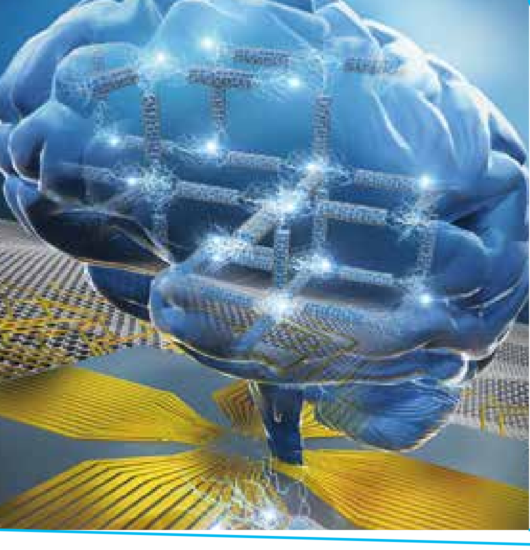


NTT Basic Research Laboratories

Annual Report 2023

NTT
BASIC
RESEARCH
LABORATORIES

Message from the Director

We at NTT Basic Research Laboratories (BRL) are extremely grateful for your interest and support in our research activities during the last year.

Our laboratories central mission is to promote breakthrough in science and innovations in leading-edge technology that can advance NTT's long-term business, overcoming current limitations in speed, size, and of course energy consumption.
To achieve this, our scientists & engineers in the fields of physics, chemistry, biology, mathematics, electronics, informatics, and medicine, conduct fundamental research in material, physical, and quantum science.

An "open door" management policy allows us to collaborate with many universities and research institutes from all over the world, as well as other laboratories within NTT, further enhancing our ability to achieve our missions. We have regularly organized international symposiums, seminars, and various type of workshops at our Atsugi R&D center to disseminate our research achievements and communicate with fellow scientists, engineers and the public.

All of these activities enable us to realize our "open door" policy and mission.
Your continued support would be highly appreciated.

Kazuhide Kumakura

Dr. Kazuhide Kumakura
Vice President, Head of NTT Basic Research Laboratories

Advisory Board

The NTT BRL Advisory Board, which was first convened in 2001, held its 12th meeting on February 2 - 3, 2023. 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.

NTT-BRL Seminar

We invite distinguished researchers in the world to hold an in-house seminar. This year, we had 23 seminars dedicated to our research field and shared latest research results with the guests.

Front image:

On-chip biological model

Technology to artificially reproduce advanced biological functions such as organs by culturing cells in vitro is attracting attention in a wide range of fields including cell biology, regenerative medicine, drug discovery, and food development. If we can create an on-chip biological model that can reproduce biological functions on a sensor chip, it will be possible to obtain multifaceted information at the cellular level, which is expected to lead to the construction of a "biodigital twin" that maps us on a digital space using the information. NTT Basic Research Laboratories has developed unique technologies for on-chip shape control of bio-friendly thin-film materials (graphene and hydrogel). These various platform technologies enable to construct on-chip biological models such as a brain model that can simulate and analyze the structure and function of brain neural networks when combined with neurons [upper left], and an intestine model that can perform peristalsis and segmental movement mimicking an intestinal tract by dynamically shape controlling the flow path structure [lower right]

Riku Takahashi (left)
Engaged in basic technology research using hydrogels composed of water and polymer networks
Koji Sakai (right)
Engaged in research on culture models of the nervous system based on electrode fabrication technology

Organization

NTT Basic Research Laboratories

Director
Kazuhide Kumakura

Research Planning Section

Executive Manager
Katsuya Oguri

Multidisciplinary Materials Design and Science Laboratory

Executive Manager
Hideki Yamamoto

P5

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

Advanced Applied Physical Science Laboratory

Executive Manager
Katsuya Oguri

P7

- Nanodevices Research Group
- Nanomechanics Research Group
- Quantum Optical Physics Research Group
- Photonic Nano-Structure Research Group

Quantum Science and Technology Laboratory

Executive Manager
Hiroki Takesue

P9

- Quantum Optical State Control Research Group
- Theoretical Quantum Physics Research Group
- Superconducting Quantum Circuits Research Group
- Quantum Solid State Physics Research Group

