NTT Basic Research Laboratories

Annual Report 2017

NTT
BASIC
RESEARCH
LABORATORIES

ISNTT

International Symposium on Nanoscale Transport and phoTonics

ISNTT, biennially held in NTT Basic Research Laboratories, brought together leading scientists, researchers, and graduate students to share their latest research and discoveries related to the physics and technology of nanoscale structures. We encouraged frank and open technical discussions on recent breakthroughs and advances in related research. In 2017, we had 142 oral/poster presentations, including a keynote talk by Prof. Serge Haroche (Laboratoire Kastler Brossel, Collège de France) and 18 invited talks.

NTT-BRL School

NTT-BRL School is held to foster young researchers and to promote the international visibility of NTT. In 2017, on the subject “The principles of solid state quantum computation”, we had lectures by Prof. Kae Nemoto (NII), Prof. Yasunobu Nakamura (The University of Tokyo), and Hiroki Takesue (NTT-BRL). There was also a laboratory tours and a poster session.

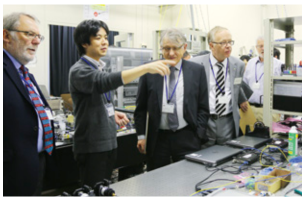
Front image:

LASOLV: A New Computer for Solving Combinatorial Optimization Problems Using Networked Optical Oscillators

We realized an Ising-type computer that employs coupled degenerate optical parametric oscillators as artificial Ising spins. By utilizing the phenomenon in which networked optical oscillators tend to oscillate at a phase configuration that minimizes the total network loss, we can efficiently search the solutions for combinatorial optimization problems. Using this computer, we succeeded in finding good approximate solutions to 2000-node combinatorial optimization problems. To stimulate research on the application of our computer, we recently started a cloud system with which general users can experience computation with LASOLV.

Message from Director

We at NTT Basic Research Laboratories (BRL) are extremely grateful for your interest and support with respect to our research activities.
BRL's missions are to promote progress in science and innovations in leading-edge technology to advance NTT's business. To achieve these missions, researchers in fields including physics, chemistry, biology, mathematics, electronics, informatics, and medicine, conduct basic research on materials science, physical science and optical science.
Our management principle is based on an "open door" policy. For example, we are collaborating with many universities and research institutes all over the world as well as other NTT laboratories. We also organize "Science Plaza", "ISNTT", and other international conferences at Atsugi R&D Center to

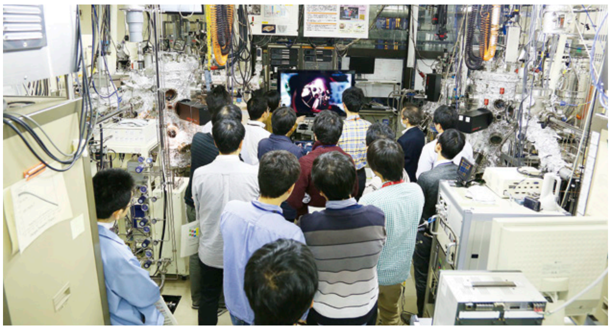


Advisory Board

The NTT BRL Advisory Board, which was first convened in 2001, held its 9th meeting on January 30 - 31, 2017. The aim of the Advisory Board is to provide an objective evaluation of our research plans and activities to enable us to employ strategic management in a timely manner. At this meeting, the BRL researchers had a lunch and a poster session with the board members, where they had chances to present their researches to the board members in a casual atmosphere.

Science Plaza

Science Plaza is an open-house event designed to disseminate our latest research accomplishments among various groups of people both inside and outside NTT and to gather diverse opinions. This event is composed of some short talks by managers to outline recent research activities of NTT laboratories, special talks presented by invited intellectuals, and topical symposiums by outstanding NTT research scientists. Many numbers of poster presentations and laboratory tours are also included.



disseminate our research output and to hear opinions from many people. In addition, we sponsor the "NTT-BRL School", which is dedicated to young researchers around the world. To this school, we invite distinguished researchers from around the world as lecturers to give young researchers including those at NTT the opportunity to learn from the foremost authorities and to share ideas with them.

These activities enable us to realize our "open door" policy and our missions with respect to the promotion of advances in science and the innovation of leading-edge technology for NTT's business. Your continued support will be greatly appreciated.

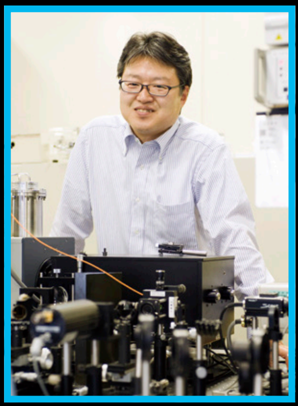
Director of NTT Basic Research Laboratories

Tetsuomi Sogawa

Organization

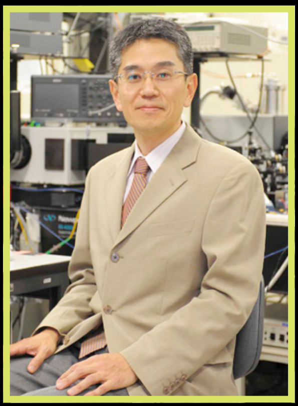
NTT Basic Research Laboratories

Director
Tetsuomi Sogawa



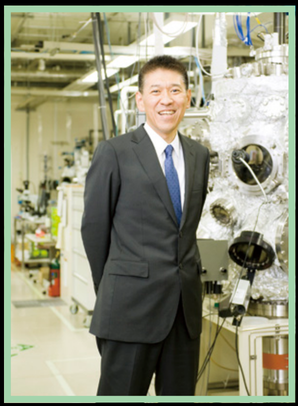
Research Planning Section

Executive Manager
Hideki Gotoh



Materials Science Laboratory

Executive Manager
Hideki Yamamoto



P5

- Thin-Film Materials Research Group
- Low- Dimensional Nanomaterials Research Group
- Molecular and Bio Science Research Group

Physical Science Laboratory

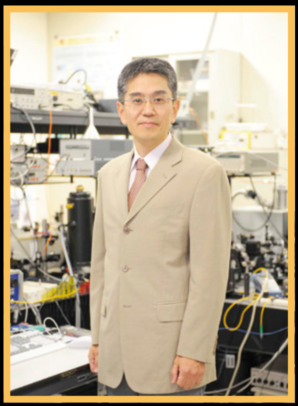
Executive Manager
Akira Fujiwara

P7

- Nanodevices Research Group
- Nanomechanics Research Group
- Superconducting Quantum Circuit Research Group
- Quantum Solid State Physics Research Group

Optical Science Laboratory

Executive Manager
Hideki Gotoh



P9

- Quantum Optical State Control Research Group
- Theoretical Quantum Physics Research Group
- Quantum Optical Physics Research Group
- Photonic Nano-Structure Research Group

The number of NTT-BRL members

- Researcher…96
- Visiting Researcher…2
- Research Associate/Specialist…13
- Total International Interns…19
- Total Domestic Interns…28

