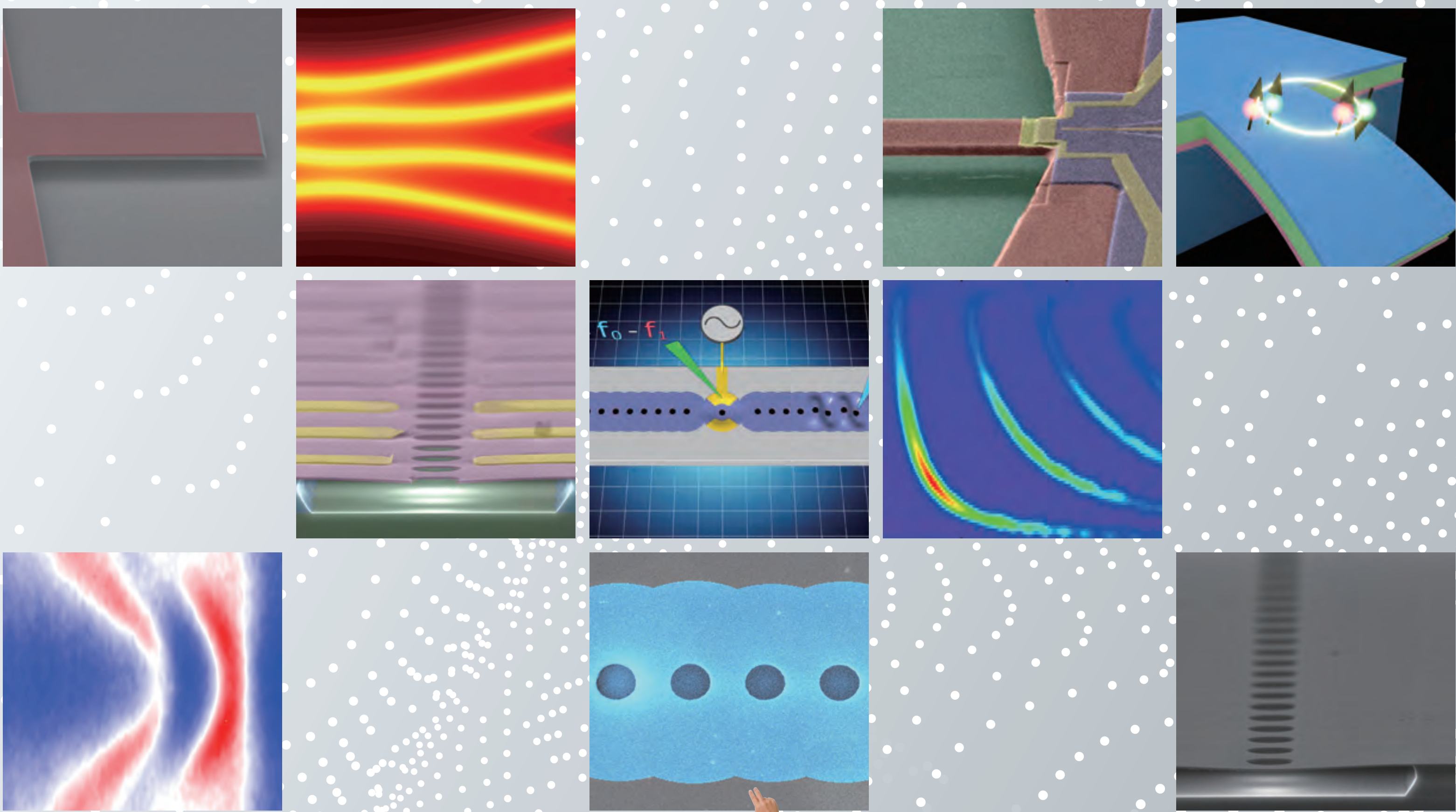
NTT Basic Research Laboratories

Annual Report 2018



NTT BASIC RESEARCH LABORATORIES

Front image:

Semiconductor Micro / Nanomechanical Devices

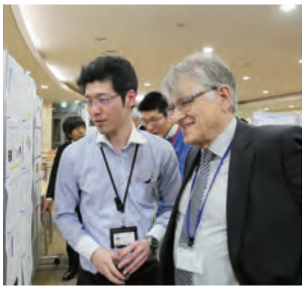
Miniaturizing mechanical resonators, such like doubly clamped beams and cantilevers, into micro and nanometer scales makes them extremely sensitive to an externally applied small force. Such a structure, in addition, can generate large strain by its elastic deformation, providing a novel tool to manipulate local material properties. We study the integrated devices of mechanical resonators with semiconductor heterostructures, aiming to develop novel functions of semiconductor fine structure devices.

NTT-BRL Seminar

We invite distinguished researchers in the world to hold an in-house seminar. This year, we had 30 seminars dedicated to our research field and shared latest research results with the guests.

Advisory Board

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, 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. Next 10th meeting will be held in 2019.



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" as an open house, "ISNTT", and other international conferences at Atsugi

ISNTT

International School and Symposium on Nanoscale Transport and phoTonics

International symposium and school “ISNTT”, biennially held in NTT-BRL, 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, College 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 were also laboratory tours and a poster session.

R&D Center to 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.

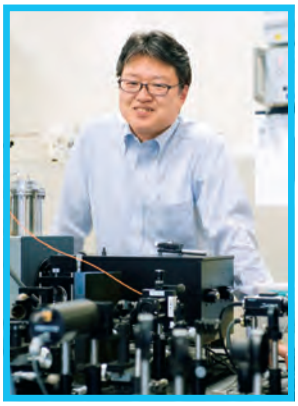
Director of NTT Basic Research Laboratories

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

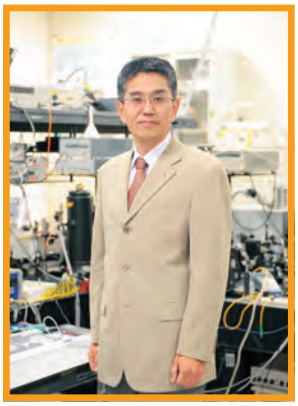
Executive Manager
Akira Fujiwara

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 population data of NTT-BRL members

- Researcher…98
- Research Associate/Specialist…12
- Joint Researcher…10
- Total International Interns…15
- Total Domestic Interns…33

As of Dec. 31, 2018

9th Advisory Board Meeting (January 30, 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

P11

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 soft materials. 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 as well as Materials Informatics.

