RIEC

Annual Report 2008

Research Institute of Electrical Communication, Tohoku University

Annual report of Research Institute of Electrical Communication 2008

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 been 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.

The organization of the research institutes and research centers affiliated with national universities has been changed from this school year. Originally, the selected research institutes as a National Center for cooperative research were designed to provide the opportunities to use their excellent facilities and equipments for the researchers in Japan. This change of organization of the institutes is aimed to further activate the cooperative research, so the selected institutes as a COE should meet the needs and demands of the community of the worldwide researcher. Since 1994 our institute as a National Centers for Cooperative research has already assumed the leadership in creating new technologies through national and international collaboration with researchers in the field of information and communication technology. Our research activities until now might be regarded as an anticipation what this change of organization will aim at. Though we will continue our current research style for a while, we have reorganized our institute every ten yeas through the self-rating and the external-rating and will make every effort to reform for better contribution. 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

Masafumi YANO,Ph.D.
Director, Research Institute of Electrical Communication.

2. Organization Chart

- Director
  - Advisory Council
  - Deputy Director
  - Faculty Council
  - Research Divisions
    - Information Devices Division
      - Nano-Photoelectronics
      - Quantum-Optical Information Technology
      - Solid State Electronics
      - Dielectric Noano-Devices
      - Materials Functionality Design
      - Magnetic Dvices
    - Broadband Engineering Division
      - Ultrahigh-Speed Optical Communication
      - Applied Quantum Optics
      - Wireless Info Tech
      - Information Storage Systems
      - Ultra-Broadband Signal Processing
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      - Computing Information Theory
      - Communication Network Systems
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      - Semiconductor Spintronics
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      - Nano-Spin Memory
    - Laboratory for Brainware Systems
      - Real-World Computing
      - Intelligent Nano-Integration System
      - Microarchitecture
      - New Paradigm VLSI System
    - Research Center for 21st Century Information Technology
      - Project Planning Division
      - Technology Development Division:
        - Mobile WirelessTechnology Group
        - Storage Technology Group
        - Intelligence Archive Group
  - Management Office for Safety and Health
  - Common Research Facilities
    - Flexible Information System Research Center
  - Fundamental Technology Center
    - Machine Shop Division
    - Evaluation Division
    - Process Division
    - Software Technology Division
  - Administration Office
    - General Affairs Group
      - General Affairs Section
      - Cooperative Research Section
      - Library Section
    - Accounting Group
      - Accounting Section
      - Purchasing Section

3.RESEARCH ACTIVITIES

Targets and achievements of the Information Devices Division

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

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

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

The target and the summary of achievements of the each sub-division in 2008 are described in the following pages. In addition, about the summary of achievement of the atomically controlled processing research section will be written in the chapter of the Laboratory for Nanoelectronics and Spntronics.

Nanophotoelectronics

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

[Research Target and Activities]

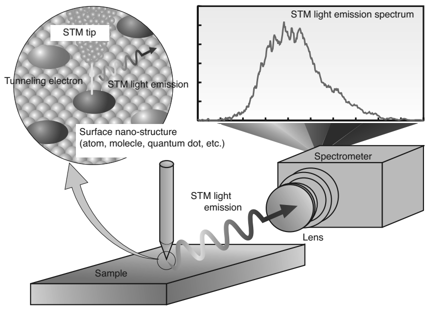

Fig. 1 STM light emission spectroscopy

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. Some chalcogenide alloys including $Ge_2Sb_2Te_5$ and Sb_2Te_3 attract strong attention because of their potential for data-storage devices with ultra-high capacity. Hence it is highly desirable that their optical, thermal, and electronic properties are explored and understood with nanometer scale spatial resolution, i.e., the resolution comparable to targeted sizes of devices. We have observed STM light emission (STM-LE) spectra of $Ge_2Sb_2Te_5$ and Sb_2Te_3. Although these chalcogenide alloys exhibit band gaps less than 0.5 eV, the STM-LE was observed with a narrow spectral width at a photon energy of 1.5 eV for both materials. We found that the STM-LE is excited by electronic transitions taking place in the local electronic structure having a direct gap-like shape with a band gap of 1.5 eV. It is also important to understand temporal behaviors of phonons in individual nano structures from a view point of nano device engineering. Hence we are interested in adding pico-second temporal resolving power to STM-LE spectroscopy. By exciting STM-LE with the tunneling electrons induced by pico-second laser pulses, we have succeeded in detecting vibrations of individual isolated single benzene molecules adsorbed on a Cu(110) surface and optical phonons of Sb_2Te_3 with pico-second temporal resolution.

[Staff]

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

[Profile of Professor UEHARA]

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] 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 **47**, 6114-6116 (2008).
[2] Y. Uehara and S. Ushioda, "Scanning tunneling microscope light emission spectroscopy with good signal-to-noise ratio", Journal of the Vacuum Society of Japan **51**, 796-800 (2008).

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Quantum Optical Information Technology

Development of optoelectronic devices for quantum information and communication technology

[Research Target and Activities]

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

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

In 2008, we have achieved (1) development of a novel scheme to generate and detect entangled photons, (2) measurement of single-photon-level optical nonlinearity in an optical fiber, and (3) tomographic measurement of optically injected electron spins in a semiconductor.

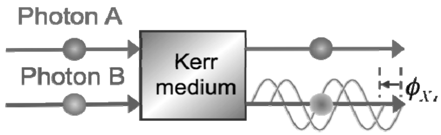

Fig. 1 Single-photon-level optical nonlinearity.

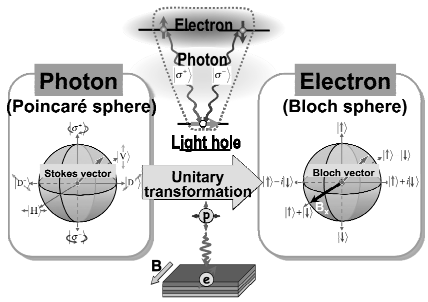

Fig. 2 Quantum media conversion from photon polarization to an electron spin.

[Staff]

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

[Profile of Professor EDAMATSU]

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] Observation of optical-fibre Kerr nonlinearity at the single-photon level [N. Matsuda, R. Shimizu, Y. Mitsumori, H. Kosaka, and K. Edamatsu: Nature Photonics **3**, 95-98 (2009)]

[2] Spin state tomography of optically injected electrons in a semiconductor [H. Kosaka, T. Inagaki, Y. Rikitake, H. Imamura, Y. Mitsumori, and K. Edamatsu: Nature **457**, 702-705 (2009)]

[3] Time-resolved photoinduced Kerr rotation in semiconductor microcavity [Y. Mitsumori, N. Kato, H. Kosaka, K. Edamatsu, N. Yamamoto, K. Akahane: Phys. Stat. Sol. (c) **6**, 292-295 (2009)]

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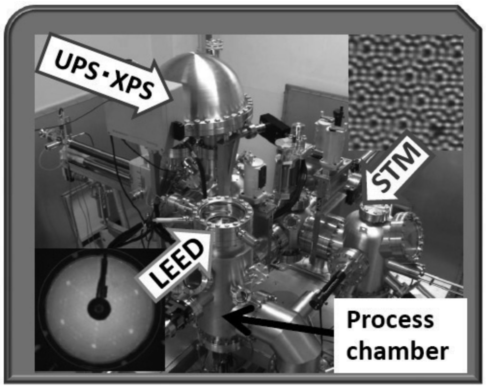
Solid State Electronics Laboratory

Ubiqitous Silicon Technology

[Research Target and Activities]

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



The integrated system for graphene formation and analysis

[Staff]

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

[Profile of Professor Suemitsu]

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

[Papers]

1. Carbon concentration dependence of charged point-defect density in semi-insulating GaAs as observed by nuclear magnetic resonance Applied Physics Letters., 57 (1990), pp. 398-399. M. Suemitsu, M. Nishijima, and N. Miyamoto
2. Observation of hydrogen-coverage- and temperatrue-dependent adsorption kinetics of disilane on Si(100) during Si gas-source molecular beam epitaxyJapanese Journal of Applied Physics., 36(1997), pp. L625-L628.M. Suemitsu, H. Nakazawa, T. Morita, and N. Miyamoto
3. Initial oxidation of Si(100)-2x1 as an autocatalytic reaction, Physical Review. Lett., 82(1999), pp.2334-2337. Maki Suemitsu, Yoshiharu Enta, Yasushi Miyanishi, and Nobuo Miyamoto

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Dielectric Nano-Devices

Research on Dielectric Nano Science and Technology

[Research Target and Activities]

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

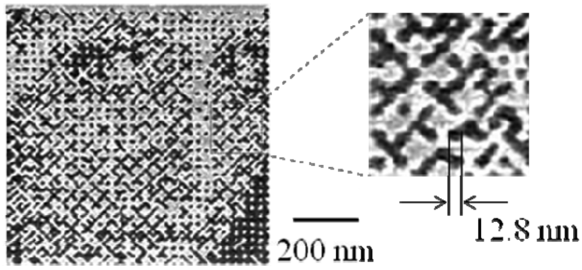

Fig.1 Digital bit data written on ferroelectric single crystal with the areal recording density of 4 Tbit/inch^2.

Major achievements of studies in 2008 are as follows: (1) Surfaces of various material (cf. silicon, fullerene molecule, oxides) were observed with atomic resolution using non-contact SNDM. (2) Digital 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.

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Assistant Professor : KIN, Nobuhiro
Technical Official : WAGATSUMA, Yasuo
Research Fellow : ISHIKAWA, Kenya Dr.
Research Fellow : KOBAYASHI, Shinichiro Dr.
Research Fellow : BHUIYAN, Moinul Dr.
Research Fellow : ODAGAWA, Nozomi

[Profile of Professor Cho]

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

[Papers]

[1] Kenkou TANAKA, Yuichi KURIHASHI, Tomoya UDA, Yasuhiro DAIMON, Nozomi ODAGAWA, Ryusuke HIROSE, Yoshiomi HIRANAGA, and Yasuo CHO, "Scanning Nonlinear Dielectric Microscopy Nano-Science and Technology for Next Generation High Density Ferroelectric Data Storage", Jpn. J. Appl. Phys, Vol.47, No.5, pp.3311-3325, 2008.
[2] Yasuo Cho and Ryusuke 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.
[3] Yasuo Cho, "Nanoscale Ferroelectric Information Storage Based on Scanning Nonlinear Dielectric Microscopy", Journal of Nanoscience and Nanotechnology, Vol. 7, pp.105-116, 2007.

Materials Functionality Design

Computational Design of Functional Materials for Spintornics Devices

[Research Target and Activities]

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

Our research activities in FY 2008 include computational materials design for spintornics as follows:

(1) Magnetic tunnel junctions (MTJ) with perpendicular magnetic anisotropy

In order to ensure enough endurance against thermal fluctuations in downsizing non-volatile magnetoresistive random access memory (MRAM), it is inevitable to adopt ferromagnetic materials with large magneto-crystalline anisotropy as electrodes of the MTJ. We investigate the effect of interfacial Fe layers into the FePt/MgO/FePt (001) MTJ on their tunneling magnetoresistance (TMR) ratio on the basis of first-principles calculations. The TMR ratio increases dramatically even for 3-4 Fe layers inserted into both sides of the MgO barrier and the FePt electrodes.

(2) Highly spin-polarized interfaces between Heusler alloys and oxides

We investigate the electronic and transport properties of MgO-based MTJ with half-metallic Heusler alloy electrodes on the basis of first-principles calculations. The insertion of thin Co_2CrAl layers between Co_2MnSi electrodes and the MgO barrier can eliminate electronic states in the minority-spin gap at the interface, leading to 100% spin polarization at the Fermi level in the interfacial region (Fig. 1). The insertion of thin Co_2CrAl layers into the MTJ can improve the TMR ratio at room temperature.

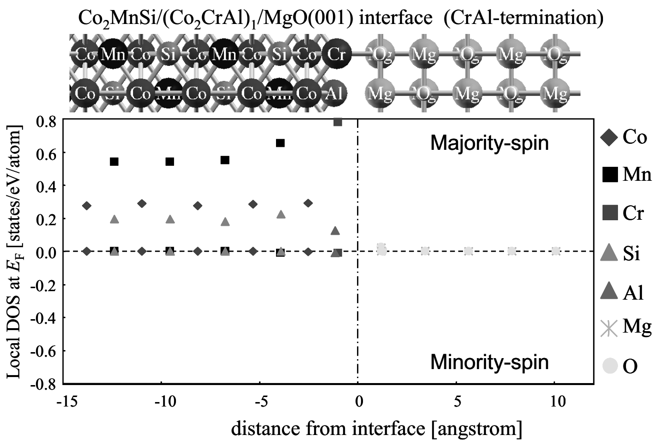

Fig. 1

[Staff]

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

[Profile of Professor SHIRAI]

Masafumi Shirai was received the Doctor of Engineering degree from Osaka University in 1989. From 1988 to 1996, he was a Research Associate, and then an Associate Professor at Osaka University. From 2002 to the present, he has been a Professor at Tohoku University. His research interests have been itinerant electron magnetism in transition-metal compounds, computational materials design on the basis of first-principles calculations, and so on.

[Papers]

[1] Y. Miura, H. Uchida, Y. Oba, K. Abe, and M. Shirai, "Half-metallic interface and coherent tunneling in Co_2YZ/MgO/Co_2YZ (YZ = MnSi, CrAl) magnetic tunnel junctions: A first-principles study," Phys. Rev. B, Vol.78, No.6, Article no.064416, pp.1-9, 2008.

[2] Y. Taniguchi, Y. Miura, K. Abe, and M. Shirai, "Theoretical studies on spin-dependent conductance in FePt/MgO/FePt(001) magnetic tunnel junctions," IEEE Trans. Magn., Vol.44, No.11, pp.2585-2588, 2008.

[3] K. Abe, Y. Miura, Y. Shiozawa, and M. Shirai, "Half-metallic interface between a Heusler alloy and Si," J. Phys.: Condensed Matter, Vol.21, No.6, Article no.064244, pp.1-5, 2009.

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Broadband Engineering Division: Research Target and Results

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

(1) Wireless Information Technology

Research and development are progressing toward Dependable Wireless Next-generation-network (DWN) in the 21st century's wireless information technology. For realizing the DWN, we are interested in developing the following wireless network; (i) next-generation mobile broadband wireless access (MBWA), (ii) dependable broadband wireless local area network (WLAN), and (iii) ultra-broadband wireless personal area network (WPAN).

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

(2) Ultra-Broadband Signal Processing

We are developing novel, integrated electron devices and circuit systems operating in the terahertz region. One example is a plasmon-resonant emitter structured by dual-grating gates high-electron mobility transistors. The microchip emitter was introduced as a broadband terahertz light source into a spectrometer and successfully measured the water-vapor absorption spectra over the terahertz range.

We are also pursuing new materials called “graphene,” a single-layered honeycomb lattice carbon crystal, featuring extraordinary carrier transport properties of massless Dirac Fermions. We have succeeded in transistor operation by introducing graphene as a channel material in a Si-based transistor.

(3) Ultrahigh-Speed Optical Communication

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

As regards the ultrahigh-speed transmission, 320 Gbit/s DPSK signal was successfully transmitted over 525 km with a time-domain optical Fourier transformation (OFT) technique. In coherent transmission, we successfully demonstrated a 6 channel FDM transmission of 64 QAM signals over 160 km, in which a total capacity of 72 Gbit/s was transmitted with only 8.4 GHz bandwidth and thus the spectral efficiency reached as high as 8.6 bit/s/Hz.

(4) Applied Quantum Optics

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

Research for ultra-high-speed semiconductor photonic devices operated by controlling signal light injection has been started. Novel THz biosensors using surface plasmon resonance are also studied to achieve sensitive detection of biomolecules and THz imaging with sub-wavelength spatial resolution. Local-field enhancement is clarified from numerical analysis and suitable structures for the resonators are clarified.

(5) Information Storage Systems

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

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

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

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

We are developing imaging systems mainly of passive mode, which enables non-invasive measurement possible. A 2-dimensional imaging array for the 35 GHz-band has been developed and the imaging speed of 0.8 s/frame has been obtained.

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

We are interested in developing air-borne synthetic aperture radars (SAR) for civilian applications contributing safety and security improvement. The SAR will be useful for all-weather surveillance and rescue in disastrous fires and smokes.

Conceptual design of a spotlight-mode SAR system has been done, targeting at a high resolution (5-10 cm), small size and light weight (20-30 kg) at Ku/Ka-band. Scientists and engineers from both universities and industries collaborate on the program.

(8) Laboratory for Nanoelectronics and Spintronics: Semiconductor Spintronics

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

Control of magnetic anisotropy in a (Ga,Mn)As film was demonstrated by the application of electric-fields. Phase coherence control of spin-3/2 ^{75}As nuclei was demonstrated in a GaAs/AlGaAs quantum well by multipulse NMR sequences and optically-detected NMR. GaAs-based quantum cascade lasers emitting at 3.8 THz was realized, and intersubband transitions in ZnO quantum wells was observed.

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

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

The TMR ratio of 604 (1144) % at RT (5 K) (world record) was demonstrated in MgO-based MTJs. Low intrinsic critical current density (J_{c0}) without degrading the thermal-stability factor $E/k_B T$ was realized by using SyF free layer. Fabrication process of magnetic tunnel junction (MTJ) on circuits was developed, and the operation of nonvolatile full adder based on logic-in-memory architecture was verified.

Research Area of Ultrahigh-Speed Optical Communication

Advanced optical communication technologies approaching the Shannon limit

[Research Target and Activities]

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

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 320 Gbit/s system, and successfully demonstrated error-free transmission over 525 km, in which tolerance to higher-order polarization-mode dispersion was greatly improved with OFT. We have also been actively engaged in coherent QAM optical transmission for achieving the ultrahigh spectral efficiency approaching the Shannon limit. This year, we successfully demonstrated a frequency-division multiplexed 64 QAM transmission, in which polarization-multiplexed 1 Gsymbol/s, 64 QAM (12 Gbit/s) data were successfully transmitted over 160 km in a 6-channel FDM with a 1.4 GHz spacing. Thus the spectral efficiency reached as high as 6 bit/s/Hz with a total capacity of 72 Gbit/s (Fig. 1).

