Annual report of Research Institute of Electrical Communication 2007

Contents

1. Preface

The Research Institute of Electrical Communication (RIEC) has continued to excel as the only research institute affiliated with a national university that addresses information technology since its establishment in 1935. In 1994, our research institute became one of the National Centers for Cooperative research, addressing "theory and applications of intelligent information science and communication technology". In the last several decades Information science and communication technology have rapidly developed and brought about great social changes including globalization of communication and physical distribution.

To meet the needs and demands of a new age, in 2004 we reorganized our institute into four research divisions, two research facilities and one research center. Research center for 21st century information science and technology has established to realize the rapid commercialization of technologies developed at the institute within a 5years horizon. Two research facilities with 8 research groups working on next generation technology have been established with a 10 years horizon. The Laboratory Nanoelectronics and Spintronics, one of the facilities, is carrying out fundamental research into high-speed semiconductor devices and advanced nano/spin electronics. The Laboratory for Brainware Systems is working towards a new computing system, in which human-being functions are incorporated into information communication technology. The Four Research Divisions are working on basic research for information communication with a 20 years horizon. The Information Devices Division carries out research into materials and devices for communication technology, whilst the Broadband Engineering Division focuses on the development of new technologies for the transmission and storage of vast quantities of information. The human Information Systems Division researches into intelligent information processing and the Systems and Software Division is developing advanced system software for the next generation information society.

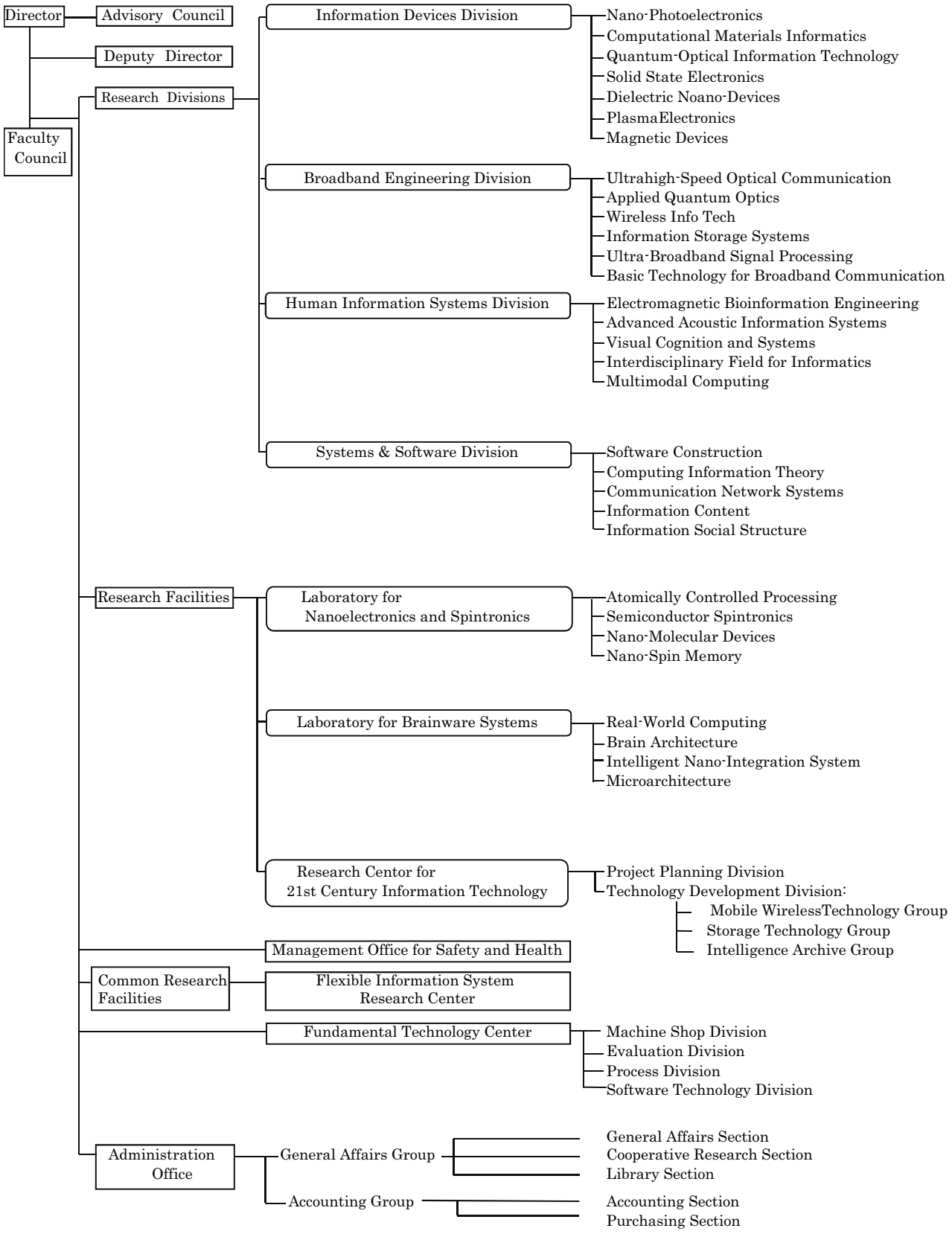
Nowadays there are a lot of discussions on restructuring the research and education systems in Japan. Even the national universities including affiliated institutes are not exceptions, then those should be discussed based on the academic freedom and the university autonomy, which are the wellsprings of creative power and innovation resulted in. RIEC has significantly contributed to the information and communication technologies as an innovation center since its establishment, in which it frequently took several decades to realize the commercialization of the innovative ideas/technologies developed at the institute. We intend to continue to work hard to ensure the progress of the information and communication technologies. In addition to research activities, we have a mission to train researchers and engineers to internationally high standard through close co-operation with the five departments in the fields of electrical communications at Tohoku University's School of Engineering and the Graduate School of Information Sciences.

We have published an annual report every year since 1994 summarized our own activities, and distribute it researchers working in the field of information sciences and technology. It is also utilized as self-checking and self-evaluation materials. Please let me hear your frank criticism.

Masafumi Yano

Director,Research Institute of Electrical Communication.

2. Organization Chart



3.RESEARCH ACTIVITIES

3．1 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 7 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. Computational Materials Informatics
3. Quantum-Optical Information Technology
4. Solid State Electronics
5. Dielectric Nano-Devices
6. Plasma Electronics
7. Magnetic Devices(Visitor Section)

The target and the summary of achievements of the each sub-division in 2007 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 spintronic.

Nanophotoelectronics

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

[Research Target and Activities]

Our main interest lies in studying the physical and chemical phenomena that take place in nanometer-scale regions and their applications in photoelectronic 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. We recently succeeded in determining the vibrational energies of each adsorbate from STM light emission spectra (we designated this method "STM light emission vibrational spectroscopy"). Since the light to be detected is usually very weak in STM light emission vibrational spectroscopy, it is desirable to improve the intensity level for measurements with good signal-to-noise ratio. This year, we tried to enhance STM light emission intensities using a tip made of Ag and/or Ag nanoparticles with diameters between 5 and 10 nm being adsorbed separately from each other on sample substrates. Consequently, the isotope shift of the vibrational energies of oxygen atoms adsorbed on Ni(110) and the phonon energies of graphite have been successfully determined from STM light emission spectra. We are also interested in adding ps temporal resolving power to this technique. In relation to this research topic, we have investigated temporal behaviors of laser-induced light emission from an evaporated Au film in the Kretschmann geometry. That is, the lifetime of emission by surface plasmon polaritons excited through a two-photon optical process was measured, and the origin of its unexpectedly long value was studied.

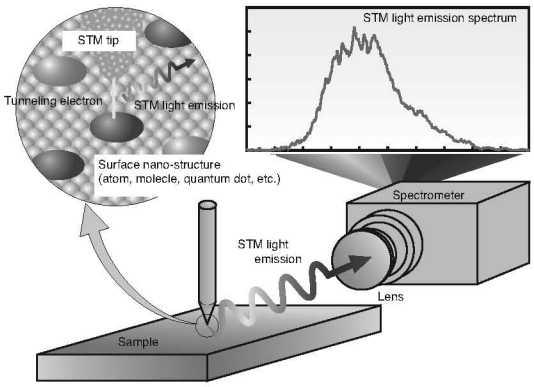


Fig. 1 STM light emission spectroscopy

[Staff]

Professor Y. Uehara
Assistant Professor S. Katano

[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 (MIM) and metal-oxide-semiconductor (MOS) tunnel junctions, (2) low-energy electron spectroscopy, and (3) light emission spectroscopy of scanning tunneling microscope (STM).

[Papers]

[1] Y. Uehara and S. Ushioda, "Vibration-induced structures in scanning tunneling microscope light emission spectra of Ni(110)-streaky (1 × 2)-H", Surface Science **601**, 5643-5648 (2007).
[2] T. Sanbongi, S. Katano, Y. Uehara, and S. Ushioda, "Time-Resolved Spectroscopy of Laser-Induced Light Emission from an Evaporated Au Film in the Kretschmann Geometry", Japanese Journal of Applied Physics (in press).
[3] Y. Uehara and S. Ushioda, "Scanning tunneling microscope light emission spectroscopy with good signal-to-noise ratio", Journal of the Vacuum Society of Japan (in Japanese) (in press).

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Computational Materials Informatics

Computational Design of Functional Materials for Information Devices

[Research Target and Activities]

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

Our research activities in FY 2007 include computational materials design for spintornics as follows:
(1) Magnetic tunnel junctions (MTJ) with perpendicular magnetic anisotropy
In order to improve the stability of the magnetization direction at each cell of non-volatile magnetoresistive random access memories (MRAM) against thermal fluctuations, we seek for MTJ with perpendicular magnetic anisotropy showing huge tunneling magnetoresistance (TMR). We have found that the TMR ratio evaluated for the FePt/MgO/FePt(001) MTJ with Fe-terminated interfaces exceeds 300%, which can be attributed to scatteing of minority-spin electrons at the Fe-O interface.

(2) Highly spin-polarized interfaces between half-metals and silicon
In order to realize efficient spin injection into silicon, we seek for highly spin-polarized interfaces bwtween half-metals and silicon. We have found that high spin polarization is almost preserved at a specific (110) interface between a Heusler alloy Co_2FeSi and silicon (see Fig. 1). The highly spin-polarized (110) interface turns out to be favorable energetically and thus is expected to be a promising candidate for the source of spin injection into silicon.

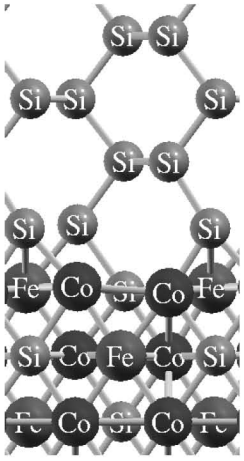

Fig. 1

[Staff]

Masafumi SHIRAI, Professor
Yoshio MIURA, Assistant Professor
Kazutaka ABE, Assistant Professor

[Profile]

Masafumi Shirai was graduated from Osaka University in 1984, and 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. His research interests have been electron-phonon interaction in oxide superconductors, itinerant electron magnetism in transition-metal compounds, and computational materials design on the basis of first-principles calculations, and so on.

[Papers]

[1] Y. Miura, H. Uchida, Y. Oba, K. Nagao, and M. Shirai, "Coherent tunneling conductance in magnetic tunnel junctions of half-metallic full Heusler alloys with MgO barriers," J. Phys.: Condensed Matter, Vol.19, No.36, Article no.365228, pp.1-7, 2007.
[2] T. Nakano, M. Shirai, Y. Miura, and K. Nagao, "The computational materials design of (Ga,Cr)N: Effects of co-doping on exchange interactions," J. Phys.: Condensed Matter, Vol.19, No.36, Article no.365238, pp.1-6, 2007.
[3] Y. Taniguchi, Y. Oba, Y. Miura, K. Abe, and M. Shirai, "A first-principles study on electronic and transport properties of FePt/MgO/FePt(001) magnetic tunnel junctions," IEEE 6th International Symposium on Metallic Multilayers, Perth, Australia, October 15-19, 2007.

Quantum Optical Information Technology

Development of optoelectronic devices for quantum information and communication technology

[Research Target and Activities]

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

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

In 2007, we have achieved (1) generation of high-purity entangled states from a semiconductor, (2) development of a novel scheme to generate entangled photons from quasi-phase-matched QPM devices, (3) generation of polarization-entangled photons from spatially correlated photon pairs, and (4) coherent transfer of light polarization to electron spins in a g-factor engineered semiconductor.

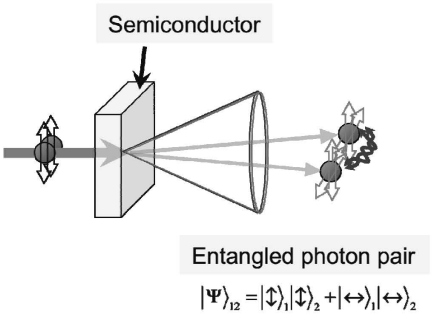

Fig. 1 Entangled photon generation from a semiconductor.

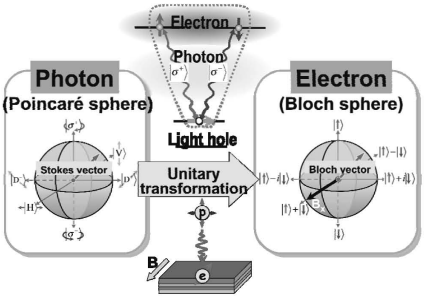

Fig. 2 Quantum media conversion from photon polarization to an electron spin.

[Staff]

Keiichi Edamatsu, Professor (January 2003~)
Hideo Kosaka, Associate professor (July 2003~)
Yasuyoshi Mitsumori, Assistant professor (February 2004~)

[Profile]

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

[Papers]

[1] Photon polarization entanglement induced by biexciton: experimental evidence for violation of Bell's inequality [G. Oohata, R. Shimizu, and K. Edamatsu: Phys. Rev. Lett. **98**, 140503/1-4 (2007)]
[2] Entangled photons: generation, observation, and characterization (invited review). [K. Edamatsu: Jpn. J. Appl. Phys. **46**, 7175-7187 (2007)]
[3] Coherent transfer of light polarization to electron spins in a semiconductor. [H. Kosaka, H. Shigyou, Y. Mitsumori, Y. Rikitake, H. Imamura, T. Kutsuwa, K. Arai and K. Edamatsu: Phys. Rev. Lett. **100**, 096602/1-4 (2008)]

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Dielectric Nano-Devices

Research on Dielectric Nano Science and Technology

[Research Target and Activities]

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

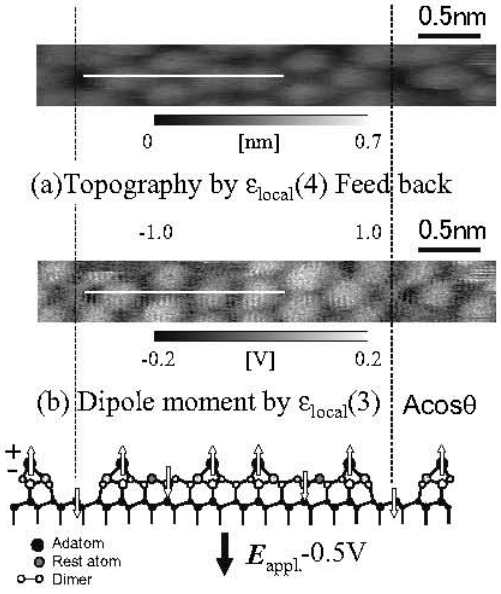


Fig.1 Si(111)7×7 atomic structure observed by NC-SNDM.

Major achievements of studies in 2007 are as follows: (1) Electric dipoles on a Si(111) surface were observed with atomic resolution using non-contact SNDM. (2) Actual information data were recorded on ferroelectric single-crystal recording media with an areal recording density of 4 Tbit/inch^2 using an SNDM-based storage system. (3) An HDD-type ferroelectric data storage test system has been developed in order to conduct fast R/W tests under conditions close to those of actual operation.

[Staff]

Yasuo CHO, Professor
Yoshiomi HIRANAGA, Assistant Professor
Nobuhiro KIN, Assistant Professor
Yasuo WAGATSUMA, Technical Official
Kenya ISHIKAWA, Research Fellow
Shinichiro KOBAYASHI, Research Fellow
Moinul BHUIYAN, Research Fellow
Nozomi ODAGAWA, Research Fellow

[Profile]

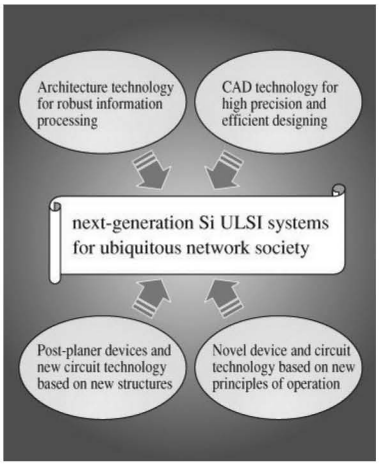
Yasuo Cho graduated in 1980 from Tohoku University in electrical engineering department. In 1985 he became a research associate at Research Institute of Electrical Communication Tohoku University. In 1990, he received an associate professorship from Yamaguchi University. He then became an associate professor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

[Papers]

[1] Yasuo Cho, " Scanning Nonlinear Dielectric Microscope with Super High Resolution", Jpn. J. Appl. Phys, Vol.46, No.7B, pp.4428-4434, 2007.
[2] Y. Hiranaga, T. Uda, Y. Kurihashi, K. Tanaka and Y. Cho, "Novel HDD-type SNDM ferroelectric data storage system aimed at high-speed data transfer with single probe operation", IEEE Trans. Ultrason., Ferroelect., Freq. Contr., vol. 54, No. 12, pp. 2523-2528, 2007.
[3] Y. Cho and R. Hirose, "Atomic Dipole Moment Distribution of Si Atoms on a Si(111)-(7×7) Surface Studied Using Noncontact Scanning Nonlinear Dielectric Microscopy", Physical Review Letters, Vol.99, No.18, pp.186101-1-186101-4, 2007.

Plasma Electronics

Research on Nanoscale Semiconductor Devices and Integrated Circuits



[Research Target and Activities]

This research field aims on realizing a ubiquitous network society by centering on the development of innovative silicon integrated circuits. Our interests include the proposals of (1) robust architecture and circuit technology that can tolerate fluctuations in the characteristics of nano devices as well as with the increased complexity in highly integrated ULSI systems, (2) post-planar devices based on innovated structures such as 3-dimensional structures and their circuit technology, (3) novel devices and circuits based on new principles of operation that become achievable in nano structures, (4) next-generation CAD (Computer Aided Design) technology with high precision and efficiency, in order to design the next-generation ULSI systems with highly integrated new devices.

[1] New architecture and circuit technology for robust information processing

Recently with the downscaling of the device size, the variations in the characteristics of the MOSFETs cause a severe degradation in circuit performance. In order to resolve this issue, we have proposed a new circuit technology that is robust against variations in the threshold voltage and supply voltage of MOSFETs, which is a determinant to the actual performance speed of LSI [1].

[2] Devices with post-planar structure and their circuit technology

In order to resolve the limits faced by conventional planar structure and progress the 3-dimenstional devices and its circuits, the device design technology for 30nm scale DG-MOSFET has been laid out [2]. In addition, the basic characteristics of Vertical MOSFETs in the 10nm generation have been analyzed, and it has been made clear that the Vertical MOSFET is able to effectively suppress the rise of temperature due to the self-heating effect inside the device.

[3] Devices with new principles of operation and their circuit technology

The basic characteristic of post-CMOS device, the Si nano-wire device, has been analyzed. A new flash memory is proposed and proven to work with the leading data rewrite speed of 100Mbyte/s. Even more, by analyzing the leak phenomenon in thin gate oxide using a first-principle calculation, a new mechanism is discovered [3]. The fabrication process of nano-structures has been progressed.

[4] New CAD technology with high precision and high efficiency for ULSI design

Advanced the CAD system for 3-dimensional structure transistors and its circuit design.

[Staff]

Tetsuo Endoh, Associate Professor (from 1997)

[Profile]

Dr. Endoh received the B.S degree in physics from the University of Tokyo, Tokyo in March 1987. He joined the Research and Development Center, Toshiba Corporation, Kawasaki, Japan in April 1987, where he was engaged in research on high density Flash EEPROMs, leading edge devices, and high reliability silicon oxide layers. He joined the Research Institute of Electrical Communication, Tohoku University in Sendai, Japan in 1995. He became an associate professor in 1997, and since he has engaged in the research on 3-dimensional device structures and its circuit technologies, and low power and high-speed logic device structures and its circuit technologies. From 1996 to 2001, he was a research fellow for TAO Sendai Research Center. He was awarded the Nikkei BP 3rd LSIIP Design Award in 2001. He is a member of the IEEE, IEICE, and the Japanese Society of Applied Physics.