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

Biocompatible Soft Materials

Development of soft material composites for measurement of deep biological information

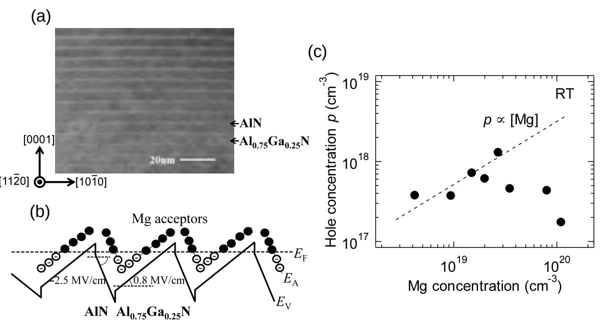
Interface Interaction

Creation of biodevices and soft robots
by controlling interactions at cell/cell and cell/non-cell substance interfaces

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.

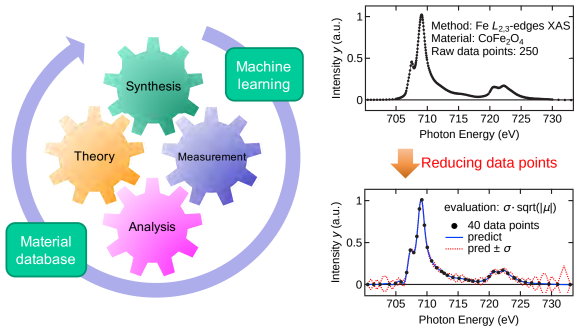


(a) Cross-sectional TEM image, (b) schematic illustration of valence band edge and (c) hole concentration of Mg-doped AlN/$Al_{0.75}Ga_{0.25}N$ superlattices

Utilizing a Polarization Field to Increase the Concentration of Holes in AlN/AlGaN Superlattices

AlGaN-based deep-ultraviolet (DUV) light-emitting diodes and laser diodes are of great interest for applications such as sterilization and medical treatment due to their small size, low power consumption, and long lifetime. The low concentration ($<10^{15}$ cm^{-3}) of holes in p-type AlGaN alloy with high Al content (>70%) is a key issue for device applications. We achieved a high hole concentration on the order of 10^{18} cm^{-3} in Mg-doped AlN/$Al_{0.75}Ga_{0.25}N$ superlattices by lowering the effective acceptor ionization energy using large polarization charges generated at the superlattice interfaces. The findings from this study may lead to significant increases in the emission efficiency of DUV devices.

K. Ebata, J. Nishinaka, Y. Taniyasu, and K. Kumakura, Jpn. J. Appl. Phys. **57**, 04FH09 (2018).

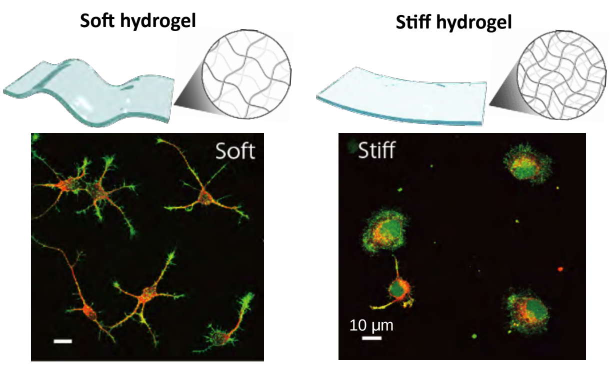


(Left) Research cycle for the development of novel materials. (Upper right) Spectrum, which consists of 250 data points, obtained by the conventional spectroscopy. (Lower right) Spectrum predicted by GPR with 40 data points.

High-throughput Spectroscopies Using Machine Learning

We developed high-throughput spectroscopies by predicting spectral shapes with Gaussian process regression (GPR), which is a basic technique of machine learning. This method allows us to predict detailed peak structures by sampling only about one-sixth of the original sample points. The reduction in time and cost of characterizing specimens afforded by this method will accelerate development of novel materials. This work is being carried out in collaboration with NTT Communication Science Laboratories.

Y. K. Wakabayashi, T. Otsuka, Y. Taniyasu, H. Yamamoto, and H. Sawada, Appl. Phys. Express **11**, 112401 (2018).

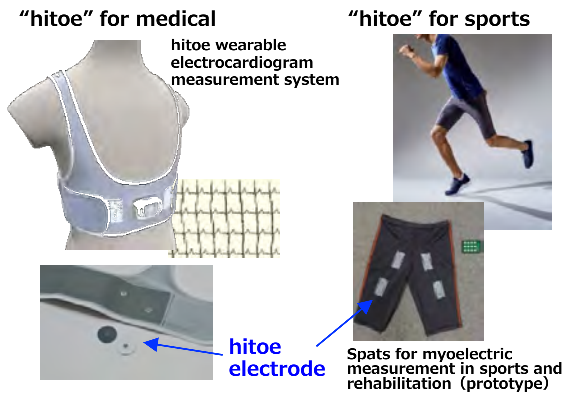


Control of neurite initiation by mechanical property of a hydrogel substrate.

Using Scaffold Stiffness to Control Cellular Growth

Cells recognize and respond to external mechanical signals in their surrounding microenvironment, such as the extracellular matrix (ECM). Here, we investigated how the mechanical properties of the microenvironment affect neurite initiation by preparing a hydrogel with various stiffnesses ranging from that of brain tissue. We found that a stiffer substrate suppressed neuritogenesis. This study provides us with insight not only for developing a scaffold for neuronal regeneration, but also for designing a compliant interface between biological tissue and implantable devices.