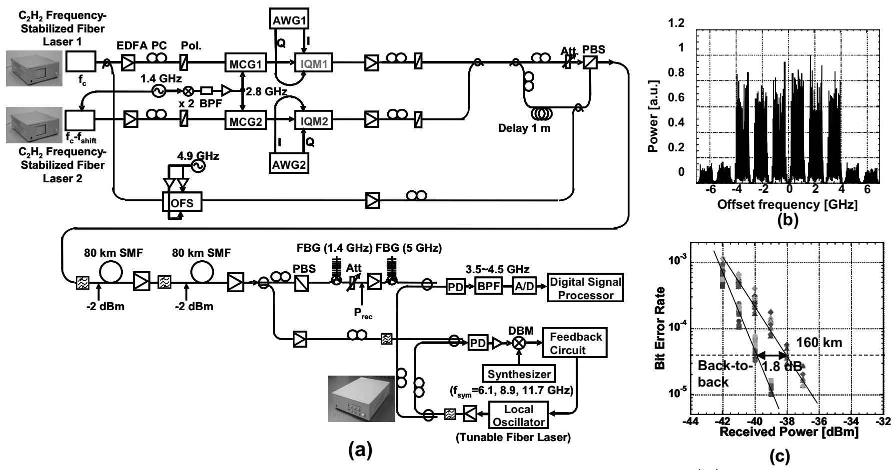

Fig. 1 Gsymbol/s, 64 QAM-FDM transmission setup (a), QAM signal spectrum (b), and bit error rate characteristics (c).

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Associate Professor: HIROOKA, Toshihiko Dr.
Assistant Professor: YOSHIDA, Masato Dr.
COE Fellow: KASAI, Keisuke Dr.

[Profile of Professor NAKAZAWA]

Prof. Nakazawa received a Ph. D. degree from the Tokyo Institute of Technology in 1980. In 1980, he joined the Ibaraki Electrical Communication Laboratory, Nippon Telegraph & Telephone Public Corporation. He was a visiting scientist at Massachusetts Institute of Technology in 1984-1985. In 2001, he moved to the Research Institute of Electrical Communication, Tohoku University as a professor, where he has been engaged in research on ultrahigh-speed optical communication including soliton transmission, nonlinear effects in fibers, mode-locked lasers, and photonic crystal fibers. He is the author and coauthor of over 380 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] H. Goto, M. Yoshida, T. Omiya, K. Kasai, and M. Nakazawa, "Polarization and frequency division multiplexed 1Gsymbol/s, 64 QAM coherent optical transmission with 8.6 bit/s/Hz spectral efficiency over 160 km," IEICE Electron. Express, vol. 5, no. 18, pp. 776-781, September (2008).
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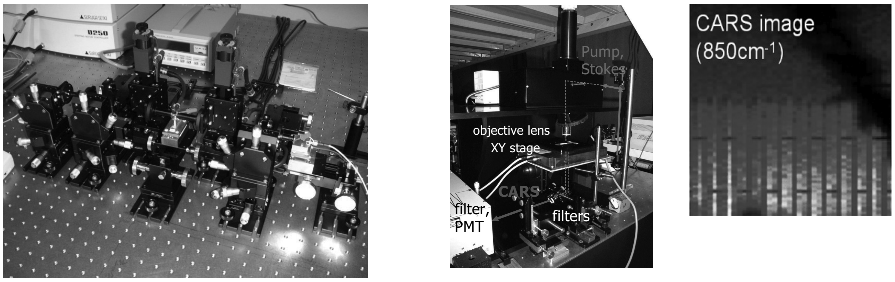
Applied Quantum Optics

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

[Research Target and Activities]

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

Ultra-high-speed semiconductor photonic active devices operated by control signal light injection are started to research by utilizing a semiconductor laser with an external feedback cavity. In order to realize highly-functional photonic semiconductor modulators, coherent optical signal generation is successfully demonstrated by using compact and low-driving-voltage semiconductor Mach-Zehnder modulators. Novel THz biosensors using surface plasmon resonance are also studied to achieve sensitive detection of biomolecules, high-spatial-resolution THz imaging beyond diffraction limit, and application to THz-frequency coherent anti-Stokes Raman (THz-CARS) microscopy system we developed. Local-field enhancement was numerically analyzed to clarify optimum design of resonator structure.



Experimental setups for novel semiconductor photonic functional devices (left), and THz-CARS (center) and its image for poled lithium niobate (right)

[Staff]

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

[Profile of Professor YASAKA]

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

[Papers]

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Wireless Info Tech

For Realizing Dependable Wireless Next-Generation-Network (DWN)

[Research Target and Activities]

Research and development are progressing toward Dependable Wireless Next-Generation-Network (DWN) in the 21st century's wireless information technology. The DWN immediately provides any information for everyone at anytime and anywhere.

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

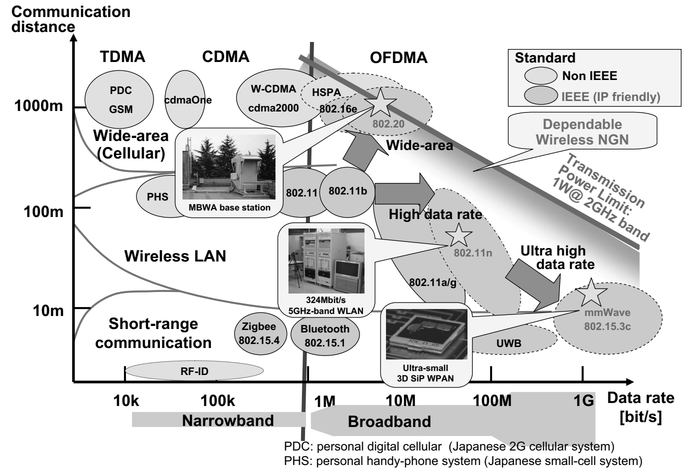

Fig. The target system of Wireless Info Tech.

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

[Staff]

Professor: TSUBOUCHI, Kazuo, Ph. D
Associate Professor: NAKASE, Hiroyuki, Ph. D (～June 2008)
Assistant Professor: KAMEDA, Suguru, Ph. D

[Profile of Professor: TSUBOUCHI]

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]

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Information Storage System

Research on Large Capacity Information Storage System Using Perpendicular Magnetic Recording

[Research Target and Activities]

Amount of digital information is rapidly growing year by year, which is projected to exceed 100 Exa-byte (10^{20} bytes) in 2010. Extremely large storage capacity by high density magnetic recording for the information is thus required. Perpendicular magnetic recording was introduced in order to continuously develop areal density of hard disk drives beyond the conventional density limit, 1 Tbit/inch^2 and even up to 5 Tbit/inch^2. We thus focus on research on high density perpendicular magnetic recording in next generation. Theoretical studies including a micromagnetic computer simulation in association with experimental approach are carried out for this purpose.

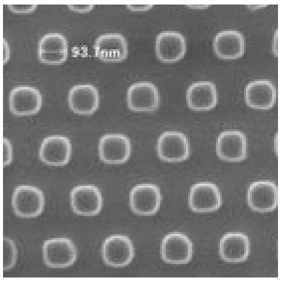

Fig 1 Fabricated bit patterned media

As we early proposed, magnetic nano-structure of recording media is the most essential parameter to achieve high density perpendicular recording. Bit-patterned medium (Fig 1 and 2) is one of promising candidates. For a target areal density of 2 Tbit/inch^2 in which the bit size corresponds to the area of 13 nm by 25 nm, recording error-rate performance for the bit-patterned medium was analyzed. A design guideline of the writing process for the media was clarified based on the statistical modeling. The analyses unveiled geographical and magnetic uniformity of the patterned dots was found to be essential, as well as the writing head resolution. The computer simulation derived concrete specifications of heads and media for high density recording.

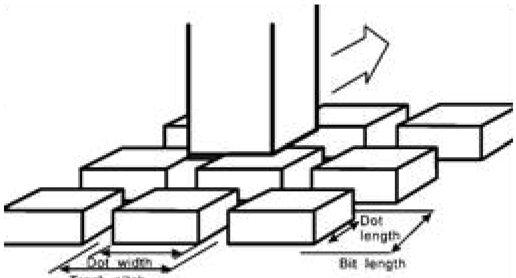

Fig 2 Recording scheme for a bit patterned medium.

In addition to the studies on magnetic recording, a novel low-power consumption architecture for extremely large capacity storage system was developed based on tiered operation of hard disk drives.

[Staff]

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

[Profile of Professor: MURAOKA]

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

[Papers]

[1] M. Hashimoto, K. Miura, H. Muraoka, H. Aoi, R. Wood, M. Salo, Y. Ikeda, "Influence of patterning fluctuation on read/write characteristics in discrete track and bit patterned media," J. Magn. Magn. Mater., 320, 2935-2943, 2008.
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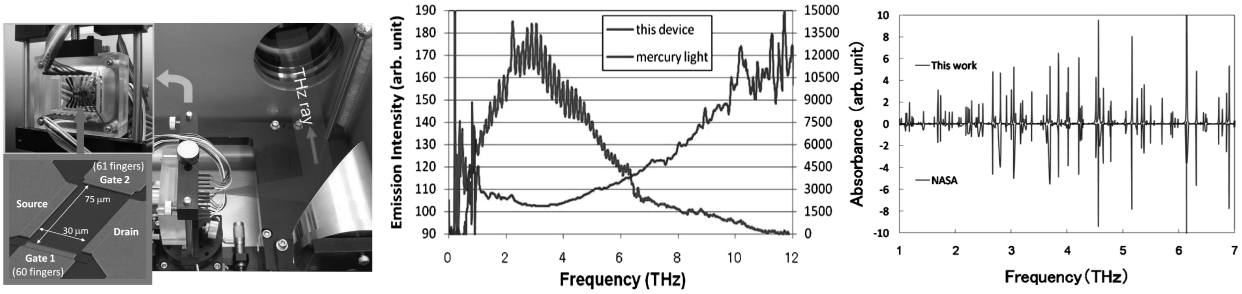
Ultra-broadband Signal Processing

Novel Millimeter-wave and Terahertz Integrated Electron Devices and Systems

[Research Target and Activities]



Original plasmon-resonant microchip emitter and its application to terahertz spectroscopic measurement.

(Left: SEM image of the die fabricated with GaAs-based heterostructure materials and its packaging/installation into the chamber of a terahertz spectrometer as a light source, center: emission spectrum in the self-oscillation mode at room temperature in comparison with that for a standard high-pressure mercury lamp, right: water-vapor absorption spectrum measured by using the microchip emitter (upper) in comparison with the reference data provided by NASA (lower).)

We are developing novel, integrated electron devices and circuit systems operating in the terahertz region. One example is a plasmon-resonant terahertz emitter structured by dual-grating gates high-electron mobility transistors (HEMT's). The microchip emitter was introduced as a broadband terahertz light source into a spectrometer and successfully measured the water-vapor absorption spectrum over the terahertz range (see the above figures). We are also pursuing new materials called “graphene” for ultrafast transistors to break through the limit on conventional transistor speed. Graphene, a single-layered honeycomb lattice carbon crystal, features extraordinary carrier transport properties due to the nature of massless Dirac Fermions. We have succeeded in transistor operation by introducing graphene as a channel material in a Si-based transistor, leading to terahertz operation.

[Staff]

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

[Profile of Professor OTSUJI]

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

[Papers]

[1] V. Ryzhii, A. Satou, M. Ryzhii, T. Otsuji, M. S. Shur, J. Phys.: Condens. Matters, Vol. 20, 384207, pp. 1-6, 2008.
[2] T. Otsuji, et al., J. Phys.: Condens. Matters, Vol. 20, Iss. 384206, pp. 1-11, 2008.
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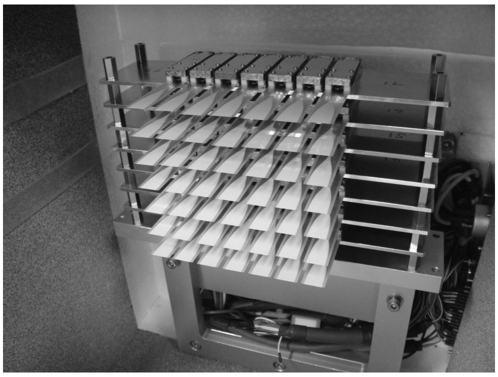
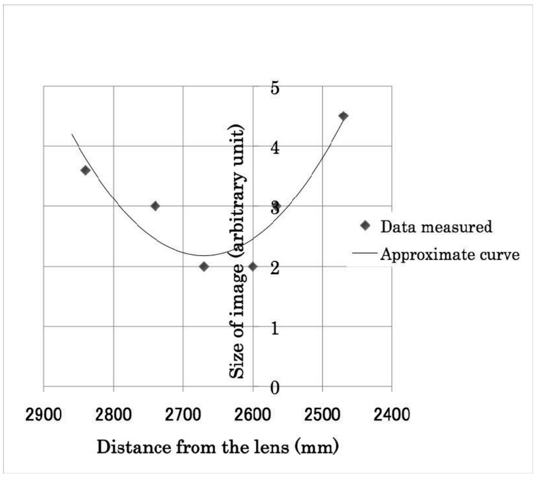
Basic Technology for Broadband Communication

Development of Measurement Instrumentation by the Millimeter and THz Wave

[Research Target and Activities]

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





[Left]: 35 GHz 2-dimensional (7 x 7) imaging array developed. [Right]: Measured depth of field. Vertical axis shows size of images (arbitrary unit) and the figure is plotted as a function of distance from lens (horizontal axis. mm).

[Staff]

Visiting Professor: MIZUNO Koji Dr.

[Profile of Professor MIZUNO]

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 (now Life Fellow), 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] M. Sato, T. Hirose, T. Ohki, T. Takahashi, K. Makiyama, H. Sato, K. Sawaya, and K. Mizuno, "InP-HEMT MMICs FOR PASSIVE MILLIMETER-WAVE IMAGING SENSORS," 20th Indium Phosphide and Related Materials Conference, Versailles, France, May 2008. (Invited)

[2] K. Mizuno, "Millimeter wave Imaging Technologies," J. IEICE, Vol. 91, No. 12, pp. 1047-1053, Dec. 2008. (Invited, in Japanese)

[3] K. Mizuno, "Passive Millimeter-wave Sensing for Secure-Life," Pro. Global COE Symposium on Secure-Life Electronics, Tokyo, pp. 17–20, Jan. 2009. (Invited)

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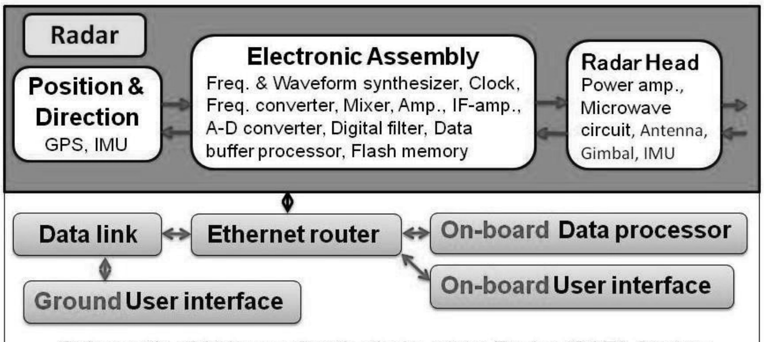
Basic Technology for Broadband Communication

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.



Schematic of Airborne Synthetic Aperture Radar (SAR) System

1. Conceptual design of a spotlight-mode SAR system has been done, as shown in Fig.1.
2. We aim for developing high resolution (5-10cm), small size and light weight (20-30kg) SAR at Ku/Ka-band microwave frequencies.
3. Domestically-available, manned and unmanned aerial vehicles, which are suitable for the SAR platforms, were identified.
4. A principle that our developments are open to all contributing parties is adopted.

[Staff]

Visiting Professor : INUTAKE Masaaki Dr.

[Profile of Professor INUTAKE]

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. 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.

[Papers]

[1] M. Inutake, A. Ando, M. Ichimura, Y. Amagishi, A. Tsushima, "Basic Researches on Alfvén Wave Phenomena and its Application", Prizes for Science & Technology (Research Category), Commendation for Science & Technology by the Minister of Education, Culture, Sports, Science and Technology, (April , 2008).
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[3] A. Mase *et al.*, "Advancement of Microwave Diagnostics and their Industrial Application", 11th IEEE Int. Conf. on Communication Technology, Hangzhou (Nov. 2008).

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Aims and Achievements of Human Information Systems Division

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

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

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

(1) Electomagnetic Bioinformation Engineering

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

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

(2)Advanced Acoustic Information Systems

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

(Achievements)In 2008, we deepen the understanding human spaciotemporal perceptual processes of audio-visual and audio-vestibular information. This is particularly important to realize future multi-modal information processing and communication systems. We continued to develop methods, such as virtual auditory displays based on our accumulated knowledge of human auditory space perception, new auralization method for concert hall based on sound field simulation and 1/10th-scale measurement, and high-precision analyzing method using a surrounding microphone array, to realize 3D immersive sound fields. They are keenly required to realize super-definition audio-visual communications in near future. Furthermore, we developed new signal processing algorithms of 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 and also that it is different from the attention-based motion system. Since slow motion signals have been paid little attention both in vision and image processing, the result provided new view of role of motion signals in visual processing. 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 (mCP) 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 b-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.

(5) Ubiquitous Communications System

(Aims) To realize communications environments in which everybody can communicate with anybody, any where and any time by carrying out researches on radio propagation characteristics, electromagnetic interferences, and radio equipment with which customers can communicate universally.

To contribute to materialize or to lead IEEE standardization based on “Japanese technologies”

(Achievements) To realize Gigabit per second transmission employing millimeter wave (60GHz) indoor PAN (Wireless Personal Area Networks) systems, a lot of measurements and experiments have been done on antenna directivity / beam width and delay spreads, reflective waves by walls and metals (or equivalents) and they lead to the inventions of simultaneous multiple signal path tracking (including the intentionally created path) and dynamic path selection to increase communications reliability enhancement. Also, a lot of physical layers have been designed and simulated to develop robust WPAN systems in various and practical fading environments. Moreover, ultra high speed MAC (Medium Access Control) has been designed and developed for high throughput Gigabit WPAN.

Through organizing a Consortium (COMPA, Chair: Professor Shuzo Kato) (22 active members) and getting a group of supporting COMPA as Partners (17 non-Japanese institutes), a global and harmonized IEEE standardization has been executed successfully (the standardization will be finalized in this year). This will be the first successful standardization of “Japanese organization driven IEEE standardization) and it will a good role model of IEEE standardization for Japanese industry.