The population data of NTT-BRL members

- Researchers (Foreign Researchers)…94(6)
- Research Associate/Specialist…7
- Joint Researcher…17
- International Interns…11*
- Domestic Interns…7*
- Guest Researchers…1*

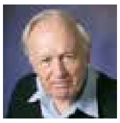
*…Jan. to Dec. 2023 total

As of Dec. 31, 2023

Advisory Board

Chalmers University of Technology, Sweden
Prof. Per Delsing

Max-Planck-Institut für Festkörperforschung, Germany
Prof. Klaus von Klitzing



University of Illinois at Urbana-Champaign,USA
Prof. Sir Anthony J. Leggett

Imperial College,UK
Prof. Sir Peter Knight

Université Pierre et Marie Curie,France
Prof. Elisabeth Giacobino

The University of Texas at Austin,USA
Prof. Allan MacDonald

Forschungszentrum Jülich, Germany
Prof. Andreas Offenhäusser

CEA Saclay, France
Prof. Christian Glattli

University of Twente, Netherlands
Prof. Dave H.A. Blank

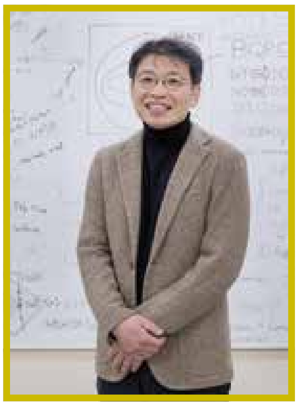
Nanophotonics Center

Project Manager
Masaya Notomi

P11

Research Center for Theoretical Quantum Information

Project Manager
Seiichiro Tani



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Bio-Medical Informatics Research Center

Project Manager
Hiroshi Nakashima

P11

Research Professors

Sakakibara Heart Institute, Advisor
Prof. Hitonobu Tomoike

Tohoku University
Prof. Masao Morita

University of Toyama
Prof. Kiyoshi Tamaki

Tohoku University, Professor Emeritus
Prof. Junsaku Nitta

Hiroshima University
Prof. Hideki Gotoh

Multidisciplinary Materials Design and Science Laboratory

Overview

The aim of the Multidisciplinary Materials Design and Science Laboratory is to contribute to progress in materials science and to revolutionize information communication technology by creating novel materials with various internal degrees of freedom (lattice, charge, spin, orbital, etc.) through materials design and synthesis beyond conventional concepts of classifications, dimensions, scales, and synthesis methods. The research groups that constitute this laboratory are investigating a wide range of materials including semiconductors, superconductors, magnetic materials, topological materials, conductive polymers, and biological soft materials. We are conducting innovative materials research based on advanced thin-film growth technologies, high-precision and high-resolution measurements of structures, properties along with theoretical studies, and data science (informatics).

Groups and Research Themes

Thin-Film Materials Research Group

Novel Semiconductor Devices

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

Low-Dimensional Nanomaterials Research Group

2D atomic-layer Materials

Creation of ultimately thin functional atomic-layer materials for next-generation electronics

Complex Oxide Thin Films

Creation of trailblazing superconductors and magnetic materials beyond conventional concepts

Molecular and Bio Science Research Group

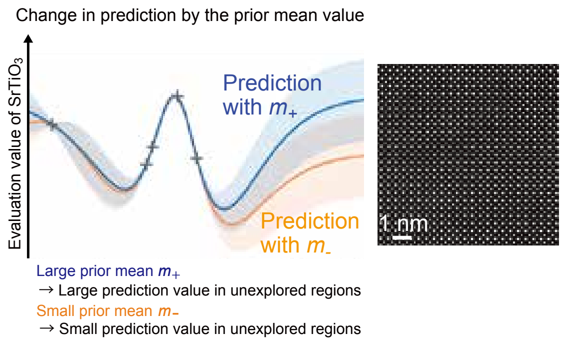
Biocompatible Electrode Materials

Development and application of bioelectrode materials for measurement of deep biological information

Bio-devices

Creation of bio-functional mimetic devices exploiting biomolecules, cells, and soft materials

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.