A. Tanaka, Y. Fujii, N. Kasai, T. Okajima, and H. Nakashima, PLOS ONE **13**, e0191928 (2018).



New Uses for "hitoe"

The wearable electrocardiogram measurement system called "hitoe", which is composed of the functional material of the same name, enables continuous measurement of biological information. It was jointly developed with Toray Industries, Inc. and has been marketed by Toray Medical since September 2018. This system allows continuous electrocardiogram measurements to be made for up to two weeks between battery charges, and it is expected to be an important tool for future home medical care. In addition to this development, we are carrying out proof-of-concept experiments on a hitoe prototype for myoelectric measurements. This unit measures muscle activity and muscle fatigue during sports, rehabilitation, etc. Through efforts like these, we are expanding the applications of hitoe.

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

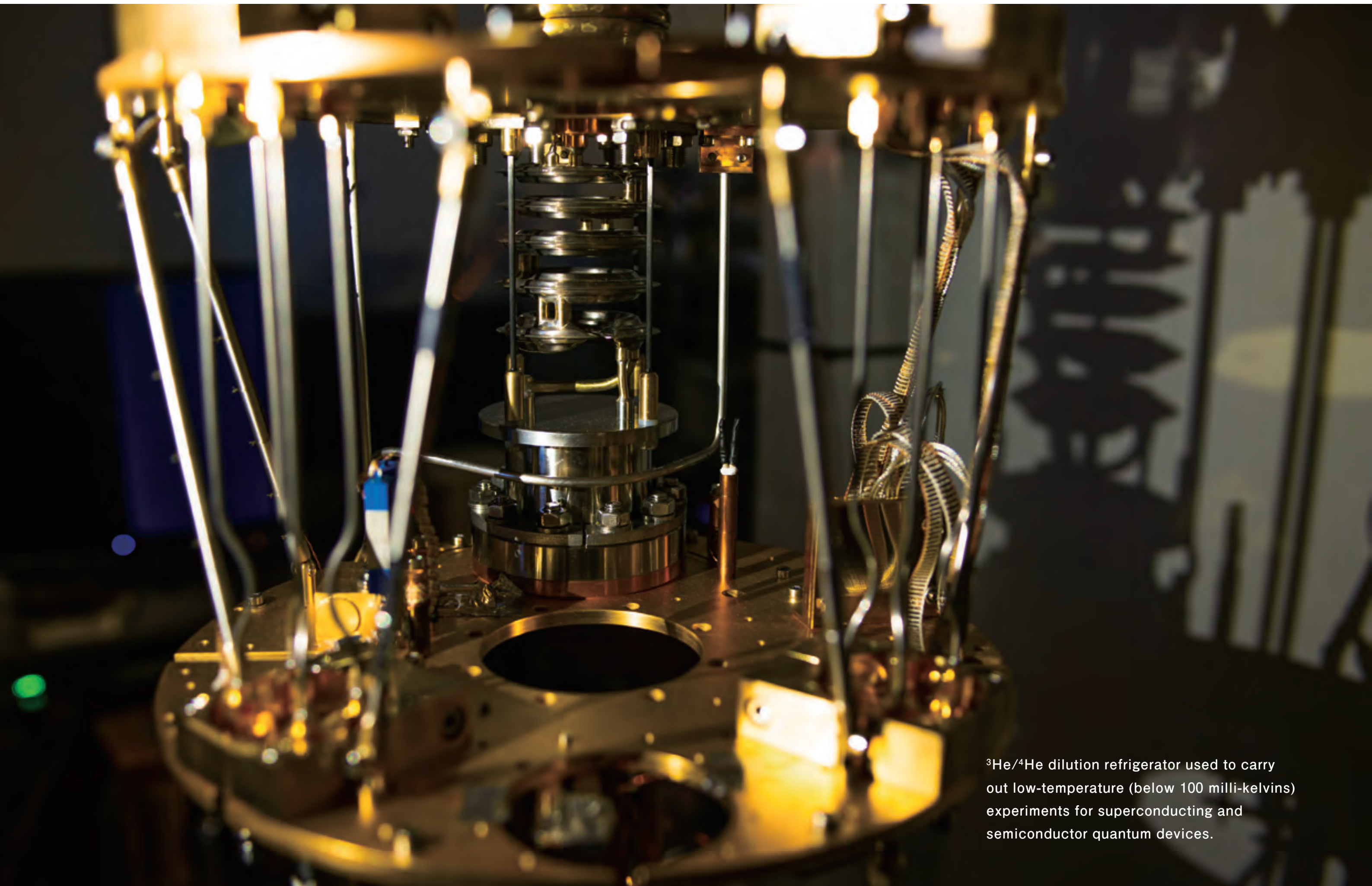
Quantum Solid State Physics Research Group

Quantum Transport in Semiconductor Hetero- and Nano-structures

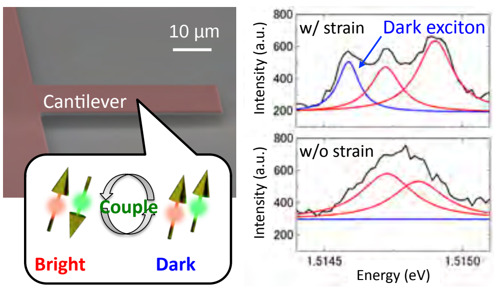
Unconventional charge and spin transport phenomena in quantum devices

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.

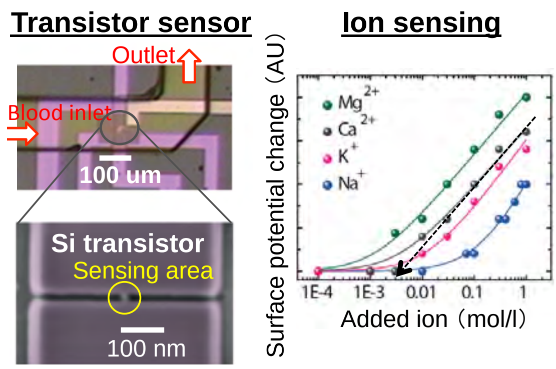


(Left) A cantilever embedding bright and dark excitons
(Right) Photoluminescence from dark excitons

Mechanical Control of Coupling between Bright and Dark Excitons

We demonstrated control of the strain-induced coupling between bright and dark excitons in a cantilever composed of semiconductor heterostructures. Dark excitons are advantageous for their long lifetime, but they have not been used in optical devices because photon absorption and emission from them are forbidden. This strain-induced coupling makes dark excitons optically accessible via bright excitons. These results will pave the way to new device concepts, such as optical storage, that take advantage of the long-lived nature of dark excitons.