Electromagnetic Bioinformation Engineering

Communication with human body

[Research Target and Activities]

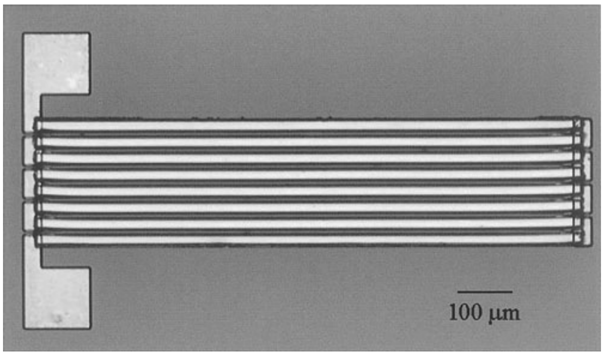

Fig.1 Sensitive magnetic field sensor

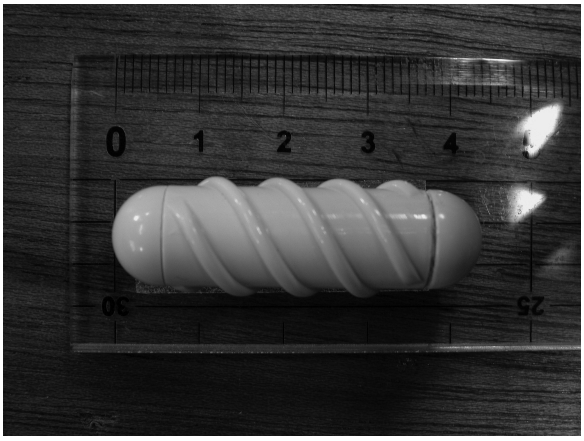

Fig. 2 Magnetic actuator for capsule-endoscope

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

[Staff]

Professor: ISHIYAMA Kazushi Dr. (Since 2007)
Assistant Professor: HASHI Shuichiro Dr. (Since 2008)

[Profile of Professor ISHIYAMA]

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

[Papers]

[1] Kazushi Ishiyama, Chikako Yokota, "Cantilevered actuator using magnetostrictive thin film," Journal of Magnetism and Magnetic Materials, vol. 320(2008), pp.2481-2484.
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[3] S. Hashi, M. Toyoda, S. Yabukami, K. Ishiyama, Y. Okazaki, K. I. Arai, H. Kanetaka, "Wireless magnetic motion capture system using multiple LC resonant magnetic markers with high accuracy," Sensors and Actuators A: Physical, Vol. 142, No. 2, pp. 520-527 (2008).

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Advanced Acoustic Information Systems

Development of next generation communication systems

[Research Target and Activities]

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

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 2008, we put a lot of efforts to investigate the spaciotemporal integration process of audio-visual and audio-vestibular information.

Furthermore, in 2008, we developed new signal processing algorithms of digital watermarking, advanced digital hearing aids, and high-performance two-stage binaural speech enhancement.

[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., TERAMOTO, Wataru Dr., and OTANI Makoto Dr.

[Papers]

- Satoshi Yairi, Yukio Iwaya and Yôiti Suzuki: “Influence of large system latency of virtual auditory display on behavior of head movement in sound localization task,” Acta Acusitca united with Acustica, 94 (6), 1016-1023, 2008
- Akihiro Tanaka, Shuichi Sakamoto, Komi Tsumura and Yôiti Suzuki: “Visual speech improves the intelligibility of time-expanded auditory speech,” Neuroreport, 20 (5) 473-477, 2009
- Junfeng Li, Shuichi Sakamoto, Satoshi Hongo, Masato Akagi and Yôiti Suzuki: “Adaptive β-order generalized spectral subtraction for speech enhancement,” Signal Processing, 88 (11), 2764-2777, 2008
- H. Wang, R. Nishimura, Y. Suzuki and L. Mao: “Fuzzy self-adaptive digital audio watermarking based on time-spread echo hiding,” Applied Acoustics, 69 (10), 868-874, 2008

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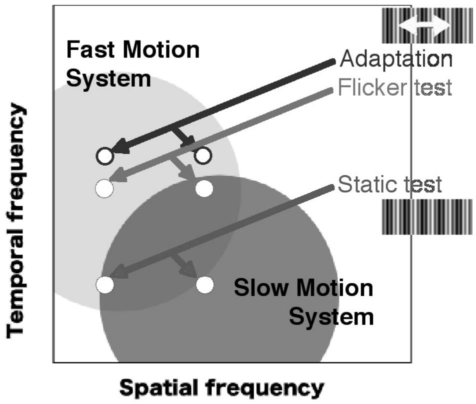
Visual Cognition and Systems

Vision sciences for visual communication

[Research Target and Activities]

The human visual system has two motion systems in an early stage of motion analysis. They differ in spatiotemporal tuning, orientation tuning, sensitvity to global motion, etc.



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

1. Parallel motion mechanisms

We have been studying on the two types of motion detectors using motion aftereffect with different spatiotemporal properties. This year we published an article that made clearly that sensitivity of the slow and fast motion detectors are different in spatiotemporal frequency, stimulus orientation, but they are not different in the effect of attention and speed. We also found that motion detecting system in vision is related to haptic movements. This could impact the field of vision science with some more detailed investigation since this suggests that the visual process does not simply process visual information.

2. Binocular integration of motion and color signals

There are two binocular process for perception of motion in depth. We revealed that these two processes are different in terms of temporal property. The motion-in-depth process that uses interocular velocity differences is sensitive to relatively higher temporal frequency than the one that uses disparity change in time. This indicates that these two process work complementary: one detects high speed motion and the other detects low speed motion. We also revealed that there is a binocular color process that integrates color information from the two eyes when the colors from the two eyes are similar (binocular AND system).

[Staff]

Professor	:	SHIOIRI, Satoshi Dr.
Associate Professor	:	KURIKI, Ichiro Dr.
Assistant Professor	:	MATSUMIYA, Kazumichi Dr.

[Profile of professor SHIOIRI]

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

[1] S. Shioiri, and K. Matsumiya, “Motion mechanisms with different spatiotemporal characteristics identified by an MAE technique with superimposed gratings” *Journal of Vision*, vol. 9, no 5, article 30, pp. 1-15, May. 2009.

[2] S. Shioiri, T. Nakajima, D. Kakehi *et al.*, “Differences in temporal frequency tuning between the two binocular mechanisms for seeing motion in depth,” *J Opt Soc Am A Opt Image Sci Vis,* vol. 25, no. 7, pp. 1574-85, Jul, 2008.

[3] Y. Watanabe, T. Kezuka, K. Harasawa , M. Usui, S Shioiri and H. Yaguchi., “A new method for assessing motion-in-depth perception in strabismic patients,” *Br J Ophthalmol,* vol. 92, no. 1, pp. 47-50, Jan, 2008.

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Interdisciplinary field for informatics

Fabrication and Application of Plasmonic Ag Nanosheet

[Research Target and Activities]

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

Fig.1 shows our latest research subject concerning *"Plasmonic Ag nanosheet"*. Uniformly sized Ag nanoparticles (d = 5 nm) form a homogeneous monolayer composed of two-dimensional (2D) crystalline domains at air-water interface by self-assembly, in which the distance between Ag cores is accurately controlled by the thickness of the capping organic molecules. The nanosheet exhibits a significant red-shift of plasmon absorption band from the position in dispersion solution, while the peak width was rather reduced (sharpened) as an evidence of homogeneous coupling of local plasmons. This flexible, transferable nanosheet, which can trap and transport bulk light at nano-interface, promises new application in the field of bio- and organic devices.

Reversible work function change of gold electrode by photoisomerization of azobenzene self-assembled monolayers has been investigated by UPS in Singapore synchrotron facilities as well.

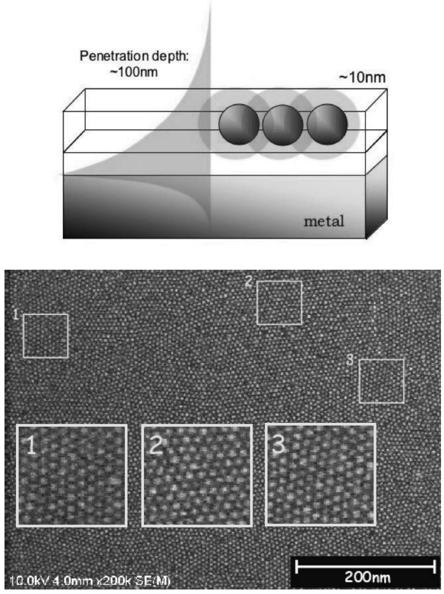

Fig.1 Plasmonic Ag nanosheet

[Staff]

Professor: TAMADA Kaoru Dr. (from Oct. ２００７)

[Profile of Professor TAMADA]

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] Bioapplication of plasmonic nanosheet (invited paper), K. Tamada, M. Michioka, X. Li, Y. Ikezoe, M. Saito, K. Otsuka, Proc. of SPIE, 7213, 72130E (2009).

[2] Reversible work function changes induced by photoisomerization of asymmetric azobenzene dithiol self-assembled monolayers on gold, L.F.N.A.Qune, H. Akiyama, T. Nagahiro, K. Tamada, A.T. S. Wee, *Apply. Phys. Lett.,*93, 083109-1-083109-3 (2008).

[3] Coordination of Carboxylate on Metal Nanoparticles Characterized by Fourier Transform Infrared Spectroscopy, P. Wulandari, T. Nagahiro, K. Michioka, K. Tamada, K. Ishibashi, Y. Kimura, M. Niwano, *Chem. Lett.,*37(8), 888-889 (2008).

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Ubiquitous Communications system

Research and Development on Super Broadband Wireless Communications

[Research Target and Activities]

(Aims)

To realize communications environments in which everybody can communicate with anybody, anywhere and anytime by carrying out researches from radio propagation characteristics to radio equipment with which customers can communicate universally.

To contribute to materialize or to lead IEEE standardization based on “Japanese technologies”

(Achievements)

To realize Multi-Gigabit per second transmission by employing millimeter wave (60GHz) indoor WPAN (Wireless Personal Area Networks) systems, a lot of measurements and experiments have been done on antenna directivity / beam width, delay spreads, reflective waves by walls and metals (or equivalents) and they have lead to the inventions of simultaneous multiple signal path tracking (including the intentionally created paths) and dynamic path selection to enhance communications reliability. Also, a lot of physical layers have been studied, designed and simulated to develop robust WPAN systems in various and practical fading environments. Moreover, ultra high speed MAC (Medium Access Control) has been designed and developed for high throughput multi-Gigabit WPAN.

Through organizing a Consortium (COMPA, Chair: Professor Shuzo Kato) (22 active members) and getting a group of supporting COMPA as Partners (17 non-Japanese institutes), a global and harmonized IEEE standardization (IEEE802.15.3c) has been executed successfully (the standardization has been finalized in September 2009). This is the first successful standardization of “Japanese organization driven IEEE standardization and it will a good role model of IEEE standardization for Japanese industry.

[Staff]

Professor Shuzo Kato, Ph.D.

Associate Professor Hiroyuki Nakase, Ph.D.

[Profile of Professor Shuzo Kato]

Prof. Shuzo Kato received his Ph. D degree in electrical and communications engineering from Tohoku University, Sendai Japan in 1977. From 1977 to 1995, he worked at NTT (Nippon Telegraph and Telephone) Research Laboratories in Japan, specializing personal and satellite communications systems R&D. He founded Pacific Communications Research Corp. focusing on ASIC, SW and system design for PCS In 1995, at the same time he served as Senior Executive Vice President, and later as President of Uniden Corporation. From January 1999 to July 2001, he served as Executive Vice President, Mitsubishi Wireless Communications Inc (MWCI) in USA, as well as President, Mobile Communications Technology Center of MWCI in San Diego, CA responsible for mobile phone technology development up to real/sellable and high yield cell phones with all certificates (FCC, CTIA and inter-operability). From 2002 to 2005, he served as Executive Vice President of Teradyne Japan responsible for P/L, Engineering, Production and Global Marketing as well as President and CEO of Omni Wireless Inc., in California, USA.

He currently is Professor, Research Institute of Electrical Communications, Tohoku University, Japan, Program Coordinator, Ubiquitous Mobile Communications at NICT (National Institute of Information and Communications Technology) working on wireless communications systems R&D focusing on millimeter wave communications systems. He has been serving as Vice-chair of IEEE802.15.3c Task Group working on millimeter wave systems standardization and Chair of COMPA (Consortium of Millimeter Wave Systems Practical Applications) promoting millimeter wave systems globally. He has published over 200 technical papers, held over 75 patents (including a patent which became DOD (Department of Defense, USA) standard in 1998), co-founded International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC). He is a Fellow of the IEEE and IEICE Japan and served as an Editor of IEEE Transaction on Communications, Chairman of Satellite and Space Communications Committee, COMSOC IEEE, a Board Member of IEICE Japan.

[Papers]

[1] Shuzo Kato, “A Dream Comes True: Multi-Gbps Millimeter Wave PAN Getting into Commercialization” Proc. 2008 Global Symposium on Millimeter Waves (GSMM2008) April, 2008

[2] R. Funada, S-C. Sean, T. Baykas, J. Wang, M A. Rahman, H. Harada, S. Kato、"Modulation and coding performances in IEEE802.15.3cSingle carrier PHY "、IEICE Technical Report、RCS、Aug. 2008.

[3] Z. Lan, C-W Pyo, F. Kojima, H. Nakase, H., S. Kato, "System Throughput Optimization by Link Adaptation on Millimeter Wave WPAN", IEICE Technical Report、RCS、Aug. 2008.

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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) Development of a new proof system based on the proof theory for machine code we developed in the previous year. This proof system yields a term calculus suitable for compiler intermediate representations and a compilation algorithm that deals with control flow merge without resorting to ad-hoc encoding. (2) Development of the SML# Compiler. In this year, we have developed a prototype code generator and a new runtime system.

(2) Computing Information Theory

Aiming at combining program transformation methods and automated theorem proving methods, we continued to pursue the possibility of program transformation by second-order templates based on term rewriting. We proposed a second-order generalization algorithm and based on this, we implemented a method to extract second-order templates from concrete program transformations. Although many automated termination provers have been proposed recently, little work is reported on automated confluence provers. We developed an automated confluence prover ACP for term rewriting systems based on several divide-and-conquer methods such as direct sum decomposition and commutative decomposition. Other research results of this year include a new automated lemma generation method for rewriting induction with disproof and a new termination proof for higher-order rewriting systems with recursive path relations.

(3) Communication Network Systems

We have studied new management schemes for next generation ubiquitous networks (SCOPE project, 2007-2009, Ministry of Internal Affairs and Communications) and promoted standardization activities in IETF WG. As an outcome of this work, our proposed idea of "NEMO Management Information Base" becomes the final draft standard in January 2009. It will be an official Internet standard (RFC) in a couple of months. 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 four keynote speeches and one invited paper in well-known international conferences. We have also received a Best Paper Award in a domestic workshop. Moreover, we also issued a press release on real/cyber space integration experiment in July 2008 that had attracted wide press coverage.

(4) Information Content

We have been developing creation technologies, retrieval technologies and distribution technologies for information content. We are developing DMD(Ditital Movie Director), which makes it possible to generate 3DCG animation content only by text (scenario) input, and AR (augmented reality)-based cloth fitting technology etc about creation technologies. As retrieval technologies, we are studying a high-performance video shot boundary detection technology, similar image retrieval technology based on PCA-SIFT and so forth. Besides, we are proposing a new cyclic broadcasting method and an overlay multicast technology for low-cost & high-performance video distribution.

(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 have obtained a basic design of special purpose 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 and a systolic array of operation 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*, *rank-1 polymorphism*, and *high-degree of interoperability with existing languages and databases*.

The major results of 2008 academic year include the following. (1) Development of a new calculus for representing control flow merge. In existing formalisms such as A-normal forms or CPS terms, control flow merge is treated in an ad-hoc way by introducing extra beta-redex. This seems to be due to the lack of proper formalism for representing case expression in the underlying calculi. In this work, we refine the correspondence between the sequent calculus and A-normal forms shown by one of the authors, and develop a proof system where control flow merge is directly represented as a logical rule for disjunction. These results yield a term calculus suitable for compiler intermediate representations and a compilation algorithm that deals with control flow merge without resorting to ad-hoc encoding. These results scale up to intermediate languages for practical compilers. The proposed calculus has been successfully used as an intermediate language of the SML# compiler. (2) Development of the SML# Compiler. In this year, we have developed a prototype code generator and a new runtime system.

[Staff]

Professor: OHORI Atsushi Dr. (2005-)

Assistant Professor: SASANO Isao Dr. (2005-2008)

Secretary: OTOMO Shoko

[Profile of Professor OHORI]

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

[Papers]

[1] Katsuhiro Ueno, Atsushi Ohori, An Optimized Type Inference Algorithm with Lazy Type Substitution, Computer Software, Vol. 25, No. 2, pp 101-113, 2008 (in Japanese)

[2] Katsuhiro Ueno, Atsushi Ohori, A Calculus for Merging Control Flows, IPSJ Transactions on Programming, Vol. 1, No 3, pp 19-33, 2008 (in Japanese)

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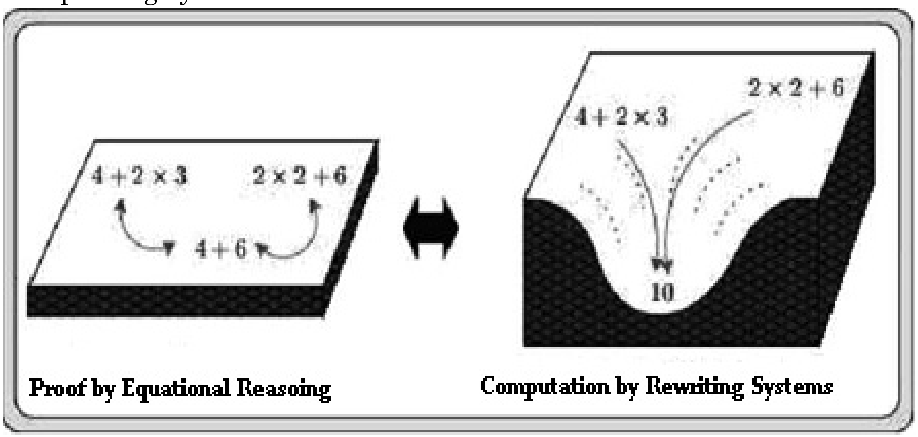
Computing Information Theory

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]

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

[Profile of Professor TOYAMA]

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

[Papers]

〔1〕Jean-Pierre Jouannaud and Yoshihito Toyama, Modular Church-Rosser Modulo: The Complete Picture, International Journal of Software and Informatics, Vol.2, No.1, pp.61-75, 2008.
〔2〕Takahito Aoto, Designing a rewriting induction prover with an increased capability of non-orientable theorems, In Proceedings of Austrian-Japanese Workshop on Symbolic Computation in Software Science (SCSS 2008), Hagenberg, Austria, pp.1-15, 2008.
〔3〕Kentaro Kikuchi, Call-by-name reduction and cut-elimination in classical logic,Annals of Pure and Applied Logic, Vol.153, No.1-3, pp.38-65, 2008.