[Papers]

[1] Kazuhiro Suzuki, Hyoung-jun Na, Yuzuru Narita, Hideki, Nakazawa, Takashi Itoh, Kanji Yasui, Maki Suemitsu and Tetsuo Endoh "Effects of Threshold Voltage Fluctuations on Stability of MOS Current Mode Logic Inverter Circuit", IEEE, IMFEDK2007 technical digest, pp. B-7, April 2007.

[2] Tetsuo Endoh and Yuto Monma "Study of 30-nm Double-Gate MOSFET with Halo Implantation Technology using a Two-Dimensional Device Simulator", IEICE Trans Electron E90-C, pp.1000-1005, 2007.

[3] Tetsuo Endoh, Kazuyuki Hirose, and Kenji Shiraishi "Physical Origin of Stress-Induced Leakage Currents in Ultra-Thin Silicon Dioxide Films", IEICE Trans Electron E90-C, pp.955-961, 2007.

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3．2 Broadband Engineering Division: Research Target and Results

In order to establish the future broadband communication systems and novel devices that flexibly applied to the future high-speed information communication, research and development are carrying out for wide bands of micro- millimeter/submillimeter- terahertz- and light-waves with regard to the information generation, transmission, processing, storage, and semiconductor spintronics technology.

(1) Wireless Information Technology

Toward wireless next generation network (NGN) in the 21st century's information technology, we investigate the wireless NGN that immediately provides any information for everyone at anytime and anywhere, i.e., next generation mobile broadband wireless access (MBWA), dependable broadband wireless local area network (WLAN), and ultra broadband wireless personal area network (WPAN).

For broadband, low power consumption, and small size, RF power amplifier etc for millimeter wave and GHz-band wireless modems, GHz-band film bulk acoustic resonator (FBAR) devices, ultra-small antennas for mobile terminals were fabricated. The MBWA field trial using frequency hopping orthogonal frequency division multiple access (FH-OFDMA) system was also evaluated.

(2) Ultra-Broadband Signal Processing

Novel, integrated electron devices and circuit systems operating in the millimeter-wave and terahertz regions with functionalities of coherent, tunable signal generation and ultra-broadband signal-processing are investigated.

A frequency-tunable plasmon-resonant terahertz emitter/photomixer structured by dual-grating gate high electron mobility transistors (HEMT's) was recently successful in terahertz emission of radiation at room temperature. A double-decked HEMT with semiconducting 2-dimensional electron gas (2DEG) grating gates has successfully enhanced the radiation power by one order of magnitude. A unique terahertz electromagnetic metamaterial system based on optoelectronic dispersion control of low-dimensional plasmons was developed.

(3) Ultrahigh-speed Optical Communication

To achieve a global ultrahigh-speed optical network, the research on ultrashort pulse generation and transmission is engaged. For ultrahigh-speed transmission, a new distortion-free transmission scheme that employs the optical Fourier transformation (OFT) in the time domain has been developed.

We applied this technique to 160 Gbit/s field transmission in an installed 200 km-long fiber link (JGNII, Tsukuba-Tokyo). Coherent QAM optical transmission was successfully demonstrated, that is, 1 Gsymbol/s, 128 QAM transmission by using heterodyne detection with a C_2H_2 frequency-stabilized fiber laser and an optical PLL technique. Here, a 14 Gbit/s data was transmitted over 160 km in an optical bandwidth of 1.4 GHz, corresponding to a spectral efficiency of as high as 10 bit/s/Hz.

(4) Applied Quantum Optics

Novel, compact and widely tunable coherent light sources, which have highly temporal and spatial controllability, by designing microscopic structure of nonlinear-optical and laser materials such as ferroelectrics, semiconductors and organic crystals, are exploring their new applications. We have also been studying utra-broadband coherent terahertz (THz) wave radiation, “tera-photonics”.

In order to achieve sensitive detection of biomolecules and THz imaging with sub-wavelength spatial resolution, we studied novel THz biosensors using surface plasmon resonance. Local-field enhancement was clarified from the finite difference time domain (FDTD) simulations.

(5) Information Storage Systems

Amount of digital information is rapidly growing year by year, which is projected to be greater than 100 Exa byte (10^{20} bytes) in 2010. For this large information storage applications further high density recording exceeding 1 Tbit/inch^2 is aimed. Fundamental recording theories are investigated.

For high areal density of 2 Tbit/inch^2, in which the bit size corresponds to the area of 13 nm by 25 nm for example, a design guideline in writing process for bit-patterned media was clarified. For the extremely large capacity storage-systems, a new low-power and high throughput RAID storage system employing parallel-operated hard disk drives was also explored.

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

Development of measurement instruments using the millimeter- and terahertz- wave region of the electromagnetic spectrum is the research target. Non-invasive measurement for materials is possible. We are developing imaging systems mainly of passive mode and mainly for security applications.

A 35 GHz passive imaging array was developed, which detected a CD-ROM under clothes. A newly developed software successfully reduced the processing time by 50 %.

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

Development of air-borne synthetic aperture radars (SAR) for all-weather surveillance and rescue in disastrous fires and smokes is aimed.

Conceptual design of a spotlight-mode SAR has been initiated targeting at a high resolution (5-10cm), small size and light weight (30-50kg) SAR at Ku/Ka-band microwave frequencies. Collaboration by universities and industries has been established for the research and development.

(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 in the mid-infrared to THz is investigated, such as memories and logic devices using spin states as well as quantum cascade lasers (QCL) with THz emission.

The current-induced magnetic domain wall creep in a ferromagnetic semiconductor (Ga,Mn)As was discovered. Artificial atomic properties and evaluation the g value of the electronic state in an (In,Ga)As quantum dot was observed. The room-temperature operation of InAs/(Al,Ga)Sb QCL at low-threshold current density (4 kA/cm^2) was demonstrated.

(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.

A high TMR ratio of 500% at RT (world record) was realized in MgO-based MTJs. Spin-transfer torque magnetization switching without an external field was observed in the MTJs with synthetic ferromagnetic free layer. Operation of a prototype of the world's first 2Mbit non-volatile random access memory (SPRAM) chip employing the spin-transfer torque writing method was verified.

Ultrahigh-Speed Optical Communication

Advanced optical communication technologies approaching the Shannon limit

[Research Target and Activities]

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

For ultrahigh-speed transmission, we have developed a new distortion-free transmission scheme which employs the optical Fourier transformation (OFT) in the time domain. This year, we applied this technique to 160 Gbit/s field transmission in an installed 200 km-long fiber link (JGNII, Tsukuba-Tokyo). Error-free transmission was successfully achieved with a low penalty by eliminating distortions with OFT. We have also been actively engaged in coherent QAM optical transmission. We successfully demonstrated 1 Gsymbol/s, 128 QAM transmission by using heterodyne detection with a C_2H_2 frequency-stabilized fiber laser and an optical PLL technique (Fig. 1). Here, a 14 Gbit/s data was transmitted over 160 km in an optical bandwidth of 1.4 GHz, corresponding to a spectral efficiency of as high as 10 bit/s/Hz. In addition, we have been developing a new Cs optical atomic clock using a regeneratively mode-locked fiber laser. Distribution of highly-precise clock signals from the Cs optical clock was successfully demonstrated over an installed 200 km-long JGNII fiber link. Another important area of our research is photonic crystal fibers (PCF) and their application to new communication systems at 850 nm. This year we succeeded in developing a 10 GHz opto-microwave oscillator by combing VCSEL and PCF, which can generate low-jitter microwave and picosecond optical pulses at 850 nm simultaneously.

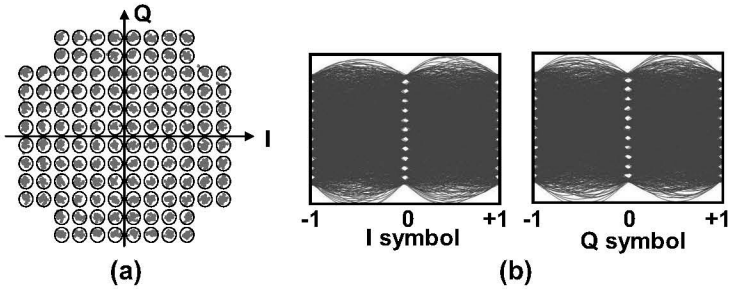

Fig. 1 Constellation (a) and eye diagram (b) of 128 QAM signal after 160 km transmission.

[Staff]

Masataka Nakazawa, Professor
Toshihiko Hirooka, Associate Professor
Masato Yoshida, Assistant Professor

[Profile]

Prof. Nakazawa received a Ph. D. degree from the Tokyo Institute of Technology in 1980. In 1980, he joined the Ibaraki Electrical Communication Laboratory, Nippon Telegraph & Telephone Public Corporation. He was a visiting scientist at Massachusetts Institute of Technology in 1984-1985. In 2001, he moved to the Research Institute of Electrical Communication, Tohoku University as a professor, where he has been engaged in research on ultrahigh-speed optical communication including soliton transmission, nonlinear effects in fibers, mode-locked lasers, and photonic crystal fibers. He is the author and coauthor of over 360 journal articles and holds more than 100 patents. He is a Fellow of IEEE, OSA, and IEICE, and has received various awards including the 2002 Daniel E. Noble Award and 2005 OSA R. W. Wood Prize.

[Papers]

[1] Y. Oikawa, H. Hasegawa, K. Suzuki, Y. Inoue, T. Hirooka, and M. Nakazawa, "4x10 Gb/s WDM transmission over a 5-km-long photonic crystal fiber in the 800-nm region," IEEE Photon. Technol. Lett., vol. 19, no. 8, pp. 613-615, April (2007).
[2] T. Hirayama, M. Yoshida, M. Nakazawa, K. Hagimoto, and T. Ikegami, "Mode-locked laser-type optical atomic clock with an optically pumped Cs gas cell," Opt. Lett., vol. 32, no. 10, pp. 1241-1243, May (2007).
[3] M. Yoshida, H. Goto, K. Kasai, and M. Nakazawa, "64 and 128 coherent QAM optical transmission over 150 km using frequency-stabilized laser and heterodyne PLL detection," Opt. Express, vol. 16, no. 2, pp. 829-840, January (2008).

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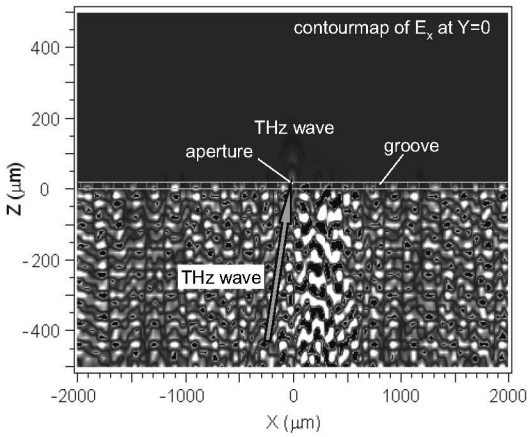
Applied Quantum Optics

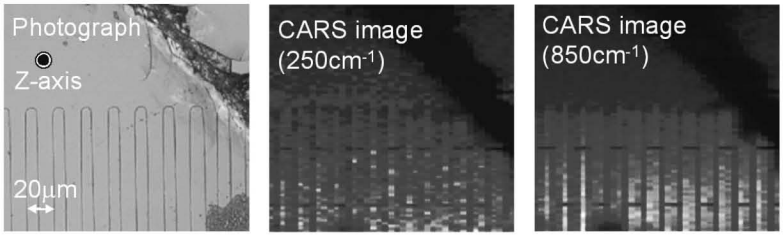
Compact, Multi-Functional Coherent Light Sources and Their Applications

[Research Target and Activities]

We are investigating novel, compact and widely tunable coherent light sources, which have highly temporal and spatial controllability, by designing microscopic structure of nonlinear-optical and laser materials such as ferroelectrics, semiconductors and organic crystals, and are exploring their new applications. We have also been studying utra-broadband coherent terahertz (THz) wave radiation to explore novel science and technology, "tera-photonics". Widely tunable, spatially and temporally coherent THz wave was generated for the first time, by using optical parametric effects.

Terahertz(THz)-frequency phonons have been of much interest because they provide various applications including THz-wave generation, THz imaging of chemical components, study of conformation, polymorph and crystallinity, etc. In order to achieve sensitive detection of biomolecules and THz imaging with sub-wavelength spatial resolution, we studied novel THz biosensors using surface plasmon resonance. Local-field enhancement was clarified from the finite difference time domain (FDTD) simulations. THz-frequency coherent anti-Stokes Raman (THz-CARS) microscopy was successfully applied to nondestructive imaging of periodic microstructure of ferroelectrics. Raman spectroscopy of mid- and far-infrared vibrational modes was successfully applied to the analysis of molecular interaction and molecular structures of long chain, aliphatic molecules.





(Left figure) FDTD simulation of local-field enhancement of THz waves using a surface plasmon resonator.
(Right figure) Coherent anti-Stokes Raman imaging of periodically poled lithium niobate using THz-frequency phonon modes.

[Staff]

Jun-ichi SHIKATA, Associate Professor

[Profile]

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 of the same university. Since 2003, he has been an associate professor. His research interests include lasers, nonlinear optical effects and their applications. He is a member of the Japan Society of Applied Physics (JSAP), Spectroscopical Society of Japan, Optical Society of Japan, and OSA.

[Papers]

[1] H. Yokoyama, H. Tsubokawa, H. Guo, J. Shikata, K. Sato, K. Takashima, K. Kashiwagi, N. Saito, H. Taniguchi, and H. Ito, "Two-photon bioimaging utilizing supercontinuum light generated by a high-peak-power picosecond semiconductor laser source," J. Biomed. Opt., Vol. 12, No.5, pp. 054019-1-5 (2007).

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[3] J. Shikata, H. Handa, A. Nawahara, H. Minamide, T. Ikari, Y. Ishikawa, and H. Ito, "Terahertz ATR spectroscopy of liquids using THz-wave parametric sources," Tech. Digest of 7th Pacific Rim Conference on Lasers and Electro-Optics (CLEO/Pacific Rim 2007) (2007).

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Wireless Info Tech

For Realizing Wireless Next Generation Network (NGN)

[Research Target and Activities]

Research and development are progressing toward wireless next generation network (NGN) in the 21st century's wireless information technology. The wireless NGN immediately provides any information for everyone at anytime and anywhere.

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

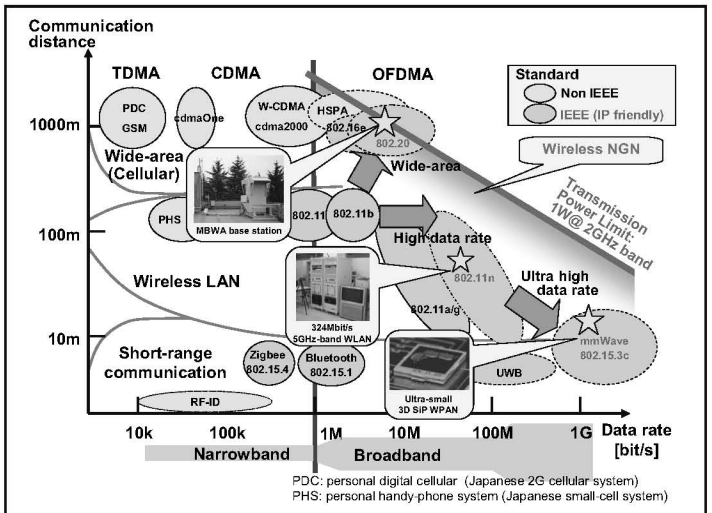

Fig. The target system of Wireless Info Tech.

In this year, we have discussed following technology for broadband, low power consumption and small size terminals; (1) RF power amplifier, synthesizer and mixer devices for millimeter wave and GHz-band wireless modems, (2) GHz-band film bulk acoustic resonator (FBAR) devices, (3) Ultra small antennas for mobile terminals, and (4) Seamless interconnection technology using 3-dementional system in package (3D SiP). Moreover, we have evaluated the MBWA field trial using frequency hopping orthogonal frequency division multiple access (FH-OFDMA) system. We are also concentrating on the coherent work toward the next-generation "Wireless next generation network (NGN) terminal" which enables signal-demodulation of any band and any type received radio wave.

[Staff]

Kazuo TSUBOUCHI, Professor
Hiroyuki NAKASE, Associate Professor
Suguru KAMEDA, Assistant Professor

[Profile]

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

[Papers]

[1] S. Oshima, G. Mori, H. Oguma, S. Kameda, H. Nakase, T. Takagi, and K. Tsubouchi," The 60GHz band multi-carrier wireless system for 2Gbps transmission with constant envelope modulation," 18th Annual IEEE Int. Symp. on Personal, Indoor and Mobile Radio Commun. (PIMRC2007), #521, Athens, Greece, Sept. 2007.
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Information Storage System

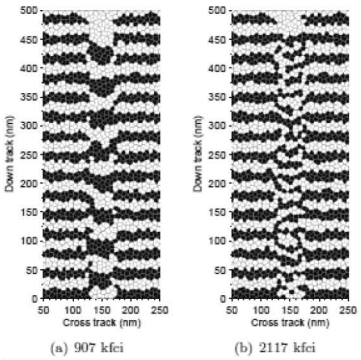
Research on Large Capacity Information Storage System Using Perpendicular Magnetic Recording

[Research Target and Activities]

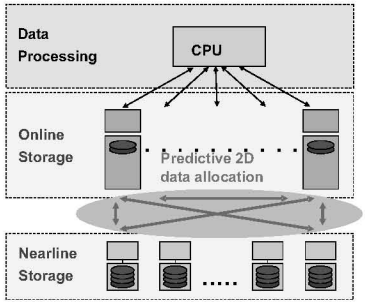
Amount of digital information is rapidly growing year by year, which is projected to be greater than 100 Exa byte (10^{20} bytes) in 2010. Extremely large capacity for information storage system is thus required. Magnetic recording is the major technology to cope with this tremendous demand. Recently perpendicular magnetic recording was commercialized to overcome the conventional density limit, and further high density recording exceeding 1 Tbit/inch^2, and even for 5 Tbits/inch^2, is aimed.

In this research division, recording theories on high density perpendicular magnetic recording are investigated based on both theoretical study including computer simulation by LLG equation and experimental approach with real heads and disks. Research on large capacity data storage system with hard disk drives is also accelerated.

As we have early stated, magnetic nano-structure of recording media is the most essential characteristics to achieve high density perpendicular recording. Recently we have proposed a new transition structure modeling in granular recording media to attain high linear density. For very high areal density of 2 Tbit/inch^2, in which the bit size corresponds to the area of 13 nm by 25 nm, a design guideline in writing process for bit-patterned media was clarified. A computer simulation utilizing micromagnetics is being carried out to obtain specifications towards ultra-high density recording greater than 5 Tbit/inch^2. In addition to these studies on magnetic recording, for extremely large capacity storage systems, a new RAID storage system employing parallel-operated hard disk drives is also explored.



Micro-magnetic simulation by super-computer.



System configuration for layered parallel operation storage.