As of Dec. 31, 2017

Advisory Board

University of California, Berkeley, U.S.A.
Prof. John Clarke

Harvard University, U.S.A.
Prof. Evelyn Hu

University of Gothenburg, Sweden
Prof. Mats Jonson

Imperial College London, U.K.
Prof. Sir Peter Knight

University of Illinois at Urbana-Champaign, U.S.A.
Prof. Anthony J. Leggett

The University of Texas at Austin, U.S.A.
Prof. Allan H. MacDonald

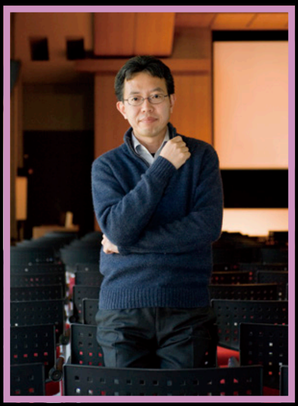
Forschungszentrum Jülich, Germany
Prof. Andreas Offenhäusser

The University of Queensland, Australia
Prof. Halina Rubinsztein-Dunlop

Max Planck Institute for Solid State Research, Germany
Prof. Klaus von Klitzing

Nanophotonics Center

Project Manager
Masaya Notomi



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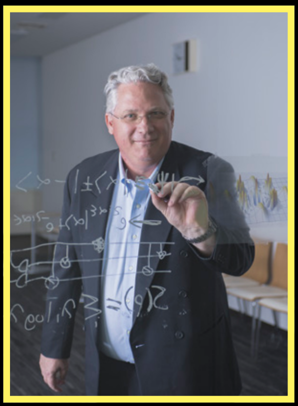
Research Center for Theoretical Quantum Physics

Project Manager
William John Munro



P11

Research Professors

Kwansei Gakuin University
Prof. Hiroki Hibino

National Cerebral and Cardiovascular Center
Japan Research Promotion Society for Cardiovascular Diseases
Sakakibara Heart Institute
Tokyo Metropolitan Hospitals Association
Dr. Hitonobu Tomoike (Medical Director)

Materials Science Laboratory

Overview

The aim of the Materials Science Laboratory is to contribute to progress in materials science and to revolutionize information communication technology by creating novel materials and functions through materials design and arrangement control at the atomic and molecular levels. The research groups that constitute this laboratory are investigating a wide range of materials including typical compound semiconductors such as GaAs and GaN, two-dimensional materials such as graphene, oxide superconductors and magnetic materials, conductive polymers, and biological molecules. We are conducting innovative materials research based on advanced thin-film growth technologies and high-precision and high-resolution measurements of structures and properties along with theoretical studies.

Group Introduction

Thin-Film Materials Research Group

Novel Compound Semiconductor Devices

Creation of light-emitting devices over a wide range from FUV to NIR, high-efficiency energy creation/conversion devices, and novel multifunctional (optical, electric, and spintronic) devices

Low-Dimensional Nanomaterials Research Group

2D Layered Materials

Creation of ultimately thin functional layered materials for atomic layer electronics

Complex Oxide Thin Films

Creation of trailblazing superconductors and magnetic materials beyond conventional concepts

Molecular and Bio Science Research Group

Nanobio

Fusion of neuroscience, bio-molecular science and nanotechnology, and novel devices based on biological functions

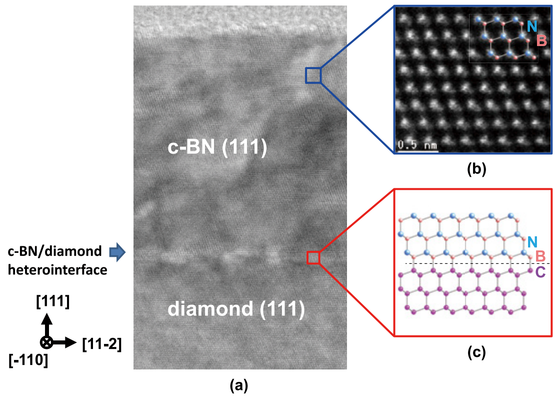
Biocompatible Soft Materials

Development of soft material composites for measurement of deep biological information

Biosensing

On-chip biosensing devices for biomolecular analysis at molecular scale

Multi-source molecular beam epitaxy apparatus: an enabling technology for high-quality thin films of complex oxides/nitrides, which is also exploited as a synthesis method *sui generis* for novel superconductors and magnetic materials.

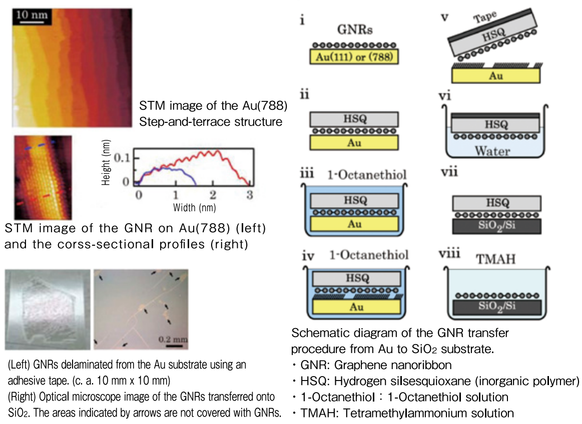


(a) Cross-sectional TEM image of c-BN (111) film (b) HAADF-STEM image of the c-BN region (c) atomic arrangement model of c-BN/diamond heterointerface.

Heteroepitaxial Growth of c-BN (111) Films

Cubic BN (c-BN) is a widegap semiconductor with excellent material properties. For c-BN, the Baliga figure of merit, indicating the expected performance limit for power switching devices, is larger than those of SiC and GaN. The thin-film growth of c-BN is difficult although we have successfully achieved the heteroepitaxial growth of c-BN (111) films on diamond (111) substrates by using an ion-beam-assisted MBE method. We revealed that the c-BN (111) surface has nitrogen polarity, which indicates that the B-C bonds are preferentially formed at the c-BN/diamond heterointerface. An understanding of the atomic arrangements of the c-BN film and the heterointerface is important for improving the crystal quality of c-BN films since this will enable c-BN films to be applied to high-efficiency and high-power transistors.

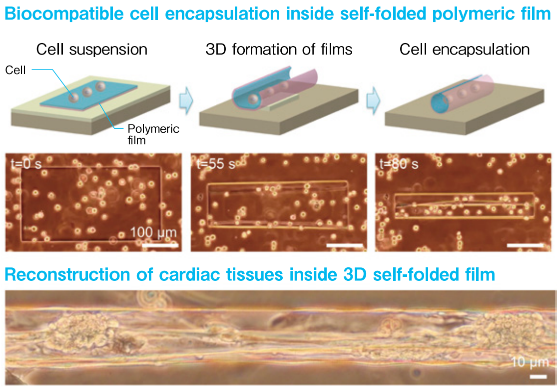
K. Hirama, Y. Taniyasu, S. Karimoto, H Yamamoto, and K. Kumakura, Appl. Phys. Express **10**, 035501 (2017).
K. Hirama, Y. Taniyasu, S. Karimoto, Y. Krockenberger, and H. Yamamoto, Appl. Phys. Lett. **104**, 092113 (2014).



Etching-free Transfer Technique for Graphene Nanoribbon

Among graphene-related materials, graphene nanoribbons (GNRs), whose widths are in the nanometer range, are potential candidates for semiconductor device applications as they exhibit electronic bandgaps unlike graphene itself. We have developed a way to mechanically delaminate well-aligned GNRs from a Au(788) surface by intercalating self-assembled monolayers (SAMs) into a GNR/Au interface, and then transferring them to an insulating substrate. Unlike previous methods, this approach does not require the etching of Au, and the GNR devices can be fabricated repeatedly by reusing the Au substrate.