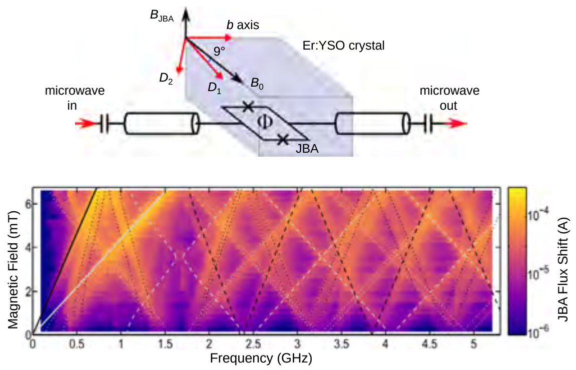
R. Ohta, H. Okamoto, T. Tawara, H. Gotoh, and H. Yamaguchi, Phys. Rev. Lett. **120**, 267401 (2018).



Selective Layer-free Blood Serum Ionogram Based on Ion-specific Interactions with a Nanotransistor

We discovered that a variety of cations in aqueous solution in contact with the surface of a nanoscale silicon transistor change the current flowing through the transistor. By utilizing this phenomenon, we can measure individual cation concentrations in blood serum. While transistor-based ion sensors usually require special treatment to distinguish and detect specific ions, our nanoscale transistor does not need such treatment, which allows for simple and stable measurements for biosensors. Additionally, this unique effect in nanoscale silicon transistors may be a means to exploit new surface chemistry.

R. Sivakumarasamy, R. Hartkamp, B. Siboulet, J.-F. Dufreche, K. Nishiguchi, A. Fujiwara, and N. Clement, Nature Mater. **17**, 474 (2018).

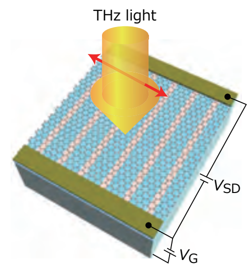


(Top) Schematic diagram. (Bottom) Observed ESR spectra.

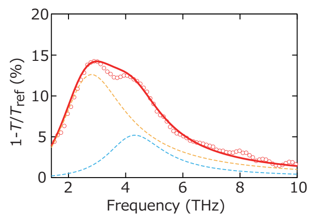
Electron Spin Resonance Spectroscopy Using a Josephson Bifurcation Amplifier

We developed a magnetic field and frequency tunable electron spin resonance spectroscopy (ESR) scheme using a tunable Josephson bifurcation amplifier, with good measurement sensitivity of about 15,000 spins. This scheme is well-suited for characterization of more complicated spin systems, such as Er-doped YSO crystal with anisotropic hyperfine and quadrupole interactions.

R. P. Budoyo, K. Kakuyanagi, H. Toida, Y. Matsuzaki, W. J. Munro, H. Yamaguchi, and S. Saito, Phys. Rev. Mater. **2**, 011403 (2018).



Experimental setup. Graphene is transferred on a SiO_2/Si substrate (light blue) covered with a micro-ribbon array of a self-assembled monolayer (SAM: orange).



Extinction spectrum. Observed two peaks correspond to excitations of plasmons localized in the graphene/SAM and graphene/SiO_2 micro-ribbon arrays.

Plasmon Confinement by Modulating the Carrier Density of Graphene

Graphene plasmons are attracting much attention for plasmonic device applications owing to their tunability by electrical means. We investigated plasmon excitations under periodic carrier density modulation in graphene. Using THz spectroscopy, we showed that plasmons can be confined by the spatial modulation of the carrier density. This technique can be used to form an electrically controllable plasmonic waveguide.

N. H. Tu, M. Takamura, Y. Ogawa, S. Suzuki, and N. Kumada, Jpn. J. of Appl. Phys. **57**, 110307 (2018).

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

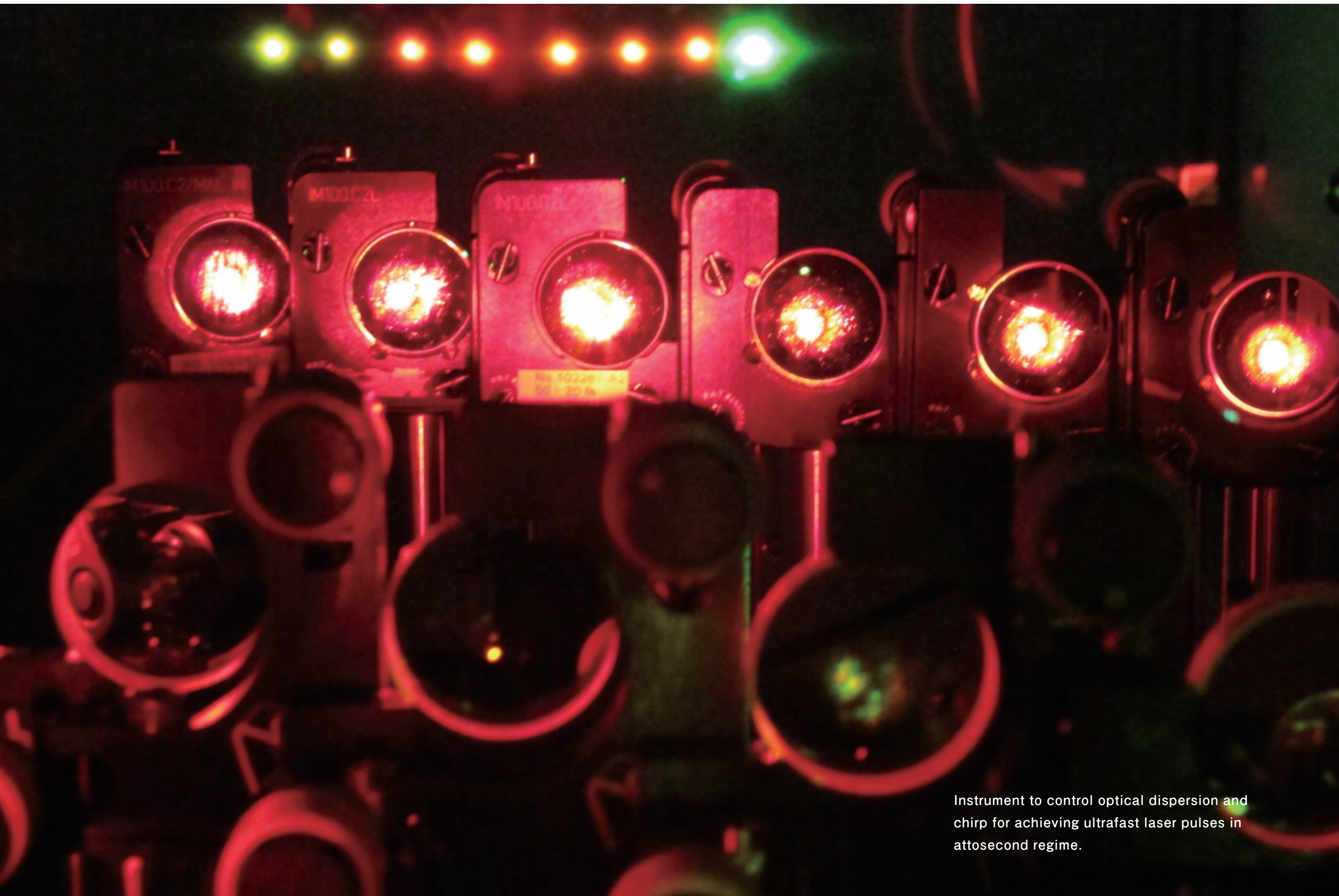
Nano-scale Physics in Optically-active Materials