[Staff]

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

[Profile]

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

[Papers]

[1] M. Hashimoto, M. Salo, Y. Ikeda, A. Moser, R. Wood, H. Muraoka, "Analysis of Written Transition Curvature in Perpendicular Magnetic Recording From Spin-Stand Testing," IEEE Trans. Magn., Vol.43, No.7, 3315-3319 (2007)
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[3] Simon Greaves, Yasushi Kanai, and Hiroaki Muraoka, "A Comparative Study of Perpendicular Media," IEEE Trans. Magn., Vol.43, No.6, 2118-2120 (2007)

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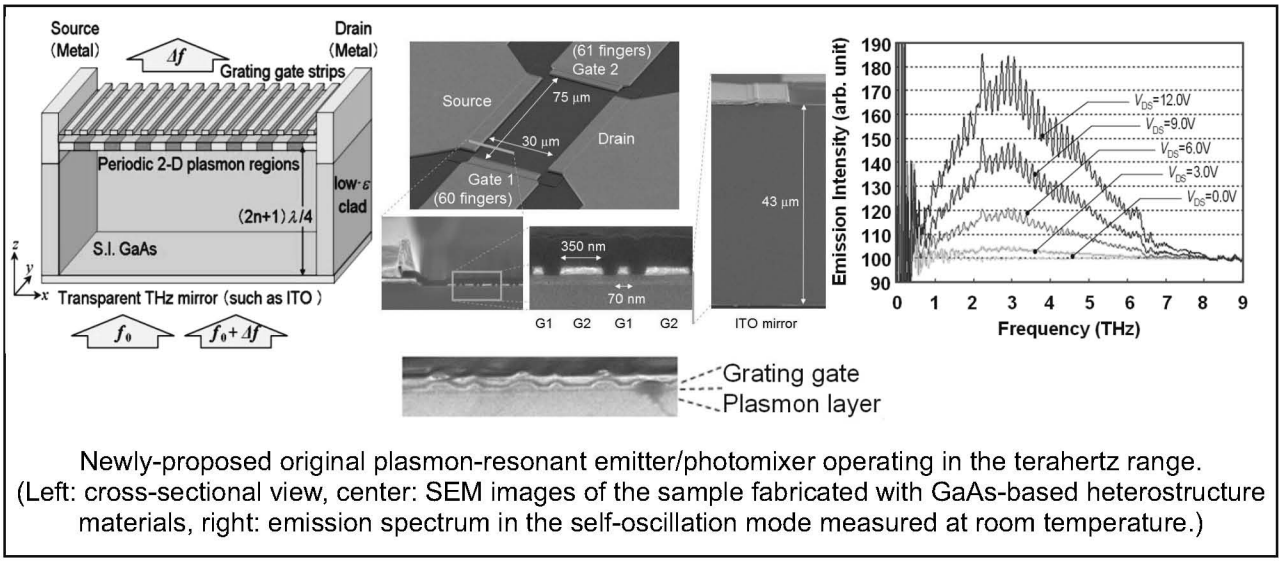
Ultra-broadband Signal Processing

Novel Millimeter-wave and Terahertz Integrated Electron Devices and Systems

[Research Target and Activities]



Newly-proposed original plasmon-resonant emitter/photomixer operating in the terahertz range.
(Left: cross-sectional view, center: SEM images of the sample fabricated with GaAs-based heterostructure materials, right: emission spectrum in the self-oscillation mode measured at room temperature.)

We are developing novel, integrated electron devices and circuit systems operating in the millimeter-wave and terahertz regions. One example is a plasmon-resonant terahertz emitter/ photomixer based on high electron mobility transistors (HEMT's). Very recently a double-decked HEMT with semiconducting 2-dimensional electron gas (2DEG) dual-grating gates has newly been developed, succeeding in enhancement of the radiation power by one order of magnitude (see the above Figures). Another example is unique terahertz electromagnetic metamaterials based on optoelectronic dispersion control of low-dimensional plasmons. We are also pursuing new materials and device structures for ultrafast transistors to break through the speed limit. By making full use of them, we are exploring new applications for future smart information and telecommunication systems.

[Staff]

Professor: Taiichi OTSUJI
Associate Professor: Tetsuya SUEMITSU
Assistant Professor: Yahya Moubarak MEZIANI
Visiting Professor: Wojciech KNAP
JSPS Research Fellow: Abdelouahad EL FATIMY
Secretary: Megumi HAMADA

[Profile]

Prof. Taiichi Otsuji received the B.S. and M.S. from Kyushu Inst. of Tech., Japan, in 1982 and 1984, and the Dr. Eng. from Tokyo Inst. of Tech., Japan, in 1994. After working for NTT Labs, Japan, since 1984, he joined Kyushu Inst. of Tech., Japan, in 1999, as an assoc. prof., being a prof. from 2002. Since 2005, he has been a professor at the RIEC, Tohoku Univ., Japan. His research interest includes terahertz and millimeter-wave integrated electron devices and circuit's. He is the recipient of the Outstanding Paper Award of the 1997 IEEE GaAs IC Symp. He is a member of IEEE, OSA, IEICE, and JSAP.

[Papers]

[1] T. Otsuji, Y.M. Meziani, M. Hanabe, T. Nishimura, and E. Sano, "Emission of terahertz radiation from InGaP/InGaAs/GaAs ….," Solid State Electronics, Vol. 51, Iss. 10, pp. 1319-1327, Oct. 2007.
[2] T. Suemitsu, Y.M. Meziani, Y. Hosono, M. Hanabe, T. Otsuji, E. Sano, "Novel plasmon-resonant terahertz-wave emitter …," 65th DRC Dig., pp. 157-158, Notre Dame, IN, USA, Jun. 18-20, 2007.
[3] V. Ryzhii, M. Ryzhii, and T. Otsuji, "Negative dynamic conductivity of graphene with optical pumping," Journal of Applied Physics, Vol. 101, No. 7, pp. 083114-1 - 083114-4, Apr 2007.

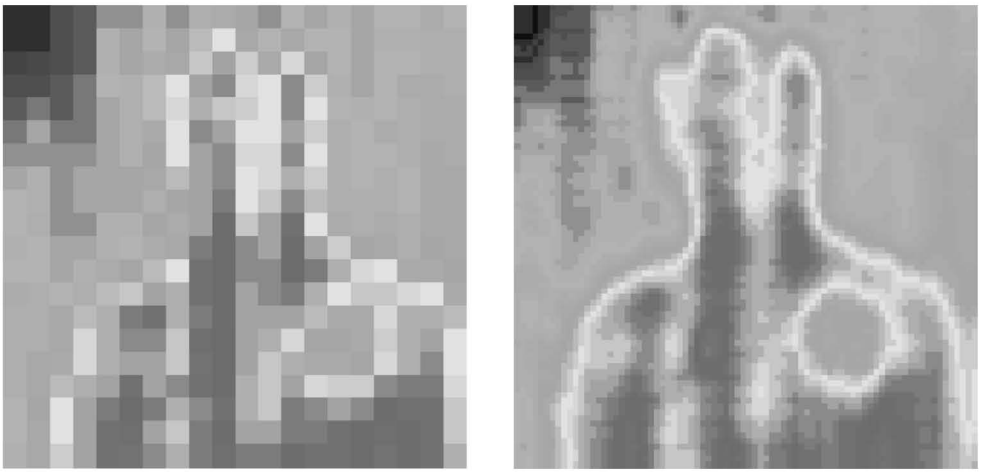
Basic Technology for Broadband Communication

Development of Measurement Instrumentation using 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. We are developing imaging systems mainly of passive mode and mainly for security applications.

The figure shows a 35 GHz passive image detecting a CD-ROM under clothes. The right-hand image is a result processed by the sampling theorem.



[Staff]

Research Professor: Koji Mizuno
Assistant: Seiko Miyanaga

[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, Y. Wagatsuma, H. Warashina. K. Sawaya, H. Sato, S. Miyanaga, and Y. Yamanaka, "Millimeter-Wave Imaging Technologies and Their Applications," IEEE IVEC (International Vacuum Electronics Conference), Kitakyuu-shi, Japan, May 2007 (Invited).

[2] M. Sato, T. Hirose, T. Ohki, H. Sato, K. Sawaya, and K. Mizuno, "94-GHz Band High-Gain and Low-Noise Amplifier Using InP-HEMTs for Passive Millimeter Wave Imager", IEEE International Microwave Symposium, Honolulu, June 2007.

[3] K. Sawaya, H. Sato, Y. Wagatsuma and K. Mizuno, "Broadband Fermi Antenna and Its Application to Mm-wave Imaging," EuCAP (European Conference on Antenna and Propagation) 2007, Edinburgh, UK, Nov. 2007 (Invited).

Contact to Professor Koji MIZUNO : koji@riec.tohoku.ac.jp

Basic Technology for Broadband Communication

High Resolution Synthetic Aperture Radar for Civilian Applications

[Research Objectives and Activities]

We are interested in developing air-borne synthetic aperture radars (SAR) for civilian applications. We intend contributing safety and security improvement of the country. The SAR will be useful for all-weather surveillance and rescue in disastrous fires and smokes. Scientists and engineers from both universities and industries collaborate on our research and development programs.

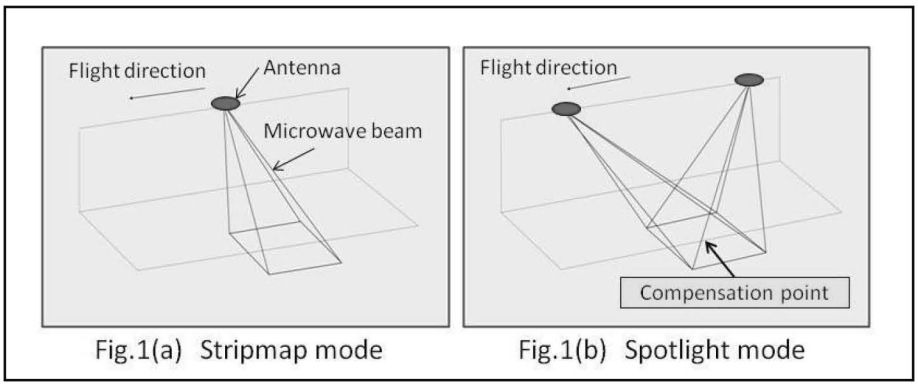


Fig.1(a) Stripmap mode Fig.1(b) Spotlight mode

1. Conceptual design of a spotlight-mode SAR, as shown in Fig.1, has been initiated. We aim for developing high resolution (5-10cm), small size and light weight (30-50kg) SAR at Ku/Ka-band microwave frequencies [1].
2. Domestically-available, manned and unmanned aerial vehicles, which are suitable for the SAR platforms, were identified.
3. SAR system designs, which provide flexibility and convenience, are being developed.
4. A principle that our developments are open to all contributing parties is adopted.

[Staff]

Visiting Professor : Masaaki Inutake

[Profile]

1966: Bachelor of Aeronautical 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: Development of dense plasma sources. Microwave/laser-aided plasma diagnostics [2]. Alfvén wave physics and its applications for the wave heating of a fusion plasma. Alfvén wave heating and acceleration of supersonic plasma flows in a magnetic nozzle for an advanced space propulsion [3].

[Papers]

[1] H. Ikezi, M. Inutake, and A. Mase, "Development of High Resolution Spotlight Mode Synthetic Aperture Radar (I)", Engineering Science Reports, Kyushu University **29**, No.3, 269~277 (2007).
[2] K. Hattori, A. Ando and M. Inutake, "Multi-Channel Microwave Reflectometer with Fermi Antenna Receivers", J. Plasma & Fusion Res. **2**, S1039-1~4 (2007).
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3.3 Aims and Achievements of Human Information Systems Division

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

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

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

(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 magnetically nano-scale controlled magnetic materials and by the development of the devices under the functions of the magnetics.

(Achievements) We proposed a new technique to control the magnetic anisotropy of the magnetic thin films to improve the accuracy of our magnetic field sensors. By this result we confirmed to be able to design the properties of the materials. The manipulating technique for controlling the coagulation and the dispersion of the magnetic small particles, which will be used in the human body, was proposed. In addition, 3D position detecting system using magnetic markers was studied to improve its position accuracy. The study about the magnetic actuator driven by external magnetic field was carried out for micro-pump, micro-cantilevered actuator, and so on. The system supporting the medical operation under the endoscopes was studied accompanied with the medical doctors.

(2)Advanced Acoustic Information Systems

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

(Achievements) In 2007, we continued to develop 3D high-defenition virtual auditory displays and precise sound field simulator based on our accumulated knowledge of human auditory space perception. These systems are expected to provide a high-quality 3D virtual sound space, which is keenly required to realize super-definition audio-visual communications in near future. We deepen the understanding human spatiotemporal perceptual processes of audio-visual and audio-vestibular information. This is particularly important to realize future multi-modal information processing

and communication systems. Furthermore, we developed new signal processing algorithms of digital watermarking, safer voice over internet protocols (VoIP) realizing high secrecy, advanced digital hearing aids, and high-performance binaural speech enhancement providing proper spatial information.

(3)Visual Cognition and Systems

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

(Achievements) We achieved results in the fields of visual attention, motion perception and motion in depth perception. Firstly, we succeeded to measure distribution of visual attention while people tracking a moving object, and the measurements showed that the visual system has difficulty to pay attention to different location other than the object tracked. This knowledge is useful to model the function of visual attention. Secondly, we showed that only slow motion detector contribute to detection of global motion among the two types of motion detectors (the slow and fast ones). Since slow motion signals have been paid little attention both in vision and image processing, the result provided new view in the role of motion signals in visual processing. Finally, we investigated temporal factors of human depth perception. Most importantly, we revealed that the visual system has two different mechanisms for seeing motion in depth perception. Using a technique to test the ability to see motion in depth based on each mechanism, we showed there are two different types of stereo blind people: ones with problem to see static depth and ones with problem to see dynamic depth change.

(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) We have developed high density DNA microarrays in combination with microcontact printing (μCP) and surface plasmon resonance (SPR) imaging. The hybridization between target DNA immobilized on gold nanoparticles and probe DNA arrayed on flat gold substrates was successfully demonstrated in high contrast image by the enhancement of optical signals based on nanoscale phenomena. Tuning of work function of carbon nanotube-based FET devices as well as characterization of specific interaction between β-cyclodextrin molecules are performed as the application works with thiolated self-assembled mono-layers. The cell cultures on nanopatterned block copolymer surfaces and the production of anti-azobenzene IgG in rabbit are also carried out as a part of nanobio study.

Electromagnetic Bioinformation Engineering

Communication with human body

[Research Target and Activities]

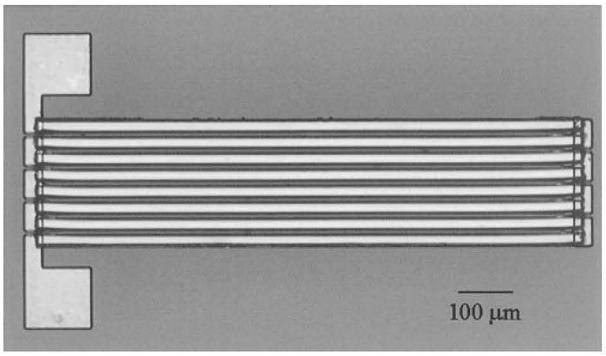

Fig.1 Sensitive magnetic field sensor

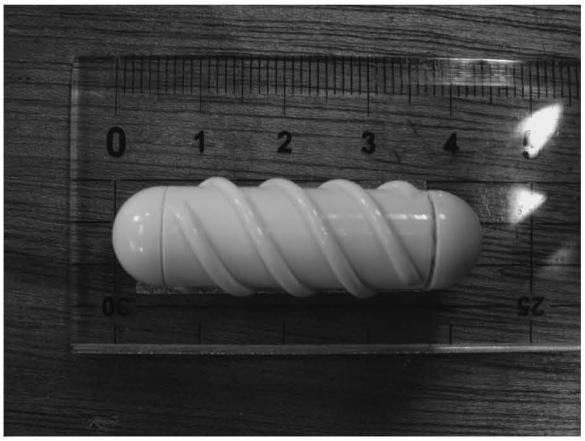

Fig. 2 Magnetic actuator for capsule-endoscope

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

[Staff]

Professor: Kazushi Ishiyama (Since 2007)

[Profile]

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

[Papers]

[1] T. Nakai, K. Ishiyama, J. Yamasaki, “Analysis of steplike change of impedance for thin-film giant magnetoimpedance element with inclined stripe magnetic domain based on magnetic energy,” Journal of Applied Physics, Vol.101, No. 09N106, (2007).

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[3] S. Hashi, M. Toyoda, S, Yabukami, K. Ishiyama, Y. Okazaki, K. I. Arai, "Wireless magnetic motion capture system - compensatory tracking of positional error caused by mutual inductance -," IEEE Transactions on Magnetics, Vol. 43, No. 6, pp. 2364-2366, (2007).

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Advanced Acoustic Information Systems

Development of next generation communication systems

[Research Target and Activities]

Since human beings can be regarded as the extreme source and recipient of information in any communication systems. Therefore, to develop advanced acoustic communication systems, good knowledge of human auditory system as well as multimodal perception relating to hearing is essential. The main interest of this laboratory is thus a study of the information processing in the human auditory system. Moreover, in recent years, we have been devoting a lot of effort to investigate human multi-modal information processing including hearing. 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 2007, we put a lot of efforts to investigate the spaciotemporal integration process of audio-visual and audio-vestibular information. Furthermore, in 2007, we developed new signal processing algorithms of digital watermarking, safer and robust VoIP communication, advanced digital hearing aids, and high-performance two-stage binaural speech enhancement.

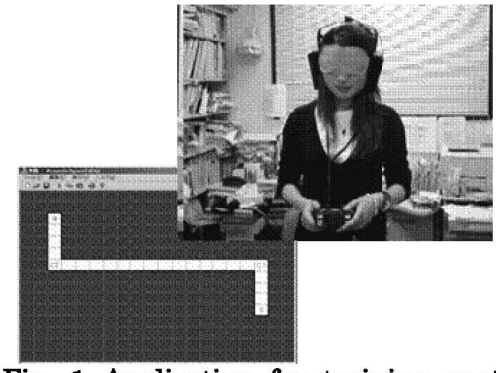

Fig. 1 Application for training spatial cognition based on high-definition virtual auditory display

[Staff]

Professor: SUZUKI, Yôiti Dr.
Associate Professor: IWAYA, Yukio Dr.
Assistant Professor: SAKAMOTO, Shuichi Dr, and MIYAUCHI, Ryota Dr.
Technical Official: SAITO, Fumitaka
Research Fellow: KOBAYASHI, Maori Dr.

[Profile of Professor]

SUZUKI graduated from Tohoku University in 1976 and received his Dr. of Engineering degree in electrical and communication engineering in 1981 and has been in the current position since 1999. His research interests include psychoacoustics, multimodal perception, high-definition auditory display and digital signal processing of acoustic signals. He received the Awaya Kiyoshi Award in 1985 and Sato Prize in 1992 and 1994 from the Acoustical Society of Japan, and received FIT2004 Funai Best Paper Award. He served as a president of the Acoustical Society of Japan from 2005 to 2007. He became a fellow of the Acoustical Society of America in 2004. He is a recipient of Takenaka Ikueikai Scholarship and RCA David Sarnoff Scholarship.

[Papers]

- Yukio Iwaya and Yôiti Suzuki: "Rendering Method of Moving Sound Source with the Doppler Effect in Sound Space," Applied Acoustics, 68 (8), 976-922, 2007
- Shuichi Sakamoto, Yôiti Suzuki and Jiro Gyoba: "Effects of auditory and visual information on the perceived direction of self-motion," Proc. 19th International Congress on Acoustics (ICA2007), PPA-03-002-IP, 2007
- Ryouichi Nishimura, Yôiti Suzuki and Byeong-Seob Ko: "Advanced Audio Watermarking Based on Echo Hiding: Time-Spread Echo Hiding," Digital Audio Watermarking Techniques and Technologies, Information Science Reference, pp. 123-151, New York, USA, 2007

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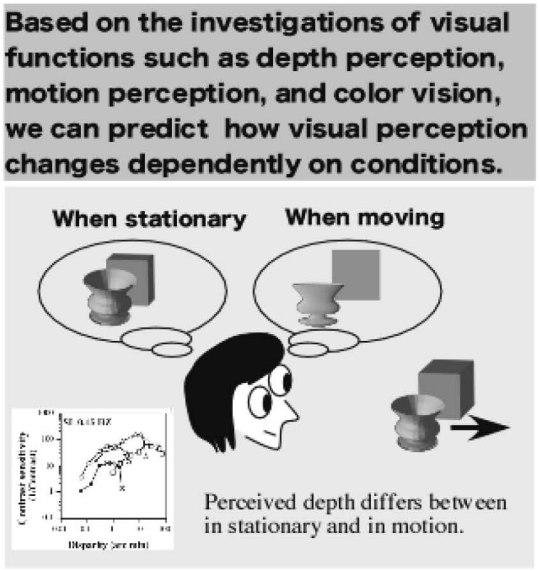
Visual Cognition and Systems

Vision sciences for visual communication

[Research Target and Activities]

It is one of the most important researches to understand the vision related brain functions in order to realize human oriented information communication systems and visual environments gentle to humans. The aims of visual cognition and systems laboratories are to investigate on vision functions in the human brain and to apply the knowledge to human factors and image sciences.



1. Spatial distribution of visual attention

We revealed that one can hardly divide attention into two different locations when he/she is tracking a moving object without eye movement.

2. Importance of slow motion signals

We found that the two types of motion detectors are different in integration of motion signals (or detecting global motion) in addition to spatiotemporal properties. Activity of the slow motion detector increased with increase in degree of global motion while that of the fast motion detector did not. This finding points an important slow motion signals in human motion analysis, which has been ignored in the both fields of visual science and image processing. Attention has to be paid to slow motion components in visual information.

3. Temporal factors in stereopsis

We revealed that the visual system has sensitivity to small depth when a small stimulus moving slowly (<5 Hz) whereas it has sensitivity to large depth when a large stimulus moving fast (>10 Hz). This indicates that the depth of the same object can be seen differently dependently on temporal conditions (stationary or moving). Consideration of such sensitivity differences should be necessary for designing 3D display and creating 3D contents.