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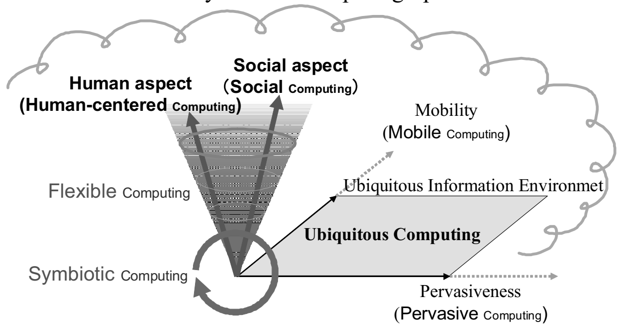
Communication Network Systems

Information Communication Systems based on Symbiotic Computing

[Research Target and Activities]

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



Concept of Symbiotic Computing

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

In 2008, for Symbiotic computing research, we have studied model and architecture of Symbiotic computing in detail. We also issued a press release on real/cyber space integration experiment in Jul. 2008. 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 the final draft standard of "NEMO Management Information Base" in Jan. 2009. This draft will be an official internet standard (RFC) in a couple of months.

[Staff]

Professor: SHIRATORI, Norio Dr. Associate Professor: SUGANUMA, Takuo Dr.
Research Associate: KOIDE, Kazuhide Dr. (until Jan. 2008)
Secretary: MIURA Kana, MORIYA Kaori

[Profile of Professor SHIRATORI]

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

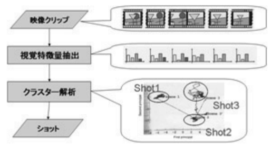
[Papers]

[1] Norio Shiratori, Debasish Chakraborty, Hideyuki Takahashi, Takuo Suganuma, "Looking beyond Ubiquitous Information Society —A new step towards Human-Computer Symbiosis," Fourth International Conference on Intelligent Computing and Information Systems (ICICIS), 2009 . <Keynote Speech>
[2] Norio Shiratori, "Towards Symbiosis Information Society," 2008 International Computer Symposium, 2008. <Keynote Speech>
[3] Norio Shiratori, "Post Modern Ubiquitous Information Society —Bridging the gap between human and computer—", Proc. of 2008 WSEAS International Conference on Computers, 2008. <Invited Speech>

Information Contents

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

DMD



Video Shot Boundary Detection

[Research Target and Activities]

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

1, Automatic Character Positioning Method in DMD

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

2. A Cyclic Broadcasting Method for NVoD for IPTV era

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

3. A New Cloth Simulation Method based on Complex Systems

A light-weight cloth simulation system is thought of as one of the most difficult implementations in CG field. We developed a new cloth simulation algorithm based on the theory of complex systems, the feature of which is a light-weight processing.

4. An Intuitive Character Motion Creation System

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

5. High-performance Video shot Boundary Detection Technology

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

[Staff]

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

[Profile of Professor Numazawa, Junji]

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

[Papers]

[1]Terumasa AOKI and Hiroshi YASUDA, " Automatic Movie Generation System by Scenario Input and its Creation Process", Journal of IPSJ(Information Processing Society of Japan), Vol.49, No.6, 2008..(in Japanese)

[2]Terumasa AOKI, "Trends of the Latest "Scenario to Anime" Technologies towards the Video CGM Age", Education Column Pages, Journal of IEICE(the Institute of Electronics, Information and Communication Engineering),

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Research area on the structure of information society

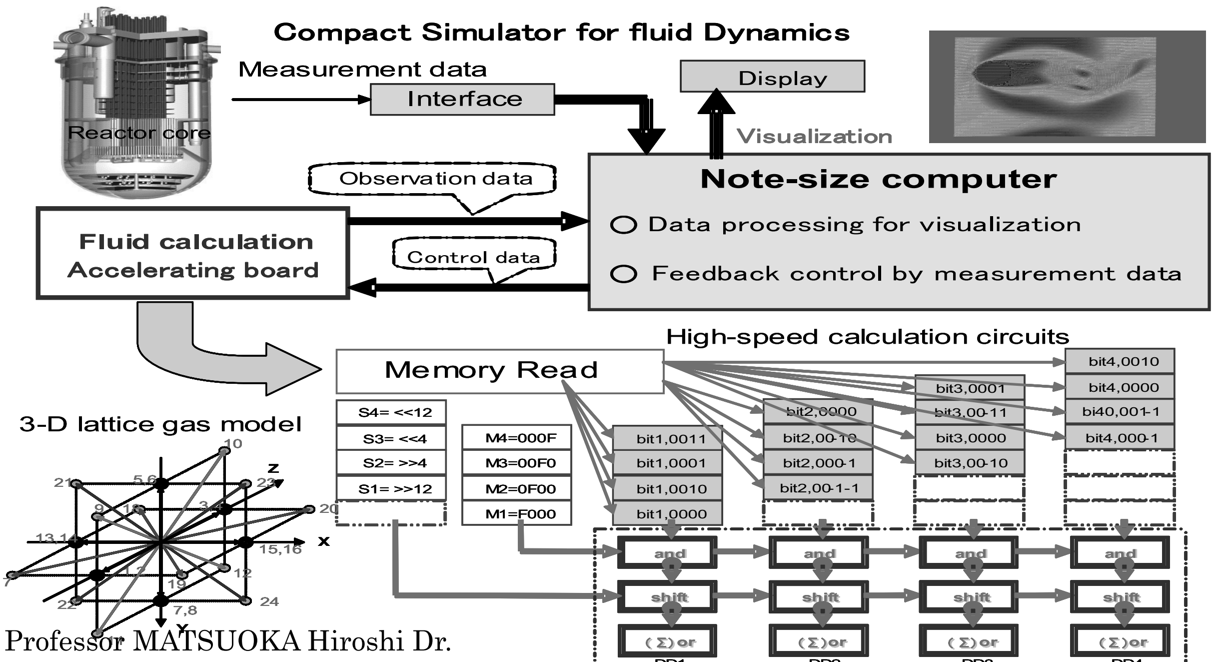
Numerical Simulation Technologies by ultra high performance computing as a measure to encourage human innovative activities

[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 2008, 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. We have completed a basic design of the Compact Simulator for fluid dynamics.

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.



[Staff]

Visiting Professor MATSUOKA Hiroshi Dr.

Technical Assistant Staff: KIKUCHI Noriko

[Profile of Professor MATSUOKA]

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]

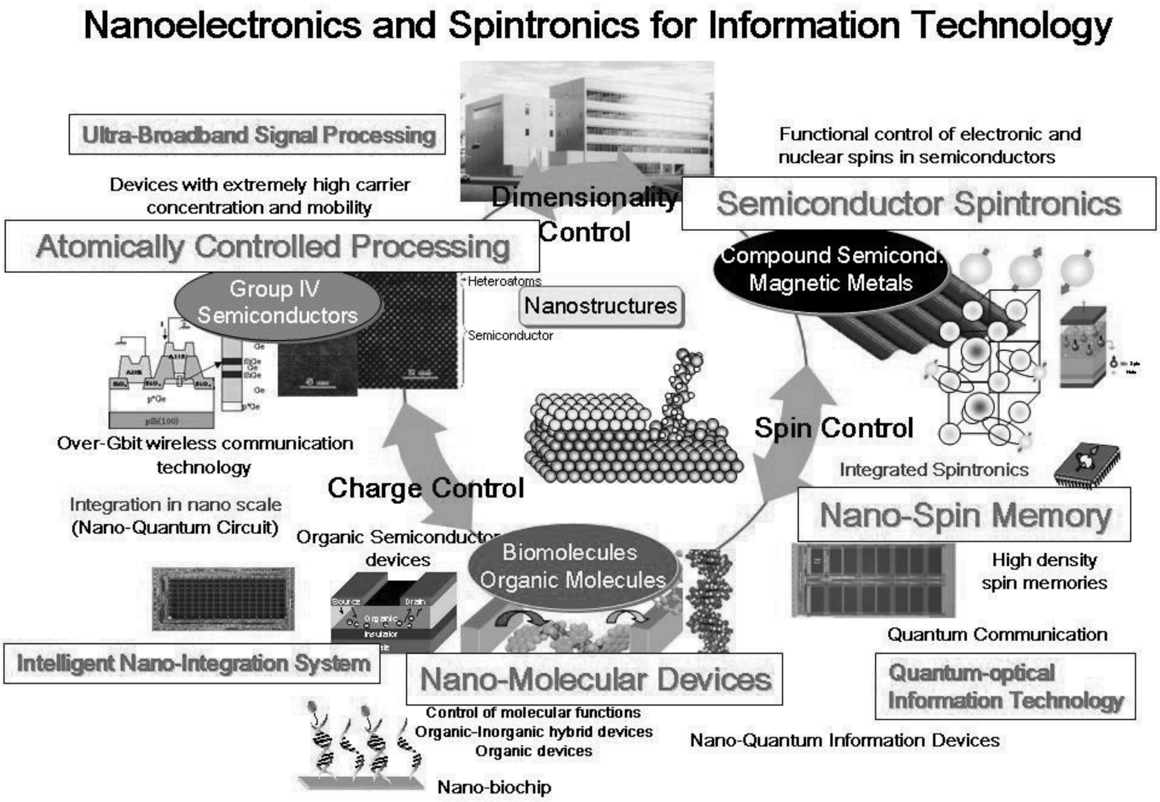
No papers in 2008

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 2008:

Atomically Controlled Processing [Murota Laboratory]

In order to create atomically controlled processing for nanometer-order artificial heterostructures of group IV semiconductors, following experimental results have been obtained: (1) In the research on atomic-layer doping with high carrier concentration, low-temperature SiH_4 exposure to suppress B clustering in thermal CVD is effective to improve electrical activity and to suppress lattice strain in Si. (2) By lowering process temperature utilizing plasma CVD without substrate heating, B atomic-layer doping in Si epitaxial growth. (3) In the research on formation of local-strain introduced $Si_{1-x}Ge_x$/Si nanometer-order heterostructure, by control of thermal nitridation and $Si_{1-x}Ge_x$ film formation using low-temperature thermal CVD, N atomic-layer doping in $Si_{1-x}Ge_x$ epitaxial growth can be realized. (4) Using the Ge thin film substrate with strain relaxation enhancement by ion-energy control in plasma CVD, formed by plasma CVD, nanometer-order thick highly strained Si can be epitaxially grown.

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 demonstrated the modulation of magnetic anisotropy in a (Ga,Mn)As thin film by purely electrical means, e.g., by the application of electric-fields. (2) We demonstrated phase coherence control of spin-3/2 ^{75}As nuclei with multipulse NMR sequences in a GaAs/AlGaAs quantum well by optically-detected nuclear magnetic resonance (NMR). (3) We demonstrated the operation of terahertz (THz) GaAs quantum cascade lasers emitting at 3.8 THz. We also observed intersubband optical transitions in ZnO-based quantum wells for the first time.

Nano-Molecular Devices [Niwano Laboratory]

①We investigated the dependence of anodization process of an aluminum microwire on its cross-sectional structure. The anodization process of an aluminum microwire depended strongly on the aspect ratio of the cross-sectional profile of the aluminum microwire. ②Single electron transistors (SETs) were fabricated by controlling anodization process of the aluminum microwire and we demonstrated that the SET fabricated by anodization process can operate at room temperature. ②Planar bilayer lipid membranes (BLMs) were formed in microfabricated apertures in Si chips. We have succeeded in preparing BLMs which are stable enough for repetitive solution exchanges and allow current recordings at the single-channel level.③We have applied our surface infrared spectroscopic method for *in situ* real-time monitoring of ATP synthesis and hydrolysis in mitochondria extracted for rat livers.

Intelligent Nano-Integration System [Nakajima Laboratory]

(1) By using high-order synapses for an inverse function delayed neural network, we

demonstrated that an optimal solution for the traveling salesman problem is obtained as a stationary state similar to the N-Queen problems. Furthermore, we have also proposed a new analysis for nonlinear dynamics, in which a new concept based on the relationship between a potential and an active region is introduced. (2) We evaluated the quality factor of a Bi-2212 intrinsic Josephson junction from its resonant activation property, and found the required condition for observing Rabi oscillation. We studied numerically the computational power of our neuromorphic quantum computation algorithm as a function of the magnitude of decoherence. The result shows that the computational power decreases in proportion to decoherence, but the degradation is smaller than other quantum algorithms. (3) A 4-bit parallel multiplier using a carry look-ahead adder was demonstrated successfully with Nb integrated circuits to improve the performance of high-speed operation for the single flux-quantum fast Fourier transform. A 4-bit high-speed up/down counter for the neural computation using stochastic logic was fabricated and successfully demonstrated.

Quantum-Optical Information Technology [Edamatsu Laboratory]

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

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. We have achieved optical spin state tomography of optically injected electrons in a 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) The use of SyF free layer consisting of Fe-rich CoFeB ferromagnetic layers resulted in low intrinsic critical current density (J_{c0}) without degrading the thermal-stability factor $E/k_B T$. 3) We developed fabrication process of magnetic tunnel junction (MTJ) on circuits based on 0.14□m node CMOS technology. 4) Operations of the world's first nonvolatile full adder based on logic-in-memory architecture, standby-power-free compact ternary content-addressable memory, and reconfigurable logic block employing the spin-transfer torque writing method were verified.

Ultra-Broadband Signal Processing [Otsuji Laboratory]

The goal of our research is to explore the terahertz frequency range by means of novel electron devices and systems. Graphene has mass-less carriers and their peculiar characteristics are expected to be useful as a candidate to realize such systems. Using an epitaxial graphene formed on silicon substrates provided by Prof. Suemitsu's group, we have fabricated a backgate transistor and confirm the drain current modulation by a gate bias voltage. W have also developed a terahertz spectroscopy system using 2D-plasmon-resonant terahertz-wave emitters based on compound semiconductor heterostructures.

Basic Technology for Broadband Communication [Mizuno Laboratory]

In this section the development of passive millimeter wave imaging systems is being carried on. In 2008, millimeter-wave optics for 35 GHz-band imaging system have successfully been studied to obtain useful data including depth of field for practical systems. A 35 GHz-band 7 x7 imaging array for getting millimeter wave movie with 2 frames/sec has also been developed.

Wireless Info Tech [Tsubouchi Laboratory]

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

Electromagnetic Bioinformation Engineering [Ishiyama Laboratory]

We study about a high accuracy strain sensor for detecting the bio-information. In the year 2008, the research work about the internal residual stress of the magnetic materials for this sensor was carried out to obtain the high accuracy. As the result, the experimentally obtained accuracy was one-order higher than the high accuracy semi-conductor strain gage. By using the technique for controlling the magnetic anisotropy as we already established in the magnetic field sensor, the accuracy of this sensor will be improved.

Solid State Physics [Takahashi Laboratory]

For high areal density HDD (Hard Disk Drive) over 1 Tbit/inch^2, achievement of further low *RA* product, high magnetoresistance ratio and stable magnetization of pinned layer in tunnel magnetoresistance devices are required. Regarding the former requirement, *RA* product of 2.1 $\Omega\mu m^2$ and TMR ratio of 210 % were successfully obtained by employing a novel fabrication process to promote a MgO tunnel barrier crystallization. And inverse TMR effect could be enhanced using epitaxial Cu under layer. Regarding the latter requirement, ferromagnetic component which has exchange coupling with antiferromagnet was observed using PEEM technique as a preliminary study on the design for enhancement of exchange anisotropy. As a result, correlation between exchange filed and domain structure of ferromagnetic layer in Mn-Ir / Co-Fe bilayers are experimentally clarified.

Electromagnetic Theory [Yamaguchi Laboratory]

Ni-Fe thin films and Fe particle assembly have been investigated as seeds of new materials with high performance in the RF(GHz range) applications. The initial permeability measurements of Fe composite particles suggests that, with the help of Fe_3O_4 nanoparticle (10 nm), Fe particles (1 μm) is almost free from the demagnetizing field, resulting in enhancement of Fe permeability up to its intrinsic values. This effect was exemplified more significantly with the particle composites that include $Ni_{50}Fe_{50}$ or Fe-Si-B-Cr particles. According to a calculation of the eddy current in spheres with high permeability, reduction of the particle size to less than 1 μm is essential for further improvement of the high-frequency performance of particle composites.

As for Ni-Fe films, the damping constant(α) of various thick Ni-Fe films was estimated using a coplanar waveguide (CPW)-FMR system. It was found that α is almost maintained constant for film thickness in the range of 10 - 1000 nm. The value of α was 0.012-0.014, which is larger than that of bulk-Ni-Fe.

Microelectronics [Sahashi Laboratory]

It is important to understand the mechanism of microwave generated by spin transfer torque which relates to the damping parameter (α) of ferromagnetic material. Experimentally, in this study, a appropriate electrode structures for the measurement of α were investigated. For the measurement of spin dynamics generated by spin transfer torque, we designed several masks of coplanar wave guide (CPW) electrode structure which the high frequency can transmit. The CPW transmission line and attenuation characteristics are evaluated by S11 parameter of network analyzer. The CPW transmission line is found to show good noise attenuation characteristics. The signal reflection is relatively small, being below −5 dB. The magnitude of the reflected signal increases progressively with increasing cross section area. The study on spin torque oscillation and measurement of α for perpendicular magnetized thin films will be continued by using the most suitable pattern of electrode for microwave transmission.

Solid State Electronics [Itoh Laboratory]

High-performance TFTs with pseudo-single-crystal silicon has been investigated. The effects of a cap SiO_2 at the laser crystallization were investigated. The cap SiO_2 suppressed the generation of void in silicon thin film, and the available condition of the lateral crystallization was expanded. By using the cap SiO_2 thin film, the surface of the laser-crystallized poly-Si thin film became smooth. The chemical mechanical polishing (CMP) on laser-crystallized poly-Si thin films was carried out. After CMP with conventional colloidal silica slurry, the surface of laser-crystallized poly-Si thin films became rougher than that of before CMP. Carbon segregation in the grain boundary was occurred by the laser crystallization. For the improvement of this problem, a hydrophilic organic solution was added to conventional slurry. As a hydrophilic organic solution ethyl alcohol was used, and planarized surface was obtained. The nanograting MOSFET has been investigated to achieve higher current drivability. The mobility difference between the nanograting nMOSFET and pMOSFET became slighter, and the area balance of the CMOS circuit could be improved.

Basic Plasma Engineering [Hatakeyama Laboratory]

Unique optical properties of free-standing single-walled carbon nanotubes (SWNTs) grown by plasma chemical vapor deposition have been investigated. It was found that the photoluminescence intensity of SWNTs drastically increases through the morphology transition from completely-isolated to thin-bundled structure. Optoelectrical measurements have been realized for fullerene (C_{60}) and azafullerene ($C_{59}N$) encapsulated SWNTs. The threshold gate voltage to turn on the SWNTs device shifted after the light irradiation. Based on the investigation of electron donor and acceptor encapsulated SWNTs, the dopant combination was found to be a critical factor to decide p-n junction features. The hump current feature can be observed only when a symmetrical depletion layer is formed between a p-n junction area.