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

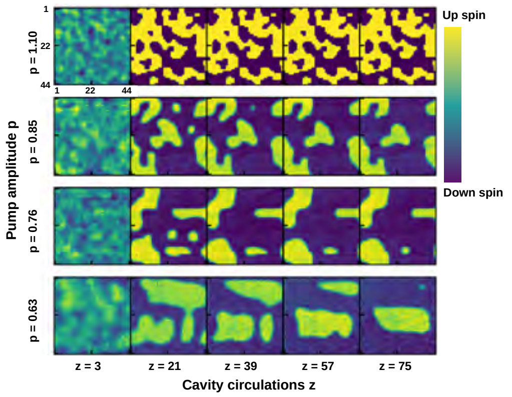
Photonic Nano-Structure Research Group

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.

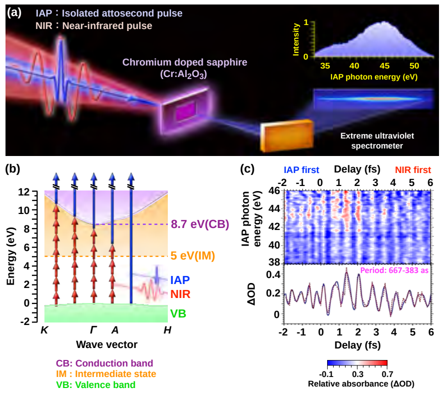


Observation of domain formation process in 2D model

2D Ising Model Simulation with OPO Network

We simulated a 2D Ising model at low temperature with a coherent Ising machine (CIM) based on a network of the optical parametric oscillators (OPOs). By observing the domain formation process in 2D Ising model, we determined that the performance of the CIM is limited by the freeze-out effect. We adjusted the pump amplitudes of the OPOs closer to the threshold to avoid the freeze-out effect and found that the CIM could reach the ground state of a 2D Ising model consisting of 1,936 spins.

F. Böhm, T. Inagaki, K. Inaba, T. Honjo, K. Enbutsu, T. Umeki, R. Kasahara, and H. Takesue, Nature Commun. **9**, 5020 (2018).

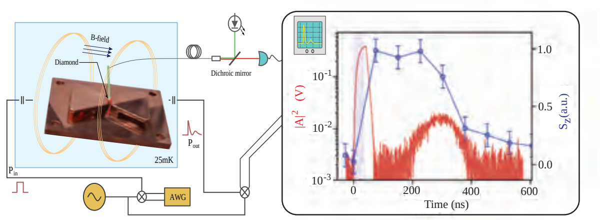


(a)Transient absorption attosecond spectroscopy, (b)Energy band structure of Chromium doped Sapphire, (c)Attosecond electron interferogram

Ultrafast Electron Oscillation Monitored by Attosecond Light Source

The lightwave field in visible and ultraviolet regions can reach petahertz (10^{15} Hz: PHz) frequencies. We observed the lightwave field-induced electronic dipole oscillations with 667-383 attosecond (10^{-18} sec.: as) periodicity, which is characterized by an extremely short isolated attosecond light source. Since electron oscillations are the origin of light-matter interactions, this study lays the essential groundwork for exploring various optical phenomena in solids; the ultrafast time dependence will also be important in studies of electronic and photonic devices.

H. Mashiko, Y. Chisuga, I. Katayama, K. Oguri, H. Masuda, J. Takeda, and H. Gotoh, Nature Commun. **9**, 1468 (2018).

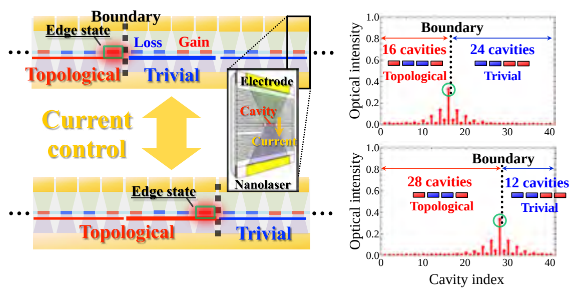


Superradiant emission of microwave light in a hybrid system

Superradiant Emission in a Hybrid Quantum System

Superradiance is a fundamental collective effect where radiation is amplified by the coherence of multiple emitters. Here, we explored superradiance in the fast cavity limit by using a system composed of a three-dimensional lumped element resonator inductively coupled to an inhomogeneously broadened ensemble of nitrogen–vacancy centers. We observe a superradiant pulse being emitted a trillion times faster than the decay for an individual nitrogen–vacancy center. This finding was further confirmed by the nonlinear scaling of the emitted radiation intensity with respect to the ensemble size. Our work provides the foundation for future quantum technologies including solid- state superradiant masers.