[Staff]

Shioiri, Satoshi	Professor (2006-)
Kuriki, Ichiro	Associate Professor (2007-)
Matsumiya, Kazumichi	Assistant Professor (2006-)

[Profile]

Professor Shioiri graduated Tokyo Institute of Technology and received DEng 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. his research interests include early and middle vision such as motion perception, depth perception, color vision, mechanisms of visual attention and eye movements, and modeling of visual functions.

1. S. Lee, S. Shioiri, and H. Yaguchi, "Stereo channels with different temporal frequency tunings," Vision Res **47**(3), 289-297 (2007).
2. S. Shioiri, K. Yamamoto, Y. Kageyama, and H. Yaguchi, "Smooth shifts of visual attention," Vision Res **42**(26), 2811-2816 (2002).
3. S. Shioiri, H. Saisho, and H. Yaguchi, "Motion in depth based on inter-ocular velocity differences," Vision Res **40**(19), 2565-2572 (2000).

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Interdisciplinary field for informatics

Plasmonic Devices for Biosensing Applications

[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.

Figure 1 is high density DNA microarrays (2500 dots/cm2) developed in our laboratory in combination with microcontact printing (μCP) and surface plasmon resonance (SPR) imaging. The hybridization between target DNA immobilized on gold nanoparticles and probe DNA arrayed on flat gold substrates was successfully demonstrated in high contrast image by the enhancement of optical signals based on nanoscale phenomena. This enhancement effect can be well described by the simulation based on the Maxwell-Garnett theory for the effective dielectric constants and Fresnel's equation.

Tuning of work function of carbon nanotube based FET devices as well as characterization of specific interaction between β-cyclodextrin molecules are performed as the application works with thiolated self-assembled mono-layers. The cell cultures on nanopatterned block copolymer surfaces are also investigated as a part of nanobio study.

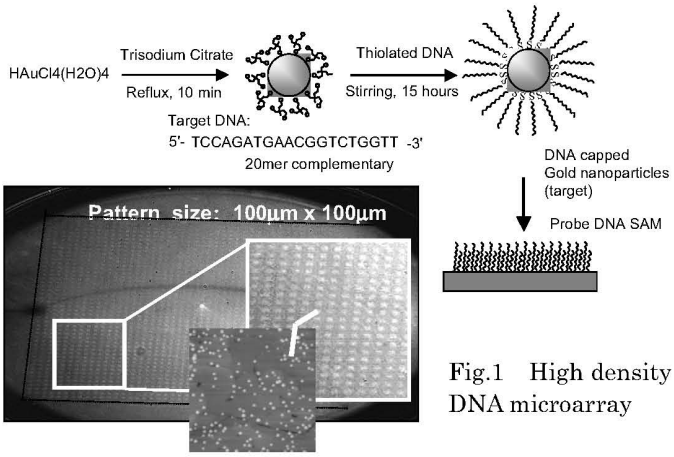

Fig.1 High density DNA microarray

[Staff]

Professor Kaoru tamada (from Oct. 2007)

[Profile]

1984 B.S.chemistry, Nara Women's University, 1984-1991 JSR Co. Ltd. Tokyo and Tsukuba research center. 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-date Adjunct professor, Department of physics, NUS, Singapore. 2007-date Professor, Research institute of electrical communication, Tohoku university.

[Papers]

[1] M. Ito, F. Nakamura, A. Baba, K. Tamada, H. Ushijima, K. H. A. Lau, A. Manna, W. Knoll, "Enhancement of surface plasmon resonance signals by gold nanoparticles on high-density DNA microarrays", J. Phys. Chem. C, Vol. 111, No. 31, pp11653-11662, 2007.

[2] M. Sadaie, N. Nishikawa, Y. Kumashiro, Y. Ikezawa, Y. Kumagai , K. Makino, S. Ohnishi, K. Tamada, M. Hara, "Quantitative friction map on surface composed of beta-cyclodextrin monolayer", Jpn. J. Appl. Phys. PART 1, Vol. 46, No.12, pp7838-7845, 2007.

[3] L.F.N.A. Qune, K. Makino, K. Tamada, W. Chen , A.T.S. Wee ATS, "Selective adsorption of L-tartaric acid on gemini-type self-assembled monolayers", J. Phys. Chem. C, Vol.112, No. 8, pp3049-3053, 2008.

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3．4 Research Targets and Activities of Systems & Software Division

The goal of System & Software Division is to realize the Ubiquitous environment. In an ideal ubiquitous environment, everyone can communicate with anybody, anywhere, at any time, with any kind of information, freely and in real time. Our division has the following 5 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 Systems : Symbiotic computing.
— Information Content : Network-oriented contents management and utilization technology.
— Structure of Information Society (Visitor Section).

Research results from 2007 Apr. to 2008 Mar. in each field are described later. The summary is as follows.

(1) Software Construction

We have been researching on theoretical foundations for flexible yet reliable programming languages, and have been conducting a development project of SML#, a new programming language in the ML family, that embodies some of our recent results such as more flexible static typing and high-degree of interoperability with existing languages and databases. The last year's major results include the following: (1) a proof theory for machine code published in ACM TOPLAS, which establishes a Curry-Howard isomorphism between a sequent style proof system and a low-level code language; (2) a prototype SML# compiler released in July 2007, which provides various new features such as record polymorphism and transparent interoperability with C.

(2) Computing Information Theory

Aiming at combining program transformation methods and automated theorem proving methods, we continued to pursue the possibility of program transformation by second-order templates based on term rewriting. We proposed a second-order generalization algorithm and based on this, we implemented a method to extract second-order templates from concrete program transformations. Although many automated termination checkers have been proposed recently, not many researches on automation of confluence checkers are known. We implemented a confluence checker for term rewriting systems based on decomposition methods such as direct sum decomposition and commutative decomposition. Other research results of this year include a new automated lemma generation method for rewriting induction with disproof and a new encoding method for SAT-based termination proving.

(3) Communication Network Systems

We have studied new management scheme for next generation ubiquitous network (SCOPE project, 2007-2009, Ministry of Internal Affairs and Communications) and promoted standardization activities in IETF WG. As an outcome of this work, our proposed idea of "NEMO Management Information Base" becomes draft standard in February 2008 and get international recognition. In the field of "Symbiotic computing", we have investigated the details of its model and architecture, and have developed some prototype systems, such as supervisory support system for elderly people (uEyes). We were invited for a keynote speech and three invited papers in international conferences. We have also received an Outstanding Paper Award in a well recognized international conference.

(4) Information Content

In order to realize the environment in which creators'groups collaborate and create video content with each others by using video creation tools separately located on the Internet and/or an intranet, we developed two innovative systems. One is CoMES, a new collaborative video creation system which is based on the concepts of Wiki and SNS, and Flash technology. And the other is CMCS, which makes it possible to realize eye contact and finger pointing between distant users. We presented the effectiveness of these two prototyping systems at ITE and IPSJ symposiums and they both attracted the participants' attention strongly. Besides, we started a new research on video shot boundary detection for the sake of efficient archiving of super high-capacity data generated by super high-speed & super high-resolution camera.

(5) Structure of Information Society

"Numerical simulation technologies by ultra high performance computing" is a powerful measure to encourage human innovative activities in the human society. Our research focuses on the basic technologies to make it spread across the world. We are currently designing a special processor to accelerate the speed of fluid simulation which can be widely applicable to the various fields. The computing is expected to be done with ultra high speed and with low power consumption by using compact-size electric circuits. We have adopted a simple algorithm of lattice gas automaton to decrease the power consumption during the recursive computation by avoiding the use of complicated electric circuits such as multiplication circuits. In addition, we have bright perspective to attain much lower power consumption by using "spin operation circuits with TMR devices" proposed by Professor Hanyu of RIEC.

Software Construction

Foundations for Developing High-level and Reliable Programming Languages

[Research Target and Activities]

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

The major results of 2007 academic year include the following. (1) Establishment of a proof theoretical framework for machine code and compilation. In this framework, a machine code language is interpreted as a sequent-style proof system of intuitionistic propositional logic, and compilation process is represented as a proof transformation from the natural deduction proof system to the sequent style proof system of the code language. This establishes a Curry-Howard isomorphism for a low-level code language. These results were published in ACM Transactions on Programming Languages and Systems, 2007. (2) a prototype SML# compiler released in July 2007, which provides various new features such as record polymorphism and transparent interoperability with C.

[Staff]

Professor Atsushi Ohori（2005-）

Assistant Professor Isao Sasano（2005-）

Research Fellow Yutaka Matsuno

Research Fellow Huu-Duc Nguyen（until July 2007）

Research Fellow Liu Bochao

Secretary Shoko Otomo

[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] Atsushi Ohori, A proof theory for machine code, ACM Transactions on Programming Languages and Systems, Vol. 29, No. 6, October 2007.

[2] Atsushi Ohori and Satoshi Osaka, A fresh look at pattern matching compilation, Computer Software, Vol. 24, No. 2, pp. 113-132, May 2007. (in Japanese)

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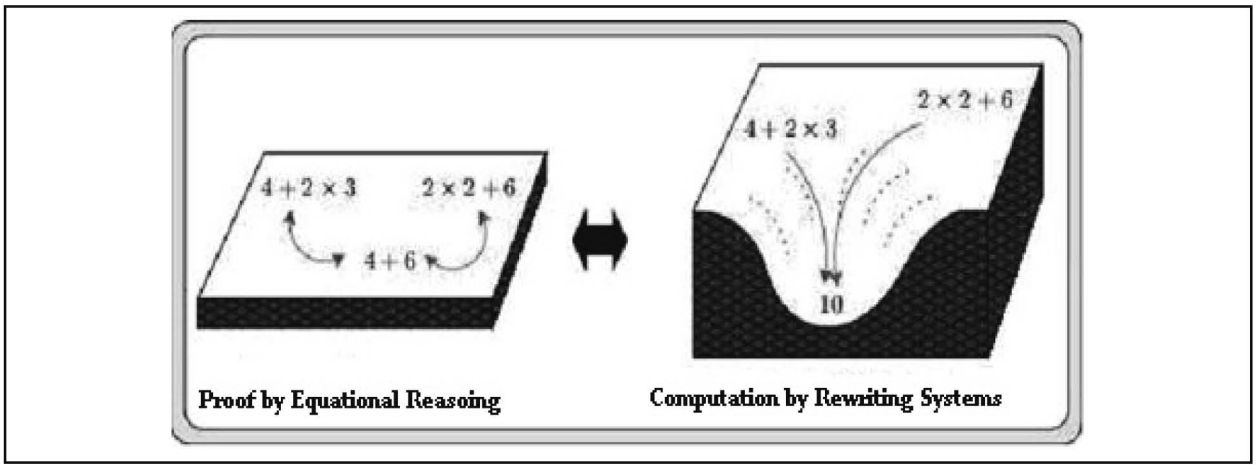
Computing Information Theory

Towards a New Software Paradigm Arising from Computation and Proof



[Research Target and Activities]

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

[Staff]

Yoshihito TOYAMA, Professor
Takahito AOTO, Associate Professor
Kentaro KIKUCHI, Assistant Professor
Jeroen KETEMA, Research Fellow

[Profile]

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

[Papers]

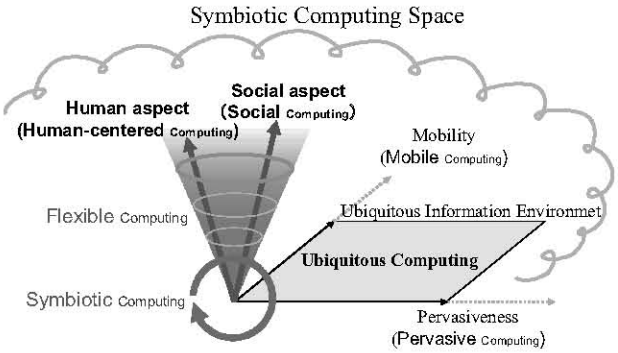
[1] Y.Toyama, On the Church-Rosser Property for the Direct Sum of Term Rewriting Systems, Journal of the ACM, Vol.34(1), pp.128-143, 1987.
[2] Y.Toyama, Counterexamples to Termination for the Direct Sum of Term Rewriting Systems, IPL, Vol.25(3), pp.141-143, 1987.
[3] Y.Toyama, J.W.Klop, H.P.Barendregt,Termination for Direct Sums of Left-Linear Complete Term Rewriting Systems, Journal of the ACM, Vol.42(6), pp.1275-1304, 1995.

Communication Network Systems

Information Communication Systems based on Symbiotic Computing

[Research Target and Activities]

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



Concept of Symbiotic Computing

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

In 2007, for Symbiotic computing research, we have studied model and architecture of Symbiotic computing in detail, which consists of Perceptual, Social and Network-ware. For network management research, we have investigated IPv6 network mobility support and designed a MIB specialized in network mobility. We also promoted standardization activities in IETF Working Group and proposed a draft standard of "NEMO Management Information Base" in Feb. 2008.

[Staff]

Professor: Norio Shiratori (From 1993) Associate Professor: Takuo Suganuma (From 2003)
Research Associate: Gen Kitagata (until April 2007), Kazuhide Koide Secretary: Kana Miura

[Profile]

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

[Papers]

[1] H. Takahashi, Y. Tokairin, K. Yamanaka, T. Suganuma, T. Kinoshita, K. Sugawara, N. Shiratori, "A Ubiquitous Care-Support Service based on Agent-oriented Multiple-Context Coordination," Journal of Networks, Vol.2, No.5, p.33-45, 2007
[2] N. Nakamura, D. Chakraborty, D. S.L. Wei, N. Shiratori, "Efficient Channel Utilization for IEEE 802.11 ad hoc Networks,", Mobile Intelligence: Mobile Computing and Computational Intelligence Chapter 5, Wiley & Sons, Inc.
[3] N. Shiratori, "Year 2025: Towards Symbiosis Society -A New Computing Concept for Post Ubiquitous Environment-," International Conference on Engineering, Applied Sciences, and Technology (ICEAST 2007), 2007 (**Keynote Speech**)

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Information Content

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

[Research Target and Activities]

In our laboratory, we are tackling the following research topics.

1. Automatic Character Positioning method in DMD

We are developing DMD(Digital Movie Director), which is an automatic 3DCG movie creation system only by scenario input. We developed automatic character positioning method in this system, which is innovative and useful because user does not have to take three dimensional CG space into account. According to some experiments, this proposed method shows very good subjective evaluation.

2. A Proposal and Prototyping of Collaborative Movie Creation System(CMCS) over the Internet

Eye contact and finger pointing are thought to be important for some kinds of meetings (planning meeting, creation meeting, and decision meeting, etc). However they are very difficult to realize on the Internet without using special screens or devices. We proposed and prototyped a new method to support these functions by a simple way.

3. High-performance Video shot Boundary Detection Technology

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

4 .Error Resilient Broadcast Scheduling Method for Personal Broadcast Stations

We proposed a new broadcast scheduling method called SDBB(Synchronized Double Buffering Broadcasting) for end user to distribute their video content with their PC and network resources. The features of this method is to own network-error resilience.

[Staff]

Junji NUMAZAWA, Professor
Terumasa AOKI, Associate Professor
Nobuko MUTO, Secretary

[Profile]

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

[Papers]

[1]Terumasa AOKI, Junji NUMAZAWA and Hiroshi YASUDA, "WebCoFIP : A new architecture for guarantee of authenticity of Web pages", IEICE 2nd MIH Workshop, Oct., 2007.(in Japanese)

[2]Daisuke SHIMIZU, Terumasa AOKI, Hiroshi YAMADA and Junji NUMAZAWA, "Prototyping of Collaborative Movie Creation System for distant meeting", IPSJ 70th Annual Symposium, Mar., 2008.(in Japanese)

[3]Terumasa AOKI, Junji NUMAZAWA and Hiroshi YASUDA, " Automatic Animation Movie Creation Technology by Digital Movie Director (DMD)"、IEICE Annual Symposium (Invited Lecture), Mar., 2008.(in Japanese)

Research area on the structure of information society

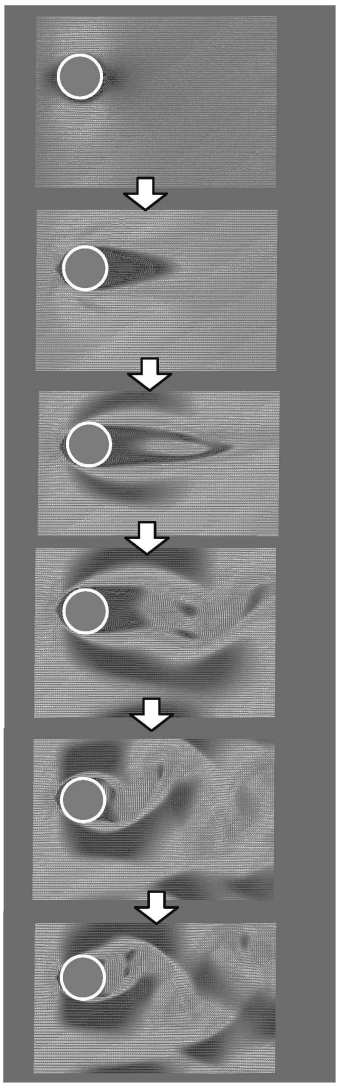
Numerical Simulation Technologies by ultra high performance computing as a measure to encourage human innovative activities

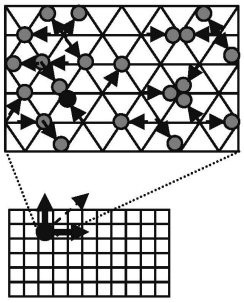
[Research Target and Activities]

"Numerical simulation technologies by ultra high performance computing" is a powerful measure to encourage human innovative activities in the human society. Our research focuses on the basic technologies to make the measure spread across the world.

In 2007, we studied on the design of special processors to accelerate the speed of fluid simulation which can be widely applicable to the various fields such as cooling systems of Fast Breeder Reactors, positioning systems of Autonomous Underwater Vehicles, and so on. The main target of the design is to attain ultra high computing speed, very low power consumption and compact in size. For this purpose we have adopted a very simple simulation model of lattice gas automaton. The model is so simple that the recursive computation based on it does not need the complicated calculation such as multiplication with floating-point representation, and that the power consumption by the relevant electric circuits can be kept low. In addition, we have bright perspective to attain much lower power consumption by using "spin operation circuits with TMR devices" proposed by Professor Hanyu of RIEC.

We also executed several large-scale numerical simulations by high performance computers. The figures on the right are the simulation results by using "Earth Simulator (ES)" of JAMSTEC (Japan Agency for Marine-earth Science and TECnology). We can use it as a member of research group of JAEA (Japan Atomic Energy Agency) in the framework of cooperation agreement for the research area of ultra high performance computing. The agreement was concluded in April, 2005.





Figures: Fluid flow simulation behind a cylinder by the calculation of about billion lattice-points by using ES by Kikuchi

[Staff]

Hiroshi MATSUOKA, Visiting Professor
Noriko KIKUCHI, Technical Assistant Staff

[Profile]

Hiroshi MATSUOKA received his B.E. and M.E. from Tokyo University, Japan, in 1977 and 1979, respectively, and Dr. Eng. from Ibaraki University, Japan, in 1997. From 1979, he worked for Science and Technology Agency of Japanese Government, and transferred to Ministry of Industry and International Trade, Japan Atomic Energy Agency, National Institute of Metal, IAEA (International Atomic Energy Agency), Tohoku University and so on.