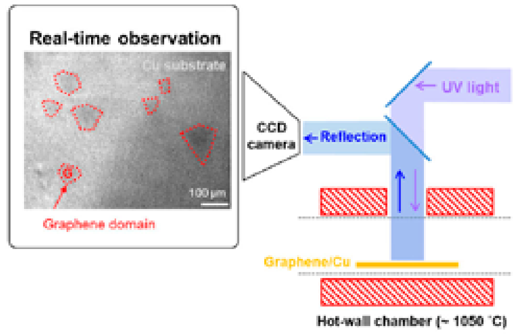


(Left) Change in prediction due to the prior mean value
(Right) Electron microscopy image of a stoichiometric $SrTiO_3$ thin film

Stoichiometric Growth of $SrTiO_3$ Films via Bayesian Optimization with Adaptive Prior Mean

To efficiently optimize the growth parameters for synthesizing thin oxide films, we developed a new method based on a statistical machine learning technique called Bayesian optimization (BO). We then used it to synthesize high-quality thin films of $SrTiO_3$, a candidate material for next-generation high-*k* capacitors and photocatalysts. Whereas conventional BO has a problem of focusing too much on searching within a certain region that shows good evaluation values rather than around the global optimal region of the evaluation value, the new BO method encourages exploration of a larger area by adapting the prior mean of the prediction model to escape from the local optimal region.

Y. K. Wakabayashi, T. Otsuka, et. al., APL Mach. Learn. 1, 026104 (2023).
Y. K. Wakabayashi, T. Otsuka, et. al., APL Mater. 7, 101114 (2019).

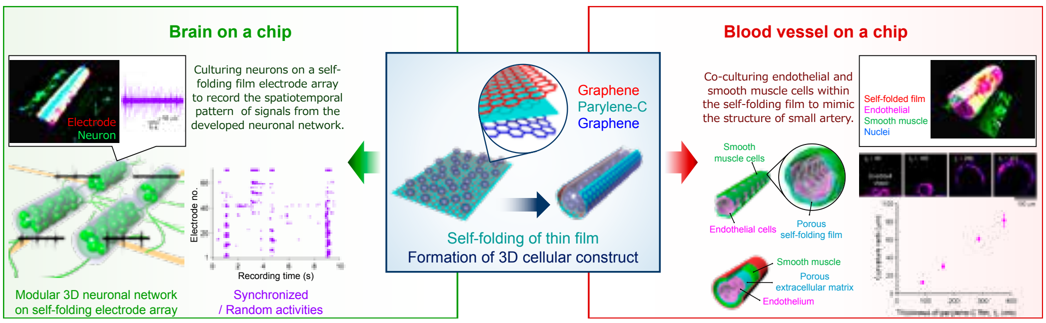


Schematic illustration of real-time optical observation system for thermal CVD (right) and optical reflection micrograph of graphene on Cu substrate (left).

Real-time Observation of Graphene CVD Growth Using Ultraviolet Reflection

Two-dimensional (2D) materials such as graphene are promising for the next generation of devices. Here, we performed a real-time observation of graphene growth on a Cu substrate by using ultraviolet (UV) reflection during the chemical vapor deposition (CVD) process. This observation method improves the controllability and reproducibility of the growth process of high-quality 2D materials and thereby will foster their device applications.

Y. Ogawa, T. Tawara, and Y. Taniyasu, ACS Appl. Nano Mater. 6, 21405 (2023).



(Upper left) Staining image of encapsulated 3D neuronal aggregate and representative recorded neuronal signal
(Lower left) Schematic images of self-folding electrode array and modular 3D neuronal network
(Lower right) Activity patterns recorded from modular 3D neuronal network

(Left) Schematic images of artery-mimicking cell culture using cell encapsulation method
(Upper right) Staining image of co-cultured vascular endothelial and smooth muscle cells
(Lower right) Control of curvature radius of tubular tissue by adjusting film thickness

Self-folding Electrode Array for Recording from a Modular 3D Neuronal Network

We previously studied a self-folding graphene-based electrode that can encapsulate living neurons within a folded structure. In this study, we developed a self-folding electrode array that allows for simultaneous formation of neuronal 3D aggregate inside each folded electrode and enables us to record neuronal activities from a neuronal network consisting of interconnected aggregates. We also demonstrated that the brain-like structural features, including three-dimensionality and modularity, of this neuronal network affect a variety of activity patterns with a mixture of synchronized and random activities.