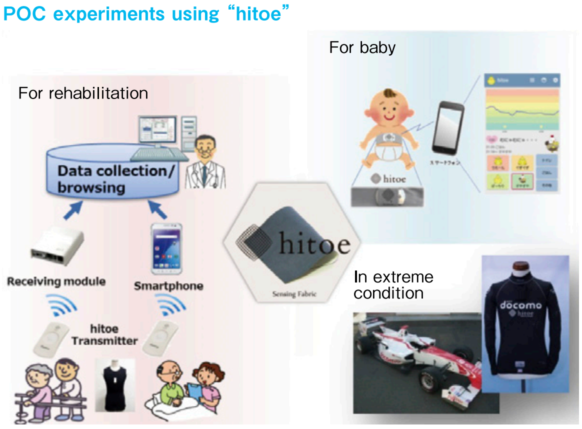
M. Ohtomo, Y. Sekine, H. Hibino, and H. Yamamoto, Appl. Phys. Lett. **112**, 021602 (2018).



Composite Polymer for the Artificial Assembly of Tissues

We developed a method for reconstructing tiny biological tissues by incorporating cells into 3D structures that are entirely composed of highly biocompatible polymer. This method utilizes soft thin films that are self-assembled into arbitrary 3D shapes, which allows for the encapsulation and long-term culture of cells. With this 3D structure, the encapsulated cells are successfully reconstructed into biological tissues such as cardiac muscle and nerves. We expect this technique to be used in such applications as flexible substrates for cell cultures and implantable elements that fit to the surface shape of biological tissues.

T. Teshima, H. Nakashima, Y. Ueno, S. Sasaki, C. S. Henderson, and S. Tsukada, Sci. Rep. **7**, 17376 (2017).



Proof-of-concept Experiments Using Functional Material "hitoe"

We carried out various proof-of-concept experiments utilizing the wearable bioelectrode "hitoe", which we jointly developed with Toray. While promoting open innovation, we are expanding the use of "hitoe" in experiments including (1) the long-term activity monitoring of patients undergoing rehabilitation in collaboration with Fujita Health University, (2) heart rate measurement and condition monitoring of babies in airplanes in the "Flying without crying for babies" project being undertaken jointly by ANA, Combi, Toray, and NTT, and (3) the heart rate and electromyography measurement of a racing car driver under extreme conditions at the All Japan Super Formula Championship.

Physical Science Laboratory

Overview

The Physical Science Laboratory aims to develop semiconductor- and superconductor-based devices and hybrid-type devices, which will have a revolutionary impact on the ICT society of the future. We are using high-quality crystal growth and nanofabrication techniques to explore novel properties that could lead to nanodevices for ultimate electronics and novel information processing applications based on new degrees of freedom such as single electrons, mechanical oscillations, quantum coherent states, electron correlation, and spins.

Group Introduction

Nanodevice Research Group

Single-electron Devices for Ultimate Electronics

Highly accurate, highly sensitive, and low-power devices based on single charge transfer and detection

Nanodevices with Novel Functions

Novel and high performance nanodevices based on silicon and hybrid materials

Nanomechanics Research Group

Semiconductor Opto/electromechanics

Novel devices using mechanical functionality in semiconductor fine structures

Phonon Manipulation

Propagation control of acoustic waves using artificial structures

Superconducting Quantum Circuit Research Group

Superconducting Quantum Circuits

Manipulating quantum states using superconducting devices

Ultimate Quantum Measurement and Sensing

Highly sensitive measurement technologies using quantum mechanical effects

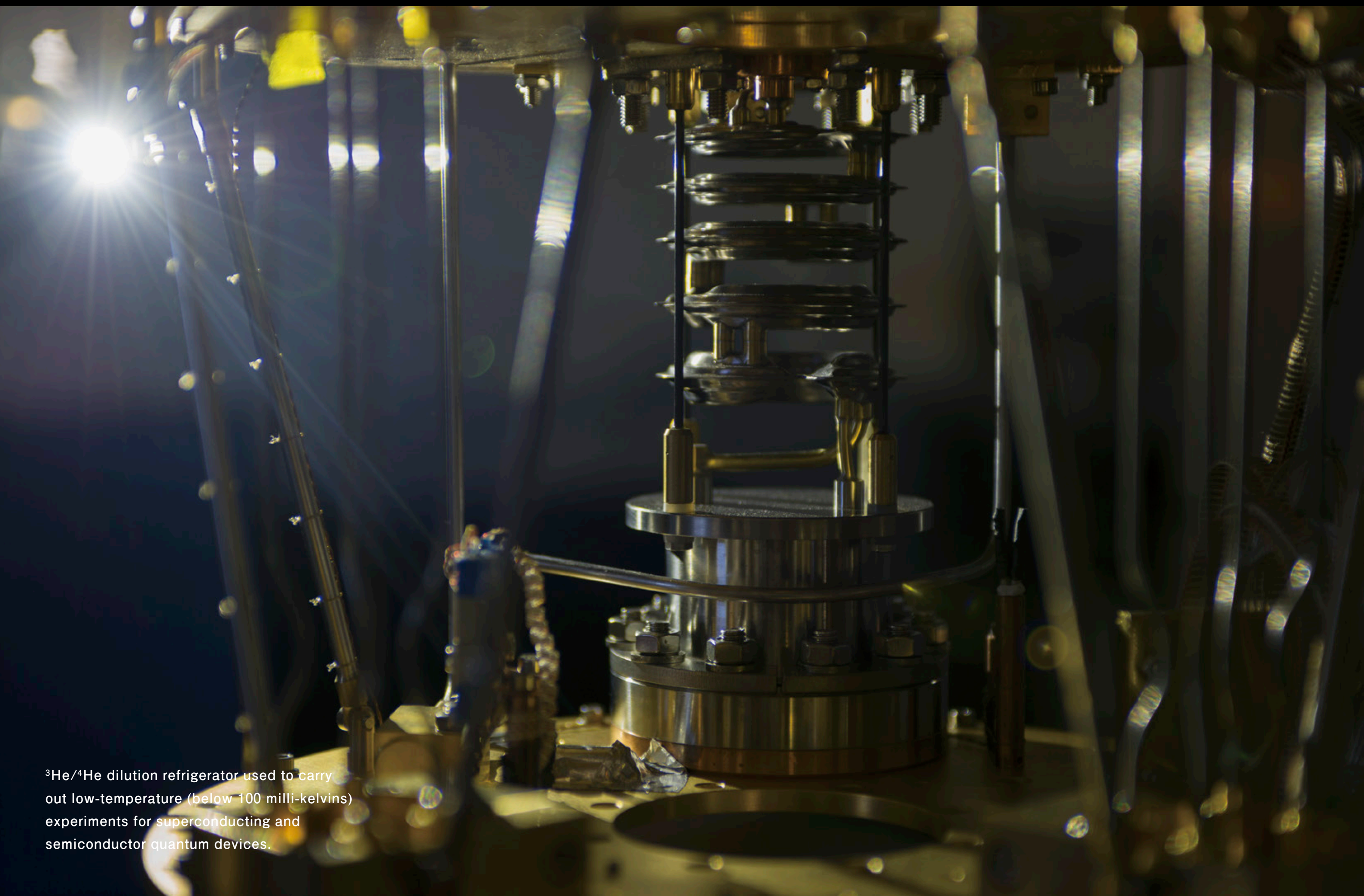
Quantum Solid State Physics Research Group

