RIEC Newsletter No.1

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TOHOKU UNIVERSITY

Message from Director

Prof. Hideo Ohno

Communication is the foundation of society. It plays a vital role at all levels from our interactions with the people around us to science, literature, business and the operation of systems that keep our society safe and secure. Information and communications technology has transformed over the years, starting with the telegraph and telephone to today's information communication systems such as the Internet. These systems connect people together and provide an infrastructure for the actions of a society, making them indispensable in our everyday lives. Because of this, demands for the implementation of faster, higher-capacity energy-saving communications are increasing ever. Another key attribute of the social infrastructure is disaster tolerance; a requirement that was demonstrated only too well by the impact of the Great East Japan Earthquake of 2011. There is also a growing expectation, based on fast, low-energy and high-capacity information processing and communications technology, that one can realize a new paradigm of information processing and communication that bridge people in a fundamentally different way.

Since its foundation in 1935, Research Institute of Electrical Communication (RIEC) has made a succession of pioneering achievements in laying the foundations of modern information and communications technology, including antenna, magnetic recording, semiconductor devices and optical communication, and has continued to play a world-leading role. To build on this tradition, we will exploit new possibilities by addressing social needs, and we will take full advantage of our position as a university-affiliated research institute to conduct research into the scientific principles and applications of science and technology to enhance current communications as well as realize a new paradigm of communications that enrich people's lives.

To achieve these targets, we are making advances in research ranging from basic materials and information science to integrated systems comprising devices, circuits, architecture and software that generate, recognize, transmit, store, process and control information, on the basis of collaboration between researchers from RIEC and other organizations. Our organizational structure consists of four Research Divisions (Information Devices, Broadband Engineering, Human Information Systems and Systems & Software), two Laboratories (Laboratory for Nanoelectronics and Spintronics and Laboratory for Brainware Systems), and one center (Research Center for 21st Century Information Technology). We have been certified by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) as a Joint Usage/Research Center for collaborative research in information and communications technology, and are engaging in joint research projects with outside researchers.

We are also promoting R&D projects centered around RIEC. In March 2010, Tohoku University established the Center for Spintronics Integrated Systems. Under the Cabinet Office's program "Funding Program for World-Leading Innovative R&D on Science and Technology" (the FIRST Program), RIEC members together with others are working on a collaborative project between industry, academia and government to develop low-power logic integrated circuits. In October 2011, in response to the Great East Japan Earthquake, Tohoku University resolved to set up the Research Organization of Electrical Communication (ROEC) under the guidance of RIEC. As one of the eight projects under way at Tohoku University's Institute for Disaster Reconstruction and Regeneration Research (IDRRR), research and development for the construction of disaster-tolerant telecommunication networks is being carried out under collaboration between industry, academia and government at ROEC.

RIEC will continue to respond to present-day demands, open up new worlds of communication for the future, create core technologies leading to the creation of new industries working together with industry, and, through these efforts, promote the strengthening of education and human resource development. As always, your suggestions and comments are more than welcome.

In this issue

Toward the creation of graphene terahertz lasers

Prof. Taiichi Otsuji

Exploring the frequency resources on electromagnetic spectra for brighter human-conscious ubiquitous information and communication technology (ICT) society is the philosophy and the mainstream of spiritual/cultural heritage of RIEC. Ultra-Broadband Signal Processing Laboratory that the author conducts is responsible for one important part of it, exploring the devices/circuits/systems utilizing terahertz (THz) waves. The technical staff includes Assoc. Profs. Tetsuya Suemitsu and Stephane Albon Boubanga Tombet, Assist. Profs. Akira Satou and Susumu Takabayashi, Visiting Prof. Victor Ryzhii, Post Doctral Fellow Adrian Dobroiu, Research Assistants Kayo Ueno and Kaori Sugawara, and myself. Two doctor-course and ten master-course students in graduate school, and three bachelor-course students in undergraduate school are studying in my laboratory.

