control, Measurement, and System Integration |
| 7. | Journal of Communications and Networks |
| 8. | Journal of Nanoscale Science and Technology |
| 9. | NPG Asia Materials |
| 10. | Journal of Magnetics (Korean Magnetics Society) |
| 11. | Journal of SPIN |

| | |
|---|---|
| 12. | Nature Communications |
| 13. | The Journal of Computer Animation and Virtual Worlds |
| 14. | Japanese Jpurnal of Applied Physics |
| 15. | Applied Acoustics) |
| 16. | Acoustical Science and Technology |
| 17. | Nonlinear Theory and Its Applications, ZEZCE |
| 18. | International Journal of Wireless Information Networks |
| 19. | Optical Fiber Technology |

**Recent International Conferences programmed by a staff in RIEC**:

| | |
|---|---|
| 1. | 3rd Semiconductor Technology for Ultra Large Scale Integrated Circuits and Thin Film Transistors (ULSIC vs. TFT) |
| 2. | 7th International Conference on Silicon Epitaxy and Heterostructures (ICSI-7) |
| 3. | Symp.E9: "ULSI Process Integration 7", 220th Meeting of the Electrochem. Soc |
| 4. | 2011 Conference on Lasers and electro-Optics (CLEO2011) |
| 5. | 16th OotoElectronics and Communications Conference (OECC2011) |
| 6. | 2010 Asia-Pacific Microwave Conference (APMC2010) |
| 7. | 6th International ICST Conference on Cognitive Radio |
| 8. | Oriented Wireless Networks and Communications (Crown Com 2011) |
| 9. | The 2010 IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology |
| 10. | International Conference on knowledge Engineering and Ontology Development 2010 |
| 11. | The 22nd International Conference Industrial & Engineering Applications of Artif. Intell. & Exp. Systems (IEA/AIE 2010) |
| 12. | The 5th International Conference on Ubiquitous Information Technologies & Applications (CUTE2010) |
| 13. | The 4th International Conference on Complex, Intelligent and Software Intensive Systems (CISIS 2010) |
| 14. | The 5th International Symposium on Adaptive Motion of Animals and Machines |
| 15. | SPIE International Conference on Defence, Security, and Sensing |
| 16. | Topical Workshop on Heterostructure Microelectronics (TWHM) |

| | |
|---|---|
| 17. | Asia- Pacific Workshop on Fundamentals and Applications of Advanced Semiconductor Devices (AWAD) |
| 18. | International Conference on Optical Terahertz Science and Technology (OTST) |
| 19. | 11th International Conference on Atomically Controlled Surfaces, Interfaces and Nanostructures (ACSIN) |
| 20. | 4th International Conference on Smart materials, Structures and Systems (CIMTC) |
| 21. | 16th International Conference on Solid Films and Surfaces (ICSFS) |
| 22. | European Solid-State Device Research Conference (ESSDERC) |
| 23. | SPIE Photonics West, Conference OE01 |
| 24. | IQEC/CLEO Pacific Rim, Program Subcommittee (Quantum Information and Cryptography) |
| 25. | 2011 Spintronics Workshop on LSI |
| 26. | 15th International Symposium on the Physics of Semiconductors and Applications (ISPSA-XV) |
| 27. | 6th International School and Conference on Spintronics and Quantum Information Technology (SPINTECH 6) |
| 28. | International Conference on Superlattices, Nanostructures, and Nanodevices (ICSNN) |
| 29. | International Conference of Magnetism (ICM) |
| 30. | Asia Pacific Vision Conference 2011 |
| 31. | International Multisensory Research Forum 2011 |
| 32. | 10th Asia Pacific Conference on Computer Human Interaction (APCHI) |
| 33. | 6th Annual ACM Conference on interactive Tabletops and Surfaces (ITS2011) |
| 34. | 6th Advances in Computer Entertainment Technology Conerence (ACE2010) |
| 35. | ACM Symposium on Virtual Reality Software and Technology (VRST) |
| 36. | IEEE Symposium on 3D User Interfaces (3DUI) |
| 37. | IEEE International Symposium on Multiple-Valued Logic |
| 38. | International Symposium on Low Power Electronics and Design |
| 39. | 6th International Symposium on Control of Semiconductor Interfaces (ISCSI-VI) |
| 40. | International Multisensory Research Forum (IMRF) 2011 |

| | |
|---|---|
| 41. | Inter-noise 2011 |
| 42. | International Symposium on Nonlinear Theory and its Applications |
| 43. | 6th International Workshop on Nanoscale Spectroscopy and Nanotechnology |
| 44. | Personal, Indoor and Mobile Radio Communications (PIMRC) |
| 45. | Global Symposium on Millimeter Waves (GSMM) 2012 |
| 46. | Magnetism and Magnetic Materials (MMM) |
| 47. | Intermag |
| 48. | European Conference on Optical Communication |