[Papers]

No papers in 2007

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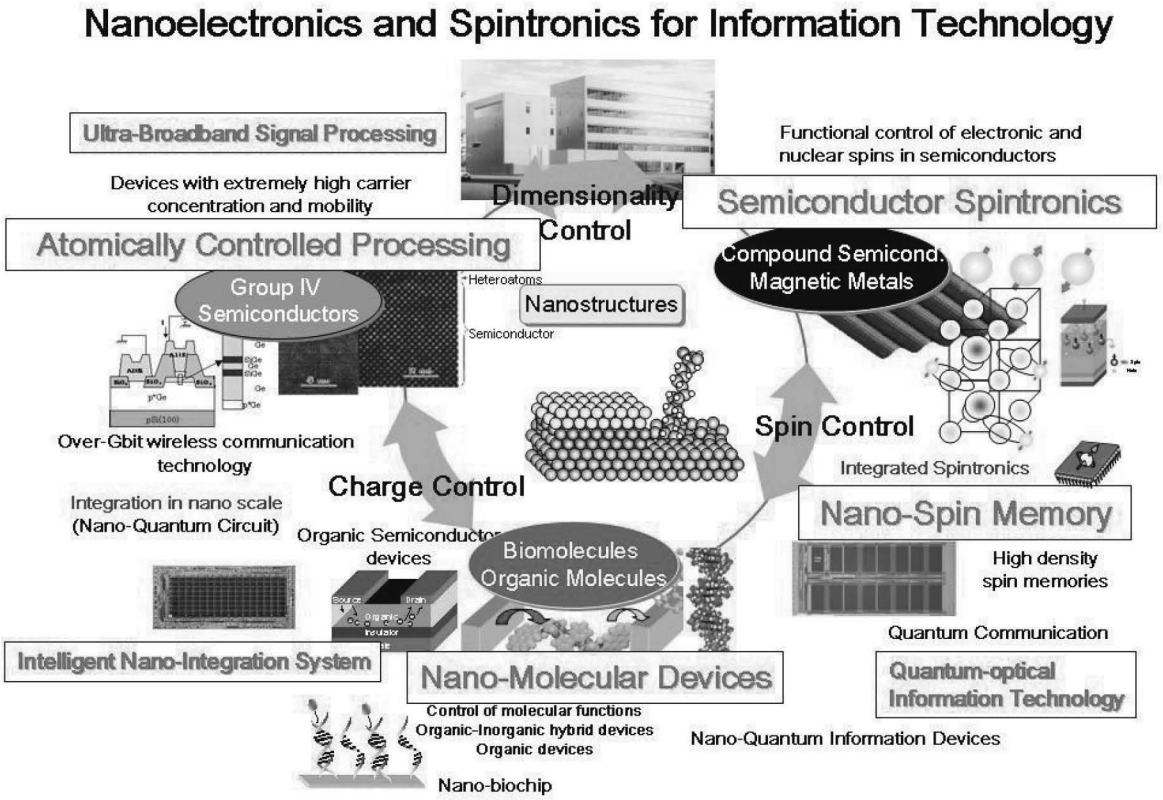
3．5 Laboratory for Nanoelectronics and Spintronics

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

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

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



Highlights of Research Activities in 2007:

Atomically Controlled Processing [Murota Laboratory]

By using ultraclean low-pressure chemical vapor deposition, formation of heavily B atomic-layer doped Si epitaxial films on Si(100) with atomic-order flatness was achieved, and it is clarified that the B_2H_6 exposure at 180°C and subsequent SiH_4 exposure at 180-300°C are effective to suppress B clustering and to achieve extremely high carrier concentration. Moreover, it is found that, at an atomic-order nitrided SiGe surface, N atoms bonded to Ge atoms tends to be transferred to Si atoms by heat treatment with increase of the Ge fraction beneath the nitrided layer. With low-temperature SiH_4 exposure to the SiGe surface, high Ge fraction (58%) p-type resonant tunneling diodes with atomic-order flat Si/SiGe heterointerfaces are successfully fabricated and the diode shows negative differential conductance (NDC) characteristics at around 290K. It is also clarified that thinning the Si barrier down to around 1 nm is effective to improve the NDC characteristics. These results are important for group-IV semiconductor heterostructure formation with atomic-order control which enables novel material properties.

Semiconductor Spintronics [Ohno Laboratory]

Our research activities focus on the establishment of the fundamental technologies for future spintronic devices. The outcomes in the last fiscal year are following. (1) We discovered the current-induced magnetic domain wall creep in a ferromagnetic semiconductor (Ga,Mn)As. We found that the creep motion belongs to previously unknown universality class. (2) We successfully observed the artificial atomic properties and evaluated the g value of the electronic state in a narrow-gap semiconductor (In,Ga)As quantum dot with MIS-gate and air-bridge drain structures. (3) We demonstrated the room-temperature operation of InAs/(Al,Ga)Sb quantum cascade lasers (QCL) at low-threshold current density (4 kA/cm^2) and the simultaneous lasing of interband and intersubband in InAs/AlSb QCLs.

Nano-Molecular Devices [Niwano Laboratory]

(1)Titanium oxide nanotubes were rapidly and homogeneously formed by anodizing metal titanium in a mixture of ethanol and perchloric acid. The diameter of them could be controlled by an anodic potential. (2)We investigated the influence of the interface between the electrode and the organic film on the output characteristic of an organic field effect transistor and demonstrated that the output characteristic of an organic field effect transistor can depend strongly on the carrier injection to the organic film from the electrode. (3)Antibody-antigen reactions were sensitively characterized using infrared spectroscopy. We showed that infrared spectroscopy has a potential for identifying target antibody or antigen by analyzing peak positions of the spectra that reflects their secondary structures. (4)We developed an infrared observation system for in-situ and real-time monitoring of cell responses to drugs. The process to apoptotic cell death was observed using this system.

Intelligent Nano-Integration System [Nakajima Laboratory]

(1) We clarified the mechanism of undesirable oscillating states of an Inverse Delayed neuron model, which is a main obstacle when we search solutions of combinatorial optimization problems. Such oscillating states can be avoided by tuning one of model parameters. By using these results, we can solve combinatorial optimization problems successfully. Furthermore, we implemented a prototype chip composed of burst Inverse Delayed neurons and confirmed successful operations in solving the N-Queen problem. (2) We observed successfully a single photon resonant activation of a Bi-2212 intrinsic Josephson junction, and clarified that the coupling strength between junctions, which affects on the collective behavior of junctions, changes according to the fabrication process. (3) A 4-bit parallel multiplier for the single flux-quantum fast Fourier transform was demonstrated successfully with Nb integrated circuits. Prospective operations of a high-speed up/down counter for the neural computation using stochastic logic were observed experimentally. An experimental result showed that the flux-quantum pulse signal accumulation more than 100GHz was possible.

Quantum-Optical Information Technology [Edamatsu Laboratory]

1. We investigate entangled photon generation from semiconductor and quasi-phase-matched (QPM) nonlinear optical materials. We have achieved (1) generation of high-purity entangled states from a semiconductor, (2) development of a novel scheme to generate entangled photons from QPM devices, and (3) generation of polarization-entangled photons from spatially correlated photon pairs. 2. We are developing a quantum media converter from a single photon to a single electron spin to realize a quantum repeater, which is expected to extend the transmission distance of quantum info-communication. The project is supported mainly by CREST-JST. We have achieved coherent transfer of light polarization to electron spins in a g-factor engineered semiconductor.

Nanospin Memory [Ikeda Laboratory]

We are developing technologies to realize advanced spin memory and logic devices using magnetic tunnel junctions (MTJs) consisting of ferromagnetic metal electrodes and insulating barriers. In our group, the following results were obtained: 1) The TMR ratios of 604% at RT and 1144% at 5K (world record) were realized in MgO-based MTJs. 2) Spin-transfer torque magnetization switching without an external field was observed in the MTJs with synthetic ferromagnetic free layer. 3) Operation of a prototype of the world's first 2Mbit non-volatile random access memory (SPRAM) chip employing the spin-transfer torque writing method was verified.

Ultra-Broadband Signal Processing [Otsuji Laboratory]

The terahertz-wave photomixing devices utilizing the plasmonic oscillation of two-dimensional electron system are being studied as a possible candidate of the solid-state devices for coherent continuous electromagnetic wave in terahertz frequency range. The basic concept of the device

has been proven by the GaAs-based heterostructure system. In this year a novel photomixing device with a semiconductor grating gate structure was proposed. The device was designed with the CAD system in the laboratory facility. The fabricated device exhibited a significant improvement in the intensity of terahertz-wave emission.

Basic Technology for Broadband Communication [Mizuno Laboratory]

In this Division, we use the millimeter wave spectrum to develop new medical diagnosis and to develop instruments for security application. This year we have studied and developed probes for skin disease diagnosis and signal processing for reconstructing mm-wave images for security applications.

Wireless Info Tech [Tsubouchi Laboratory]

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

Technology Development Division: Storage Technology Group of IT-21 Center [Aoi Laboratory]

In March 2007, the IT21 cooperative research project between industry, academia and government was successfully finished. An ultra-high small perpendicular magnetic recording prototype HDD and basic technologies for densities of 0.5 to 1 Tbits/inch^2 were developed during the project. A new project ;Development of super high-speed mass storage HDD systems started in August 2007 under the collaborations between RIEC including IT21 storage technology group, major Japanese HDD manufacturers and other laboratories researching related technologies within Tohoku University. A development of high density patterned media is one of research subjects in this project, and we fabricated fine dot arrays of CoPt perpendicular films, and studied fundamental properties.

Electromagnetic Bioinformation Engineering [Ishiyama Laboratory]

To obtain a high accuracy magnetic field sensor for detecting the bio-information, the most important factor is to control the magnetic anisotropy of the magnetic materials for the sensor. In the year of 2007, we confirmed to be able to control the magnetic anisotropy quantitatively by controlling the shape of the magnetic materials closely using the micro-processing technology. This result enables to apply a new technique for controlling the anisotropy onto the conventional annealing method, and that enables to control the properties in wider range.

Solid State Physics [Takahashi Laboratory]

For high areal density HDD (Hard Disk Drive) over 1 Tbit/inch2, achievement of CPP

(Current Perpendicular to the Plane)-GMR (Great Magneto Resistance) head is required. However, its MR ratio is smaller than the target value, still remaining in a serious problem. In this study, in order to overcome such problem, small amount of NM (non-magnetic) impurity atoms are diluted into the FM (ferro-magnetic) layer. Moreover, the mechanism of the enhancement of spin dependent scattering effect is investigated by XMCD analysis considering the spin polarization of diluted NM atom. As the result, the enhancement of the MR ratio was obtained due to dilution of the NM atoms, and it was revealed that an increment of the MR ratio due to enhancement of the spin dependent scattering effect was correlated to be proportional to the magnitude of the spin polarization.

Electromagnetic Theory [Yamaguchi Laboratory]

RF(GHz range) device application seeds of both micropatterned metal/magnetic thin-film multilayer and Fe-system particulate film have been studied. Using the multilayer, coplanar transmission line was microfabricated and its frequency profile of resistance was analyzed. It is experimentally clarified that there is such a frequency range where the resistance decreases as the frequency increases, and such frequency range shifts toward higher with the application of external dc magnetic field. Therefore it is possible to suppress the skin effect and reduce rf resistance of a conductor in an integrated circuit by means of metal/magnetic multilayer. Theoretical calculation clarified that this structure is extensively applicable for integrated thin-film inductor. Besides, the Fe-system particulate material was dropped on to only 8-micron wide coplanar line made of Si multilayer to find out the capability of RF electromagnetic noise suppression by a few dB. This result suggests a new technique to suppress electromagnetic noise on a chip.

Microelectronics [Sahashi Laboratory]

The microwave oscillation induced by the spin transfer torque (STT) has been already reported on fabricating a mono-pillar or a point contact of magnetic multilayers. The coherent oscillation has been also reported by the double point contacts. We propose to apply our original nano-confined structure formed by self-assembling nano-oxide layer to the microwave oscillator. For the comparison between mono- and coherent- oscillation, first of all, the mono-pillar of 100nm×100nm sized CPP-GMR element has been fabricated by the EB lithography and milling process. The mono-pillar of 100nm size was successfully confirmed by SEM and AFM. The study on STT oscillation will be continued by using this element fabrication process with the design of most suitable pattern of electrode for microwave oscillation.

Solid State Electronics [Itoh Laboratory]

High-performance TFTs with one-dimensional long and narrow grains was investigated. Low temperature recrystallization of amorphous silicon (a-Si) thin films using continuous-wave (CW) green laser was carried out, and one-dimensional lateral large grain was obtained.

Typical grain size of lateral recrystallized Si thin film was 20 ×2 μm^2. Electron field effect electron mobility was 391 cm^2/Vs. The fluctuation of TFT device characteristics strongly depended on the gate width W. It is found that the fluctuation was proportional to $W^{-1/2}$ ruled by the central limit theorem. And also the laser recrystallization of ferroelectric thin film was investigated. The crystal grain size and density was controlled by laser scanning conditions.

Basic Plasma Engineering [Hatakeyama Laboratory]

The growth kinetics of single-walled carbon nanotubes (SWNTs) during plasma chemical vapor deposition (CVD) have precisely been investigated. The growth equation was successfully established based on the time evolution of Raman scattering spectra, which can well describe the unique growth mode of SWNTs under plasma CVD. Fabrication of novel carbon nanotubes (CNTs) with an arc discharge in a water phase reaction was also studied. The combination of electrode materials is found to strongly influence the structure of produced materials. Through the investigation of the SWNTs functionalization with various kinds of atoms and molecules such as alkali metals, magnetic nanoparticles, and bio-molecules, it was also revealed that the electronic transport property of SWNTs can be adjustable to p-type, pn junction diode, and n-type features. Since the encapsulated atoms and molecules inside the hollow-space of nanotubes significantly affect the electronic features of SWNTs, adjusting the dosage ratio of electron donor to acceptor materials with plasma ion irradiation is the key element to realize such precise electronic transport property control of SWNTs.

Optical Physics Engineering [Yamada Laboratory]

The silicon photonic-wire waveguides, with silicon (Si) core and silica (SiO_2) cladding, have achieved light confinement in waveguides with very small cross section of 300 × 300 nm, and with very small bending radius. Therefore, compared with all-silica devices, a huge reduction in size and power consumption is expected. That high optical confinement makes the devices very sensitive to roughness of the sidewalls. Even nm order roughness can affect the performance of the device. Very accurate design and fabrication techniques are required. This year, we have designed spot size converters using numerical electromagnetic field calculations based on BPM and FDTD methods. Regarding device fabrication, we have verified the quality of the writing field stitching in the electron beam exposure machine.

New Intelligence for IC Differentiation Project [Ohmi Laboratory at New Industry Creation Hatchery Center]

Current drivability improvement of the p-channel MOS transistor is necessary for the performance enhancement of the CMOS circuit. However, the p^+ region of the p-channel MOS transistor has a problem that the boron is easy to be inactivated by plasma damages. Therefore, the increase of the resistance in the p^+ region becomes limit the current drivability of the p-channel MOS transistor. We realize that the formation of the high-quality silicon

dielectric films at low temperature (<400°C) those films have approached the electrical characteristics of high temperature thermal silicon dielectric films and the low resistivity ($<10^{-9}\Omega cm^2$) silicon/silicide contact those processes are indispensable to the CMOS circuit fabrications without plasma damages for the p^+ region.

Spin Electronics [Ando Laboratory at Department of Applied Physics]

Magnetic tunnel junctions (MTJs) with a half-metallic Co_2MnSi Heusler alloy electrode and a high-quality MgO tunneling barrier have been developed. We have succeeded to observe very large tunnel magneto resistance (TMR) ratios of 217% at room temperature and 753% at low temperature, respectively. The observed TMR ratio is highest among the MTJs with Heusler alloy electrodes. It is considered that the large TMR ratio result from coexistence of half-metallicity of Co_2MnSi and coherent tunneling through the MgO barrier. Moreover, we found that the developed Co_2MnSi alloy film had a small magnetic damping constant compared with other ferromagnetic materials. Therefore, the Co_2MnSi alloy is a promising ferromagnetic material used in spin-electronics devices.

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

Recently, transport properties of high mobility two-dimensional electron gas (2DEG) have been strongly investigated at various oxide heterointerfaces. At one of oxide heterointerfaces, MgZnO/ZnO, we have successfully observed quantum Hall effect. Next trial in this study is improvement of controllability for 2DEG density with modulation doping or applying electric field. The improvement of controllability promotes realization of high performance oxide-based transparent field effect transistor and investigations of solid-state properties at oxide heterointerfaces. Co-doped TiO_2 is one of room temperature ferromagnetic oxide semiconductor. In this study, we applied a sputtering method to fabricate Co-doped TiO_2 films. The films also exhibited ferromagnetic MCD and anomalous Hall effect at room temperature. In particular, we found higher magnetization of the sputtering-grown films than those of PLD-grown films.

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

We have investigated the spin orbit interaction (SOI) in semiconductor heterostructures and the magnetization reversal process of submicron-sized ferromagnetic ring structures. (1) Rashba SOI parameter of 2.41×10^{-12} eVm was obtained in the shallow $In_{0.53}Ga_{0.47}As$ / $In_{0.7}Ga_{0.3}As$ two dimensional electron gas (2DEG) which is located below 6.4 nm from the sample surface. Investigated 2DEG structure becomes the possible candidate for the spin controlled device combined with electrical spin injection and detection. (2) Magnetization reversal process of single Fe / Au / Fe ring structure was investigated by local Hall effect using $In_{0.63}Ga_{0.37}As$ 2DEG. We separately detected the magnetization reversal process of two Fe layers by the different magnitude of the resistance steps. (3) Inner diameter dependence of magnetostatic coupling in Fe / Au / Fe rings was measured by the magneto-optical Kerr effect.

As the inner diameter decreases, the magnetostatic coupling is enhanced between two Fe layers due to an increase of a stray field from ring edges.

Electrochemical Science and Technology [Itaya Laboratory at Department of Applied Chemistry]

Field effect transistor by the use of organic semiconductor, such as pentancene, has been recently extensively studied. For further progress, the quality of the organic semiconductors should be highly improved. Along this line, we could succeed in fabricating nearly perfect single crystals of organic semiconductor by solution-grown method. The field effect effect transistor based on this nearly perfect single crystals of organic semiconductors grown from solutions possesses much higher performance than those of vacuum-evaporated organic thin films.

Magnetic Materials and Devices [Kitakami Laboratory at Institute of Multidisciplinary Research for Advanced Materials]

One of the final goals of our group is development of ultra-high density non-volatile memory using magnetic materials, including so-called spin devices. Main topics are development of high-K_u materials and magnetization behavior of nanosized magnets. We have investigated static magnetic properties of single nanodots down to 50 nm in diameter made of $L1_0$-FePt or Co/Pt multilayers by detecting anomalous Hall effect of those single dots. Those works are now being expanded to the "dynamic" region in nanoseconds time scale, which would be more important for applications.

Solid State Photophysics Group [Ishihara Laboratory at Department of Physics]

In out laboratory, metamaterials at visible and near-infrared wavelengths are investigated. To substantiate near-field super-resolution in uniaxial organic-inorganic semiconductors, we fabricated metallic nano-slit. By measuring the near-field image of the nano-slit, we test the subwavelength-scale image which breaks diffraction limit. As another subject, we conducted the fabrication of the metamaterials which are known hard to be realized but are actually designed to obtain negative refractive-index media at visible wavelengths. The negative refractive index will be examined in the near future.

Atomically Controlled Processing

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

[Research Target and Activities]

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

In this year, formation of heavily B atomic-layer doped Si epitaxial films on Si(100) with atomic-order flatness was achieved, and it is clarified that the B_2H_6 exposure at 180°C and subsequent SiH_4 exposure at 180-300°C are effective to suppress B clustering and to achieve extremely high carrier concentration. Moreover, it is found that, at an atomic-order nitrided SiGe surface, N atoms bonded to Ge atoms tends to be transferred to Si atoms by heat treatment with increase of the Ge fraction beneath the nitrided layer. High Ge fraction (58%) p-type resonant tunneling diodes with atomic-order flat Si/SiGe heterointerfaces are successfully fabricated and the diode shows negative differential conductance characteristics at around 290K.

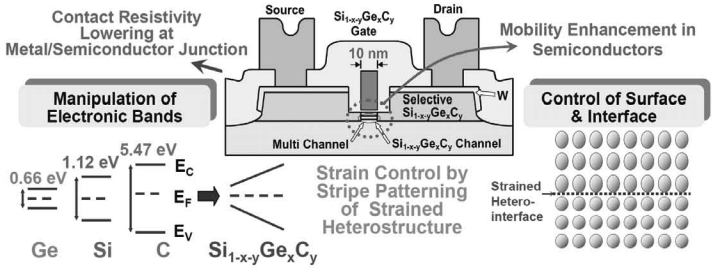


Fig. 1. 10 nm-scale quantum nanodevices with strain controlled nano-scale patterned heterostructure of group IV semiconductors.

[Staff]

Professor: Junichi Murota
Associate Professor: Masao Sakuraba

[Profile]

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

[Papers]

[1] J. Murota, J. Uhm and M. Sakuraba, "Strain Control of Si and $Si_{1-x}Ge_x$ Layers in the Si/$Si_{1-x}Ge_x$/Si Heterostructures by Stripe-Shape Patterning for Future Si-Based Devices" (**Invited Paper**), Symp. E9: ULSI Process Integration 5 (212th Meeting of the Electrochem. Soc.), Washington, DC, USA, Oct. 7-12, 2007, Abst.No.1280: ECS Trans., Vol.11 (Edited by C. Claeys et al., The Electrochem. Soc., Pennington, NJ, 2007), pp.91-99 (2007).

[2] M. Sakuraba, R. Ito, T. Seo and J. Murota, "Fabrication of Hole Resonant Tunneling Diodes with Nanometer Order Heterostructures of Si/Strained $Si_{1-x}Ge_x$ Epitaxially Grown on Si(100)" (**Invited Paper**), Symp. E9: ULSI Process Integration 5 (212th Meeting of the Electrochem. Soc.), Washington, DC, USA, Oct. 7-12, 2007, Abst.No.1283: *ibid*, pp.131-139 (2007).