Optical Physics Engineering [Yamada Laboratory]

The silicon photonic-wire waveguides, with silicon (Si) core and silica (SiO_2) cladding, have achieved light confinement in nanometer size small cross-section waveguides. Therefore, compared with all-silica devices, a huge reduction in size and power consumption is expected. We attempt to fabricate ultra-small Si photonic-wire waveguide devices using electron beam lithography and inductively coupled plasma dry etching techniques. We achieved the fabrication of in-line Bragg gratings with 400 nm cycle and 75 nm air gap, and the directional couplers with 120 nm gap between waveguides based on 300 $\times$ 300 nm cross-section Si wire waveguides.

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. The low resistivity ($<10^{-9}\Omega cm^2$) silicon/silicide contact 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 a very large tunnel magneto resistance (TMR) ratio of 217% at RT and 753% at 2K. The observed large TMR ratio results from both half-metallicity of Co_2MnSi and coherent tunneling through the crystalline MgO barrier. In addition, we succeeded to suppress temperature and bias voltage dependence of TMR ratio by inserting a very thin CoFeB layer into the Co_2MnSi/MgO interface.

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

One of oxide heterointerfaces, MgZnO/ZnO, can provide an interesting arena for investigation of quantum transport properties with high-mobility two-dimensional electron gas (2DEG). We have realized to control the 2DEG density by electrostatic field effect with polymer poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (PEDOT:PSS) Schottky contact or MIS structure. In fact, we observed metal-insulator transition at zero magnetic field and systematic variation of quantum Hall states as a function of the 2DEG density under applied magnetic field. The improved controllability will lead to higher performance of transparent field effect transistor.

Co-doped TiO_2 is one of room temperature ferromagnetic oxide semiconductor. In this study, we fabricated Co-doped TiO_2 films on glass substrates by sputtering method. The films exhibited ferromagnetic MCD and also anomalous Hall effect at room temperature. In addition, we observed the large enhancement of magneto-optical effect in a simple one-dimensional magnetophotonic crystal structure.

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

We have investigated the spin orbit interaction (SOI) in semiconductor heterostructures. (1) We demonstrated gate voltage control of spin precession in InGaAs mesoscopic ring arrays with Al_2O_3 gate insulator. Al'tshuler-Aronov-Spivak oscillations were clearly observed and the oscillation phases at $B = 0$ switched between negative and positive by changing the gate bias voltages. It corresponds to the electrical manifestation of spin rotation due to the Rashba SOI. (2) We proposed a method to determine the relative strength of Rashba and Dresselhaus spin-orbit interaction from transport measurements without the need of fitting parameters. In narrow quantum wires which exhibit weak localization even in the presence of spin-orbit coupling, an in-plane magnetic field can suppress the weak localization effect. We employed the unique angular dependence of this effect to suggest a method for the direct and experimental determination of the ratio between Rashba and Dresselhaus spin-orbit strengths from transport measurements.

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

The current research subjects in the research group are development of high-K_u materials and investigation of magnetization reversal behavior of nanoscale magnets, aiming to development of ultra-high density non-volatile magnetic memory. One of the recent topics is study on magnetization reversal behavior of nanoscale hard magnetic material under a short pulse field. We have developed a nanoseconds pulse generator with the maximum field of 3 kOe and irreversible magnetization behavior of a nanoscale Co/Pt multilayer dot was investigated.

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

In our laboratory, artificial periodic structures (metamaterials and photonic crystals) atvisible and near-infrared wavelengths have been investigated. Based on the transmission line metamaterials at microwaves, we designed a visible metamaterial, fabricated it, and evaluated the optical characteristics and the focusing effect. Besides plasmonic crystals and plasmonic lens were fabricated and measured at visible wavelengths. We found novel behavior of eigen modes such as pair annihilation, extreme enhancement of transmission, and plasmonic resonant second harmonic generation.

Dept. of Biomedical Engineering [Tanaka Lab at Graduate School of Biomedical Engineering]

The novel SPRAM-based reconfigurable logic block has been proposed, and fabricated through 140nm CMOS process techonology combined with a MTJ process. This logic block included the SRAM for LUT and the SPRAM for configuretion data, where both memories were embedded in one chip. The MTJ element with the area size of 50x200nm2 and CMOS logic circuit were fully integrated. Experimental results showed that the reconfigurable logic block achieved 25MHz read-out operations with the magnetic resistance of 1.62kohm (parallel) and the MR ratio of 91.7%.

New Paradigm VLSI System [Hanyuu Laboratory]

Our research group has fabricated a nonvolatile logic-in-memory integrated circuit, where a nonvolatile storage function is merged into a logic-circuit function, using magnetic tunnel junctions (MTJs) in combination with MOS transistors. It is the first time to succeed the fabrication of this type of integrated circuit, where the MOS-transistor part is fabricated by Hitachi Co., Ltd. and the MTJ-device part is fabricated by Laboratory for Nanoelectronics and Spintronics, Research Institute of Electrical Communication, Tohoku University. This is the collaboration of Prof. H. Ohno's, Prof. S. Ikeda's and our laboratories

Low Temperature Condensed State Group [Iwasa Lab at Institute for Material Research]

Very thin single crystals fabricated by mechanical micro cleavage are materials received a great interest recently as promising candidates for microelectronics due their unique electronic properties. Our research is based on the combination of layered materials and electrochemical transistors for the advantages as large tunable electron density at lower gate voltage. Layered-material EDLTs are successfully fabricated on the top of SiO_2/Si substrates. The thickness of the layered material samples, single, double or multi-layers, is characterized by Raman scattering and atomic force microscope. The electronic devices are fabricated by standard photolithography and e-beam lithography method by using the facilities in Laboratory for Nanoelectronics and Spintronics. By applying ionic liquid as the gating media, we observed ambipolar characteristics by low gate voltage smaller than 1 V on graphene EDLT. As a general method, we can apply it to a broader spectrum of material.

Technology Development Division Storage Technology Group[Fujimoto Laboratory]

A cooperative research project between industry, academia and government; Developmentof super high-speed mass storage HDD systems started in August 2007 under the collaborations between RIEC including IT21 storage technology group, major Japanese HDD manufacturers and other laboratories researching related technologies within Tohoku University. Developments of high density patterned media and high sensitivity sensor are research subjects in this project, and we fabricated fine dot arrays of Co based alloy filmsand spin accumulation devices and studied fundamental properties.

Solid State Electronics[Suemitu Laboratory]

Graphene is expected to be a key material in the next-generation semiconductor devices.The main challenge for the graphene devices, however, is the lack of cost-effective fabrication method of graphene with large scale. To solve this point, we have been studying formation of graphene on silicon substrates (GOS) by use of heteroepitaxy of SiC on Si. As a result, we have succeeded in realization of a GOS structure for the first time. Thisachievement allows us to form graphene on low-cost, large-scale silicon wafers, which will lead to graphene-based electronics in the future.

Researching Section [Endoh Lab at Center for Interdisciplinary Research]

To develop a novel Spin device technology for the Magnetic Tunneling Junction (MTJ) combined with the Si-CMOS circuit, we have systematically studied the Spin device technology, the integration process technology, the circuit design and the measurement. To realize the ultra high-speed operation of MTJ, we have proposed the new circuit technique of the Dynamic Feedback MOS Current Mode Logic (DF-MCML) and the Current Controlled MCML (CC-MCML), which function low power consumption in the GHz operation. This circuit technique has realized the stable operation even in the presence of threshold voltage fluctuations by using the feedback technology. We have successfully fabricated the DF-MCML and the CC-MCML inverter with the 180nm CMOS process, for the first time.

Atomically Controlled Processing

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

[Research Target and Activities]

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

In this year, following experimental results have been obtained: (1) In the research on atomic-layer doping with high carrier concentration, low-temperature SiH_4 exposure to suppress B clustering in thermal CVD is effective to improve electrical activity and to suppress lattice strain in Si. (2) By lowering process temperature utilizing plasma CVD without substrate heating, B atomic-layer doping in Si epitaxial growth. (3) In the research on formation of local-strain introduced $Si_{1-x}Ge_x$/Si nanometer-order heterostructure, by control of thermal nitridation and $Si_{1-x}Ge_x$ film formation using low-temperature thermal CVD, N atomic-layer doping in $Si_{1-x}Ge_x$ epitaxial growth can be realized. (4) Using the Ge thin film substrate with strain relaxation enhancement by ion-energy control in plasma CVD, formed by plasma CVD, nanometer-order thick highly strained Si can be epitaxially grown.

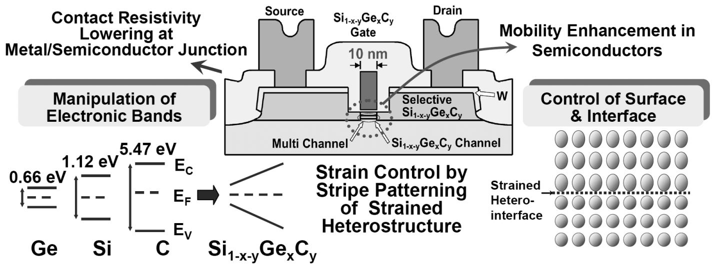


Fig. 1. 10 nm-scale quantum nanodevices with strain controlled nano-scale patterned heterostructure of group IV semiconductors.

[Staff]

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

[Profile of Prof. J. Murota]

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

[Papers]

[1] J. Murota, M. Sakuraba and B. Tillack, “Atomically Controlled CVD Processing for Future Si-Based Devices” (**Invited Paper**), 9th Int. Conf. on Solid-State and Integrated-Circuit Technol. (ICSICT 2008), Beijing, China, Oct. 20-23, 2008, No.E6.7.

[2] T. Kawashima, M. Sakuraba and J. Murota, “Nitrogen Atomic-Layer Doping in Nanometer-Order Heterostructure of $Si/Si_{1-x}Ge_x/Si(100)$ by Ultraclean Low-Pressure CVD”, Symp. Z: “Material Science and Process Technologies for Advanced Nano-Electronic Devices”, Int. Union of Mat. Res. Soc. - Int. Conf. in Asia 2008 (IUMRS-ICA 2008), Nagoya, Japan, Dec. 9-13, 2008, No.ZO-4.

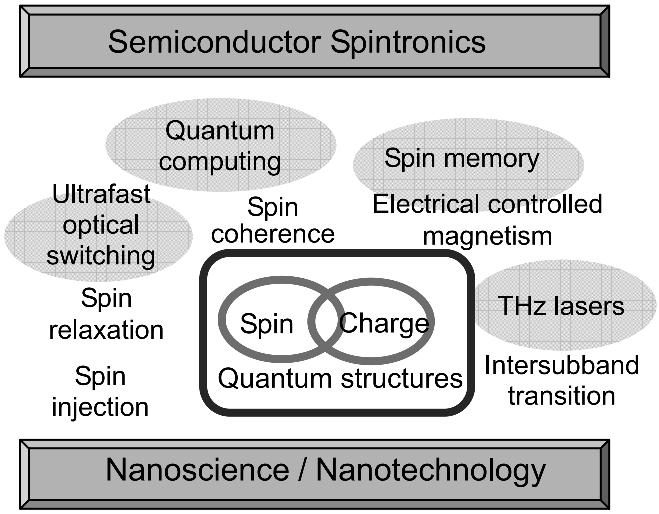
[3] K. Sugawara, M. Sakuraba and J. Murota, “Epitaxial Growth of Highly Strained B Doped Si on Relaxed Ge/Si(100)”, Symp. Z: “Material Science and Process Technologies for Advanced Nano-Electronic Devices”, Int. Union of Mat. Res. Soc. - Int. Conf. in Asia 2008 (IUMRS-ICA 2008), Nagoya, Japan, Dec. 9-13, 2008, No.ZP-9.

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) Demonstration of electric-field control of magnetic anisotropy and magnetization rotation in a (Ga,Mn)As thin film. (2) Demonstration of the phase coherence control of spin-3/2 ^{75}As nuclei with multipulse nuclear magnetic resonance (NMR) sequences in a GaAs/AlGaAs quantum well by optically-detected NMR. (3) Demonstration of a GaAs THz quantum cascade laser emitting at 3.8 THz and first observation of intersubband optical transitions of ZnO quantum wells

[Staff]

Professor : OHNO Hideo Dr.
Associate Professor : OHNO Yuzo Dr.
Associate Professor : MATSUKURA Fumihiro Dr.
Assistant Professor OHTANI Keita Dr.

[Profile of Professor OHNO]

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

[Papers]

[1] Y. Kondo, M. Ono, S. Matsuzaka, K. Morita, H. Sanada, Y. Ohno, and H. Ohno, "Multipulse operation and optical detection of nuclear spin coherence in a GaAs/AlGaAs quantum well", Physical Review Letters, Vol. 101, pp. 207601, November 2008.

[2] D. Chiba, M. Sawicki, Y. Nishitani, Y. Nakatani, F. Matsukura, and H. Ohno, "Magnetization vector manipulation by electric fields," Nature, Vol. 455, pp. 515-518, September 2008.

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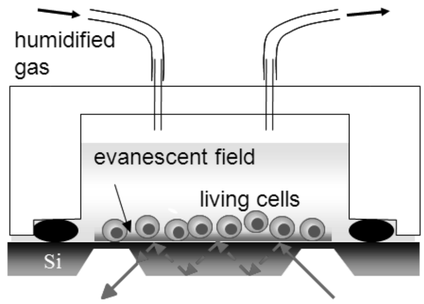
Nano-Molecular Devices

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

[Research Target and Activities]

Our research aims at application of the Si technology to organic semiconductor devices or many kinds of biosensors. We have investigated development of 1) an in-situ monitoring system of cultured cells or biological materials using infrared absorption spectroscopy, 2) an ion channel sensor using a Si technology, and 3) a nanofabrication method using electrochemical processes such as anodization of valve metals. Especially, we have applied TiO_2 nanotubes formed by anodization to dye-sensitized solar cells (DSSC).



In-situ monitoring of cultured cells using infrared spectroscopy

1) An in-situ monitoring system for cultured cells

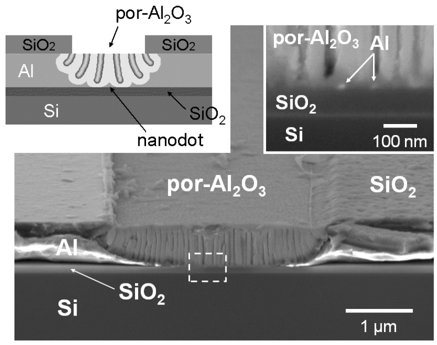
We have succeeded in discrimination between apoptotic and viable cells using infrared spectroscopy and demonstrated that the cell apoptotic process could be analyzed through protein amide bands.

2) An ion channel sensor using a Si technology

Using a Si microfabrication technology, we have fabricated an artificial lipid bilayer in which gramicidin peptides can form transmembrane ion channels. The lipid bilayer exhibited mechanical strength enough for application to drug screening.

3) A nanofabrication method using electrochemical processes

We demonstrated that a room-temperature operation single electron transistor could be fabricated by controlling a cross-sectional profile of an Al microwire before anodization.



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

[Staff]

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

[Profile of Professor NIWANO, Michio]

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

[Papers]

1. Y. Kimura, T. Oba, N. Shimakura, and M. Niwano, "The thermal-field emission model for carrier injection characteristics of an organic field effect transistor", Appl. Phys. Lett. **94** (2009) 073303.
2. R. Yamaguchi, A. Hirano-Iwata, Y. Kimura, K. Miyamoto, H. Miyazaki, H. Isoda, and M. Niwano, "In situ real-time monitoring of apoptosis on leukemia cells by surface infrared spectroscopy", J. Appl. Phys. **105** (2009) 024701.
3. K. Ishibashi, Y. Kimura, and M. Niwano, "An extensively valid and stable method for derivation of all parameters of a solar cell from a single current voltage characteristic", J. Appl. Phys. **103** (2008) 094507

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Nano-Spin Memory

Research of spin based device and memory

[Research Target and Activities]

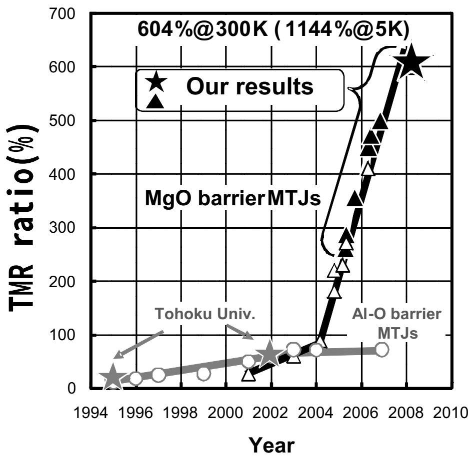
We are developing technologies to realize advanced spin memory and logic devices using magnetic tunnel junctions (MTJs) consisting of ferromagnetic metal electrodes and insulating barriers. In our group, the following results were obtained.

1) The TMR ratios of 604% at RT and 1144% at 5K (world record) were realized in MgO-based MTJs.

2) The use of SyF free layer consisting of Fe-rich CoFeB ferromagnetic layers resulted in low intrinsic critical current density (J_{c0}) without degrading the thermal-stability factor $E/k_B T$.

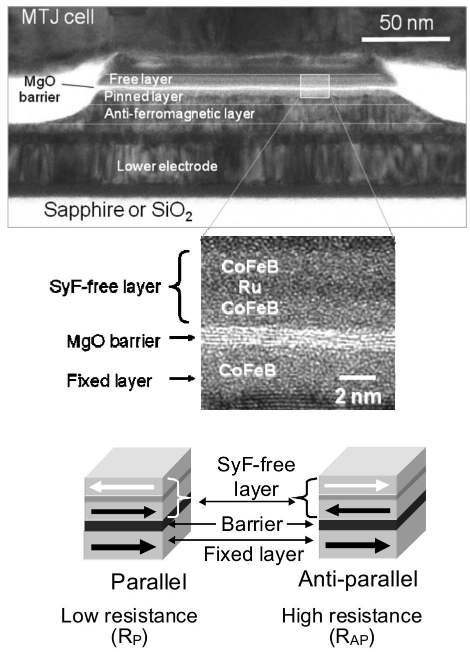
3) We developed fabrication process of MTJs on circuits based on 0.14μm node CMOS technology.

4) Operations of the world's first nonvolatile full adder based on logic-in-memory architecture, standby-power-free compact ternary content addressable memory, and reconfigurable logic block employing the spin-transfer torque MTJs with SyF free layer were verified.



Appl. Phys. Lett., 93 (2008) 082508.

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



IEEE Trans. Magn, 44 (2008) 1962.

Magnetic tunnel junction with SyF free layer consisting of CoFeB/Ru/CoFeB ferromagnetic layers.