Quantum Transport in Semiconductor Hetero- and Nano-structures

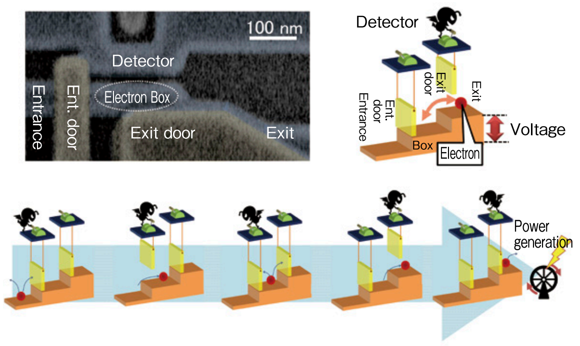
Unconventional charge and spin transport phenomena in quantum devices

Coherent Carrier Dynamics in Electronic Devices

Information processing with coherent electron motion



^3He/^4He dilution refrigerator used to carry out low-temperature (below 100 milli-kelvins) experiments for superconducting and semiconductor quantum devices.

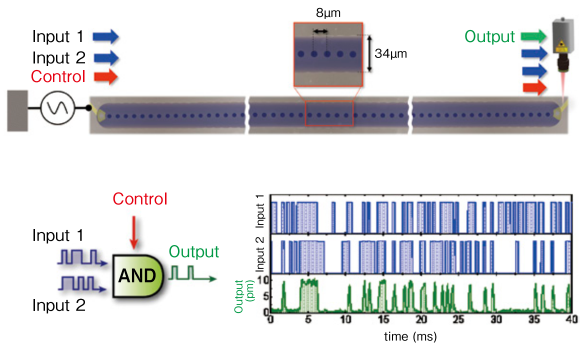


Structure of our device and the operation of Maxwell's demon

Power Generation with Maxwell's Demon

We succeeded in generating an electrical current and power by performing the Maxwell's demon operation with nanometer-scale silicon transistors. Since Maxwell's demon is related to the lower bound of energy consumption in electrical devices and power generation efficiency in small heat engines, such as biomolecules, we anticipate that this achievement will help to create small, energy-efficient electrical devices.

K. Chida, S. Desai, K. Nishiguchi, and A. Fujiwara, Nature Commun. **8**, 15310 (2017).

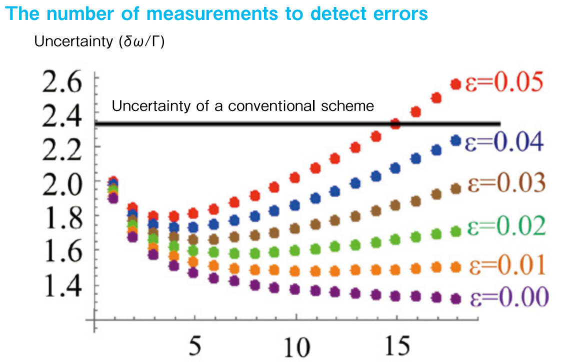


A phonon waveguide (top) executes AND gate (right) as schematically depicted in left panel.

Reconfigurable Logic Gates in a Phonon Waveguide

Frequency-division-multiplexing logic gates are implemented using an electromechanical phonon waveguide. This device has broad phonon bands that enable multiple input and output signal waves to be processed in parallel. Moreover, by adjusting the number, frequency and phase of the control signal waves we can selectively execute fundamental logic gates such as AND, OR and XOR. The results show the availability of phonon vibrations in a signal processing application.

D. Hatanaka, I. Mahboob, K. Onomitsu, and H. Yamaguchi, Nature Nanotech. **9**, 520 (2014).
D. Hatanaka, T. Darras, I. Mahboob, K. Onomitsu, and H. Yamaguchi, Sci. Rep. **7**, 12745 (2017).

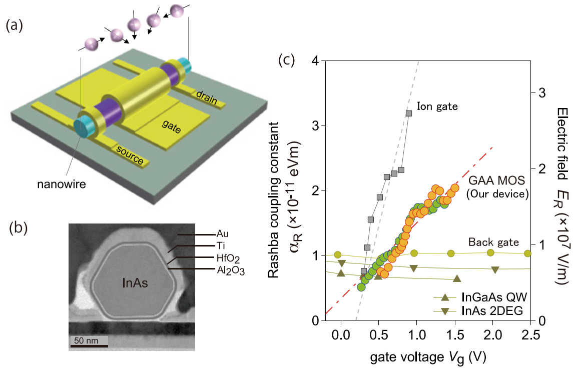


The uncertainty of the frequency shift ($\delta\omega$) due to magnetic fields where Γ and ε denote a decay rate and measurement error rate, respectively.

Magnetic-field Sensing with Quantum Error Detection under the Effect of Energy Relaxation

Magnetic field sensing with a qubit has been studied by many researchers because of its high sensitivity. Recently, quantum error correction to suppress noise has been discussed to improve sensitivity. We have theoretically estimated the performance of quantum error correction under the effect of the energy relaxation. We have showed that while a typical quantum error correction strategy proposed for quantum sensors does not actually improve sensitivity, this can be achieved with an alternative strategy called quantum error detection.

Y. Matsuzaki and S. Benjamin, Phys. Rev. A **95**, 032303 (2017).



(a) Sketch of our gate-all-around InAs nanowire MOSFET. (b)Cross-sectional TEM image of our typical device. (c) Rashba coupling constant as a function of gate voltage. Our data is compared to those obtained for different types of devices.

Gate Control of Spin Orbit Interaction in a Nanowire FET

We have developed a gate-all-around InAs nanowire MOSFET using a thin high-k gate insulator, which enables the electric field to be applied uniformly and strongly around an InAs channel. As a result, the Rashba spin orbit interaction, which is proportional to the electric field, was effectively controlled by the gate voltage. The gate controllability obtained for our device is 10 times higher than that obtained for the MOSFETs and Schottky FETs that have been studied as promising candidates for spin FETs. Our results will pave the way to realizing low power consumption spin FETs.

K. Takase, Y. Ashikawa, G. Zhang, K. Tateno, and S. Sasaki, Sci. Rep. **7**, 930 (2017).

Optical Science Laboratory

Overview

The Optical Science Laboratory is pursuing the development of core technologies that will lead to innovations in optical communication and optical signal processing and to fundamental scientific progress. Central themes are quantum communication, physical computing with optical techniques, ultra-short light-matter physics pulse light, the optical frequency standard, and optical and spin properties in nanostructures.

Group Introduction

Quantum Optical State Control Research Group

Photonic Quantum Communication

Control of quantum state of light and its application to novel communication systems

Non-von Neumann Computation Using Quantum Optics

New computers based on coupled optical oscillators

Theoretical Quantum Physics Research Group

Theoretical Quantum Information Science

Proposal and systematic design of quantum computation, communication, network and metrology schemes including architectures.