THz waves are electromagnetic waves situated in between radio waves and light waves (Fig. 1). Seeing from the radio waves the THz is an extremely high frequency region where transistors or any electron devices hardly operate whereas seeing from the light waves it is an extremely low frequency region in which laser diodes or any photonic devices hardly operate at room temperature. Recently the application of THz waves is emerging in various scenes, from safety and security fields like radioscopy of illegal drugs and hazardous materials, to the field of future ultra-broadband wireless communications. In order to make these industrial applications in reality, the development of devices that can be miniaturized/ integrated and operate at room temperature is essential. To breakthrough conventional technological limitations, we are developing novel semiconductor devices operating in the THz range. In this article I would like to focus on an interesting and hottest topic regarding “graphene THz lasers,” and to invite you to a pleasant scientific journey in the THz world.

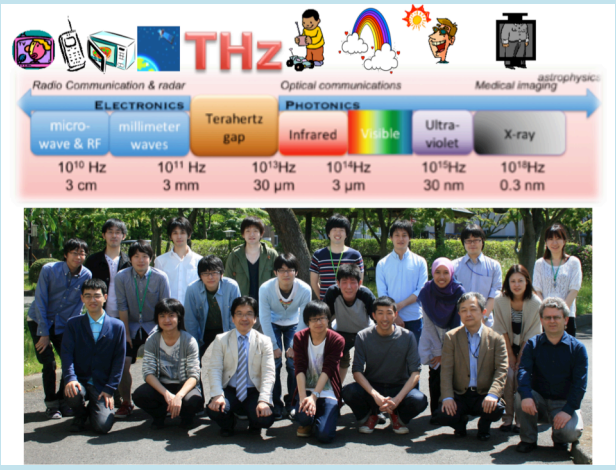

Fig. 1. We are in the “THz.”

Graphene, a relative of graphite, is a single-layer sheet of a carbon-atomic honeycomb lattice. Since A.K. Geim and K. Novoselov in UK succeeded in isolation of graphene in 2004 (they won the Nobel Prize in Physics in 2010 by “groundbreaking discovery of graphene”), graphene becomes one of the hottest materials in scientific community. In relatively early stage in 2005 we began study on graphene based THz devices. The first theoretical discovery was “the occurrence of THz gain in optically pumped graphene” in 2007, which was experimentally verified by ourselves in 2012 (Fig. 2). In 2011 we made another important discovery of “giant gain enhancement effect in population-inverted graphene,” which has recently been manifested experimentally by ourselves in 2013. Now we are taking an initiative in the field toward the creation of graphene THz lasers.

The other activities of our research and development include ultimately high-speed transistors and plasmon-resonant THz emitters/detectors/ modulators using graphene and compound semiconductors. These research and development are being conducted by international collaborations with many scientists and groups in US, Russia, France, Spain, and Japan, and financially supported substantially by JST CREST (Japan Science and Technology Agency Funding Program for Core Research for Evolutional Science and Technology) since 2007 and JSPS (Japan Society for the Promotion of Science) Grant-in-Aid for Specially Promoting Research since 2011. If you have any interest on our activities please visit our laboratory web site (http://www.otsuji.riec.tohoku.ac.jp).

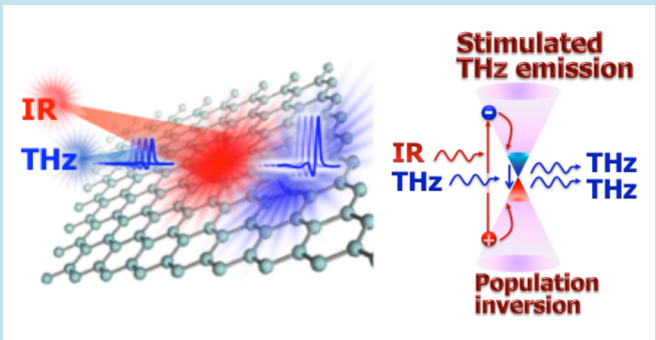

Fig. 2. Amplification of THz waves in optically pumped graphene. Left: image sketch (IR: infrared). Right: graphene band structure showing the physical mechanism.

Tohoku University's Focused Research Program "RIEC-RLE Project"

Research collaboration in photonics with MIT towards future University Partnership Agreement

Prof. Masataka Nakazawa
Project Leader

Tohoku University has been expanding its activities as regards international relationships and collaborative research and education. "Tohoku University's Focused Research Program" was established in 2010 as part of the President's Strategic Program for promoting research projects to meet this goal. Our proposal regarding research collaboration in photonics with the Research Laboratory of Electronics (RLE) at MIT was approved along with seven other projects from among 48 applications, and the five-year project led by Prof. Nakazawa got underway in Nov. 2010.