[Staff]

Visiting Professor: HASEGAWA HaruhiroDr.
Associate Professor: IKEDA Shoji Dr.
Research Fellow: Huadong GAN,
Research Fellow: Ji Ho PARK,
Research Fellow: MIURA Katsuya,
Research Fellow: HAYAKAWA Jun,
Research Fellow: YAMAMOTO Hiroyuki,

[Papers]

[1] J. Hayakawa, S. Ikeda, K. Miura, M. Yamanouchi, Y. M. Lee, R. Sasaki, M. Ichimura, K. Ito, T. Kawahara, R. Takemura, T. Meguro, F. Matsukura, H. Takahashi, H. Matsuoka, and H. Ohno, "Current-induced magnetization switching in MgO barrier magnetic tunnel junctions with CoFeB-based synthetic ferrimagnetic free layers", IEEE Transactions on Magnetics, Vol. 44, pp. 1962-1967, July 2008.

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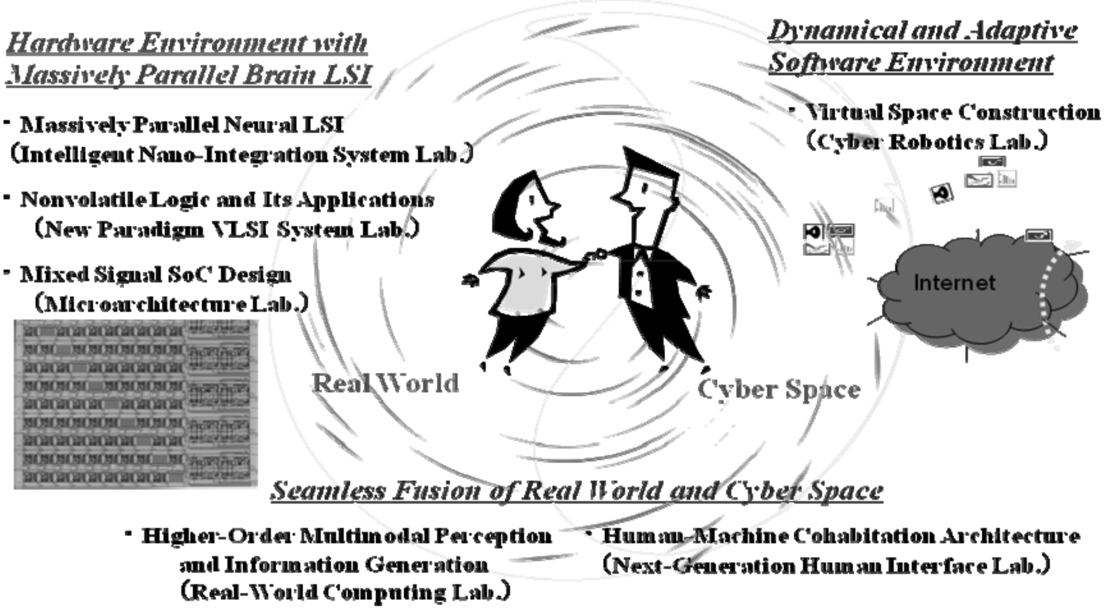
Laboratory for Brainware Systems

Research Targets and Activities of Laboratory for Brainware Systems

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

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

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



[Research Target]

Real-World Computing Section: Our main aim is to understand highly harmonic and autonomous biological-information systems, and to propose 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.

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

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

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

[Research Activities]

Real-World Computing Section (Yano Laboratory): We obtained the following three main results. First, we mathematically analyzed our adaptive, autonomous decentralized model for arm reaching movement in which each joint command is determined through mobility-based interactions among joints, and clarified that the model includes two different type controllers and they are switched in real-time depending on difference of mobility among joints. Second, using multi-electrodes, we measured neural activity of the primate prefrontal cortex during a path-planning task, and found that synchronous neural activity in the prefrontal cortex is critical for the animal to put a motion plan into practical action. Third, for clarifying a fundamental mechanism of sensory information processing in brain, we use the mini-brain of terrestrial slug Incilaria fruhstorferi, and found that there are two olfactory pathways having different dynamics of each, and that their interactions would be important for the olfactory information processing in real time.

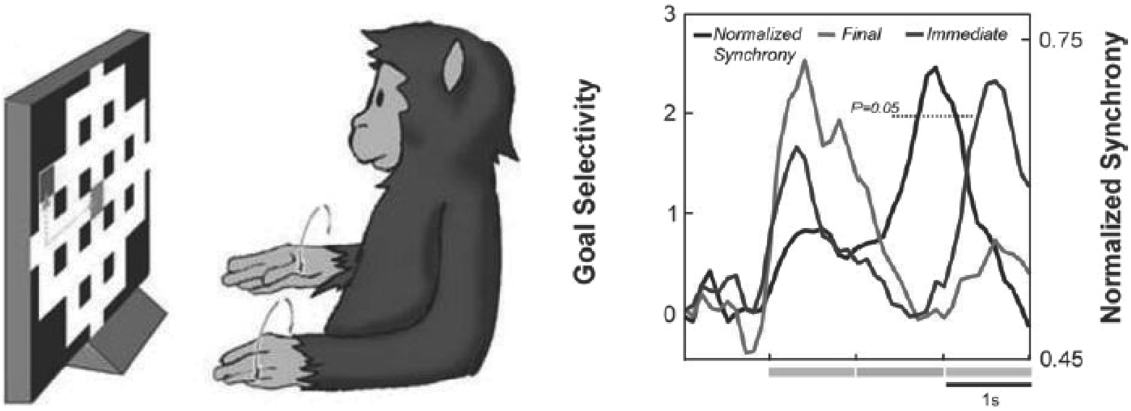
New Paradigm VLSI System Section (Hanyu Laboratory): As a this-year research result in the nonvolatile logic-in-memory technology, we have succeeded the chip fabrication of MTJ/CMOS-hybrid a compact cell circuit for a nonvolatile TCAM (ternary content-addressable-memory), and confirmed the basic behavior of its logic operation. We have also designed and fabricated a high-throughput asynchronous multiple-valued single-track data-transfer test chip, whose performance is evaluated to be 1.5-times faster than that of a conventional hardware with maintaining less wire counts.

Intelligent Nano-Integration System Section (Nakajima-Sato Laboratory): By using high-order synapses for an inverse function delayed neural network, we demonstrated that optimal solutions for traveling salesman problems were obtained as stationary states like N-Queen problems. Furthermore, we have also proposed new analyses for nonlinear dynamics, in which a new concept based on the relationship between a potential and active regions was introduced. We evaluated the quality factor of a Bi-2212 intrinsic Josephson junction from its resonant activation property, and found the required condition for observing Rabi oscillation. We studied numerically the computational power of our neuromorphic quantum computation algorithm as a function of the magnitude of decoherence. The result shows that the computational power decreases in proportion to decoherence, but the degradation is smaller than other quantum algorithms. A 4-bit parallel multiplier using a carry look-ahead adder was demonstrated successfully with Nb integrated circuits to improve the performance of high-speed operation for the single flux-quantum fast Fourier transform. A 4-bit high-speed up/down counter for the neural computation using stochastic logic was fabricated and successfully demonstrated.

Microarchitecture Section (Masui Laboratory): We have been investigating architecture and circuit techniques for low-power and low-cost CMOS transceiver ICs applicable to wireless sensor network. We have been explored a low-power fractional-N PLL design and a complex bandpass filter in low-IF architecture for software-defined radio applications. A design tool for fractional-N PLL optimizing an integrated loop filter considering influences of VCO and sigma-delta modulator noises to entire PLL phase noise is under development. In terms of design productivity enhancement, we have investigated the gm/Id lookup table design optimization methodology for OTA (operational transconductance amplifier), and have succeeded to generate an optimization flow for high-gain and high-speed OTA with a complex topology.

Real-world computing

Problem solving and neuronal synchrony in monkey prefrontal cortex



A schematic image of a monkey executing a maze task (left). Selectivity for final (red line), immediate (blue line) goals and neuronal synchrony (black line) (right) [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 this year, to investigate the temporal relationship between synchrony in the discharge of neuron pairs and modulation of the discharge rate, we recorded the neuronal activity of the lateral prefrontal cortex of monkeys performing a behavioral task that required them to plan an immediate goal of action to attain a final goal. Information about the final goal was retrieved via visual instruction signals, whereas information about the immediate goal was generated internally (left figure). The synchrony of neuron pair discharges was analyzed separately from changes in the firing rate of individual neurons during a preparatory period. We focused on neuron pairs that exhibited a representation of the final goal followed by a representation of the immediate goal at a later stage. We found that changes in synchrony and discharge rates appeared to be complementary at different phases of the behavioral task. Synchrony was maximized during a specific phase in the preparatory period corresponding to a transitional stage when the neuronal activity representing the final goal was replaced with that representing the immediate goal (right figure). We hypothesize that the transient increase in discharge synchrony is an indication of a process that facilitates dynamic changes in the prefrontal neural circuits in order to undergo profound state changes.

[Staff]

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

[Profile of Professor YANO]

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

[Papers]

[1] Sakamoto K, Mushiake H, Saito N, Aihara K, Yano M and Tanji J. “Discharge synchrony during the transition of behavioral-goal representations encoded by discharge rates of prefrontal neurons” Cerebral Cortex, vol. 18 pp. 2036-2045, 2008.
[2] Makinae H, Makino Y, Obara T and Yano M. “Specific spatio-temporal activities in the cerebral ganglion of Incilaria fruhstorferi in response to superior and inferior tentacle nerve stimulation” Brain Research, vol. 1231, pp.47-62, 2008.
[3] Yoshihara Y, Tomita N, Makino Y, and Yano M “Autonomous Control of Reaching Movement by 'Mobility Measure'. International Journal of Robotics and Mechatronics” vol.19, pp.448-458, 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 2008

(1) By using high-order synapses for an inverse function delayed neural network, we demonstrated that optimal solutions for traveling salesman problems were obtained as stationary states like N-Queen problems. Furthermore, we have also proposed new analyses for nonlinear dynamics, in which a new concept based on the relationship between a potential and active regions was introduced. (2) We evaluated the quality factor of a Bi-2212 intrinsic Josephson junction from its resonant activation property, and found the required condition for observing Rabi oscillation. We studied numerically the computational power of our neuromorphic quantum computation algorithm as a function of the magnitude of decoherence. The result shows that the computational power decreases in proportion to decoherence, but the degradation is smaller than other quantum algorithms. (3) A 4-bit parallel multiplier using a carry look-ahead adder was demonstrated successfully with Nb integrated circuits to improve the performance of high-speed operation for the single flux-quantum fast Fourier transform. A 4-bit high-speed up/down counter for the neural computation using stochastic logic was fabricated and successfully demonstrated.

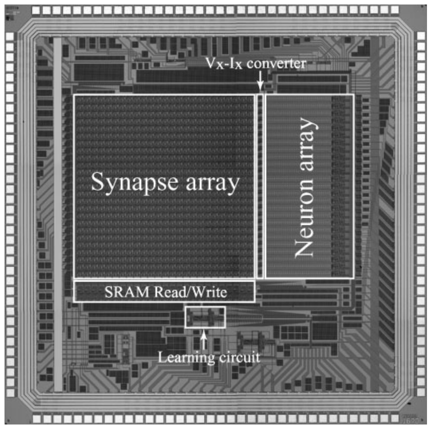

Fig.1 Inverse Function Delayed neuro-chip

[Staff]

Professor NAKAJIMA Koji Dr.
Associate Professor SATO Shigeo Dr.
Assistant Professor ONOMI Takeshi Dr.

[Profile of Professor NAKAJIMA]

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. S. Chun, Y. Hayakawa, and K. Nakajima, Hardware Neural Network for a Visual Inspection System, IEICE Trans. Fundamentals, vol. E91-A, no. 4, pp. 935-942, April 2008.
2. J. Sveholm, Y. Hayakawa, and K. Nakajima, Recalling Temporal Sequences of Patterns Using Neurons with Hysteretic Property, IEICE Trans. Fundamentals, vol. E91-A, no. 4, pp. 943-950, April 2008.
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4. Y. Yamada, K. Nakajima, and K. Nakajima, RF impedance of intrinsic Josephson junction in flux-flow state with a periodic pinning potential, Physica C, vol. 468, pp. 1295–1297, Sep. 2008.

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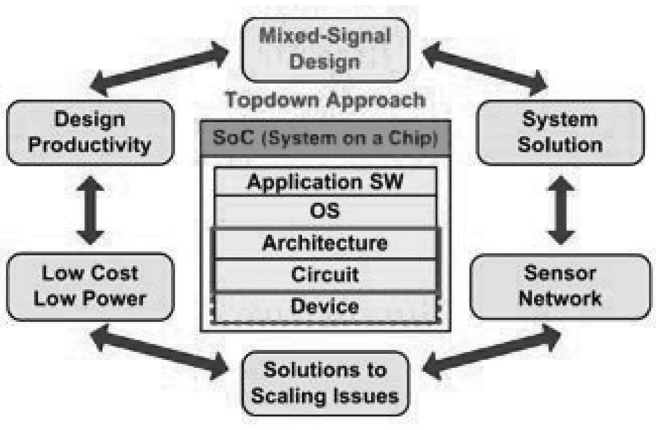
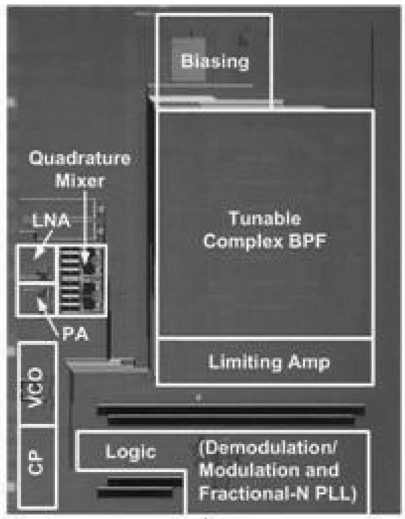
Microarchitecture Laboratory

Mixed-Signal SoC Design

[Research Target and Activities]



Mixed-Signal SoC Design Hexagon



Transceiver IC for Sensor Network

Ubiquitous society has been established by the deployment of various wireless systems ICs, and it demands advances in mixed-signal (analog and digital) design technique as well as higher integration through SoC (System on a Chip). Our research activities include architecture and circuit design of mixed-signal SoC applicable to sensor network systems for the investigation of brain activities researches as well as design automation of RF/analog circuit. We have developed a complex bandpass filter for low-IF architecture in a transceiver IC for sensor network systems and been expanding this technology to software defined radio. Moreover, we have been researching on the OTA design optimization flow by using gm/Id based lookup table methodology.

[Staff]

Professor: MASUI Shoichi Dr.

[Profile of Professor MASUI]

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

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New Paradigm VLSI System Research Group

Realization of a New-paradigm VLSI System

[Research Target and Activities]

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

As a this-year research result in nonvolatile-logic area, we have succeeded the chip fabrication of MTJ(Magnetic Tunnel Junction)-based basic logic component, a compact cell circuit for nonvolatile TCAM (ternary content-addressable-memory) (Fig.3). We have also designed and fabricated a highly reliable multiple-valued current-mode multiplier chip (Fig. 1) and a high-throughput asynchronous multiple-valued single-track data-transfer test chip (Fig. 2), whose performance is evaluated to be 1.5-times faster than that of a conventional implementation with maintaining less wire counts..

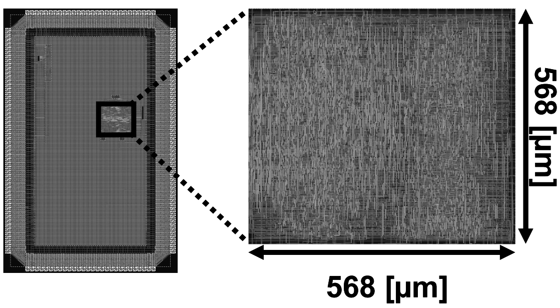

Fig. 1: Highly-reliable 16-bit MVCM multiplier chip.

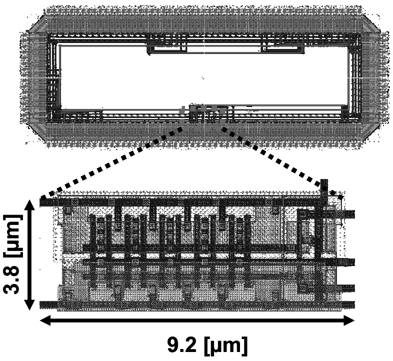

Fig. 2: Multiple-valued current- mode single-track-data-transfer chip

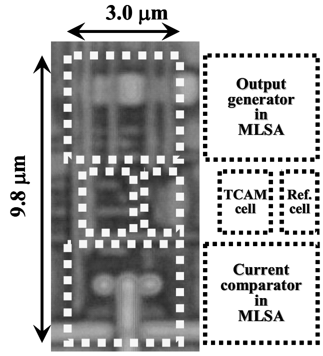

Fig. 3: MTJ-based nonvolatile TCAM

[Staffs]

Professor	HANYU Takahiro Dr.
Assistant Professor	MATSUMOTO Atsushi Dr.
Assistant Professor	NATSUI Masanori Dr.

[Profile of Professor HANYU]

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) K. Mizusawa, N. Onizawa, and T. Hanyu, "Power-Aware Asynchronous Peer-to-Peer Duplex Communication System Based on Multiple-Valued One-Phase Signaling," IEICE Trans. Electron., Vol.E91-C, No.04, pp.581-588, Apr. 2008.

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(3) S. Matsunaga, K. Hiyama, A. Matsumoto, S. Ikeda, H. Hasegawa, K. Miura, J. Hayakawa, T. Endoh, H. Ohno, and T. Hanyu, "Standby-Power-Free Compact Ternary Content-Addressable Memory Cell Chip Using Magnetic Tunnel Junction Devices," Applied Physics Express (APEX), vol. 2, no. 2, pp. 023004-1-023004-3, Feb. 2009.

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IT-21 center

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

[Research Target and Activities]

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

1. Development of Dependable Wireless System and Devices

Our new project “Development of Dependable Wireless System and Devices” was accepted in 2007 as the Japan Science and Technology Agency (JST) CREST type research program “Fundamental Technology for Dependable VLSI System.” The project has been executed by the collaborations between RIEC including IT21 mobile wireless technology group, major Japanese mobile terminal manufacturers and other universities. 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 domain equalizer technology, and (4) scalable AD converter.

2. Development of Low Power Consumption Mass Storage HDD Systems

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

[Staff]

Director: Professor TSUBOUCHI Kazuo, Dr.
Technical Official: SAGAE Katsumi

Project Planning Division

Professor: FURUNISHI Makoto, Dr.

Technology Development Division (Mobile Wireless Technology Group)

Professor: TAKAGI Tadashi Dr.
Visiting Professor: IWATA Makoto Dr.