Quantum Optical Physics Research Group

Manipulation of Ultrafast and Ultra-stable Laser Field

Explore ultrafast physics and establish the standard optical frequency

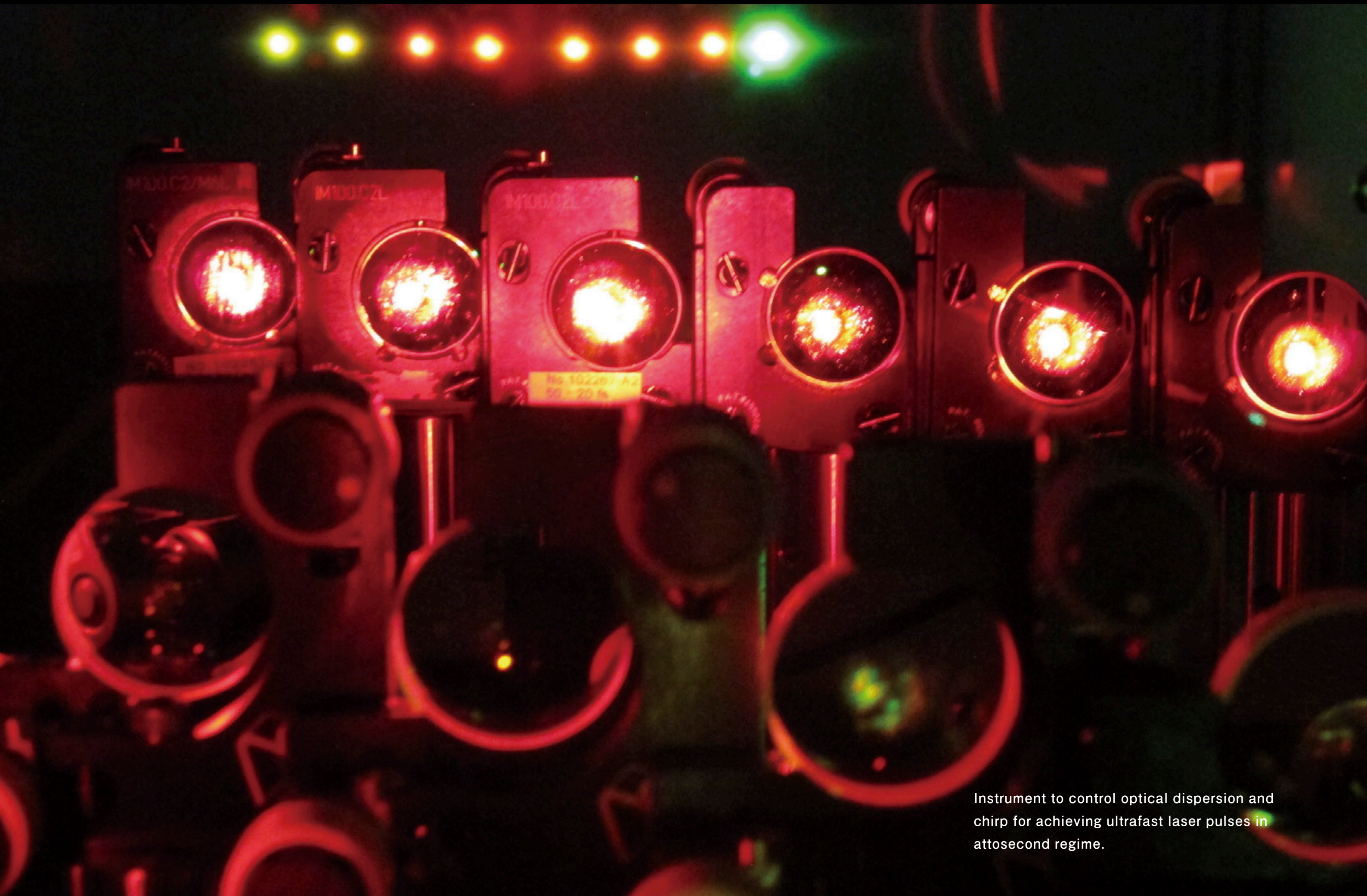
Nano-scale Physics in Optically-active Materials

Characterize photons, excitons and spins in the semiconductor nano-structures and rare-earth ions.

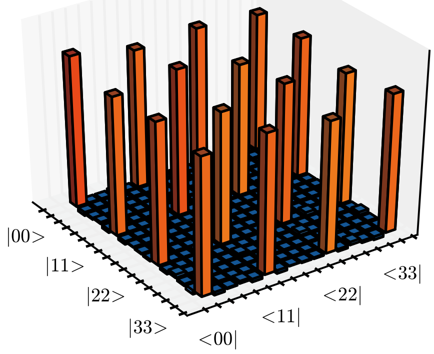
Photonic Nano-Structure Research Group

Integrated nanophotonics technologies

Ultra-compact and ultra-low power photonic devices and circuits, novel photonic phenomena in nanostructures



Instrument to control optical dispersion and chirp for achieving ultrafast laser pulses in attosecond regime.

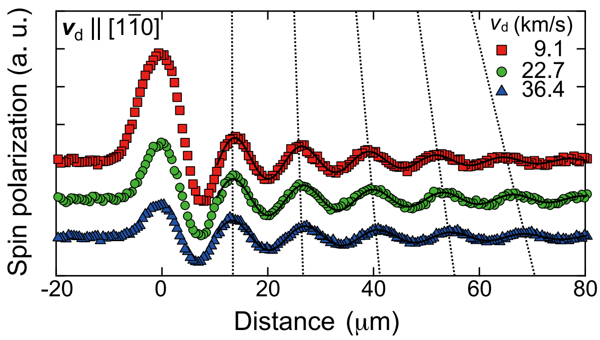


Real parts of the density operator reconstructed by the proposed QST method.

Quantum State Tomography for a High-dimensional Time-bin State

A high-dimensional quantum state has been intensively investigated for advanced quantum information processing. Quantum state tomography (QST) is a key method for evaluating the quality of a quantum state. However, as the dimension of a quantum state under test increases, the measurement procedure becomes more complex. We have realized a simpler QST method for a high-dimensional time-bin state of a photon using cascaded optical interferometers. With the proposed scheme, we observed a four-dimensional quantum entanglement with a fidelity of 95 % with only 16 measurement settings.

T. Ikuta and H. Takesue, New J. Phys. **19**, 013039 (2017).

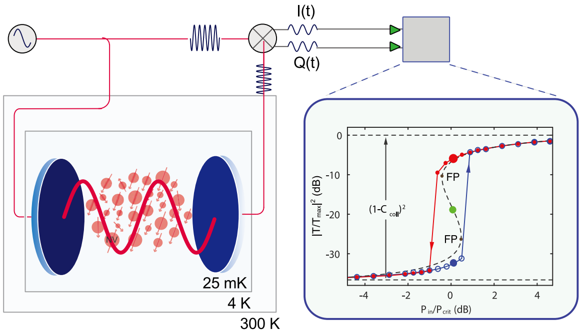


Spatial distribution of drifting spins in a compound semiconductor. Spin precession period depends on the drift velocity vd.

Electron Spin Manipulation by Drift-induced Spin-orbit Interaction

We observe (with a highly-sensitive spin-resolved microscope) that the precession period of drifting electron spins in compound semiconductors depends on drift velocity. This phenomenon is due to a drift-induced effective magnetic field. Our finding will be beneficial for a further understanding of SOI-related phenomena as well as for spintronics applications using spin transport with electric fields in semiconductors.

Y. Kunihashi, H. Sanada, Y. Tanaka, H. Gotoh, K. Onomitsu, K. Nakagawara, M. Kohda, J. Nitta, and T. Sogawa, Phys. Rev. Lett. **119**, 187703 (2017).