K. Sakai, T. F. Teshima, T. Goto, H. Nakashima and M. Yamaguchi, Adv. Funct. Mater. 33, 2301836 (2023).

Small-artery-mimicking Cell Culture Using Porous Self-folding Film

We encapsulated vascular cells within a self-folding porous film to form a tubular vessel-like cellular construct. To mimic the structural features of small arteries that important in vascular pathology, we formed a 10-micrometer-scale tubular construct by utilizing the curvature tunability of self-folding film while co-culturing endothelial cells that uptake nutrients from blood and smooth muscle cells that generate driving force for vasoconstriction. The porous film emulates the extracellular matrix between endothelial and smooth muscle cells and reproduces the microenvironment of small arteries in which their cellular interaction is modulated by pores.

K. Sakai, S. Miura, T. F. Teshima, T. Goto, S. Takeuchi and M. Yamaguchi, Nanoscale Horiz. 8, 1529 (2023).

Advanced Applied Physical Science Laboratory

Overview

The Advanced Applied Physical Science Laboratory has launched towards the creation of innovative information communication technologies and future functional devices that bring long-term value for the accelerating technology-driven society. Leading research groups in the fields of nanoelectronics, nanomechanics, nanophotonics, spintronics, and quantum electronics are closely collaborating for this exciting challenge. We will pioneer the forefront of the applied physical science field and discover novel functionalities in solid-state quantum systems based on our nanofabrication technology, advanced measurement technology, and light-wave technology.

Groups and Research Themes

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

Quantum Optical Physics Research Group

Manipulation of Ultrafast and Ultra-stable Laser Field

Ultrafast physics investigated by attosecond spectroscopy, Optical-lattice clock network

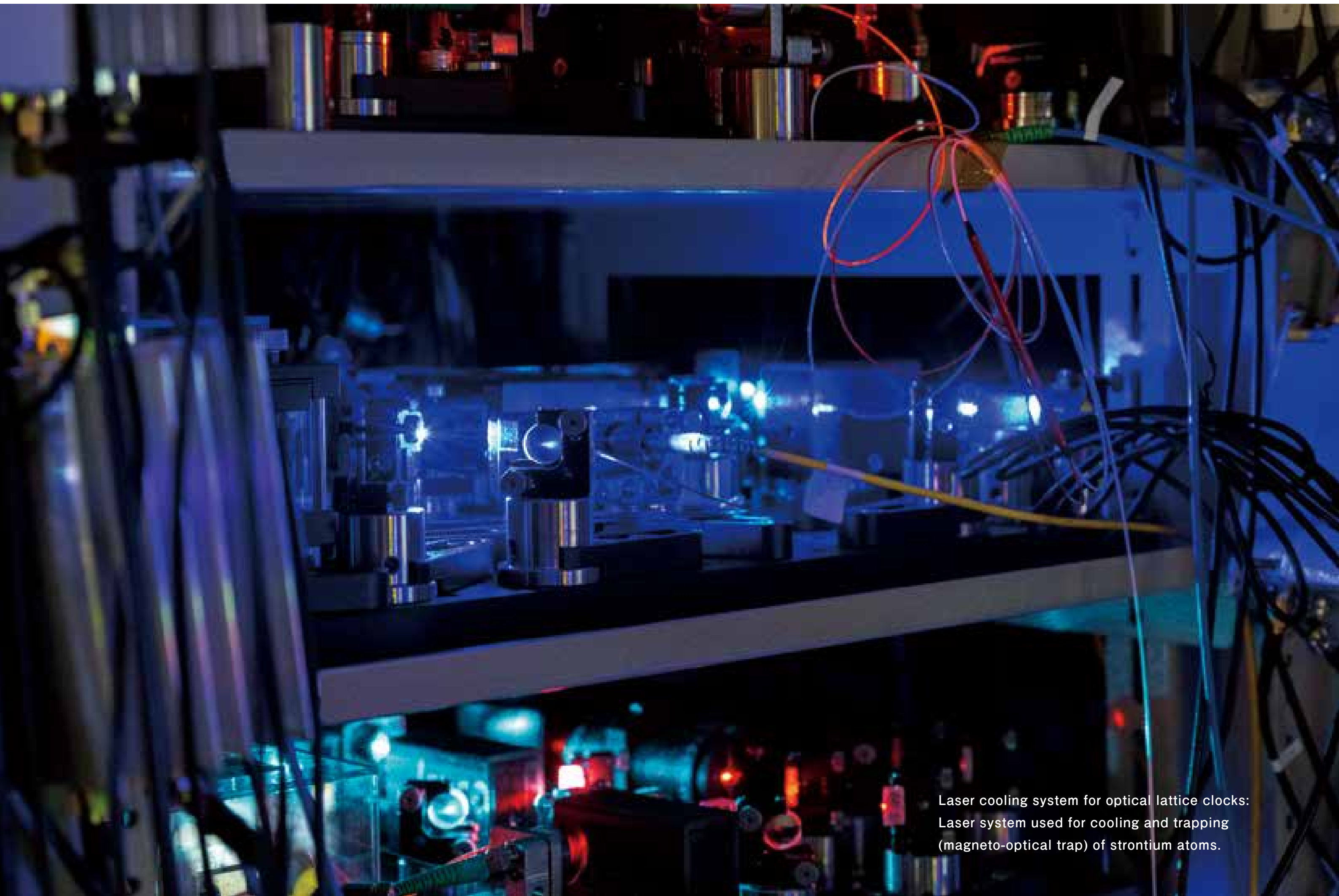
Nano-scale Physics in Optically-active Materials