Technology Development Division (Storage Technology Group)

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

The IT-21 Center Project Planning Division

Planning and Encouraging of R&D Projects

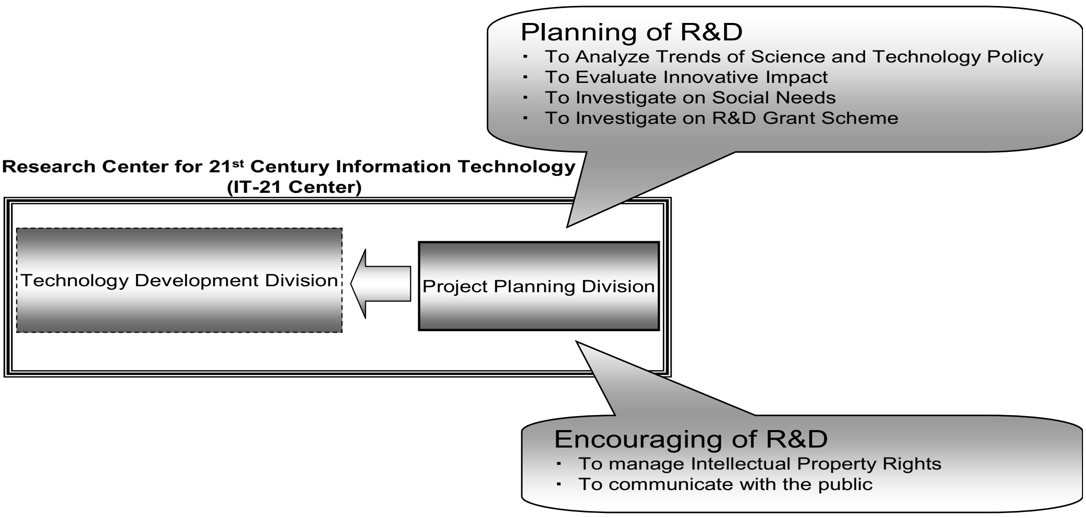
[Research Target and Activities]

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

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

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

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



[Staff]

Professor : FURUNISHI, Makoto

Secretary : KAGAMITANI, Machiko

[Profile of Professor FURUNISHI]

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, 2006.11-2008.3 Special Advisor to President

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IT21 Center Mobile Wireless Technology Group

Development of DWS (Dependable Wireless System) Technology for DWN (Dependable Wireless NGN)

[Research Target and Activities]

1. All Si CMOS RFIC

(1) We have developed a 5 GHz band Si CMOS VCO (Voltage Control Oscillator) having a novel resonant circuit which can suppress 1/f noise from bias circuit and capacitance fluctuation of varactor by harmonics. The VCO has performed tuning range of 17.9% and phase noise of -110.8dBc @ 1MHz offset over full tuning range, which is the world top class performance.

(2) We have developed a novel design technology of FET gate width optimization and high accurate device modeling in 60GHz frequency range. Using this technology, we have developed a 60GHz band Si CMOS 2-stage HPA (High Power Amplifier), which has successfully performed gain of 8dB over 59~66GHz, output power of 8.8dBm with efficiency of 14.5%.

2. Digitally Assisted Compensation Technology

   We have developed a novel FDE (Frequency Division Equalizer) technology implemented to a FPGA (Field Programmable Gate Array). We have demonstrated a transmission test under multi-pass fading environments. Due to the FDE, we have realized to improve BER (Bit Error Rate) characteristics. Conventionally, FDE technology has been evaluated by simulation. Here, we have been able to realize it by experiment.

3. Adaptive and Scalable ADC/DAC (Analog to Digital Converter/ Digital to Analog Converter)

   We have devised a current mode pipeline ADC, which is suitable for process miniaturization and low supply voltage. We have designed several core circuits of the ADC and have realized static characteristics.

[Staff]

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

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

[Profile of Professor TAKAGI, Tadashi]

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

[Papers]

[1] K. Shimoyama, S. Yoshida, T. T. Thanh, K. Matsuzaki, H. Oguma, S. Kameda, H. Nakase, T. Takagi, and K. Tsubouchi, "5GHz Si-CMOS differential power amplifier module with directly connected dipole antenna," IEICE Electronics Express, vol.5, no.7, pp.229-234, April 10, 2008.

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[3] V. Gheorghiu, S. Kameda, T. Takagi, K. Tsubouchi, and F. Adachi, "Implementation of single carrier packet transmission with frequency domain equalization," 68th IEEE Vehicular Tech. Conf. (VTC2008-Fall), 4H-3, Sept. 2008.

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

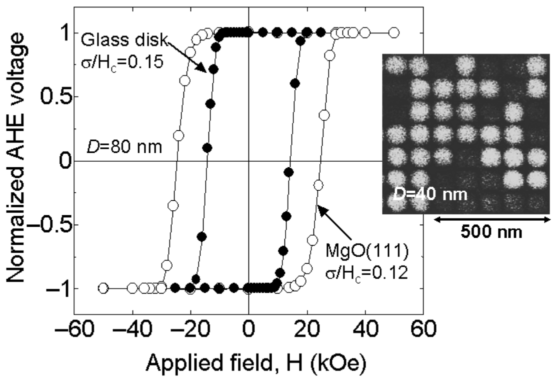
Development of low power consumption mass storage HDD systems

[Research Target and Activities]

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

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

1) High density recording media: $L1_1$-type CoNiPt ordered alloy films with a large uniaxial magnetic anisotropy of the order of 10^7 erg/cm^3 and relatively low saturation magnetization were successfully fabricated using UHV sputter film deposition. Moreover, we experimentally showed that the surface anisotropy enhances the thermal stability of hard/soft stacked dot arrays.
2) High sensitivity sensor technology: New process for high sensitivity spin accumulation sensor structure was developed. And MgO barrier as a high spin polarization material was investigated.
3) Single pole type writer with a high recording resolution: Optimization of multiple tapered main-pole structure is carried out utilizing simulation. Process for shaping main-pole was started.
4) New recording algorithm for over terabits per square inch densities: Possibility of attaining 2Tb/in^2 using hard/soft stacked structure bit patterned media (BPM) was revealed using simulation. Investigations of energy assist recording method utilizing BPM and two dimensional magnetic recording method utilizing granular media were started for attaining over 2Tb/in^2.
5) High performance tiered storage system: From the power consumption estimation based on the measurement results using prototype, it was showed that "2-dimension data allocation method with an access prediction" is possible to reduce the storage system power consumption by half. We started developments of control software.



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

[Staff]

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

[Profile of Professor FUJIMOTO]

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, H. Sato, K. Mitsuzuka, H. Kataoka, H. Aoi, S. Okamoto, and O. Kitakami, "Dot arrays of $L1_1$ type Co-Pt ordered alloy perpendicular films," *J. Appl. Phys*, vol. 105, pp. 07C109 (1-3) (2009).

[2] H. Sato, T. Shimatsu, H. Kataoka, H. Aoi, S. Okamoto, and O. Kitakami, "Fabrication of $L1_1$-type (Co-Ni)-Pt ordered alloy films by sputter deposition," *J. Appl. Phys*, vol. 105, pp. 07B726 (1-3) (2009).

[3] K. Mitsuzuka, T. Shimatsu, N. Kikuchi, O. Kitakami, H. Muraoka, and H. Aoi, "Magnetic properties of thin hard/soft-stacked dot arrays with a large uniaxial magnetic anisotropy," *J. Appl. Phys,* vol. 105, pp. 07C103 (1-3), (2009).

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Management Office for Health and Safety

Realizing and Maintaining a Safe and Comfortable Environment to Support Research

[Research Target and Activities]

Safety and health seminar

First aid training course

1. Outline of the Management Office for Health and Safety

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

2. Activities by the Management Office for Health and Safety

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

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

[Staff]

Manager: NIWANO Michio Dr., Professor

Deputy Manager: UEHARA Yoichi Dr., Professor

SATO Nobuyuki Dr., Assistant Professor

CHIBA Ayako, Clerk

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Flexible Information System Research Center

Development of Flexible Information Systems and Management of Network

[Research Target and Activities]

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

Our goal is to investigate principles of the flexible information processing through the theories and experiments, and establish their system construction methodology. Moreover, we also study the flexible distributed systems for advanced organization, utilization, administration, operation and putting out scientific information. Through practical applications of above results to the real network in RIEC, we confirm effectiveness of our methods. To achieve the above goal, this year we have conducted the following researches: (1) development of distributed and scalable authentication method for large scale overlay network, (2) development of an agent based network management system (Fig.1) and (3) improvement of accuracy of virtual auditory display system, and flexible computing mechanism in biological systems.

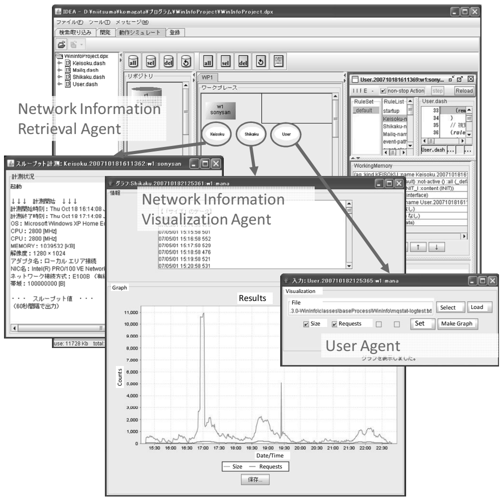

Fig. 1 Agent based Network Management System.

[Staff]

(1) Steering Committee
Professor: SUZUKI Yôiti Dr., SHIRATORI Norio Dr., TOYAMA Yoshihito Dr., KINOSHITA Tetsuo Dr., SHIRAI Masafumi Dr., OHORI Atsushi Dr.
(2) FIR Committee
Professor: TOYAMA Yoshihito Dr., KINOSHITA Tetsuo Dr.
Associate Professor: AOTO Takahito Dr., KITAGATA Gen Dr.
Assistant Professor: HAYAKAWA Yoshihiro Dr., YOSHIDA Masato Dr., SASANO Isao Dr., YAIRI Satoshi Dr.
Research Fellow: SASAI Kazuto Dr.
Technical Support Member: DAIGAKU Noriko / KOBAYASHI Kenichi, SUZUKI Midori, NIITSUMA Sachiko
(3) Regular Staff
Associate Professor: KITAGATA Gen Dr.
Assistant Professor: YAIRI Satoshi Dr.
Research Fellow: SASAI Kazuto Dr.
Technical Support Member: DAIGAKU Noriko / KOBAYASHI Kenichi, SUZUKI Midori, NIITSUMA Sachiko

[Profile of Professor SUZUKI]

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

[Papers]

1. Debasish Chakraborty, Jun Makishi, Toshiaki Osada, Gen Kitagata, Atushi Takeda, Kazuo Hashimoto, Norio Shiratori, "Construction of Overlay Application Layer Multicast Tree for Efficient Multisource Multimedia Communication", Proc. of the Fourth International Conference on Intelligent Computing and Information Systems (ICICIS 2009), 2009.03. **(Session's Best Paper Award)**
2. Satoshi Yairi, Yukio Iwaya, Yo-iti Suzuki, "Influence of Large System Latency of Virtual Auditory Display on Sound Localization Task", Acta Acustica united with Acustica, Vol. 94, No. 6, pp.1016-1023, November/December 2008.
3. Kazuto Sasai, Yukio-Pegio Gunji, "Heterarchy in biological systems: A logic-based dynamical model of abstract biological network derived from time-state-scale re-entrant from", Biosystems, Vol. 92, No.2, pp.182-188, 2008.

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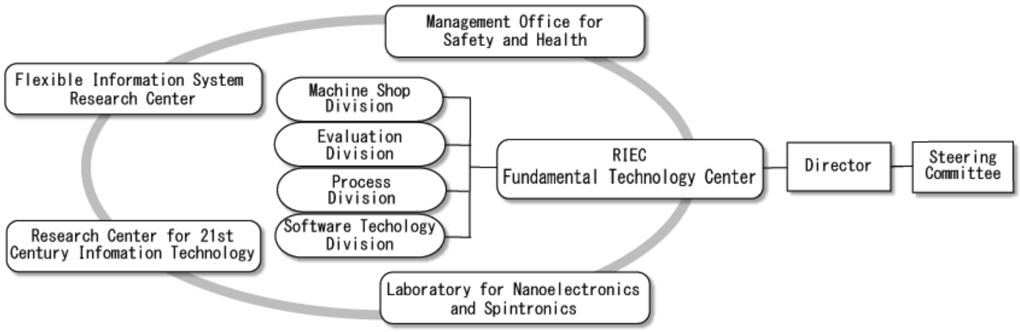
Fundamental Technology Center

Supporting research with high-level specialized knowledge and technology



Overview of Fundamental Technology Center

[Research Target and Activities]

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

1. Machine Shop Division

The Machine Shop Division has previously pioneered a number of new machining methods, and contributed to research on high-density magnetic recording and many other types of research relating to advanced information and communications. This year, there were 123 fabrication requests from laboratories (128 from inside the Institute, 10 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, scanning probe microscope, spectrophotometer, digital microscope, dicing saw, UV & ozone dry stripper

4. Software Technology Division

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

[Staff]

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

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

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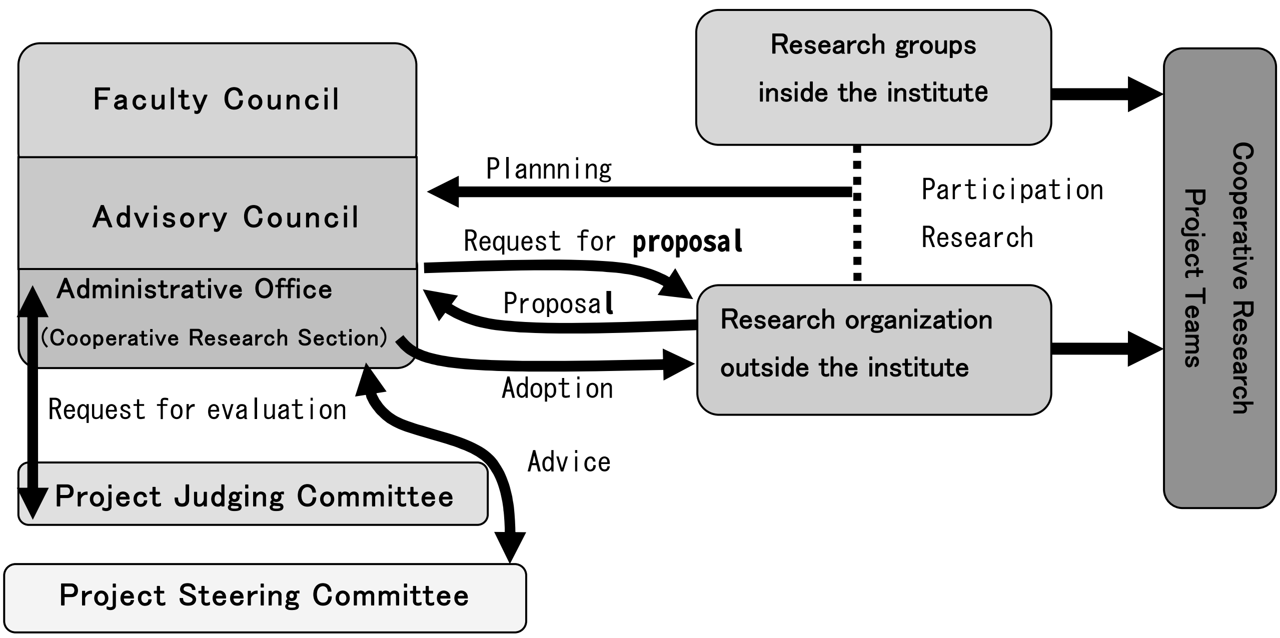
4. Nation-wide Cooperative Research Projects

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

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

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

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



Nation-wide cooperative research projects list 2008

Project Number / Research Project Theme	Project Leader	Facilitator in RIEC
H18／A01 Study on terahertz plasma-wave devices based on semiconductor Heterojunction nano-structures	**Victor, RYZHII** The University of Aizu Computer Science Division	Taiichi OTSUJI
H18／A02 Study on the improvement of performance and reliability in nonclassical group-IV semiconductor hetero-devices	**Toshiaki TSUCHIYA** Shimane University Interdisciplinary Faculty of Science and Engineering	Junichi MUROTA
H18／A03 Construction of Wearable Information Sharing Space by Sensor Computing	**Teruo HIGASHINO** Osaka University Graduate School of Sicence Information and Technology	Norio SHIRATORI
H18／A04 Generation of THz signals by management ofnonlinear waves developed in semiconductor devices and circuits	**Koichi NARAHARA** Yamagata University Graduate School of Science and Engineering	Taiichi OTSUJI
H18／A07 Basics and Applications of Superconducting Computers	**Yoshinao MIZUGAKI** The University of Electro-Communications	Shigeo SATO
H18／A12 Growth of New Lead-free Piezoelectric and Optical SingleCrystals and Their Ultrasonic Micro-spectroscopies	**Jun-ichi KUSHIBIKI** School of Engineering Tohoku University	Yasuo CHO
H18／A13 Internal representation of visual information in the brain	**Satoshi SHIOIRI** Research Institute of Electrical Communication, Tohoku University	Satoshi SHIOIRI
H19／A01 Development of magnetic-dielectric material using magnetic nanoparticle assembly for ultra-high frequency devices	**Migaku TAKAHASHI** New Industry Creation Hatchery Center, Tohoku University	Yasuo CHO

Project Number / Research Project Theme	Project Leader	Facilitator in RIEC
H19／A02 A basic research for gaining IP network aspect	**Hiroshi UEDA** Library and Information Technology Center,Gunma University	**Yukio IWAYA**
H19／A03 Theoretical Design and Fabrication of Multi-functional Spintronics Materials	**Akio KIMURA** Hiroshima University, The Graduate School of Science	**Masafumi SHIRAI**
H19／A04 Valency Control of Group IV Semiconductor Quantum Dots and Their Application to MOS Memory	**Seiichi MIYAZAKI** Hiroshima University, Advanced Sciences of Matter	**Junichi MUROTA**
H19／A05 Study of Orientation and Mobility Training for the Persons with Visual Impairment by using Wide-Range Three Dimensional Acoustical Technologies.	**Yoshikazu SEKI** National Institute of Advanced Industrial Science and Technology	**Yukio IWAYA**
H19／A06 Research on accurate HRTF measurement systems	**Tatsuya HIRAHARA** Toyama Prefectural University Faculty of Engineering	**Yôiti SUZUKI**
H19／A07 Study on the representation of color signal in visual cortex	**Ichiro KURIKI** Research Institute of Electrical Communication, Tohoku University	**Ichiro KURIKI**
H19／A08 Development of new measurement techniques with nanometer scale spatial resolution and exploration of the electronic and optical properties of surface nanostructures	**Yoichi UEHARA** Research Institute of Electrical Communication, Tohoku University	**Yoichi UEHARA**
H19／A10 On application of frequency domain binaural model for hearing aids	**Tsuyoshi USAGAWA** Kumamoto University, Graduate School of Science and Technology	**Yôiti SUZUKI**
H19／A13 Physiological Evaluation and Development of a Distributed Multi-display System Adapting to User's situation	**Atsumi IMAMIYA** University of Yamanashi, Interdisciplinary Graduate School of Medicine and Engineering	**Takuo SUGANUMA**