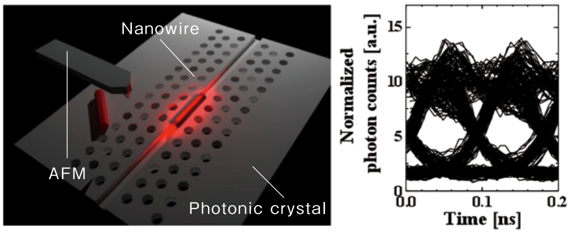


Demonstration of amplitude bistability in a hybrid system composed of a superconducting resonator coupled to an ensemble of NV centers

Ultralong Relaxation Times in Bistable Hybrid Quantum Systems

Nonlinear systems are well known to exhibit many interesting and important phenomena that have profoundly changed society's technological landscape. Our ability to engineer novel quantum systems through hybridization has allowed us to explore such nonlinear effects in systems with no natural analog. We investigated amplitude bistability in a hybrid system composed of a superconducting resonator coupled to an ensemble of NV centers and demonstrated a critical slowing down of 1000+ seconds in the cavity population. This shows the potential for realizing future quantum technologies based on nonlinear phenomena.

A. Angerer, S. Putz, D. O. Krimer, T. Astner, M. Zens, R. Glattauer, K. Streltsov, W. J. Munro, K. Nemoto, S. Rotter, J. Schmiedmayer, and J. Majer, Science Advances **3**, e1701626 (2017).



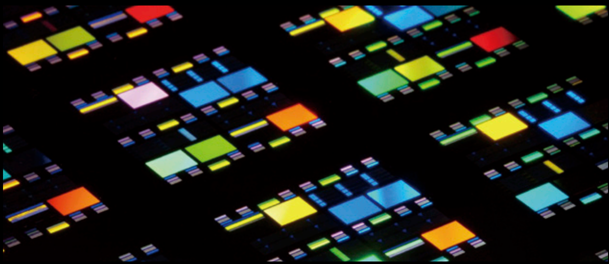
(a)Schematic of nanowire laser on a photonic crystal with an AFM manipulation
(b)Eye pattern (10 Gbps)

Demonstration of On-chip Telecom-band Nanowire Lasers and High-speed Signal Modulation

We have demonstrated the first continuous wave sub-wavelength nanowire (NW) lasers in the telecom band, which we achieved by placing a sub-wavelength semiconductor NW on a silicon photonic crystal to form a hybrid nanocavity. We have also demonstrated the first high-speed signal modulation of NW lasers. This technology enables us to integrate a large number of nanophotonic devices based on compound semiconductor NWs with various functions and is promising for realizing high density optical networks in a processor chip, which is expected to lead to ultrafast information communication technology with low energy consumption.

M. Takiguchi, A. Yokoo, K. Nozaki, M. D. Birowosutob, and K. Tateno, APL Photonics **2**, 046106 (2017).
A. Yokoo, M. Takiguchi, M. D. Birowosuto, K. Tateno, G. Zhang, E. Kuramochi, A. Shinya, H. Taniyama, and M. Notomi, ACS Photonics **4**, 355 (2017).

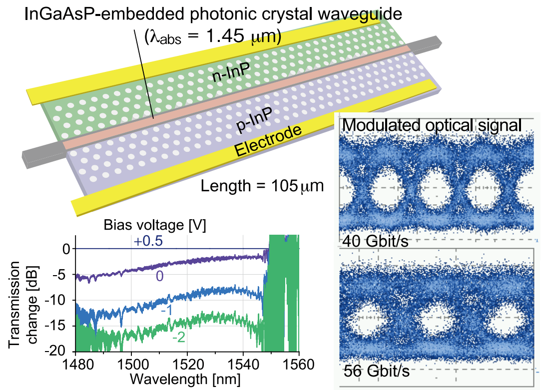
Nanophotonics Center



Overview

The Nanophotonics Center was established in April 2012 and is composed of several groups involved in nanophotonics research at NTT Basic Research Laboratories and NTT Device Technology Laboratories. We are conducting studies of photonic crystals to reduce the footprint and energy consumption of various photonic devices, such as optical switches, optical memories, modulators, lasers, and photo-detectors. We are also studying various photonic nanostructures to greatly enhance light-matter interactions, and exploiting photonic integrated circuits and devices for on-chip signal processing.

- **Extreme enhancement of light-matter interactions by using photonic crystals and plasmonics**
- **Integrable nanophotonic devices with extremely small energy consumption**
- **Nano-imprint, SPM lithography and manipulation**
- **Integration of various high-performance devices on a silicon platform**



Photonic crystal waveguide and the optical modulation by applying the signal voltage

Ultralow-energy Optical Modulator Based on Photonic Crystal

We fabricated a compact optical modulator by embedding electro-absorptive InGaAsP material in a photonic-crystal waveguide, and demonstrated optical modulation with a low signal voltage of <1 V and a high bit rate of up to 56 Gbits/s. Since almost no bias voltage is required, the photocurrent dissipation energy, which has been a significant bottleneck for the previous electro-absorptive modulator, was greatly reduced. In addition, the low capacitance of only about 10 fF suppresses the charging energy when driving the device. These are the keys to reducing the energy consumption to only 2 fJ per bit, which is promising for dense electro-optic conversion and consequent high-performance photonic information processing on a chip.

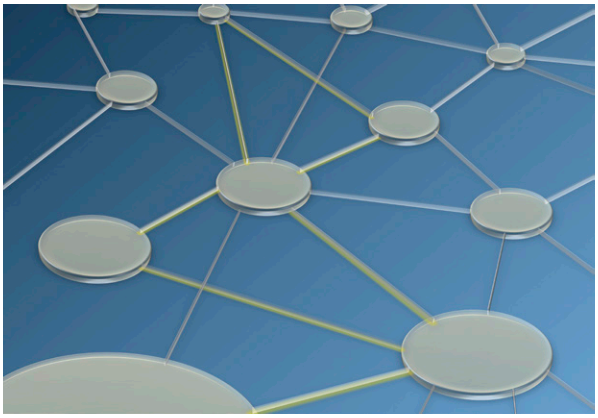
K. Nozaki, A. Shakoor, S. Matsuo, T. Fujii, K. Takeda, A. Shinya, E. Kuramochi, and M. Notomi, APL Photonics **2**, 056105 (2017).

Research Center for Theoretical Quantum Physics

Overview

The twentieth century saw the discovery of quantum mechanics, a set of principles that explains the nature of matter and light at the atomic level. These counter-intuitive principles have not only dramatically changed our understanding of the reality of our physical world but also enabled a technological revolution. They are responsible for the digital age in which we live. Naturally arising questions are what further can we learn from these principles and what technological advances could be enabled. The newly formed Center for Theoretical Quantum Physics established in July 2017 brings together diverse researchers (physicists, computer scientists, mathematicians and even chemists) from across NTT to pursue cutting edge research in a highly collaborative environment.

- **The foundation of quantum mechanics**
- **Quantum matter (hybrid quantum systems, strongly correlated systems, condensed matter and superconducting systems)**
- **Quantum algorithms and complexity**
- **Quantum communication, simulation and computation**
- **Quantum metrology and sensing**
- **Atomic, molecular and optical physics**



Quantum network

Aggregated Quantum Repeaters for the Quantum Internet

The quantum internet holds promise for accomplishing quantum communication, such as quantum teleportation and cryptography, freely between arbitrary clients all over the globe, as well as the simulation of quantum many-body systems. We propose a universal quantum internet protocol that works over any quantum network irrespective of its quantum channels and topology. This protocol is based on the idea of simply running quantum repeater protocols in parallel between communicators. Nonetheless, the protocol achieves the quantum/private capacity of any optical fiber network, namely the quantum theoretical limit to the performance.