The aim of this project is to establish a global-scale initiative on photonic ICT technologies, promote innovations in ICT with photonic technologies, and expand the scope to photonics in general while pursuing the possibility of a University Partnership Agreement with MIT.

Our ICT photonics research activities at Tohoku University are mainly focused on ultrahigh-speed communication, highly functional optical devices, optical physics and materials, and quantum information processing. At RIEC, we have promoted interdepartmental collaboration through our Optical Science Forum since 2007. Since 2009, the JSPS Core-to-Core Program "Collaborative research on ultrahigh-speed optical communication" has also been running. These activities have greatly enhanced interdepartmental research collaboration in photonics at Tohoku University. Our partner, RLE at MIT, is well known throughout the world as an outstanding research institution in electronics, including optics and quantum electronics, quantum computing and communication, photonic and THz devices, and photonic crystals and nanostructures. These research areas provide a good match with ours, and hence collaboration with RLE and related departments at MIT in photonics are expected to offer significant potential for novel applications.

Strongly motivated by these possible collaborations between the two institutes, we started to undertake activities designed to promote joint research in photonics, and have organized opportunities for individual discussions. The first visit to MIT was originally scheduled for the end of March, 2011 and involved five professors; Prof. Nakazawa, Prof. Edamatsu, Prof. Otsuji, Prof. Yasaka of RIEC, and Prof. Yamada of the Graduate School of Engineering. However, owing to the Great Earthquake on March 11, 2011, the visit was postponed to Oct. 20-21. Fourteen professors and young researchers from RLE joined the meeting, and it gave us great opportunities for mutual understanding and encouraged future collaboration.

To further strengthen the partnership, the second RIEC-RLE Meeting was held in Sendai on Jan. 21-22, 2013, in which seven MIT professors visited RIEC. The President of Tohoku University Susumu Satomi also attended the meeting, and the interaction between MIT and Tohoku University was further enhanced. The third RLE-RIEC Collaboration Meeting was held at MIT on Sep. 30 and Oct. 1, 2013. This time, 12 professors and associate professors attended from Tohoku University and 16 participants from RLE, and researchers working in the field of electronic devices and materials also joined for the first time. In parallel to the meeting, several graduate students also joined RLE to perform joint research on THz devices. We held individual in-depth technical discussions, and a specific direction for the partnership agreement was discussed with the RLE Director, Prof. Fink.

The next RIEC-RLE Meeting will be held in June 2014 at Tohoku University. We hope the research collaboration can expand to include wider academic areas, and lead to an official International Academic Exchange.

In the RIEC

Dr. William H.A. Beaudot
Visiting Associate Professor
at the Visual Cognition & Systems Laboratory of Prof. Satoshi Shioiri

As a visiting associate professor between Nov 18 and Dec 25 2013 at the Visual Cognition and Systems Laboratory of Prof. Shioiri (Human Information Systems Division, RIEC), I explored the potential of consumer EEG (Electroencephalography) mobile devices for brain-computer interface (BCI) applications and vision research purpose using steady-state visual evoked potentials (SSVEP). During my month-long visit, I developed in particular a software platform that simultaneously present visual stimuli, record and analyze brain activity in real-time. Though still at an early development stage, we hope this tool will be useful to study the effects of a variety of visual stimuli on attention modulation and to investigate the potential of mobile solutions (based on a wireless EEG headset attached to a smartphone or tablet for example) to continuously monitor attention in critical operational environments that demand some quality of visual vigilance. Finally, despite cultural differences, I found the RIEC and the University facilities on the Katahira campus to be a great working environment for international researchers.