Physics related to photons, excitons, and spins, in semiconductor nanostructures and rare-earth oxides

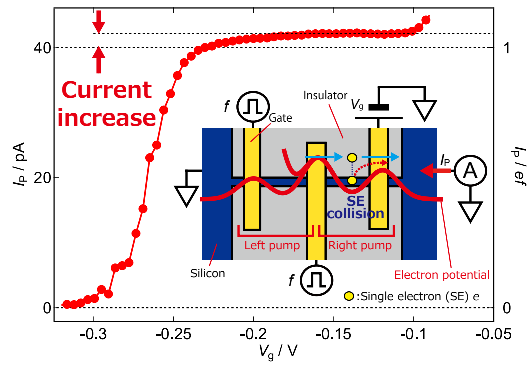
Photonic Nano-Structure Research Group

Integrated Nanophotonics Technologies

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



Laser cooling system for optical lattice clocks: Laser system used for cooling and trapping (magneto-optical trap) of strontium atoms.

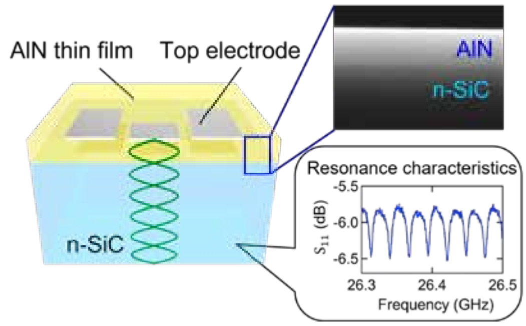


Pump current during single-electron collisions. The current exceeded the current generated from the left pump (elementary charge *e* × clock frequency *f*). Inset: Schematic diagram of the device and part of the electrical measurement system.

Coulomb Collisions of Single Electrons in Series-coupled Silicon Single-electron Pumps

Investigation of the Coulomb interaction between single electrons in a silicon single-electron pump, which can transfer single electrons accurately, is important for improvement of the transfer accuracy and for the quantum manipulation of single electrons, but so far there have been no observations of this interaction. Here, we connected two silicon single-electron pumps in series and collided a single electron emitted from the left pump with a single electron trapped in the right pump. As a result, the current increase due to the single-electron emission in the right pump due to the Coulomb interaction during the collision could be observed. This is the first observation of the Coulomb interaction in a silicon single-electron pump and is an important insight for developing electric standards and quantum devices.

G. Yamahata, N. Johnson, and A. Fujiwara, Physical Review Applied 20, 044043 (2023).

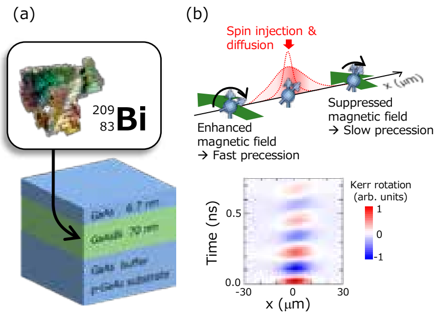


Schematic of the acoustic-impedance matched GHz acoustic device (left). Cross-sectional SEM image (upper right) and resonance characteristics (lower right) of the device.