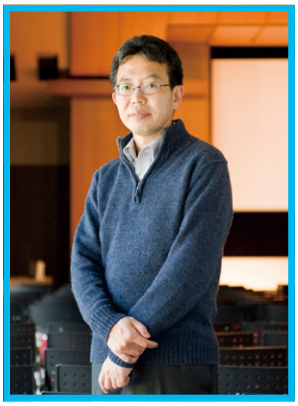
K. Azuma and G. Kato, Phys. Rev. A **96**, 032332 (2017).

"Distinguished Researcher" is a title given to innovative researchers who have been recognized as outstanding both within and outside NTT. "Senior Distinguished Researcher" is a title given to highly outstanding "distinguished researchers." They are responsible for leading innovative research or cutting-edge technical development in research areas considered to be important for the NTT Group in the long term.

Senior Distinguished Researcher

December 31, 2017

Masaya Notomi



Research Subject

Photon Manipulation in Photonic Nanostructures

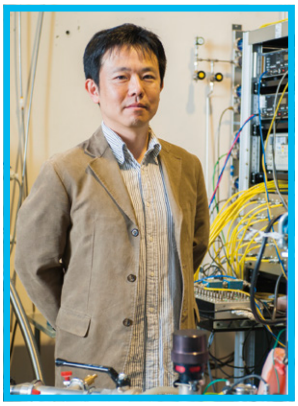
Quantum and Nano Device Research

Hiroshi Yamaguchi

Research Subject

Nano-mechanics in Semiconductors

Koji Muraki



Research Subject

Electron Correlation in Semiconductor Nanostructures

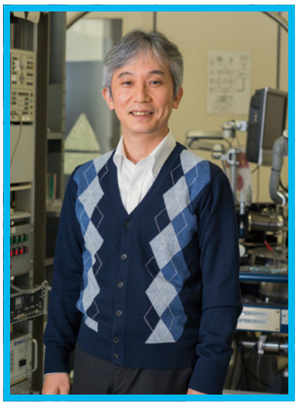
Biomedical and Exercise Physiology Research

Shingo Tsukada

Research Subject

Biological Information Elucidation Using Advanced Medical Materials

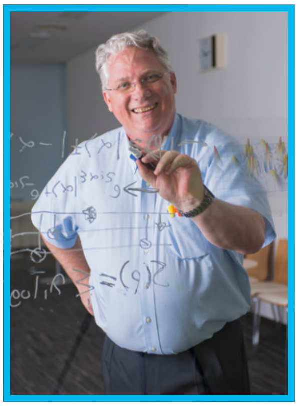
Akira Fujiwara



Research Subject

Ultimate Electronics Using Semiconductor Nanostructures

William John Munro



Research Subject

The Design of Quantum Interfaces & Quantum Repeaters

Hiroki Takesue

Research Subject

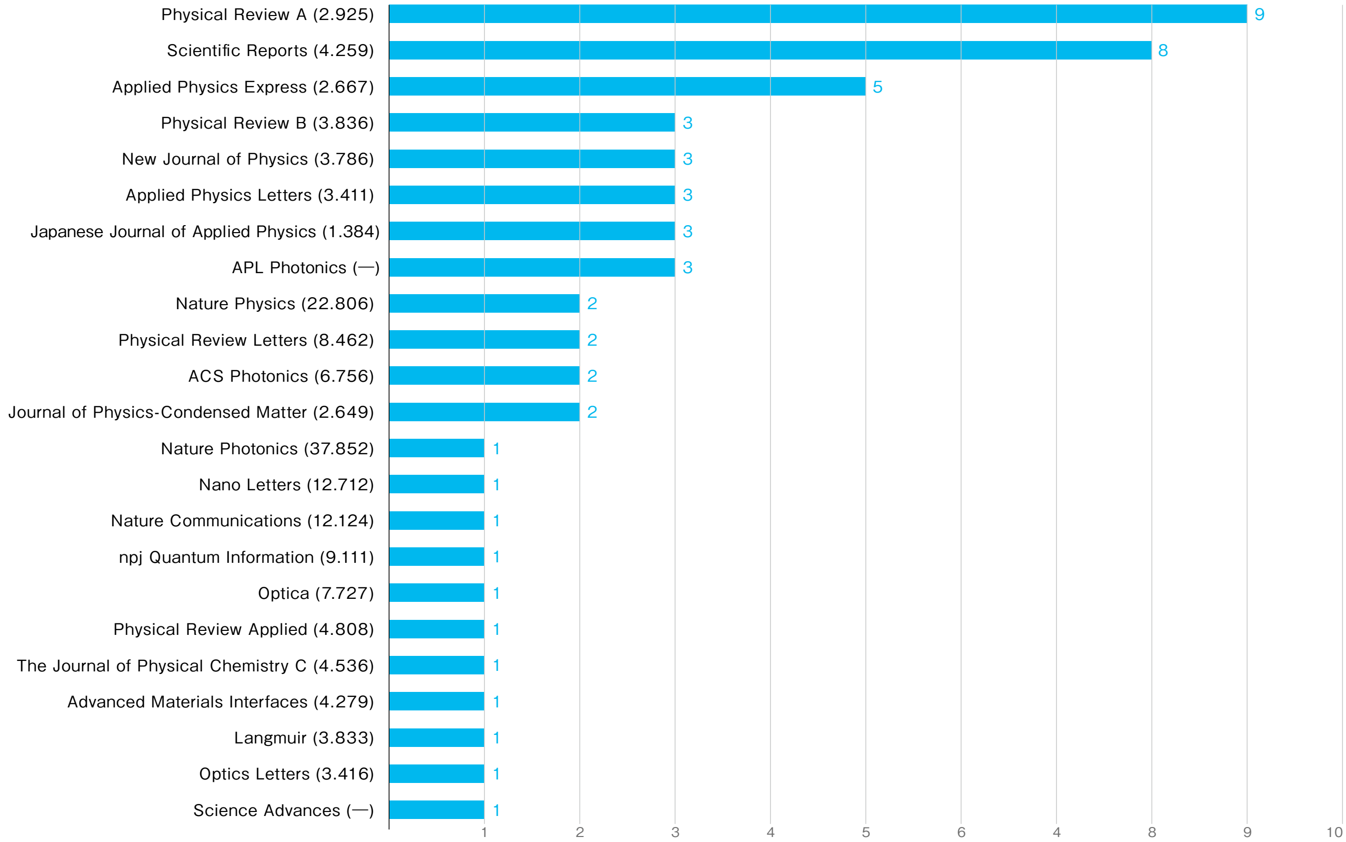
Quantum Communication Experiments in Telecommunication Band

Distinguished Researcher

Norio Kumada
Katsuhiko Nishiguchi
Shiro Saito
Imran Mahboob
Haruki Sanada
Yoshiharu Krockenberger
Kazuhide Kumakura
Kengo Nozaki
Nobuyuki Matsuda

Publication List

(　)…The average IF2016 for all research papers from NTT Basic Research laboratories is 5.012
The number of papers published in international journals in 2017 is 73.