[3] H. Tanno, M. Sakuraba, B. Tillack and J. Murota, "Heavy Atomic-Layer Doping of B in Low-Temperature Si Epitaxial Growth on Si(100) by Ultraclean Low-Pressure Chemical Vapor Deposition", Appl. Surf. Sci., Vol.254, (2008, in press).

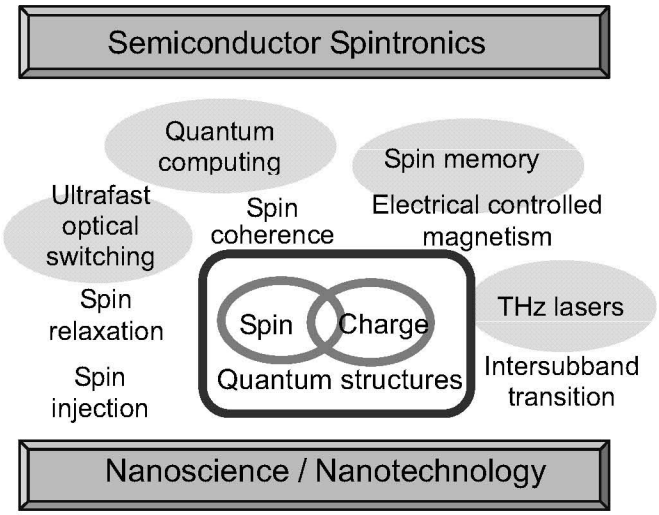
Semiconductor Spintronics

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 the current-induced magnetic domain wall creep in a ferromagnetic semiconductor (Ga,Mn)As. (2) Observation of artificial atomic properties and evaluation the g value of the electronic state in an (In,Ga)As quantum dot. (3) Demonstration of the room-temperature operation of InAs/(Al,Ga)Sb QCL at low-threshold current density (4 kA/cm^2) and simultaneous lasing due to interband and intersubband transitions in InAs/AlSb QCLs.

[Staff]

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

[Profile]

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). He is a member of JSAP, JPS, JACG, IEICE, APS, IOP, IEEE, and AVS.

[Papers]

[1] K. Ohtani, H. Ohnishi, and H. Ohno, "Simultaneous lasing of interband and intersubband transitions in InAs/AlSb quantum cascade laser structures", Applied Physics Letters, Vol. 92, 041102 (1)-(3), January 2008.
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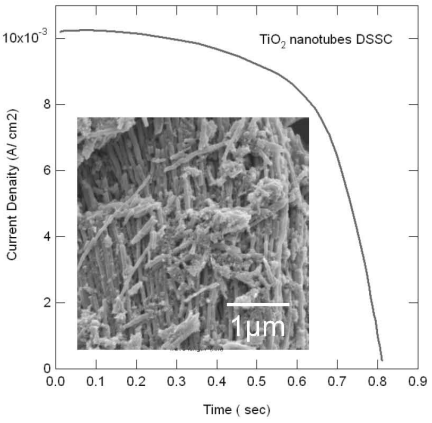
Nano-Molecular Devices

Fabrication of electronic devices from functional molecules and nanostructures

[Research Target and Activities]

The continuously increasing amount of data to be stored and manipulated requires molecular- and nano-electronic devices that are fabricated from various functional molecules and nano-scaled structures. The use of such molecules and nanostructures will open entirely new horizons in the field of electronic device technology. The need to manipulate large amounts of genetic data also requires the development of new types of bio-information devices, which may be constructed by combining molecular device technology with biotechnology. In accordance with these requirements, we are now developing bio-sensing systems, flexible organic electronic devices such organic transistors and organic light-emitting diodes, and solar cells using new types of molecular materials. Our goal is the realization of molecule-sized electronic devices that enable signal generation, processing, transfer, amplification and more on the molecular scale. Recent research topics are as follows:



DSSC with titanium oxide nanotubes

1. Development of bio-sensing systems- We have developed a label-free DNA micro array in which DNA hybridization may be detected on porous Si using infrared microspectroscopy. We also demonstrated that antigen-antibody reactions can be in-situ and in real time monitored with high throughput and sensitivity using surface infrared spectroscopy.
2. Fabrication of dye-sensitized solar cells (DSSCs)- We have developed a simple method for synthesis of TiO_2 nanotubes by electrochemical process (anodization), and fabricated hybrid DSSCs in which a mixture of TiO_2 nanotubes and powders is used as the electrode. The solar cells showed a conversion efficiency of about 5 %.

[Staff]

Professor: Dr. Michio Niwano (1998~)
Assistant professor: Dr. Yasuo Kimura (1999~)
Assistant professor: Dr. Ayumi Hirano (2006~)

[Profile]

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

[Papers]

[1] Ken-ichi Ishibashi, Ryo-taro Yamaguchi, Yasuo Kimura, and Michio Niwano, "Fabrication of titanium oxide nanotubes by rapid and homogeneous anodization in a mixture of perchloric acid and ethanol", J. Electrochem. Soc., 155(1), K10-14 (2008).
[2] Ryo-taro Yamaguchi, Ko-ichiro Miyamoto, Ken-ichi Ishibashi, Ayumi Hirano, Suhana Mohd Said, Yasuo Kimura, and Michio Niwano "DNA hybridization detection by porous silicon-based DNA microarray in conjugation with infrared microspectroscopy" J. Appl. Phys., 102, 014303-1-7 (2007).
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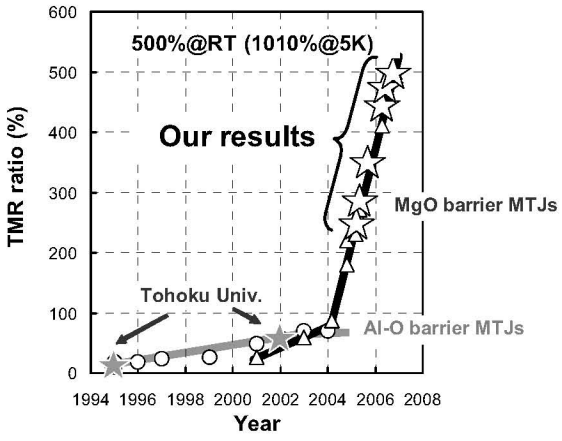
Nano-Spin Memory

Research of spin based device and memory

[Research Target and Activities]

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

1) A high TMR ratio of 500% at RT (world record) was realized in MgO-based MTJs.
2) Spin-transfer torque magnetization switching without an external field was observed in the MTJs with synthetic ferromagnetic free layer.
3) Operation of a prototype of the world's first 2Mbit non-volatile random access memory (SPRAM) chip employing the spin-transfer torque writing method was verified.

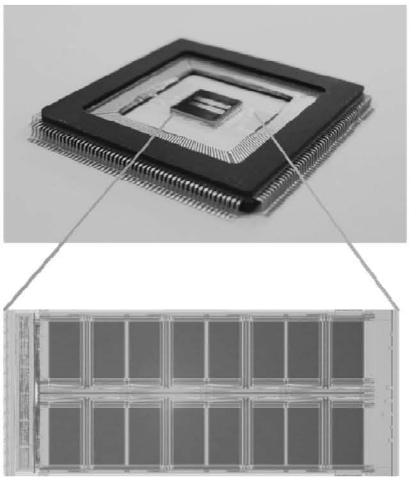


Appl. Phys. Lett., 90 (2007) 212507.

Development of TMR (tunnel magnetoresistance) ratio for MTJs with Al-O and MgO tunnel barriers.

[Staff]

Shoji Ikeda, Associate Professor
Haruhiro Hasegawa, Visiting Professor
Katsuya Miura, Research Fellow



IEEE J. Solid-State Circ., 43 (2008) 109.

2Mb Spin-Transfer Torque RAM (SPRAM) chip.

[Profile]

Shoji Ikeda received the B.S., M.S., and D.E. degrees from Muroran Institute of Technology, Muroran, Japan, in 1991, 1993, and 1996, respectively. He was a Research Associate in the Department of Electrical and Electronic Engineering at the Muroran Institute of Technology from 1996 to 1999. He was with Fujitsu Ltd., Atsugi/Nagano, Japan, from 1999 to 2003. He was with Tohoku University, Sendai, Japan, in 2003, where he is currently an Associate Professor in the Laboratory for Nanoelectronics and Spintronics, Research Institute of Electrical Communication.

[Papers]

[1] T. Kawahara, R. Takemura, K. Miura, J. Hayakawa, S. Ikeda, Y. Lee, R. Sasaki, Y. Goto, K. Ito, T. Meguro, F. Matsukura, H. Takahashi, H. Matsuoka, and H. Ohno, "2 Mb SPRAM (spin-transfer torque RAM) with bit-by-bit bidirectional current write and parallelizing-direction current read", IEEE Journal of Solid-State Circuits, vol. 43, pp. 109-120, Jan. 2008.

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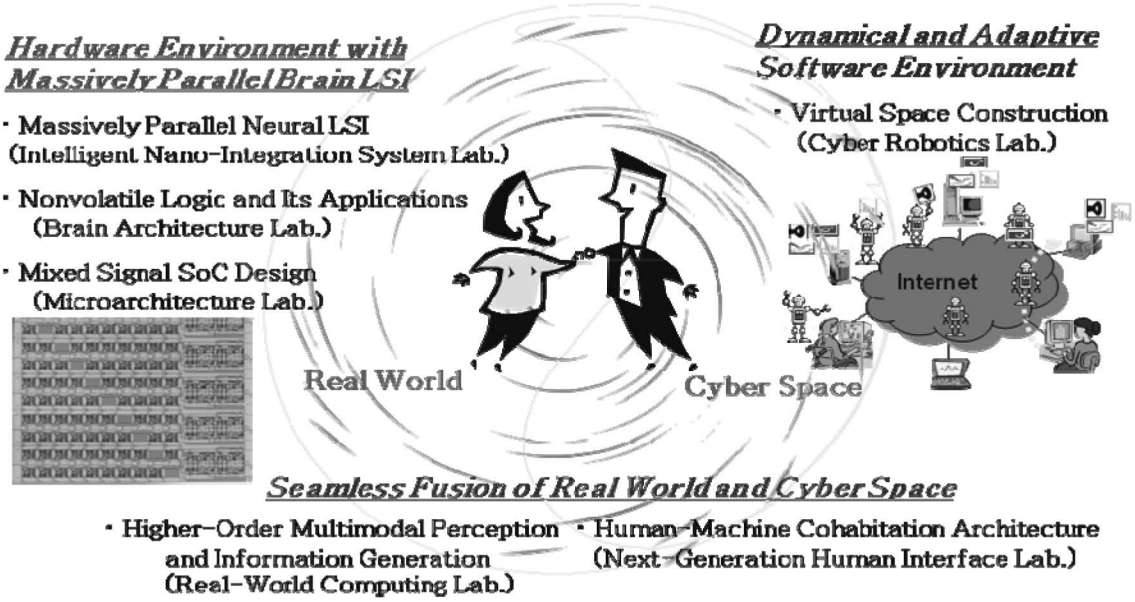
Laboratory for Brainware Systems

3．6 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), Brain Architecture (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 a new system designing principles. For carrying out various purpose and functions in the real-world, the biological system must solve inverse problems. Since in general 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 satisfy 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.

Brain Architecture 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

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): Using the model simulation, we revealed that, even in unpredictably changing environments, the flexible arm reaching movements can emerge from the system, in which the controller evaluates the mobility of each joint based on the real-time sensory information about kinematical and dynamical properties of the body, and consequently determines the control commands for each joint through the autonomously decentralized interactions. These imply that the interaction between the system and environments is critical for creating and satisfying the constraints, and the system has to include "the self-referential mechanism" and "the autonomously decentralized network" to work well in the real-world. For examining the adaptability of proposed model in the real-world, we designed and built the 2-joints and 6-muscles arm robot equipped with various sensors. In addition, for clarifying biological mechanisms with respect to creating and satisfying the constraints, we designed and built the manipulandum that enables us to measure arm reaching movements under various conditions of external force.

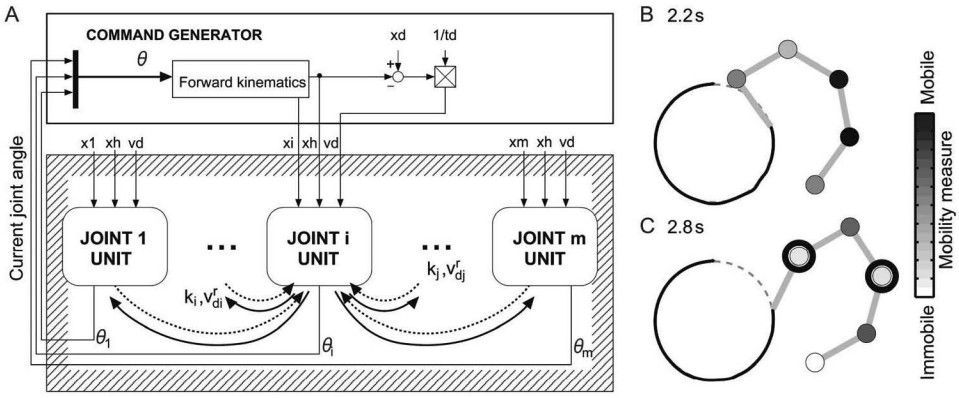
Brain Architecture Section (Hanyu Laboratory): As a this-year research result in nonvolatile-logic area, we have succeeded the chip fabrication of TMR-based basic logic components such as a full adder with a one-bit nonvolatile storage element, 4-bit LUT for nonvolatile FPGA and a compact cell circuit for nonvolatile TCAM (ternary content-addressable-memory). We have also designed and fabricated a 256-bit LDPC decoder chip under a 90nm CMOS process, whose performance is evaluated to be 1.65-times faster than that of a conventional hardware implementation.

Intelligent Nano-Integration System Section (Nakajima-Sato Laboratory): We clarified the mechanism of undesirable oscillating states of an Inverse Delayed neuron model, which is a main obstacle when we search solutions of combinatorial optimization problems. Such oscillating states can be avoided by tuning one of model parameters. By using these results, we can solve combinatorial optimization problems successfully. Furthermore, we implemented a prototype chip composed of burst Inverse Delayed neurons and confirmed successful operations in solving the N-Queen problem. We observed successfully a single photon resonant activation of a Bi-2212 intrinsic Josephson junction, and clarified that the coupling strength between junctions, which affects on the collective behavior of junctions, changes according to the fabrication process. A 4-bit parallel multiplier for the single flux-quantum fast Fourier transform was demonstrated successfully with Nb integrated circuits. Prospective operations of a high-speed up/down counter for the neural computation using stochastic logic were observed experimentally. An experimental result showed that the flux-quantum pulse signal accumulation more than 100GHz was possible.

Microarchitecture Section (Masui Laboratory): We have been investigating low-power and low-cost CMOS transceiver ICs applicable to wireless sensor network. The implementation of complex bandpass filter in low-IF architecture is optimized with an automatic digital tuning circuit for the compensation of RC process variation. Active RC filter realization presents an area advantage of 2.35 over g_m-C filter. The basic principle of simultaneous tuning on center frequency and bandwidth through the calibration of a capacitor array is developed, and a scalable automatic digital tuning circuit with only 835 gates is proposed. The developed capacitor tuning technique can achieve a tuning error below ± 3.5%, and reduce a peaking in the passband of filter characteristics. An experimental tunable complex BPF is designed using a 0.18μm CMOS, and can successfully reduce the tuning error from -20% before the tuning to below ± 2.5%.

Real-world computing

Autonomous Control for Voluntary Movement in the Real World



A: Block diagram of the autonomous control for reaching movement. B: Simulated results of a five-joints arm in normal case. C: Malfunction case when two joints (with black circles) fixed [1].

[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.

In the field of the motor control, we developed a new adaptive control model of reaching movement based on a 'mobility' criterion. In the real world, body properties (such as limb length/inertia, or joint viscosity etc.) would change unexpectedly. To adapt to such uncertain changes, redundancy of joints is important since it would enable us to reach a target even when one joint is immobile, by using the other ones to generate a desired hand motion. In our model (Fig. A), we hypothesized that each joint (1) calculates a "mobility measure" from sensory information, which reflects its instantaneous mobility, and (2) compares the measure among the joints through interactions, to determine its control signal such that more mobile one works dominantly in generating a desired hand motion, which is specified as a desired hand velocity vector (Vd).

The model was tested using a five-joints arm simulator. When setting Vd as a rotating field, the redundant five joints were coordinated to generate the desired circular motion (Fig. B). In the malfunction condition that two joints were abruptly fixed, the controller detected it through their mobility measures and autonomously switched to use the other normal three joints, resulting the hand to maintain the circular motion (Fig. C). These results indicate that the model is adaptable to sudden changes of the body properties, which may occur due to various indefinite factors in the real world.

[Staff]

Professor	Masafumi YANO
Assistant professors	Yoshinari MAKINO, Kazuhiro SAKANOTO, Haruki MIURA
Research associates	Nozomi TOMITA, Masashi ITO

[Profile]

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

[Papers]

[1] Y. Yoshihara, N. Tomita, Y. Makino, and M. Yano, "Autonomous Control of Reaching Movement by `Mobility Measure'," Journal of Robotics and Mechatronics, Vol.19, No 4, pp. 448-458, 2007.

[2] Ito, M. and Yano, M., "Sinusoidal modeling for nonstationary voiced speech based on a local vector transform," J. Acoust. Soc. Am., Vol. 121, No. 3, pp. 1731-1741, 2007.

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Brain Architecture Research Group

Realization of New-paradigm VLSI System

[Research Target and Activities]

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

As a this-year research result in nonvolatile-logic area, we have succeeded the chip fabrication of TMR-based basic logic components such as a full adder with a one-bit nonvolatile storage element, 4-bit LUT for nonvolatile FPGA and a compact cell circuit for nonvolatile TCAM (ternary content-addressable-memory). We have also designed and fabricated a 256-bit LDPC decoder chip under a 90nm CMOS process, whose performance is evaluated to be 1.65-times faster than that of a conventional hardware implementation.

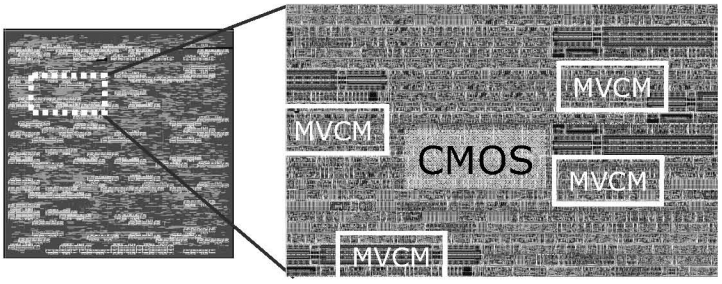

Fig. 1: 256-bit LDPC-decoder chip.

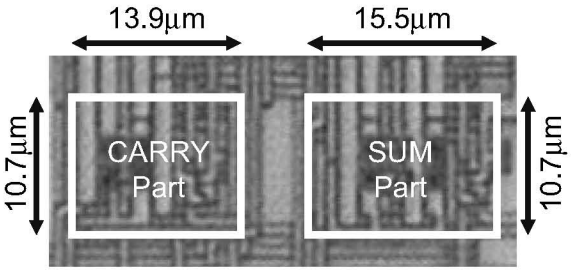

Fig. 2: Nonvolatile logic chip

[Staffs]

Professor	Takahiro Hanyu
Assistant Professor	Atsushi Matsumoto

[Profile]

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

[Papers]

(1) A. Mochizuki, H. Shirahama and T. Hanyu, "Design and Evaluation of a 54 × 54-bit Multiplier Based on Differential-Par Circuitry," IEICE Trans. Electron, Vol.E90-C, No.04, pp.683-691, Apr. 2007.
(2) N. Onizawa, T. Ikeda, T. Hanyu, and V. C. Gaudet, "3.2-Gb/s 1024-b Rate-1/2 LDPC Decoder Chip Using a Flooding-Type Update-Schedule Algorithm," Proc. 50th IEEE Midwest Symposium on Circuits and Systems (MWSCAS), pp.217-220, Aug. 2007.
(3) K. Kimura and T. Hanyu, "A Standby-Power-Free TCAM Based on TMR Logic," Proc. 50th IEEE Midwest Symposium on Circuits and Systems (MWSCAS), pp.855-858, Aug. 2007.