A. Angerer, K. Streltsov, T. Astner, S. Putz, H. Sumiya, S. Onoda, J. Isoya, W. J. Munro, K. Nemoto, J. Schmiedmayer, and J. Majer, Nature Phys. **14**, 1168 (2018).



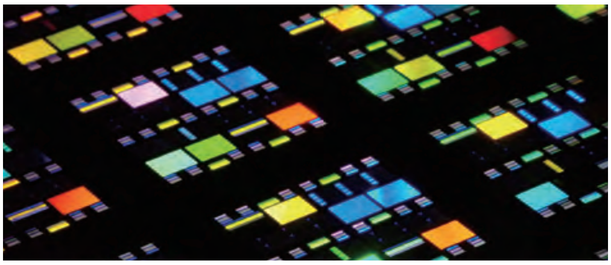
Controllable photonic topological insulator and boundary edge states

Photonic Topological Insulator Induced by Optical Gain and Loss

A photonic topological insulator is an artificial material that is optically insulating inside but has peculiar photonic states immune to structural disorder on its surface (topological edge states). However, the presence or absence of robust edge states (photonic topology) is determined by the device structure, and hence, it has been difficult to change. We have theoretically found a scheme to create and control a one-dimensional photonic topological insulator based on a coupled laser array, solely by changing the optical gain and loss by electrical means. This enables us to control the location and number of edge states in the single array, and it thereby paves the way to novel technologies for reconfigurable and robust photonic topological circuits.

K. Takata and M. Notomi, Phys. Rev. Lett. **121**, 213902 (2018).

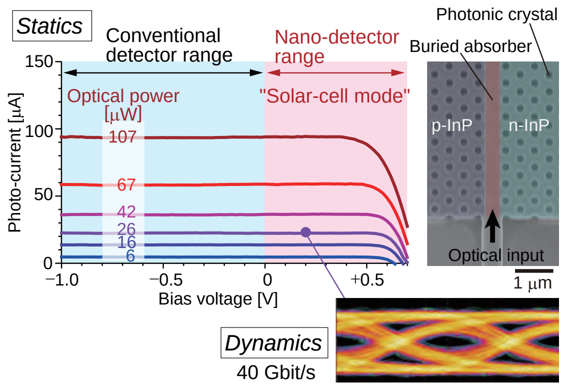
Nanophotonics Center



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**



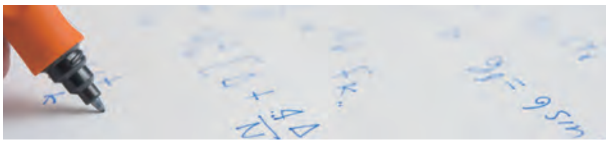
Photonic-crystal nano-detector operating fast in solar-cell mode

Efficient and Fast Nano-photonic Detector Operating in Solar-cell Mode

Conventional photodetectors (PDs) convert an optical signal into a current by extracting photo-generated electron-hole pairs with a reverse bias voltage. On the other hand, a photonic crystal nanostructure allows one to fabricate nano-scale PDs that can be used to form optical waveguides, absorbers, and pn junctions with extremely small dimensions. This enables such "nano-PDs" to operate without degradation of photo-current and at high speed even in the forward voltage range, which is used in solar cells. These PDs require only a small amount of optical energy and do not use any electrical energy, giving them excellent prospects for optical communications, especially in dense photonic networking and computing on a CMOS chip.

K. Nozaki, S. Matsuo, T. Fujii, K. Takeda, A. Shinya, E. Kuramochi, and M. Notomi, APL Photonics **3**, 046101 (2018).

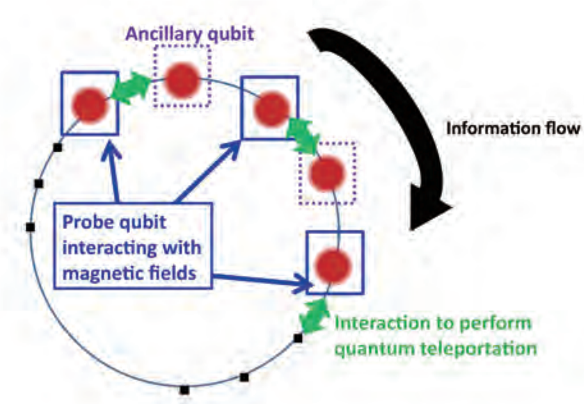
Research Center for Theoretical Quantum Physics



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**



Schematic illustration of a quantum teleportation based magnetic field sensor.

Quantum Metrology Beyond the Classical Limit under the Effect of Dephasing

It is well known that the sensitivity of classical sensors increases with the square root of the measurement time T. A quantum sensor, on the other hand, can in principle achieve a sensitivity scaling linearly with T under ideal conditions. However, quantum sensors are susceptible to environmental noise, and it has remained unclear whether they can reach their ideal sensitivity under realistic circumstances. Here, we propose to use quantum teleportation to suppress environmental noise of quantum sensors, which in turn allows us to show that the sensitivity can increase linearly with T under dephasing effects (a typical noise source). Our scheme paves the way for realizing ultra-sensitive quantum enhanced sensors.

Y. Matsuzaki, S. Benjamin, S. Nakayama, S. Saito, and W. J. Munro, Phys. Rev. Lett. **120**, 140501 (2018).

NTT Fellow

The title of "NTT Fellow" is reserved for our most gifted scientist and engineers whose research and development activities have brought them significant distinction both within NTT and internationally. Our "Fellows" are extremely highly regarded. Next the title of "Senior Distinguished Researcher" is given to outstanding individuals who have established themselves as global intellectual leaders of their own research areas. The "Distinguished Researcher" title is given to innovative researchers whose impressive achievement has been recognized both within and outside NTT.
They all are responsible for leading innovative research and cutting-edge technical developments in research areas considered important to NTT.