Number of Presentations

211
(59 Invited talks)

Number of Patents

81

List of Award Winners

IOP Publishing Outstanding Reviewer Award 2016
Outstanding Reviewer for New Journal of Physics in 2016
W. J. Munro

The Japan Society of Applied Physics (JSAP) Young Scientist Presentation Award
Dispersion Effects on Phonon Temporal Waveforms in a Phononic Crystal Waveguide
M. Kurosu

The Japan Society of Applied Physics (JSAP) Young Scientist Presentation Award
Implementation of Quantum State Tomography for High-dimensional Time-bin Entanglements
T. Ikuta

Young Scientist Award of the Physical Society of Japan
Robust Magnetic Field Sensing Beyond the Standard Quantum Limit
Y. Matsuzaki

Prizes for Science and Technology, The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology
Research on the Ultimate Control of Electrons in Nanostructures and the Device Application in
A. Fujiwara

The Japan Society of Applied Physics (JSAP) Young Scientist Presentation Award
Controllable One-Dimensional Photonic Topological Phase with PT-symmetry Breaking
K. Takata

CHEMINAS conference awards
Cell Assembly in Self-folded Multi-layered Soft Films
T. Teshima, H. Nakashima, Y. Ueno, S. Sasaki, and C. Henderson

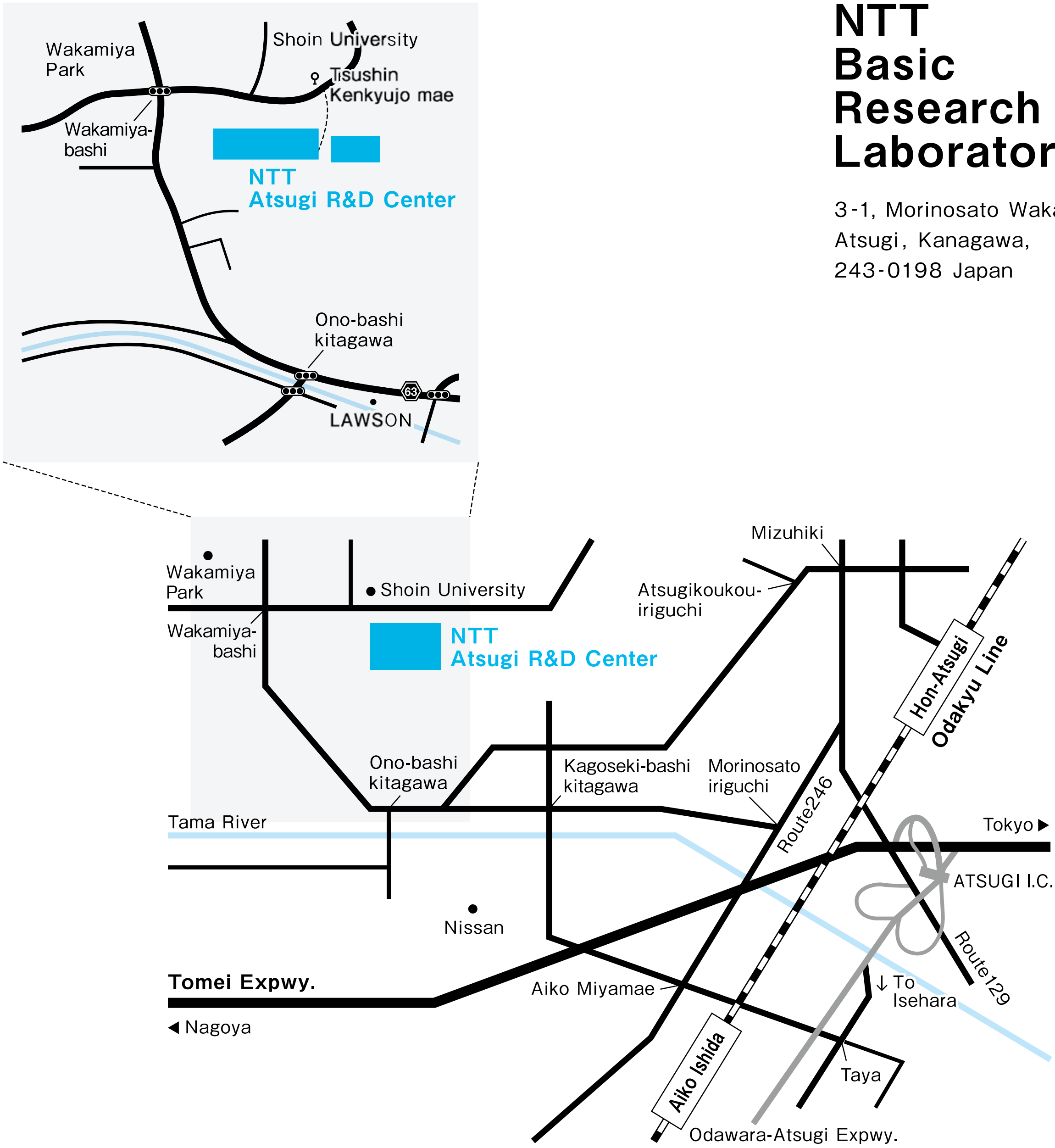
International Symposium on Ultrafast Intense Science XVI The Best Poster Presenter Award
Development of Time-resolved ARPES and Absorption Spectroscopy System Based on Quasi-monocycle-pulse Driven High-order Harmonic Source
K. Oguri

Nishina Memorial Prize
Realization of Large-scale Coherent Ising Machine
H. Takesue

International Conference on BioSensors, BioElectronics, BioMedical Devices, BioMEMS/NEMS & Applications (Bio4Apps 2017) Best Presentation Award
Three-Dimensional Protein Detection by Graphene Micro-roll Aptasensor
Y. Ueno, T. Teshima, C. Henderson, and H. Nakashima

NTT Basic Research Laboratories

3-1, Morinosato Wakamiya,
Atsugi, Kanagawa,
243-0198 Japan



Access

By train and bus

"Aiko-Ishida" station on Odakyu Line (1 hour from Shinjuku by express)
North Exit Bus Depot 4
20 minutes bus ride on "愛17, 愛19 Morinosato" route; get off at "Tsushin Kenkyujo-mae" bus stop.
20 minutes bus ride on "愛18, 愛21 Shoin Daigaku" route; get off at "Tsushin Kenkyujo-mae" bus stop.

"Hon-Atsugi" station on Odakyu Line (1 hour from Shinjuku by express)
East Exit Bus Center Pole 9
30 minutes bus ride on "厚44 Morinosato via Akabane/Takamatsuyama" or
"厚45 Morinosato via Funako/Morinosato-Aoyama" get off at "Tsushin Kenkyujo-mae" bus stop.

By taxi

15 minutes from "Aiko-Ishida" station on Odakyu Line (around 1,500yen) or 20 minutes from "Hon-Atsugi" station on Odakyu Line (around 2,500yen)

By car

20 minutes (5km) drive from Tomei Expwy "Atsugi I.C."; get off the Expwy toward Isehara and turn right at the Taya crossroads.

NTT

NTT Basic Research Laboratories

3-1, Morinosato Wakamiya, Atsugi, Kanagawa, 243-0198 Japan
TEL +81-46-240-3312 MAIL brl-info@hco.ntt.co.jp
http://www.brl.ntt.co.jp/