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Intelligent Nano-Integration System

Basic Technology of Integrated System for Intelligent Processing

[Research Target and Activities]

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

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

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

Research Activities in 2007

(1) We implemented a prototype chip composed of Burst Inverse Function Delayed neurons and confirmed successful operations in solving the N-Queen problem. (2) We observed successfully a single photon resonant activation of a Bi-2212 intrinsic Josephson junction, and clarified that the coupling strength between junctions, which affects on the collective behavior of junctions, changes according to the fabrication process. (3) A 4-bit parallel multiplier for the single flux-quantum Fast Fourier Transform was demonstrated successfully with Nb integrated circuits. Prospective operations of a high-speed up/down counter for the neural computation using stochastic logic were observed experimentally. An experimental result showed that the flux-quantum pulse signal accumulation more than 100GHz was possible.

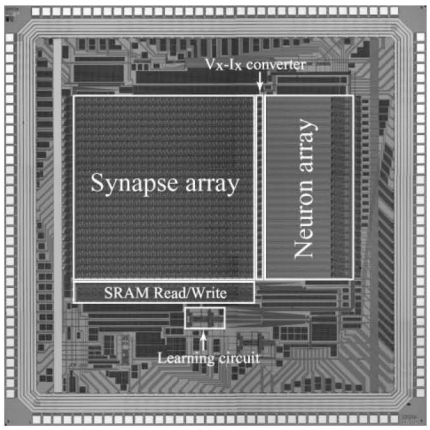


Fig.1 Inverse Function Delayed neuro-chip

[Staff]

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

[Profile]

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

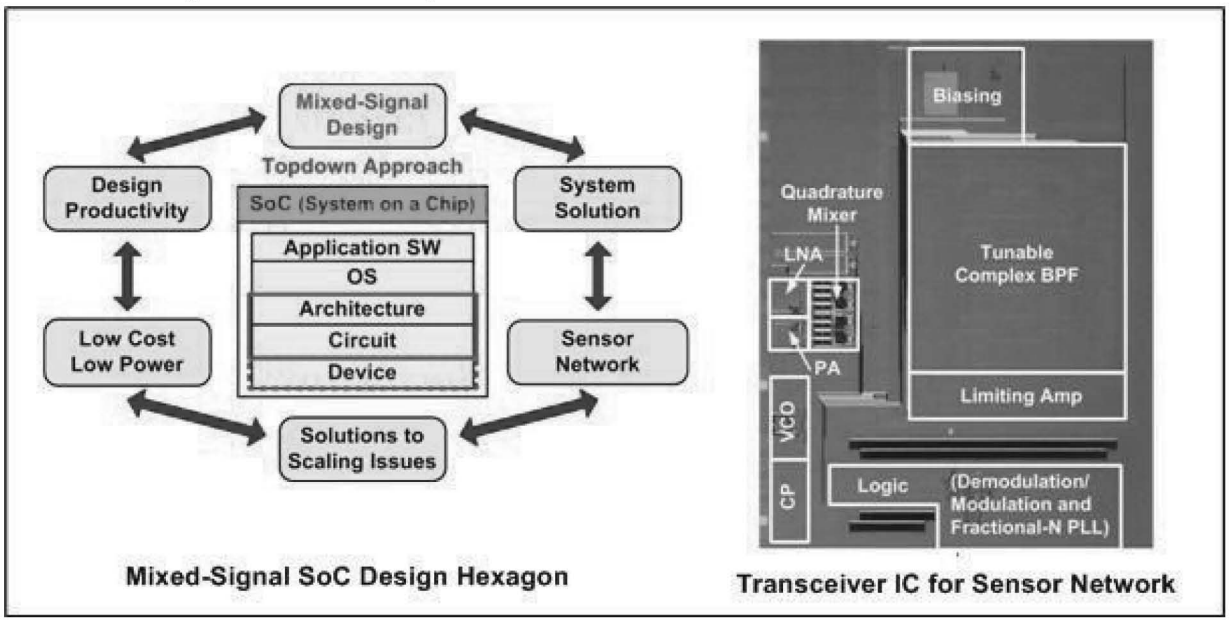
[Papers]

1. Design of a Neural Network Chip for the Burst ID Model with Ability of Burst Firing, IEICE Trans. Fundamentals, vol. E90-A, no. 4, pp.715-723, April 2007, Shinya Suenaga, Yoshihiro Hayakawa and Koji Nakajima
2. Avoidance of the Permanent Oscillating State in the Inverse Function Delayed Neural Network, IEICE Trans. Fundamentals, vol. E90-A, no. 10, pp.2101-2107, Oct. 2007, Akari Sato, Yoshihiro Hayakawa and Koji Nakajima
3. High-speed single flux-quantum up/down counter for neural computation using stochastic logic, Journal of Physics: Conference Series, vol.97, p.012187, March 2008, Takeshi Onomi, Taizo Kondo, and Koji Nakajima

Microarchitecture Laboratory

Mixed-Signal SoC Design

[Research Target and Activities]



Ubiquitous society has been established by the deployment of various wireless systems ICs, and it demands advances in mixed-signal (analog and digital) design technique as well as higher integration through SoC (System on a Chip). Our research activities include architecture and circuit design of mixed-signal SoC applicable to sensor network system applicable to brain activity research along with mixed-signal topdown design methodology. We have developed a complex bandpass filter for low-IF architecture in a transceiver IC for sensor network with an automatic digital tuning circuit for the compensation of RC process variation.

[Staff]

Shoichi Masui, Professor

[Profile]

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

[Papers]

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

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

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

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IT-21 center

3．7 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. It aims for development of (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) frequency equalizer technology, and (4) scalable AD converter.

2. Development of Low Power Consumption Mass Storage HDD Systems

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

[Staff]

Director: Kazuo TSUBOUCHI, Professor
Katsumi SAGAE, Technical Official

Project Planning Division
Makoto FURUNISHI, Professor

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

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

The IT-21 Center Project Planning Division

Planning and Encouraging of R&D Projects

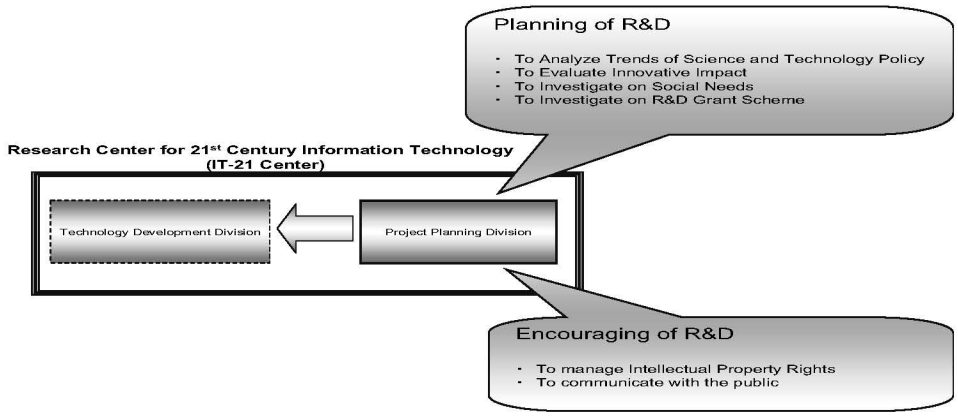
[Research Target and Activities]

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

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

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

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



[Staff]

Professor Makoto FURUNISHI

Secretary Machiko KAGAMITANI

[Profile]

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

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

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

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

[Papers]

A Study on the Roles of the Research Institute of Electrical Communication (RIEC) in the Management of Intellectual Property Rights, 2007.7, Record of Electrical and Communication Engineering Conversazione, Vol.76 No.1

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Technology Development Division Mobile Wireless Technology Group

Mobile Dependability for Wireless NGN

[Research Target and Activities]

1. Project of “Development of Dependable Wireless System and Devices”

Our new project “Development of Dependable Wireless System and Devices” was accepted in 2007 as the JST CREST type research program “Fundamental Technology for Dependable VLSI System.” It aims for development of (1) all IP dependable wireless network which can realize a communication speed of 10Mbps~2Gbps, (2) all Si CMOS mixed signal LSI with frequency range of 500MHz~70GHz, (3) frequency equalizer technology, and (4) scalable AD converter. The project continues for 5.5 years since Oct. 2007.

2. Broadband Wireless Communication Technology for Wireless-NGN

(1) A new concept of a high-efficient MBWA (Mobile Broadband Wireless Access) system was devised according to the field test data using FLASH-OFDM.

(2) A frequency equalizer technology for wireless terminal was theoretically studied and was successfully implemented, which was the world first experimental demonstration.

(3) A multi-carrier MSK system was devised, which performed a transmission speed of 500Mbps with multi-carrier MSK signals.

3. High-speed and High-frequency Si System LSI for Universal Radio

(1) A 5GHz band Si CMOS high-efficient push-pull power amplifier LSI was developed and it performed an efficiency of 49.1% with an output power of 16.6dBm. An active integrated antenna consisting of the amplifier LSI and a dipole antenna directly connected without a balun was successfully demonstrated.

(2) A 5GHz band Si CMOS VCO (Voltage Controlled Oscillator) LSI was developed, which realized a wide tuning rage covering IEEE802.11n standard. Now, its phase noise characteristic is being improved.

[Staff]

Professor; Tadashi Takagi (since 2005)

Guest Professor; Makoto Iwata (since 2003)

[Profile]

Tadashi 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, Sizuoka, Japan, in 1973 and 1995, respectively. In 1973, he joined the Mitsubishi Electric Corporation, where he was engaged in development on microwave and millimeter-wave circuits technology. Since 2005, he has been with Tohoku University, where he is now a professor. Now, his main area of research interest is mobile wireless broadband communication circuits and systems technology. He is a senior member of the IEEE and a member of IEICE of Japan.

[Papers]

[1] Shoichi Oshima, Goro Mori, Hiroshi Oguma, Suguru Kameda, Hiroyuki Nakase, Tadashi Takagi, and Kazuo Tsubouchi, "The 60GHz band multi-carrier wireless system for 2Gbps transmission with constant envelope modulation," 18th Annual IEEE Int. Symp. on Personal, Indoor and Mobile Radio Commun. (PIMRC2007), #521, Athens, Greece, Sept. 2007.

[2] H. Ueda, K. Nakajima, G. Kanazawa, M. Shimozawa, J. Koide, M. Uesugi, R. Takeuchi, N. Suematsu, Y. Isota,S. Kameda, H. Nakase, T. Takagi and K.Tsubouchi, "A 5GHz-band SiGe-MMIC Transceiver for 324Mbps Transmission" in Proc. IEEE RWS 2008, Jan. 2008.

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

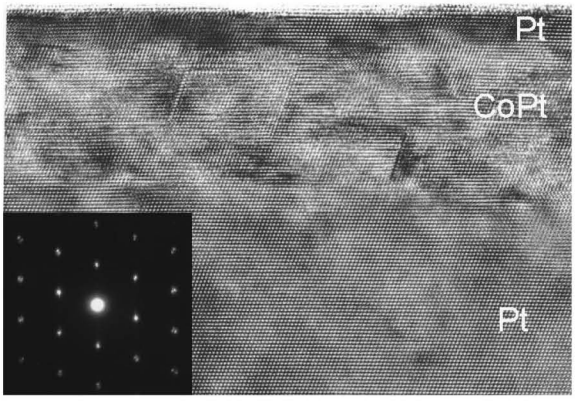
Development of low power consumption mass storage HDD systems

[Research Target and Activities]

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

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

1) High density recording media: $L1_1$-type CoPt ordered alloy films with a large uniaxial magnetic anisotropy over 3.5x10^7 erg/cm^3 were successfully fabricated using UHV sputter film deposition. Moreover, we experimentally showed that hard/soft stacked granular media was effective at significantly reducing the switching field.
2) High sensitivity sensor technology: Spin accumulation effects are experimentally investigated, and new sample preparations with original structures were started.
3) Single pole type writer with a high recording resolution: It was revealed that multiple tapered main-pole structure is very effective to improve the recording resolution (simulation work).
4) New recording algorithm for over terabits per square inch densities: Simulation work revealed that suppression of leakage field from adjacent dots is very important for recording systems using bit patterned media (BPM) in the future. A feature for the measurements of write margin was equipped to improve testability of the static tester.
5) High performance tiered storage system: In order to propose a control algorithm for the key method in the system architecture, which called "2-dimension data allocation method with an access prediction", we started developments of a computer simulation for the high performance tiered storage system and its computation model.



TEM images of $L1_1$-type CoPt ordered alloy films successfully fabricated.

[Staff]

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

[Profile]

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

[Papers]

[1] T. Shimatsu, Y. Inaba, S. Watanabe, O. Kitakami, S. Okamoto, H. Aoi, H. Muraoka, and Y. Nakamura, "Recording Resolution and Writability for (Co-Pt)-SiO_2/Co-SiO_2 Hard/Soft-Stacked Granular Perpendicular Media," *IEEE Transactions on Magnetics*, vol. 43, pp. 2103-2105 (2007).

[2] H. Sato, T. Shimatsu, Y. Okazaki, H. Muraoka, H. Aoi, S. Okamoto, and O. Kitakami, "Fabrication of $L1_1$ type Co-Pt ordered alloy films by sputter deposition," *J. Appl. Phys*, vol. 103, pp. 07E114(1-3) (2008).

[3] K. Mitsuzuka, T. Shimatsu, H. Muraoka, H. Aoi, N. Kikuchi, and O. Kitakami, "Magnetic properties of Co-Pt/Co hard/soft stacked dot arrays," *J. Appl. Phys*, vol. 103, pp. 07C504(1-3) (2008).

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Flexible Information System Research Center

3．8 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.

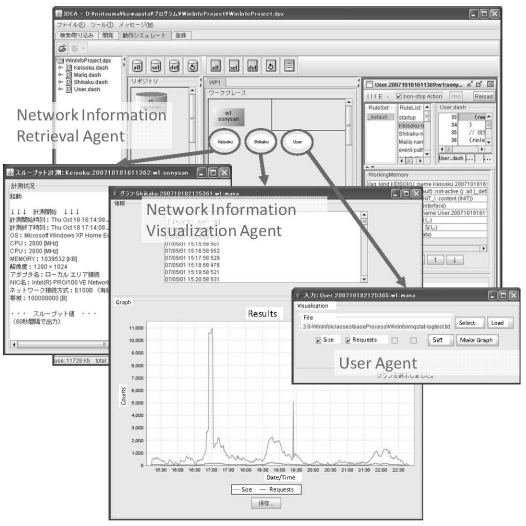


Fig. 1 Agent based Network Management System.

To achieve the above goal, this year we have conducted the following researches: (1) basic analysis about distributed and scalable authentication method for large scale overlay network, (2) development of an agent based network management system (Fig.1) and (3) improvement of accuracy of virtual auditory display system.

[Staff]

(1) Steering Committee
Professor: Yôiti SUZUKI, Norio SHIRATORI, Yoshihito TOYAMA, Tetsuo KINOSHITA, Masafumi Shirai, Atsushi OHORI
(2) FIR Committee
Professor: Yoshihito TOYAMA, Tetsuo KINOSHITA
Associate Professor: Takahito AOTO, Gen KITAGATA
Assistant Professor: Yoshihiro HAYAKAWA, Masato YOSHIDA, Isao SASANO, Satoshi YAIRI
Technical Support Member: Noriko DAIGAKU, Midori SUZUKI, Junko KOMAGATA / Sachiko NIITSUMA
(3) Regular Staff
Associate Professor: Gen KITAGATA
Assistant Professor: Satoshi YAIRI
Technical Support Member: Noriko DAIGAKU, Midori SUZUKI, Junko KOMAGATA / Sachiko NIITSUMA

[Profile]

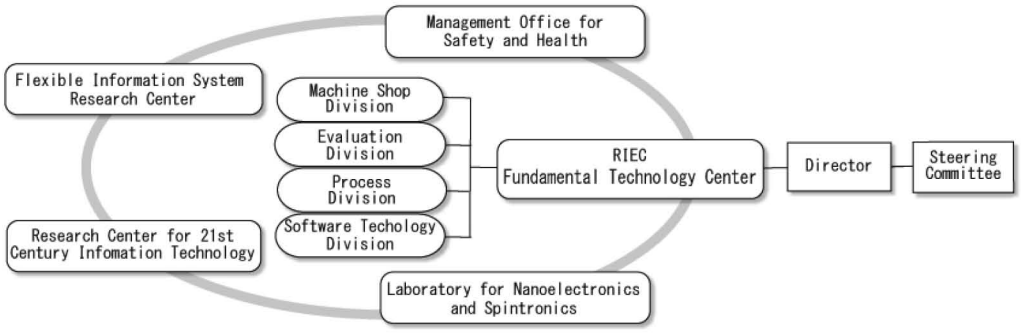
Refer to the Advanced Acoustic Information Systems Laboratory for the profile Prof. Yôiti Suzuki.

[Papers]

1. Atushi Takeda, Kazuo Hashimoto, Gen Kitagata, Salahuddin Muhammad Salim Zabir, Tetsuo Kinoshita and Norio Shiratori, "A New Authentication Method with Distributed Hash Table for P2P Network", Proc. of the 22nd International Conference on Advanced Information Networking and Applications - Workshops (AINAW2008), pp.483-488, 2008.
2. Naoki Nakamura, Debasish Chakraborty, Apichet Chayabejara, Gen Kitagata, Takuo Suganuma, Goutam Chakraborty, Norio Shiratori, "Efficient Channel Utilization Schemes for IEEE 802.11 DCF over MANET", IPSJ Journal, Vol.48, No.2, pp. 448-458, 2007.
3. Satoshi Yairi, Yukio Iwaya, Yôiti Suzuki, "Estimation of Detection Threshold of System Latency of Virtual Auditory Display", Applied Acoustics Vol.68, No.8, pp.851-863, 2007.

Fundamental Technology Center

3．9 Supporting research with high-level specialized knowledge and technology



Overview of Fundamental Technology Center

[Research Target and Activities]

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

1. Machine Shop Division

The Machine Shop Division has previously pioneered a number of new machining methods, and contributed to research on high-density magnetic recording and many other types of research relating to advanced information and communications. This year, there were 123 fabrication requests from laboratories (119 from inside the Institute, 4 from outside).