December 31, 2018

Medicine, Physiology, Biomedical interface & data analysis

Shingo Tsukada

Research Subject

Biological Information Elucidation Using Advanced Medical Materials

Senior Distinguished Researcher

Nanophotonics Center Project Manager

Masaya Notomi

Research Subject

Photon Manipulation in Photonic Nanostructures

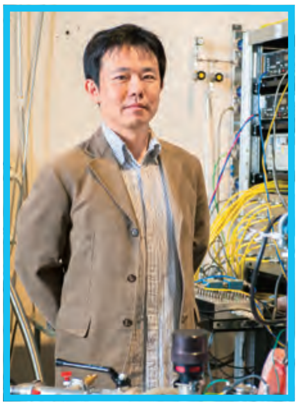
Quantum and Nano Device Research

Hiroshi Yamaguchi

Research Subject

Nano-mechanics in Semiconductors

Koji Muraki

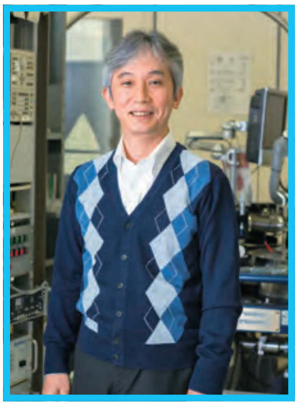


Research Subject

Electron Correlation in Semiconductor Nanostructures

Physical Science Laboratory Executive Manager

Akira Fujiwara

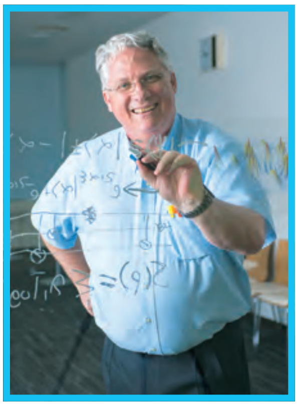


Research Subject

Ultimate Electronics Using Semiconductor Nanostructures

Research Center for Theoretical Quantum Physics Project Manager

William John Munro



Research Subject

The Design of Quantum Interfaces & Quantum Repeaters

Hiroki Takesue

Research Subject

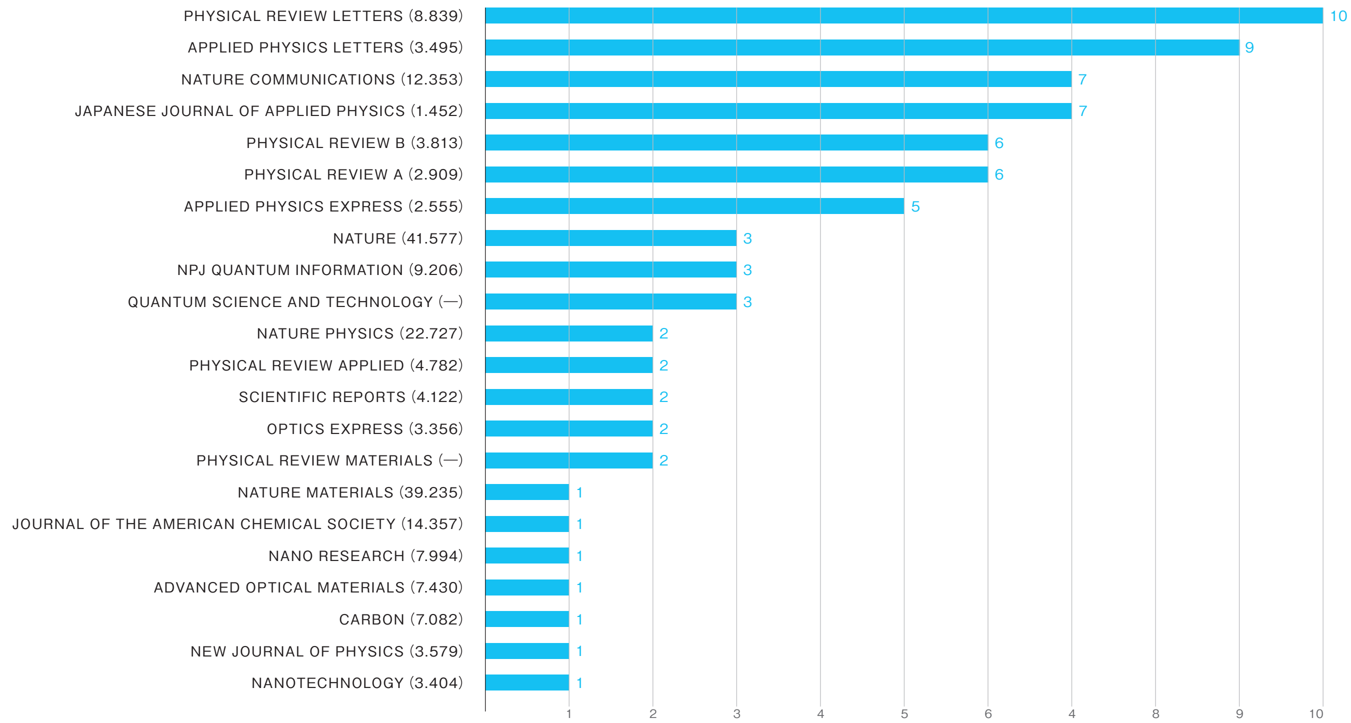
Quantum Communication Experiments in Telecommunication Band
Coherent Ising Machine

Distinguished Researcher

Norio Kumada, Shiro Saito, Haruki Sanada, Kengo Nozaki, Hiroki Mashiko, Katsuhiko Nishiguchi, Imran Mahboob, Kazuhide Kumakura, Koji Azuma, Yuko Ueno

Publication List

(　)…The average IF2017 for all research papers from NTT Basic Research Laboratories is 7.307
The number of papers published in international journals in 2018 is 95.