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Chief Scientist, KyberVision, Montreal (Canada)

RIEC's Academic Exchange Agreements with Foreign Institutions - University Level Agreements -

University of California, Santa Barbara	USA — 15 March 1990
King Mongkut's Institute of Technology Ladkrabang	Thailand — 15 April 2004
The University of York	United Kingdom — 7 June 2004
The Dresden University of Technology	Germany — 26 June 2006
Berlin Institute of Technology	Germany — 26 August 2009
National Tsing Hua University	Taiwan — 2 December 2009
Université de Technologie de Compiègne	France — 15 March 2010
Harvard University	USA — 22 July 2010
Technische Universität Kaiserslautern	Germany — 1 February 2012
Johannes Gutenberg University	Germany — 6 February 2012

RIEC's Academic Exchange Agreements with Foreign Institutions - Department Level Agreements -

Institute of Physics, Polish Academy of Sciences	Poland — 3 August 1976
IHP - Innovations for High Performance Microelectronics	Germany — 22 January 2001
The Interdisciplinary Center on Nanoscience of Marseille, National Center of Scientific Research	France — 24 October 2005
Institute of Semiconductors, Chinese Academy of Sciences	P.R. China — 12 April 2007
WINLAB (Wireless Network Laboratory), Rutgers University	USA — 9 December 2009
University of Vigo	Spain — 25 February 2011
The College of Nanoscale Science and Engineering, State University of New York at Albany	USA — 30 September 2011
Department of Physics, National Sun Yat-Sen University	Taiwan — 8 May 2013

RIEC International Symposiums

The 2nd RIEC International Symposium on Brain Functions and Brain Computer	21-22 February 2014
8th International Symposium on Medical.Bio – and Nano – Electronics	6 March 2014
The 5th International Workshop on Nanostructures and Nanoelectronics	6-7 March 2014

RIEC's New Research Building to be constructed in the Katahira Campus of Tohoku University

The construction of RIEC's new building in the north area of the present RIEC second building began in 2013. The figure at right shows the planned appearance of the new building.

We had originally planned to build a 26,000 m^2 building in the new campus located in Aoba-yama, but the Great East Japan Earthquake altered that situation completely. The plan of RIEC's movement to Aoba-yama was canceled. A building of around half the scale was subsequently slated be built in Katahira Campus, where RIEC is presently located. The concept determined by the RIEC Faculty meeting was then re-discussed to read as follows: "RIEC shall lead research in the field of electronic communications for a hundred years or more, realizing an environment and functions to support world-leading frontier ICT research and education".

The new building has an area of 13,000 m^2 with five floors (in some areas, six floors). Moreover, it has one floor underground, which is equipped with special experimental functions such as extremely low vibration experiment rooms, a radiofrequency anechoic chamber, a shield room, and an anechoic room. An open space for meetings, a large seminar room, several conference rooms, and other facilities will also be arranged.

Because of our severe experiences of the Great East Japan Earthquake, the building will be furnished with a quake-absorbing structure. However, to assure a good experimental environment, extremely low-vibration experiment rooms on B1 Floor will be outside of the quake-absorbing structure because the vibration level of Katahira campus is quite low.

The quake-absorbing structure of this building has a special structure with arrangement of a high-viscosity damper, which would significantly reduce resonance (Q) to realize low vibration levels in the section guarded by the quake-absorbing structure.

It has already been about 20 years since the original plan was drawn. RIEC's new building will be completed this autumn. Moreover, the budgetary request for rebuilding of RIEC's No. 2 building is underway. Therefore, we expect the environment to be strengthened for the further facilitation of cutting-edge research work in the wide field of information communications technology.

(Dr. Yôiti Suzuki, a new RIEC building construction committee member)

About RIEC - Research Institute of Electronic Communication, Tohoku University

Tohoku University was founded in 1907 as Tohoku Imperial University, the third national university in Japan.

The Research Institute of Electrical Communication (RIEC) was established in 1935 as a research institute affiliated with Tohoku Imperial University.

At present, it comprises 4 research divisions consisting of 23 research groups and 3 research facilities with 12 groups. The four research divisions are the following.

The Information Devices Division carries out research into materials and devices for communication technology. The Broadband Engineering Division specifically examines the development of new technologies for the transmission and storage of vast quantities of data. The Human Information Systems Division conducts research into intelligent information processing. The Systems and Software Division is developing advanced system software for the new information society.

In FY2013, RIEC consisted of 68 research staff (24 Professors, 20 Associate Professors and 24 Assistant Professors). Its budget is 4.20 billion Japanese yen (42.0 million US Dollars). 2.86 billion JPY, which is 68.3% of the total budget, was received from external funds. The external funding per staff member is 42 million JPY, equivalent to more than twice the average research cost per researcher in Japan.

For more information

Please visit our site.

http://www.riec.tohoku.ac.jp/index-e.shtml

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