2. Evaluation Division

The Evaluation Division provides the following as measurement equipment for shared use:

Apparatus for Rutherford backscattering spectroscopy, atomic force microscope, scanning electron microscope, X-ray diffractometer, electron spin resonance spectrometer, fourier transform infrared spectrophotometer, infrared-visible spectroscope, liquid chromatograph, optical characteristic measurement equipment, in-air photoelectron measurement equipment, dicing saw

3. Process Division

The Process Division provides the following as measurement equipment for shared use:

Focused ion beam system, mask aligner, X-ray diffractometer for thin films, electron beam exposure equipment, scanning electron microscope, optical microscope, spectrophotometer, digital microscope, dicing saw, UV & ozone dry stripper

4. Software Technology Division

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

[Staff]

Director (Professor): Michio NIWANO, Assistant Professor: Nobuyuki SATO

Technical Official : Hiroshi WATANABE, Munetomo SUGAWARA, Yuji KONNO, Ryuji YONEZAWA, Choichi,TAKYU, Shigeto AGATSUMA, Koichi SHOJI, Tamotsu SUENAGA, Takeshi YAMASHITA

Management Office for Health and Safety

3．10 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

Takeshi YAMASHITA, Technical Staff

Ayako CHIBA, Clerk

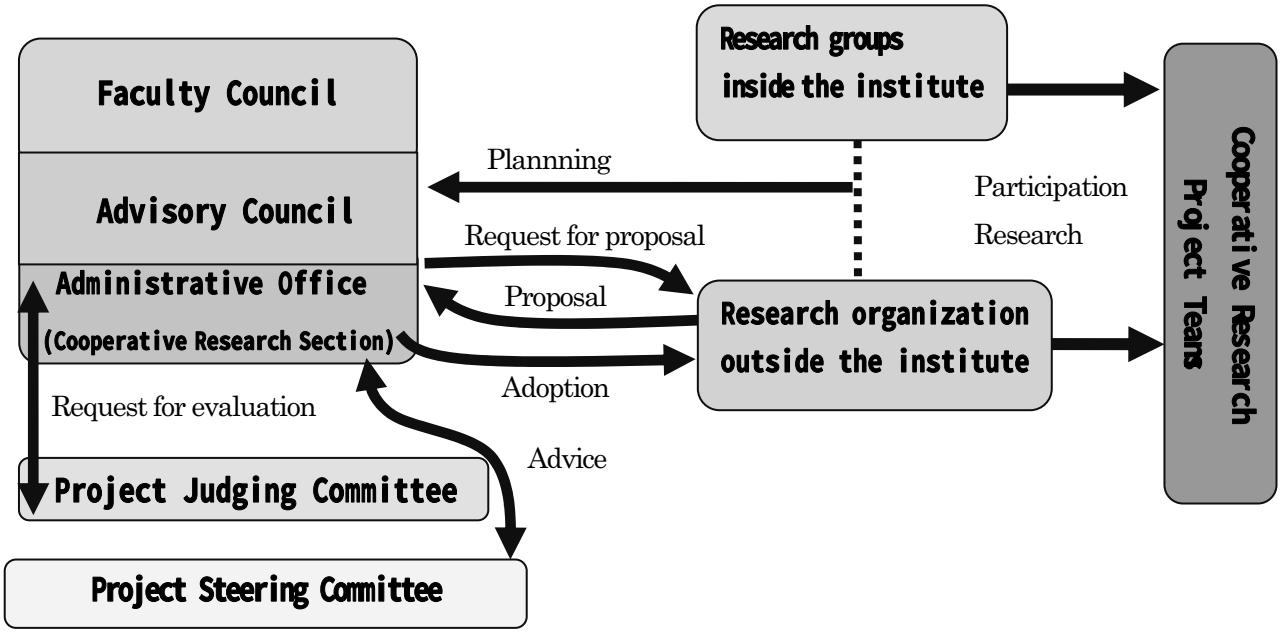
4. Nation-wide Cooperative Research Projects

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 ultrasonics, 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 2007

Project number	Research projects	Project leader	Facilitator in R.I.E.C
H17／A01	Implementation of intelligent nano integrated system	Koji NAKAJIMA	Koji NAKAJIMA
H17／A02	Study of the Step-like Giant Magnetoimpedance Sensor and Proposal of its Application	Tomoo NAKAI	Kazushi ISHIYAMA
H17／A04	Development of photonic crystal applications in optics industry	Shojiro KAWAKAMI	Masataka NAKAZAWA
H17／A05	Basis Studies in Plasma Nano Science and Technology	Rikizo HATAKEYAMA	Michio NIWANO
H17／A06	Ultimate Heterostructure Formation of Group IV Semiconductors for High-Performance Devices	Junichi MUROTA	Junichi MUROTA
H17／A08	Investigation of visual information and its appocation	Hirohisa YAGUCHI	Satoshi SHIOIRI
H17／A09	Research on Semiconductor Spin Devices based on the Rashba Spin-Orbit Effect	Takaaki KOGA	Yuzo OHNO
H17／A11	Researches on intelligent organic thin film sensors	Fumihiko HIROSE	Michio NIWANO
H17／A12	Multimodal information processing system based on human perceptual property	Akihiro TANAKA	Yôiti SUZUKI
H17／A13	Fundamental Studies on Cell Biotronics	Yasuo SHINOHARA	Michio NIWANO
H17／A14	Development of highly integrated RF devices using permeable Materials for RF-range	Masahiro YAMAGUCHI	Hiroaki MURAOKA
H18／A01	Study on terahertz plasma-wave devices based on semiconductor heterojunction nano-structures	Victor RYZHII	Taiichi OTSUJI
H18／A02	Study on the improvement of performance and reliability in nonclassical group-IV semiconductor hetero-devices	Toshiaki TSUCHIYA	Junichi MUROTA
H18／A03	Construction of Wearable Information Sharing Space by Sensor Computing	Teruo HIGASHINO	Norio SHIRATORI
H18／A04	THz generation based on management of nonlinear waves	Koichi NARAHARA	Taiichi OTSUJI
H18／A06	Research on security technology by acoustics	Kotaro SONODA	Yôiti SUZUKI

Project number	Research projects	Project leader	Facilitator in R.I.E.C
H18／A07	Basics and Applications of Superconducting Computers	Yoshinao MIZUGAKI	Shigeo SATO
H18／A10	Basic study on realization of an augmented reality based on the sense of audition	Kenji OZAWA	Yôiti SUZUKI
H18／A12	Growth of New Lead-free Piezoelectric and Optical Single Crystals and Their Ultrasonic Micro-spectroscopies	Jun-ichi KUSHIBIKI	Yasuo CHO
H18／A13	Internal representation of visual information in the brain	Satoshi SHIOIRI	Satoshi SHIOIRI
H19／A01	Development of magnetic-dielectric material using magnetic nanoparticle assembly for ultra-high frequency devices	Migaku TAKAHASHI	Yasuo CHO
H19／A02	A basic research for gaining IP network aspect	Hiroshi UEDA	Yukio IWAYA
H19／A03	Theoretical Design and Fabrication of Multi-functional Spintronics Materials	Akio KIMURA	Masafumi SHIRAI
H19／A04	Valency Control of Group IV Semiconductor Quantum Dots and Their Application to MOS Memory	Seiichi MIYAZAKI	Junichi MUROTA
H19／A05	Study of Orientation and Mobility Training for the Persons with Visual Impairment by using Wide-Range Three Dimensional Acoustical Technologies	Yoshikazu SEKI	Yukio IWAYA
H19／A06	Research on accurate HRTF measurement systems	Tatsuya HIRAHARA	Yôiti SUZUKI
H19／A07	A study on the basic representation of color (color alphabets) in the visual cortex	Ichiro KURIKI	Ichiro KURIKI
H19／A08	Development of new measurement techniques with nanometer scale spatial resolution and exploration of the electronic and optical properties of surface nanostructures	Yoichi UEHARA	Yoichi UEHARA
H19／A09	Study for STT Microwave Oscillation on Self Organized Nano-Magnet and Its Application	Masaaki DOI	Kazushi ISHIYAMA
H19／A10	On application of frequency domain binaural model for hearing aids	Tsuyoshi USAGAWA	Yôiti SUZUKI
H19／A11	Research on SNDM nano-science and technology	Yasuo CHO	Yasuo CHO

Project number	Research projects	Project leader	Facilitator in R.I.E.C
H19／A12	Study for Magnetoelectric Effect on Oxide Thin Films and Its Application to Spintronics	Masashi SAHASHI	Kazushi ISHIYAMA
H19／A13	Physiological Evaluation and Development of a Distributed Multi-display System Adapting to User's situation	Atsumi IMAMIYA	Takuo SUGANUMA
H19／A14	A Study of Next Generation HotSpot Network System	Kazuo TSUBOUCHI	Kazuo TSUBOUCHI
H19／A15	A Study on Internet Computing for Supporting Advanced Communication	Kaoru TAKAHASHI	Norio SHIRATORI
H19／A16	Scientific Research for Advanced Electron Beam Technology	Hidetaka SHIMAWAKI	Michio NIWANO
H17／B01	Research on Peta-byte Class Information Storage System	Hiroaki MURAOKA	Hiroaki MURAOKA
H17／B02	Electricity and Hydrogen Energy System	Takataro HAMAJIMA	Hiroaki MURAOKA
H17／B04	Physics in Nano-Scale Semiconductors and Its Applications to Nano-Technologies	Kenji SHIRAISHI	Hideo OHNO
H17／B05	Research of high performance exchange anisotropy materials for nano-spin manipulation	Masakiyo TSUNODA	Kazushi ISHIYAMA
H17／B07	Theory and Practice of Software Verification	Naoki KOBAYASHI	Yoshihito TOYAMA
H17／B08	New phase of spintronics	Teruo ONO	Hideo OHNO
H17／B09	Study on Microwave Magnetics	Toshirou SATO	Hiroaki MURAOKA
H17／B10	Study on Automatic Program Generation and its Correctness	Yukiyoshi KAMEYAMA	Yoshihito TOYAMA
H17／B11	Research on Ultrafast Pulse Control Technologies	Hidemi TSUCHIDA	Masataka NAKAZAWA
H17／B12	Researches on high electromechanical coupling piezoelectric materials and its applications	Jun-ichi KUSHIBIKI	Yasuo CHO
H18／B01	Development of Nano-Bioelectronic Devices	Toshio OGINO	Michio NIWANO
H18／B04	Research on Multimedia Information Hiding	Hideki NODA	Yôiti SUZUKI

Project number	Research projects	Project leader	Facilitator in R.I.E.C
H18／B05	Visualization of the Near Field Distribution of the GHz order Electromagnetic Field	Nobuyasu ADACHI	Kazushi ISHIYAMA
H18／B06	Neuronal mechanisms of emergence and regulation of adaptive behaviors	Kaoru TAKAKUSAKI	Masafumi YANO
H18／B08	Evolution of high performance computing by new electric circuit technologies　with novel concepts	Hiroshi MATSUOKA	Takahiro HANYU
H18／B09	Multi-Functional Logic Using New Paradigm Materials and Devices and Its System Integration	Takahiro HANYU	Takahiro HANYU
H18／B10	Magnetic technique for bioinformation sensing	Kazushi ISHIYAMA	Kazushi ISHIYAMA
H19／B01	Subject and View of Synthetic Aperture Radar Development for Civilian Use	Atsushi MASE	Kazuo TSUBOUCHI
H19／B02	Research on optical measurements of earthquakes and their networking	Araya AKITO	Masataka NAKAZAWA
H19／B03	Study on next generation 3D communication system	Toru OTSURU	Yôiti SUZUKI
H19／B04	Development of Science of Fine Particle Plasmas	Yasuaki HAYASHI	Michio NIWANO
H19／B05	Study on Development of Devices and Application Systems for Next Generation Communication and Measuring Systems	Yoshio NIKAWA	Tadashi TAKAGI
H19／B06	Research on the Process of Nano Structure Formation and its Application toward Semiconductor Devices with New Principles	Kikuo YAMABE	Tetsuo ENDOH
H19／B07	Research on High-Speed Large-Volume Non-Volatile Semiconductor Memories	Tetsuo ENDOH	Tetsuo ENDOH
H19／B08	Studies on the dynamics of the formation of semiconductor gatestack　nanostructures and their applications	Maki SUEMITSU	Maki SUEMITSU
H19／B09	A proof theoretical approach to principles of program construction	Masahiko SATO	Yoshihito TOYAMA
H19／B10	Fundamental characteristics and applications deeply related to flow in various plasmas	Akira ANDO	Maki SUEMITSU

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 Light 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 Symposium on Acoustelectronics	Aug.19-20, 1968
7	Current Status and Future Trends of Superconductivity	Jan.22-24, 1970
8	Speech 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 Anniversary of the Foundation of RIEC	Sep.25-26, 1975
13	Application of Amorphous Ferromagnetic Materials	Mar.10-11, 1977
14	Stoichiometry of Compound Crystals	Nov.24-25, 1977
15	Submillimeter Waves	Nov.16-17, 1978
16	Solid State Chemical Sensors	Feb. 1- 2, 1980
17	Graph Theory and Algorithms	Oct.24-25, 1980
18	Perpendicular Magnetic Recording	Mar.11-12, 1982
19	Approach to Optical Computer	Mar.10-11, 1983
20	Plasma Non-Linear Phenomena - Basic Problems for Fusion Plasmas	Mar. 8- 9, 1984
21	New Computer Architecture	Jul.25-26, 1985
22	Guided Wave Technology and Its Application at Mid-Infrared	Mar.13-14,1986
23	Physics and Applications of Tunnelling Phenomena	Mar.12-14, 1987
24	Biomagnetics and Bioelectronics	Feb.26-27, 1988
25	Ultrasonic Electronics - New Applications of Piezoelectricity	Feb. 2- 3, 1989
26	Boundaries between Light and Electromagnetic Wave	Feb. 1-2, 1990

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

International Symposium Organized by the Institute

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

15	GSIS International Symposium on Information Sciences of New Era: Brain, Mind and Society	Sep.26-27, 2005
16	The 1st RIEC International Workshop on Spintronics -Spin Transfer Phenomena-	Feb.8-9, 2006
17	4th International Workshop on High Frequency Micromagnetic Devices and Materials (MMDM4)	May 8,2006
18	4th International Conference on Physics and Applications of Spin-Related Phenomena in Semiconductors (PASPS-lV)	Aug.15-18,2006
19	2nd International Workshop on New Group IV Semiconductor Nanoelectronics	Oct.2-3,2006
20	2nd RIEC International Workshop on Spintronics	Feb.15-16,2007
21	Japan-China Joint Conference on acoustics, JCA2007	Jun.4-6,2007
22	International Conference on Discovery Science/ International Conference on Algorithmic Learning Theory	Oct.1-4,2007
23	The 3rd RIEC International Workshop on Spintronics	Oct. 31-Nov.1,2007
24	3rd International Workshop on New Group ⅣSemiconductor Nanoelectronics	Nov.8-9,2007
25	International Workshop on Nanostructures & Nanoelectronics	Nov.21-22,2007
26	The 18th International Symposium on Algorithms and Computation(ISAAC2007)	Dec.17-19,2007

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 the General Chairman or each Sub-Group Chairman for general information or more specific questions.

Title of Sub-Group	Chair	Manager
Electromagnetic and Optical Waves Engineering	Kunio SAWAYA	Eisuke KUDOH
Acoustic Engineering	Shozo MAKINO	Motoyuki SUZUKI Ryota MIYAUCHI
Sendai "Plasma Forum"	Rikizo HATAKEYAMA	Satoru IIZUKA
Sendai Seminar on EMC	Hideaki SONE	Masahiro YAMAGUCHI
Computer Science	Naoki KOBAYASHI	Takahito AOTO
Systems Control	Makoto YOSHIZAWA	Takashi WATANABE
Information-biotronics	Michio NIWANO	Tatsuo YOSHINOBU
Spinics	Hidetoshi MATSUKI	Takehito SHIMATSU Tomoyuki OGAWA
New Paradigm Computing	Masayuki KAWAMATA	Naofumi HOMMA
Ultrasonic Electronics	Shinichirou UMEMURA	Shin YOSHIZAWA
Integration of Brain Functions	Koji NAKAJIMA	Shigeo SATO Yoshihiro HAYAKAWA
Mathematical Physics and its Application to Information Sciences	Kazuyuki TANAKA	Kazuyuki TANAKA
Biocybernetics and Bioinformatics	Mitsuyuki NAKAO	Haruki MIURA
Nanoelectronics and Spintronics	Hideo OHNO	Yuzo OHNO

7. International activities

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

International academic exchange programs:

- The Institute of Physics, Polish Academy of Sciences (Poland)
- The Faculty of Science, Chulalongkorm University (Thailand)
- Harbin Institute of Technology (China)
- The James Frank Institute, The University of Chicago (U.S.A.)
- Queen Mary and Westfield College, University of London (U.K.)
- Scientific Research Department, Shenzhen University (China)
- Institute of Information and Communication Technology, Sung-Kyun-Kwan University (Korea)
- Institute of Materials Science, Faculty of Applied Physics, University of Twente (Netherlands)
- The Institute of Radioengineering and Electronics Russian Academy of Sciences (Russia)
- Department of Electronics Science and Engineering, University of Nanjing (China)
- School of Computer and Communication Engineering, Taegu University (Korea)
- Research Center of Condensed Materials and Nanosciences, National Center for Scientific Research (France)
- IHP-Innovations for High Performance microelectronics (Germany)
- Institute of Semiconductors Chinese Academy of Sciences (China)

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

1.	Acoustical Science and Technology
2.	Applied Acoustics
3.	IEICE Electronics Express
4.	International Journal of Communication Systems
5.	International Journal of Infrared and Millimeter Waves
6.	Japanese Journal of Applied Physics, The Institute of Pure and Applied Physics
7.	Journal of Communication and Networks
8.	Journal of Higher-Order and Symbolic Computation
9.	urnal of Magnetism and Magnetic Materials
10.	Optical Fiber Technology
11.	Optics Communications

12.	Semiconductor Science and Technology, Institute of Physics
13.	Solid State Communications
14.	Superlattices and Microstructures,Elsevier
15.	Virtual Journal of Nanoscale Science and Technology, American Institute of Physics

Recent international conferences programmed by a staff in RIEC:

1.	15th International Conference on Molecular Beam Epitaxy(MBE2008)
2.	2008International Conference on Solid State Devices and Materials(SSDM)
3.	29th International Conference on the Physics of Semiconductors(ICPS2008)
4.	3rd International SiGe, Ge, and Related Compounds: Materials, Processing, and Devices Symposium
5.	4th International SiGe Technology and Device Meeting(ISTDM2008)
6.	4th International Workshop on New Group Ⅳ Semiconductor Nanoelectronics
7.	53rd Annual Conference on Magnetism and Magnetic Materials(MMM2008)
8.	5th International Conference on Physics and Applications of Spin-Related Phenomena in Semiconductors(PASPS)
9.	8th International Conference on Physics of Light-Matter Coupling in Nanostructures
10.	ACM SIGPLAN International Symposium on Principles and Practice of Declarative Programming (PPDP'2007)
11.	ACM SIGPLAN Workshop on ML,2007
12.	Asia-Pacific Conference on Vision
13.	Device Research Conference
14.	European Conference on Optical Communication(ECOC)
15.	Gordon Research Conferences, Magnetic Nanostructures
16.	IEEE Computer Society Technical Committee on Multiple-Valued Logic
17.	IEEE Nanotechnology Materials and Devices Conference2008(NMDC)
18.	International Conference on Infrared, Millimeter, and Terahertz Waves
19.	International Symposium on Nonlinear Theory and its Applications (NOLTA)
20.	International Workshop on INformatics(IWIN2008)
21.	Joint European Magnetic Symposium(JEMS08)
22.	Joint MMM/Intermag Conference 2010
23.	Pacific Rim Meeting on Electrochemical and Solid-State Science(PRIME)

24.	SPIE Photonics West
25.	The 2nd International Symposium on Mobiligence in Awaji
26.	The 3rd RIEC International Workshop on Spintronics Solid-State Quantum Information Technology
27.	The 5th International Symposium on Surface Science and Nanotechnology(ISSS-5)
28.	The 8th Perpendicular Magnetic Recording Conference(PMRC2007)
29.	The eighth International Conference on Excitonic Processes(EXCON'08)
30.	The International Conference on Advanced Information Networking and Applications(AINA2009)
31.	The International Conference on Ubiquitous Intelligence and Computing (UIC2008)
32.	The Japan-China Joint Conference on Acoustics(JCA2007)
33.	The Magnetic Recording Conference 2008(TMRC2008)
34.	Topical Workshop on Heterostructure Microelectronics

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 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

(2007.6.1)

Classification	Division	Laboratory for Nanoelectronics and Spintronics	Laboratory for Brainware sysystems	Research Center for 21st century Information Technology	Fundamental Technology Center	Administration Office			Total
						Head Official	General Affairs Group	Accounting Group	
Professors	15	3	4	2					24
Associate Professors	13	4	1	0					18
Assistant Professors	19	4	6						29
Research Fellows	16	2	2	1					21
Technical Officials					14		1	1	16
Administrative Officials						1	6	8	15
Total	63	13	13	3	14	1	7	9	123

2.Land and Buildings

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

(2007.6.1)

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

3.Budget

(Unit:1,000yen)

Financial Year	Personnel Expenditure	Supplies Expenditure	Research Grant		total
			Ministry of Education,Science and Culture	Partnership Between Universities and Industry	
2003	1,108,605	942,357	390,190	1,253,283	3,694,435
2004	902,978	1,233,357	338,459	1,432,607	3,907,401
2005	984,113	1,050,647	554,680	1,303,028	3,892,468
2006	971,482	927,090	599,040	937,441	3,435,053
2007	970,961	813,724	700,615	888,833	3,374,133

10. Afterword

Recently, two disasters stroke Asian area successively. One was that Myanmar suffered great damage from the cyclone, and the other was the great earthquake attacked Sichuan Province in China. In the two disasters, there left unbelievable number of victims. In the case of cyclone, it is supposed that indiscreet usage of energy and industrial products causes the greenhouse effect and climate changes, which might brew stronger cyclones. In the latter case, houses and buildings without adequate measures for quake might cause heavy casualties. Even the modern science and technology could not keep from occurring disasters, but could reduce the damage from them. To our regret, the modern science and technology is not always properly used to minimize the damage from the disasters. On this opportunity, we need to reconsider how the modern science and technology should be used.

With regard to information science and communication technology, similar situation has developed. They brought the globalization of communication, resulted in changing the human behavior and the social structure. They are surely convenient, while produce digital divide, autistic persons and new kinds of offence. It is a universal that the natural sciences and technology are neutral against right and wrong, so the human beings are responsible for the usage of them. If the natural sciences and technology give negative effects, we need to change the way of usage or to overcome the problems by developing the technologies. The science and technology should be progressed to properly support the human life.

We have philosophically redefined in 2001 what RIEC should be. “It is possible for human society to sustainably develop, only when a barrier-free communication is guaranteed. Devoting ourselves to the research of information science and communication technology, we will contribute to the prosperity and development of our own country, and extensively to the progress of the culture and welfare of mankind.” All the staff in our institute will assume the responsibility to information and communication systems in Japan, and each research activity should be approved by the Japanese nation. Academic freedom how to approach the problems is a right of all researchers, but each is accountable for his/her own study. For doing our duty, we need to show what we are doing and what the future of the information science and communication technology will be. This annual report presents our daily research activities, so I greatly appreciate your frank and critical comments on our activities.

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