# 8. Periodicals Published by the Institute

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

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

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

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

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

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

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

# 9. Staff,Land and Buildings,Budget

## 1. Staff

(2011.7.1)

| Classification | Division | Laboratory for Nanoelectronics and Spintronics | Laboratory for Brainware sysystems | Research Center for 21st century Information Technology | Fundamental Technology Center | Administration Office | Total |
|---|---|---|---|---|---|---|---|
| Professors | 19 | 3 | 4 | 1 | | | 27 |
| Associate Professors | 13 | 5 | 1 | 1 | | | 20 |
| Assistant Professors | 18 | 3 | 6 | | | | 27 |
| Research Fellows | 13 | 4 | 2 | | | | 19 |
| Technical Officials | | | | | 15 | 2 | 17 |
| Administrative Officials | | | | | | 13 | 13 |
| Total | 63 | 15 | 13 | 2 | 15 | 15 | 123 |

## 2.Land and Buildings

Site: Katahira 2-1-1, Aoba-ku, Sendai 980-8577, Japan
Total building area: 12,913m²
Total floor area: 28,776m²

(2011.7.1)

| Name of Buildings | Structure | Year of Completion | Floor Area |
|---|---|---|---|
| Building No.1 | Reinforced Concrete, 4 floors | Building-S:1962,1963 | 7,772m² |
| | | Building-N:1959,1960 | |
| Building No.2 | Reinforced Concrete, 4 floors | 1962, 1963 | 7,085m² |
| Laboratory for Nanoelectronics and Spintronics | Steel-flame, 5 floors | 2004 | 7,375m² |
| Laboratory for Brainware sysystems | Reinforced Concrete, 1 floor | 1967, 1968, 1972 | 525m² |
| | Reinforced Concrete(partly steel-flame), 2 floors | 1986 | 1,553m² |
| | Steel-frame 1 floor | 1996 | 598m² |
| | Light-weight steel-frame, 2 floors | 1999 | 147m² |
| Research Center for 21st century Information Technology | Reinforced Concrete, 3 floors | 1930 | 1,343m² |
| | Steel-frame 1 floor | 2002 | 435m² |
| Evaluation and Analysis Center | Reinforced Concrete, 2 floors | 1981 | 790m² |
| Helium Sub-Center | Reinforced Concrete(partly light-weight steel-flame), 1 floor | 1972 | 166m² |
| Machine Shop | Reinforced Concrete(partly light-weight steel-flame), 1 floor | 1965, 1966, 1978 | 479m² |
| Others | | | 508m² |
| Total | | | 28,776m² |

## 3.Budget

(Unit:1,000yen)

| Financial Year | Personnel Expenditure | Supplies Expenditure | Research Grant | | | total |
|---|---|---|---|---|---|---|
| | | | Ministry of Education,Science and Culture | Partnership Between Universities and Industry | Leading-edge Research Promotion Fund | |
| 2006 | 971,482 | 927,090 | 599,040 | 937,441 | 0 | 3,435,053 |
| 2007 | 970,961 | 813,724 | 700,615 | 888,833 | 0 | 3,374,133 |
| 2008 | 879,481 | 953,000 | 694,883 | 1,069,832 | 0 | 3,597,196 |
| 2009 | 1,026,511 | 1,562,318 | 605,100 | 798,053 | 400,440 | 4,392,422 |
| 2010 | 777,776 | 735,496 | 418,680 | 962,712 | 1,034,827 | 3,929,491 |

# 10. Afterword

Although it has often been said that "we are only one national university affiliated research institute for a given subject in Japan," the expression "only one" does not sound very forceful. Because, from the start, university affiliated research institutes were established as organizations without overlapping research fields. It is not easy to become "number one" in a field where the competition includes both corporate research laboratories and those of national and private universities. However, against that backdrop, I believe that our key task as a university-affiliated research institute is to lay the foundation of the next-generation information industry, firmly rooted in the depth of knowledge that only a university can provide, while drawing on the strengths of our tradition and our culture.

From its early work with weak currents, RIEC first became a leader in the field of electromagnetic and electronic devices; we have since added software technologies, and today our integrated research covers the whole range from devices to software. Last year, the Director's discretionary expenses were used to establish a new Support Program for Original Research. This has the objective of promoting innovative and highly promising early-stage research capable of ensuring that RIEC will have a productive future; in particular, dynamic contributions are anticipated from younger scientists, such as assistant and associate professors. Each project receives funds amounting to 5 million yen annually for three years; thus, the program represents a decisive step by RIEC. In fiscal 2010, two researchers were chosen from a large number of applicants, and their interim reports are included for your perusal in these pages.

Another initiative we introduced last year is a series of research exchange meetings to improve contact among RIEC's nearly 30 laboratories. The series aims to overcome the compartmentalization of the four Research Divisions and the individual institutes and centers and thus to facilitate new approaches to research.

We would be delighted to receive feedback from readers of this Report. Perhaps the contents do not reflect our new direction as well as we hoped? Or perhaps you would like to suggest some interesting new line to pursue. All comments will be greatly appreciated, and I look forward to your continuing support and encouragement.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**Tohoku University**

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