Project Number / Research Project Theme	Project Leader	Facilitator in RIEC
H19／A14 Study of Hot-Spot Network for Next Generation	**Kazuo TSUBOUCHI** Research Institute of Electrical Communication, Tohoku University	**Kazuo TSUBOUCHI**
H20／A01 Basic Studies in Plasma Nanobiotronics	**Rikizo HATAKEYAMA** School of Engineering Tohoku University	**Michio NIWANO**
H20／A02 The Frontier of Photonic Crystal and Nano-Photonic Applications	**Shojiro KAWAKAMI** Sendai Foundation for Applied Information Sciences	**Masataka NAKAZAWA**
H20／A03 Investigation of interface trap density for an MIS structures using an ECR sputter-deposited high-k gate-oxides	**Toshiro ONO** Graduate School of Science and Technology Hirosaki University	**Junichi MUROTA**
H20／A04 Three-DimensionalNanostructure Formation of Strain-Controlled Group-IV Semiconductors and Its Device Application	**Junichi MUROTA** Research Institute of Electrical Communication, Tohoku University	**Junichi MUROTA**
H20／A05 Fabrication of high mobility two-dimensional hole gas	**Seigo TARUCHA** School of Engineering The University of Tokyo	**Yuzo OHNO**
H20／A06 Intelligent nano-integration system and its application	**Koji NAKAJIMA** Research Institute of Electrical Communication, Tohoku University	**Koji NAKAJIMA**
H20／A07 A research on organic heterojunction photovoltaic devices	**Fumihiko HIROSE** Yamagata University Graduate School of Science and Engineering	**Michio NIWANO**
H20／A08 Development of Ion-Channel Chips	**Masao SUGAWARA** Nihon University College of Humanities and Sciences	**Michio NIWANO**
H20／A09 Study of human visual stability during eye movements	**Masayuki SATO** Faculty of Environmental Engineering, Kitakyushu University	**Satoshi SHIOIRI**

Project Number / Research Project Theme	Project Leader	Facilitator in RIEC
H20／A10 Learning effects of sound localization in the binaural technology	**Kenji OZAWA** University of Yamanashi, Interdisciplinary Graduate School of Medicine and Engineering	**Yôiti SUZUKI**
H20／A11 Cell-based chips using infrared spectroscopy	**Yasuo SHINOHARA** Institute for Genome Research, The University of Tokushima	**Michio NIWANO**
H20／A12 Learning effects of sound localization in the binaural technology	**Kaoru TAKAHASHI** Sendai National College of Technology	**Norio SHIRATORI**
H20／A13 Study of magnetic devices with application of the thin film element with inclined stripe magnetic domain	**Tomoo NAKAI** Industrial Technology Institute, Miyagi Prefectural Government	**Kazushi ISHIYAMA**
H20／A14 A study on advanced video content retrieval technology	**Junji NUMAZAWA** Research Institute of Electrical Communication, Tohoku University	**Junji NUMAZAWA**
H20／A15 A Study on Display-free Floating Imaging Technology	**Terumasa AOKI** Research Institute of Electrical Communication, Tohoku University	**Terumasa AOKI**
H18／B01 Development of Nano-Bioelectronic Devices	**Toshio OGINO** Yokohama National University, Graduate School of Engineering	**Michio NIWANO**
H18／B04 Research on Multimedia Information Hiding	**Hideki NODA** Kyushu Institute of Technology, Computer Science and Systems Engineering	**Yôiti SUZUKI**
H18／B06 Exploration of circumstance-harmonization systems in animals and its application to engineering	**Kaoru TAKAKUSAKI** Asahikawa Medical College	**Masafumi YANO**

Project Number / Research Project Theme	Project Leader	Facilitator in RIEC
H18／B08 Evolution of high performance computing by new electric circuit technologies with novel concepts	Hiroshi MATSUOKA Japan Atomic Energy Agency	Takahiro HANYU
H18／B09 Multi-Functional Logic Using New Paradigm Materials and Devices and Its System Integration	Takahiro HANYU Research Institute of Electrical Communication, Tohoku University	Takahiro HANYU
H19／B01 Subjectand View of Synthetic Aperture Radar Development for Civilian Use	Atsushi MASE Art,Science and Technology Center for Cooperative Research,Kyushu University	Kazuo TSUBOUCHI
H19／B02 Research on optical measurements of earthquakes and their networking	Akito ARAYA Earthquake Research Institite, University of Tokyo	Masataka NAKAZAWA
H19／B04 Development of Research on Fine-Particle Plasmas	Yasuaki HAYASHI Kyoto Institute of Technology	Michio NIWANO
H19／B05 Study on Development of Devices and Application Systems for Next Generation Communication and Measuring Systems	Yoshio NIKAWA Kokushikan University School of Science and Engineering	Tadashi TAKAGI
H19／B08 Dynamics of semiconductor gate-stack nanostructure formation and its applications	Maki SUEMITSU Research Institute of Electrical Communication, Tohoku University	Maki SUEMITSU
H19／B09 A proof theoretical approach to principles of program construction	Masahiko SATO Graduate School of Informatics, Kyoto University	Yoshihito TOYAMA
H19／B10 Fundamental characteristics and applications deeply related to flow in various plasmas	Akira ANDO School of Engineering Tohoku University	Maki SUEMITSU
H20／B01 Nanophotonics and Nanoelectronics Devices with Metallic Nanomaterials	Kaoru TAMADA Research Institute of Electrical Communication, Tohoku University	Kaoru TAMADA

Project Number Research Project Theme	Project Leader	Facilitator in RIEC
H20／B02 Development of high performance piezoelectric materials and application to information and communication devices	**Jun-ichi KUSHIBIKI** School of Engineering Tohoku University	**Yasuo CHO**
H20／B03 Research on Ultra High Density Semiconductor Memories based on New Conceptual Material and Storage Principle	**Heiji WATANABE** Graduate School of Engineering Osaka University	**Tetsuo ENDOH**
H20／B04 Research on Nano Semiconductor Materials and its Application to Nano Devices	**Kikuo YAMABE** Graduate School of Pure and Applied Sciences University of Tsukuba	**Tetsuo ENDOH**
H20／B05 Cooperation of Semiconductor Science and Technologies Toward Science Driven Semiconductor Technologies-	**Kenji SHIRAISHI** Center for Computational Sciences University of Tsukuba	**Hideo OHNO**
H20／B06 Development of high-performance quantum cascade lasers and their applications to high-sensitive sensing	**Keita OHTANI** Research Institute of Electrical Communication, Tohoku University	**Keita OHTANI**
H20／B07 Study on High Frequency Micromagnetics	**Toshiro SATO** Shinshu University faculty of Engineering	**Hiroaki MURAOKA**
H20／B08 Advanced communication and measurement technologies using phase-controlled lightwaves	**Hidemi TSUCHIDA** National Institute of Advanced Industrial Science and Technology	**Masataka NAKAZAWA**
H20／B09 Research on Next-Generation Peta-byte Information Storage	**Hiroaki MURAOKA** Research Institute of Electrical Communication, Tohoku University	**Hiroaki MURAOKA**
H20／B10 Development of Dependable System Software with a Highly Reliable Programming Language System	**Kazuhiko KATO** University of Tsukuba, Graduate School of Systems and Information Engineering	**Atsushi OHORI**

Project Number / Research Project Theme	Project Leader	Facilitator in RIEC
H20／B11 Automatic program verification based on deduction engines	Mizuhito OGAWA School of Information Science,Japan Advanced Institute of Science and Technology	Atsushi OHORI
H20／B12 Studies on theorem provers and their applications	Yasuhiko MINAMIDE University of Tsukuba, Graduate School of Systems and Information Engineering	Yoshihito TOYAMA
H20／S01 Development of essential technologies for superhivision	Hidenori MIMURA Shizuoka University Research Institute of Electronics	Yôiti SUZUKI
H20／S02 Spintronics Initiative Network	Kouhei ITOH Keio University Science and Technology	Hideo OHNO

5. Symposium organized by the Institute

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

Symposium In Past

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

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

International Symposium Organized by the Institute

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

14	1st International WorkShop on New Group IV Semiconductor Nanoelectronics	May.27-28. 2005
15	GSIS International Symposium on Information Sciences of New Era: Brain, Mind and Society	Sep.26-27, 2005
16	The 1st RIEC International Workshop on Spintronics -Spin Transfer Phenomena-	Feb.8-9, 2006
17	4th International Workshop on High Frequency Micromagnetic Devices and Materials (MMDM4)	May 8,2006
18	4th International Conference on Physics and Applications of Spin-Related Phenomena in Semiconductors (PASPS-lV)	Aug.15-18,2006
19	2nd International Workshop on New Group IV Semiconductor Nanoelectronics	Oct.2-3,2006
20	2nd RIEC International Workshop on Spintronics	Feb.15-16,2007
21	Japan-China Joint Conference on acoustics, JCA2007	Jun.4-6,2007
22	International Conference on Discovery Science/ International Conference on Algorithmic Learning Theory	Oct.1-4,2007
23	The 3rd RIEC International Workshop on Spintronics	Oct. 31-Nov.1,2007
24	3rd International Workshop on New Group ⅣSemiconductor Nanoelectronics	Nov.8-9,2007
25	International Workshop on Nanostructures & Nanoelectronics	Nov.21-22,2007
26	The 18th International Symposium on Algorithms and Computation(ISAAC2007)	Dec.17-19,2007
27	International Interdisciplinary-Symposium on Gaseous and Liquid Plasmas (ISGLP 2008)	Sep.5-6,2008
28	4th International Workshop on New Group IV Semiconductor Nanoelectronics	Sep.25-27,2008
29	The 4th RIEC International Workshop on Spintronics	Oct.9-10,2008

6. Study groups on Electrical Communication

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

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

Electromagnetic and Optical Waves Engineering	
Chair	Prof. Hirohito YAMADA
Manager	Associate Prof. Yasuo OHTERA

Acoustic Engineering	
Chair	Prof. Yôiti SUZUKI
Manager	Associate Prof. Akinori ITO
Manager	Assistant Prof. Shuichi SAKAMOTO

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

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

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

Systems Control	
Chair	Prof. Makoto YOSHIZAWA
Manager	Associate Prof. Takashi WATANABE

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

Spinics	
Chair	Prof. Kazushi ISHIYAMA
Manager	Associate Prof. Fumihiro SATO
Manager	Assistant Prof. Shuichiro HASHI

New Paradigm Computing	
Chair	Prof. Michitaka KAMEYAMA
Manager	Assistant Prof. Naofumi HOMMA

Ultrasonic Electronics	
Chair	Prof. Shinichirou UMEMURA
Manager	Assistant Prof. Shin YOSHIZAWA

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

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

Biocybernetics and Bioinformatics	
Chair	Prof. Mitsuyuki NAKAO
Manager	Assistant Prof. Yoshinari MAKINO

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

7. International activities

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

International academic exchange programs:

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

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

1.	Acoustical Science and Technology
2.	Applied Acoustics
3.	Electronics Express
4.	International Journal of Communication Systems (IJCS)
5.	International Journal of Infrared, Millimeters, and terahertz Waves
6.	Japanese Journal of Applied Physics, The Institute of Pure and Applied Physics
7.	Journal of Applied Physics
8.	Journal of Communications and Network (JCN)
9.	Journal of Higher - Order and Symbolic Computation
10.	Journal of Magnetism and Magnetic Materials
11.	Optical Fiber Technology

12.	Optics Communications
13.	Smiconductor Science and Technology, Institute of Physics
14.	Solid State Communidations
15.	Superlattices and Microstructures
16.	Virtual Journal of Nano scale Science and Technology, American Institute of Physics / America Physical Society

Recent international conferences programmed by a staff in RIEC:

1.	14th International Conference on Modulated Semiconductor Structures (MSS-14 2009)
2.	1st International Workshop on Si based nano-electronics and -photonics (SiNEP-09)
3.	2009 International Conference on Solid State Devices and Materials (SSDM)
4.	Asia-Pacific Conference on Vision2010
5.	20th International Colloquim on Magnetic Films and Surfaces, 2009
6.	2nd Semiconductor Technology for Ultra Large Scale Integrated Circuits and Thin Film Transistors (ULSIC vs. TFT)
7.	38th International School & Conference on the Physics of Semiconductors "Jaszowiec" 2009
8.	5th Int. Workshop on New Group IV Semiconductor Nanoelectronics
9.	5th International Conference on Molecular Electronics and Bioelectronics (M&BE5)
10.	5th International School and Conference on Spintronics and Quantum Information Technology, 2009
11.	5th RIEC Int. Workshop on Spintronics, RIEC-CNSI Workshop on Nanoelectronics, Spintronics and Photonics, 2009
12.	6th International Conference on Silicon Epitaxy and Heterostructures (ICSI-6)
13.	Engineering Conference International (ECI), 2009
14.	European Conference on Optical Communication (ECOC)
15.	European Solid-State Device Research Conference (ESSDERC)
16.	Fuji International Symposium on Functional and Logic Programming (FLOPS2008)
17.	Global Symposium on Millimeter Waves 2009 (GSMM2009)
18.	IEEE Computer Society Technical Committee on Multiple-Valued Logic (TCMVL)
19.	IEEE International Magnetics Conference (INTERMAG2009)

20.	International Conference of Magnetism (ICM 09)
21.	International Conference on Indium Phosphide and Related Materials･(IPRM2010)
22.	International Conference on infrared, Millimeter, and Terahertz waves
23.	International Symposium on Graphene Devices
24.	International Symposium on Surface Science and Nanotechnology (ISSS-5)
25.	International Workshop on the Principles and Application of Spatial Hearing
26.	Sixth International Conference on Physics and Application of Spin-related Phenomena in Semiconductors (PASPS) 2010
27.	SPIE Defense and Security Conference 2009
28.	Symp. E10: "ULSI Process Integration6" , 216th Meeting of the Electrochem. Soc.
29.	The 11th Joint MMM-Intermag Conference 2010
30.	The 2010 International Conference on Computational Science and Its Applications (ICCSA2010)
31.	The 20th Personal, Indoor and Mobile Radio Communications Symposium 2009 (PIMRC '09)
32.	The 8th Pacific Rim Conference on lasers and Electro- Optics (CLEO/PR20･09)
33.	The ACM SIGPLAN Workshop on Types in Language Design and Implementation (TLDI2009)
34.	The Eighth Perpendicular Magnetic Recording Conference (PMRC)
35.	The Korean Magnetic Society
36.	The Sixth International Conference on Ubiquitous Intelligence and Computing (UIC2009)
37.	Topical Workshop on Heterostructure Microelectronics (TWHM)
38.	International Symposium on Nonlinear Theory and its Applications (NOLTA)

8. Periodicals Published by the Institute

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

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

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

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

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

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

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

9. Staff,Land and Buildings,Budget

1. Staff

(2008.8.1)

Classification	Division	Laboratory for Nanoelectronics and Spintronics	Laboratory for Brainware sysystems	Research Center for 21st century Information Technology	Fundamental Technology Center	Administration Office: Head Official	Administration Office: General Affairs Group	Administration Office: Accounting Group	Total
Professors	19	3	4	3					29
Associate Professors	12	4	1	1					18
Assistant Professors	18	4	6						28
Research Fellows	14	7	2	1					24
Technical Officials					16		1	1	18
Administrative Officials						1	6	7	14
Total	63	18	13	5	16	1	7	8	131

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

(2008.8.1)

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: Ministry of Education,Science and Culture	Research Grant: Partnership Between Universities and Industry	total
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
2008	879,481	953,000	694,883	1,069,832	3,597,196

10. Afterword

The state of universities closely depends on the social situation. The modern civilizations have been mainly supported by the modern science and technology, which have been developed by the concept of the subject-object separation, which is called Cartesian dualism. That is, nature was cordoned off from human beings and objectified. What is important here is that nature was cut off and one phenomenon seemed to occur independently from others. It leads us to rid ourselves of all of nature's complexity and makes it extremely simple. In other words, we attempted to find rules of an ideal world that we can regard nature as being homogeneous.

What was essential was that these isolated worlds would not interfere with each other. If so, by summing up the analytical worlds that were sought, the whole world could be constructed in its entirety. These traditional approaches were rather easy to understand, and because of that, they were accepted rather widely. By pursuing this approach, the natural sciences have acquired a universality and predictability, while evolving into a powerful methodology. But anyway, the modern society was constituted by this approach to the natural sciences. By working together in the natural science and the engineering, we have created a society with the objective of making it highly affluent.

The problem, however, is that this separation of self and other has been applied to the realm of human activities as well. This means an objectification of the various human activities themselves. Against this objectified activity, an objective of self-completion is established. From what we have heard here today, in business and academia as well, the goal is self-completion. There is no existing theory that would apply limits to the objective of attaining self-completion itself. That is why, for example, if it takes the form of the pursuit of profit, then profit is pursued without limit.

The doctrine of competition on the world market has spread all over the world, involving Japan as a matter of course. For impartial competition, it requires liberalization and internationalization of trade, and information technology for higher efficiency. That is the entity of the globalization. Thus the modern science and technology has brought about great change of social structure and industrial structure, form age of ideological opposition to age of economical competition.

Especially, information science and communication technology have rapidly developed, which are great useful tools to win in competition on the world market. Particularly in the USA, the information technology has been adopted very early in economic activities. In consequence, the USA has been the top runner in the world market. In modern society to promote efficiency is a crucial factor of a struggle for existence in the world market. Now the information technology intensifies the competitive nature of present-day market.

The market principle has been brought into the universities, that is, the university is evaluated by the market value. To market universities, it is necessary to evaluate the current states of universities numerically. Fundamentally it is, however, impossible to estimate the quality of the research and education in numbers. So there are great limitations for the numerical estimation of the universities. Originally the universities are assigned the essential role of inheriting and creating culture. It is needless to say that the universities of our country should contribute not only to the current prosperity of our country but the future one. For this purpose it is necessary to raise further the cultural level of our nation, which is exactly the mission of the universities. Now we must take leave to the age of endless materialistic desires," More is better", and open the age of fine quality of life, "Enough is best".

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 nation. Academic freedom of 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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