Number of Presentations

193
(60 Invited talks)

Number of Patents

46

List of Award Winners

IEEE Fellow
For Contributions to Silicon Single-electron Devices **Akira Fujiwara**

IEEE Distinguished Lecturer Award
Coherent Ising Machine: a Photonic Ising Model Solver Based on Degenerate Optical Parametric Oscillator Network **Hiroki Takesue**

International Symposium on Compound Semiconductors (ISCS) - Quantum Device Award -
For Leading Contributions to the Development of Compound Semiconductor Opto/Electromechanical Systems **Hiroshi Yamaguchi**

The Young Scientists' Prize, the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology
Petahertz Optical Drive with Wide-bandgap Semiconductor Characterized by Isolated Attosecond Pulse **Hiroki Mashiko**

The Young Scientists' Prize, the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology
Electron Dynamics in Quantum Hall Systems **Masayuki Hashisaka**

Nanotechnology Platform Japan, Major results of 2017
Charge Dynamics in Quantum Hall Edge Channels **Masayuki Hashisaka, Koji Muraki, Toshimasa Fujisawa**

Information Technology Standards Commission of Japan, Contribution Award for Standardization
Contribution to the Standardization **Toshimori Honjo**

The Institute of Electronics, Information and Communication Engineers (IEICE), Magazine Article Award
Development and Practical Application of a Functional Material "hitoe" that Enables Measurement of Biological Information by Simply Wearing
Nahoko Kasai, Takayuki Ogasawara, Hiroshi Nakashima, Shingo Tsukada

Encouragement award in the 42th laser society of Japan
Petahertz Electron Manipulation with Wide-bandgap Semiconductor **Hiroki Mashiko**

The Japan Society of Applied Physics, Young Scientist Presentation Award
Chemical Vapor Deposition Growth of Uniform Monolayer Hexagonal Boron Nitride **Wang Shengnan, Dearle Alice, Hibino Hiroki, Kumakura Kazuhide**

The Japan Society of Applied Physics, Young Scientist Presentation Award
Reconstruction of Micro-scale Tissues in Self-folded Micro-rolls
Tetsuhiko Teshima, Hiroshi Nakashima, Yuko Ueno, Satoshi Sasaki, Calum Henderson, Shingo Tsukada

The Japan Society of Applied Physics (JSAP) Young Scientist Presentation Award
Enhancement of Graphene Absorption in Plasmonic Waveguides with 30 x 20 nm^2 Core **Masaaki Ono**

The Japan Society of Applied Physics (JSAP) Young Scientist Presentation Award
Evanescent Coupling Between an Optical Microbottle and an Electromechanical Resonator **Motoki Asano**

The Japan Society of Applied Physics (JSAP) Poster Award
Neuronal Growth Control Using Chemical Modification of Nanopillars
Nahoko Kasai, Aya Tanaka, Tetsuhiko Teshima, Koji Sumitomo, Hiroshi Nakashima

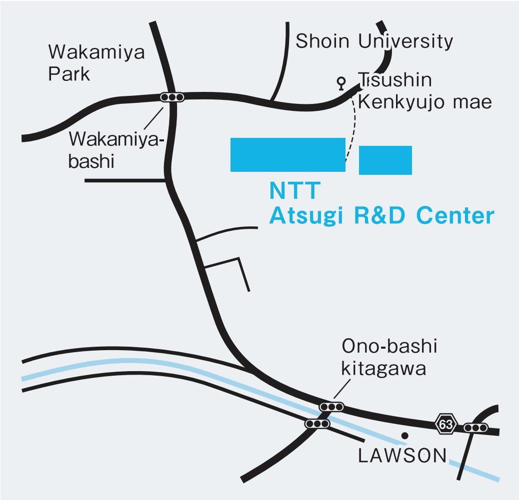
The Japan Society of Applied Physics (JSAP) Poster Award
Tuning of Plasmonic Reflection in Graphene by Carrier Density Modulation
Makoto Takamura, Norio Kumada, Shengnan Wang, Kazuhide Kumakura, Yoshitaka Taniyasu

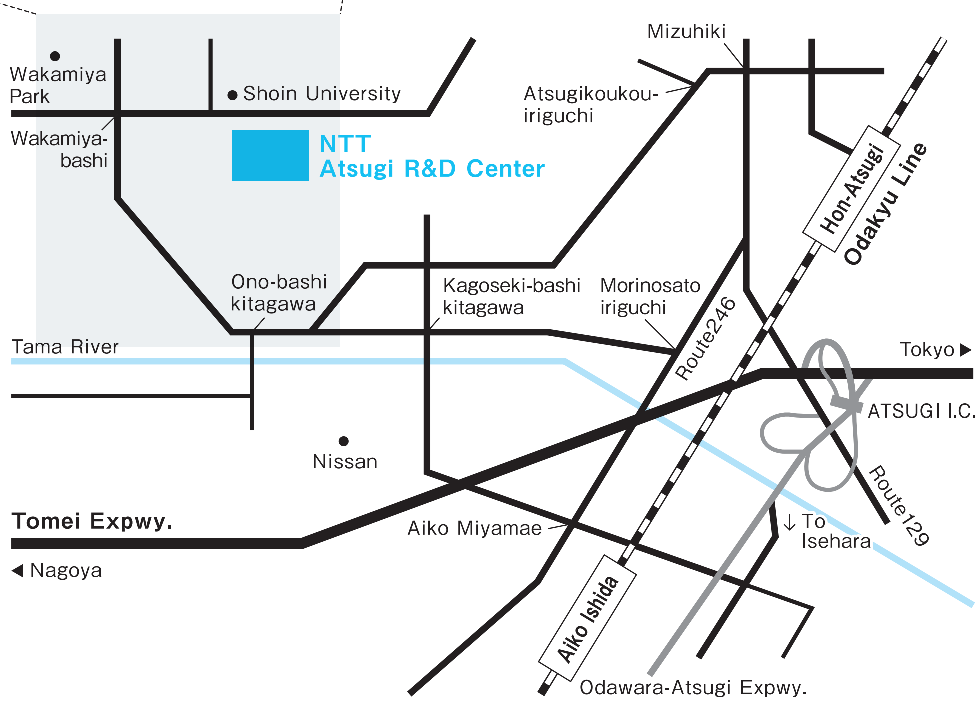
Society for Chemistry and Micro-Nano Systems (CHEMINAS) CHEMINAS Poster Award
Direction of Topological Defects in Cell Population by Computer-aided Design of Geometrical Boundaries
Hiroki Miyazako, Tetsuhiko Teshima, Yuko Ueno

Research Institute of Electrical Communication, Tohoku University, RIEC Award
Research on Advanced Quantum State Engineering of Single Photons for Quantum Information Technologies **Nobuyuki Matsuda**

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 Basic Research Laboratories

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