Title: Realization of an Impedance-matched GHz Acoustic Device

Aluminum nitride (AlN) has a high speed of sound and piezoelectricity and is used in acoustic devices such as high-frequency filters. AlN acoustic devices that use bulk acoustic waves consist of an AlN thin film sandwiched by metal top and bottom electrodes grown on a crystal substrate. However, an acoustic-impedance mismatch due to the insertion of metal layers has been a problem with these devices. In this study, we developed a high-quality and impedance-matched acoustic device operating in the GHz range by directly growing AlN thin film on a conductive SiC substrate acting as a bottom electrode.

M. Kurosu, D. Hatanaka, R. Ohta, H. Yamaguchi, Y. Taniyasu, and H. Okamoto, Appl. Phys. Lett. 122, 122201 (2023).

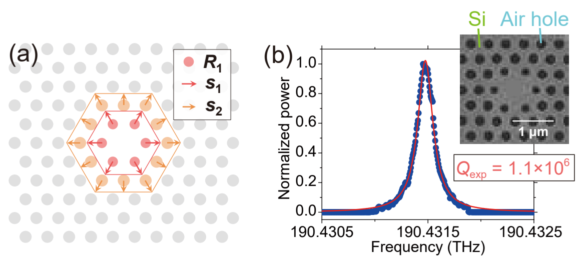


(a) Schematic structure of sample in which Bi atoms are incorporated in GaAs
(b) Spatiotemporal mapping of the magneto-optical Kerr effect. The spin precession frequency, which appears as red and blue oscillations, changes with the probe position *x*, as a result of the enhanced spin-orbit interaction.

Enhancement of Spin Manipulation Efficiency by Incorporation of Bismuth Atoms into Gallium Arsenide

The incorporation of a small amount of bismuth (Bi) atoms into gallium arsenide (GaAs) enhances the spin-orbit interaction, which is known to produce a non-real (effective) magnetic field that is experienced by the electrons moving in an electric field. This phenomenon is due to the strong local electric field generated by the heavy bismuth atoms at the interface between the GaAs and GaAsBi layers. Such an effective strong magnetic field generated by the spin-orbit interaction enables us to manipulate spins more quickly in smaller areas, creating a new avenue for developing spintronics with highly efficient control of spins.

Y. Kunihashi, Y. Shinohara, S. Hasegawa, H. Nishinaka, M. Yoshimoto, K. Oguri, H. Gotoh, M. Kohda, J. Nitta, and H. Sanada, Appl. Phys. Lett. 122, 182402 (2023).



(a)Schematic design of single-point-defect PCN. The cavity Q factor is optimized by varying the radii R1 of the holes nearest to the defect and two hole-layer shift parameters (s_1, s_2).
(b)Device image and optical transmission spectrum of our cavity samples. By calculating the ratio of the measured peak frequency and linewidth, the Q factor was estimated to be 1.1×10^6.

Ultrahigh-Q Single-point-defect Photonic Crystal Nanocavity

A small single-point-defect photonic crystal nanocavity (PCN) is suitable for composing large-scale arrays in various forms. However, its light confinement capability has been weaker than those of other PCNs. By controlling the radii of the air holes closest to the defect and the radial shift of the two hole layers around the defect, we have improved its theoretical cavity quality (Q) factor to 4.5×10^8, which is two orders of magnitude larger than the previous record value. It is still considered in principle infeasible to obtain such an extremely high Q value for PCNs in an experiment. Nonetheless, our samples had Q factors over one million (termed the ultrahigh-Q level), unprecedented values for this type of PCN. These results suggest that our PCNs have potential for device applications.

K. Takata, E. Kuramochi, A. Shinya, and M. Notomi, Opt. Express 31, 11864 (2023).

Quantum Science and Technology Laboratory

Overview

The Quantum Science and Technology Laboratory will contribute to the exploration of the quantum science field and the development of new technologies for overcoming the conventional information processing limits with quantum-enabled devices and systems. With quantum information theory and our experimental research in photonic, semiconductor, and superconducting systems as a basis, we aim to achieve new technologies in the areas of quantum communication, quantum sensing, optical oscillator-based computing, and quantum computing based on superconducting circuits and topological phenomena.

Groups and Research Themes

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.

Superconducting Quantum Circuits Research Group

Superconducting Quantum Circuits

Manipulating quantum states using superconducting devices

Ultimate Quantum Measurement and Sensing

Highly sensitive measurement technologies using quantum mechanical effects

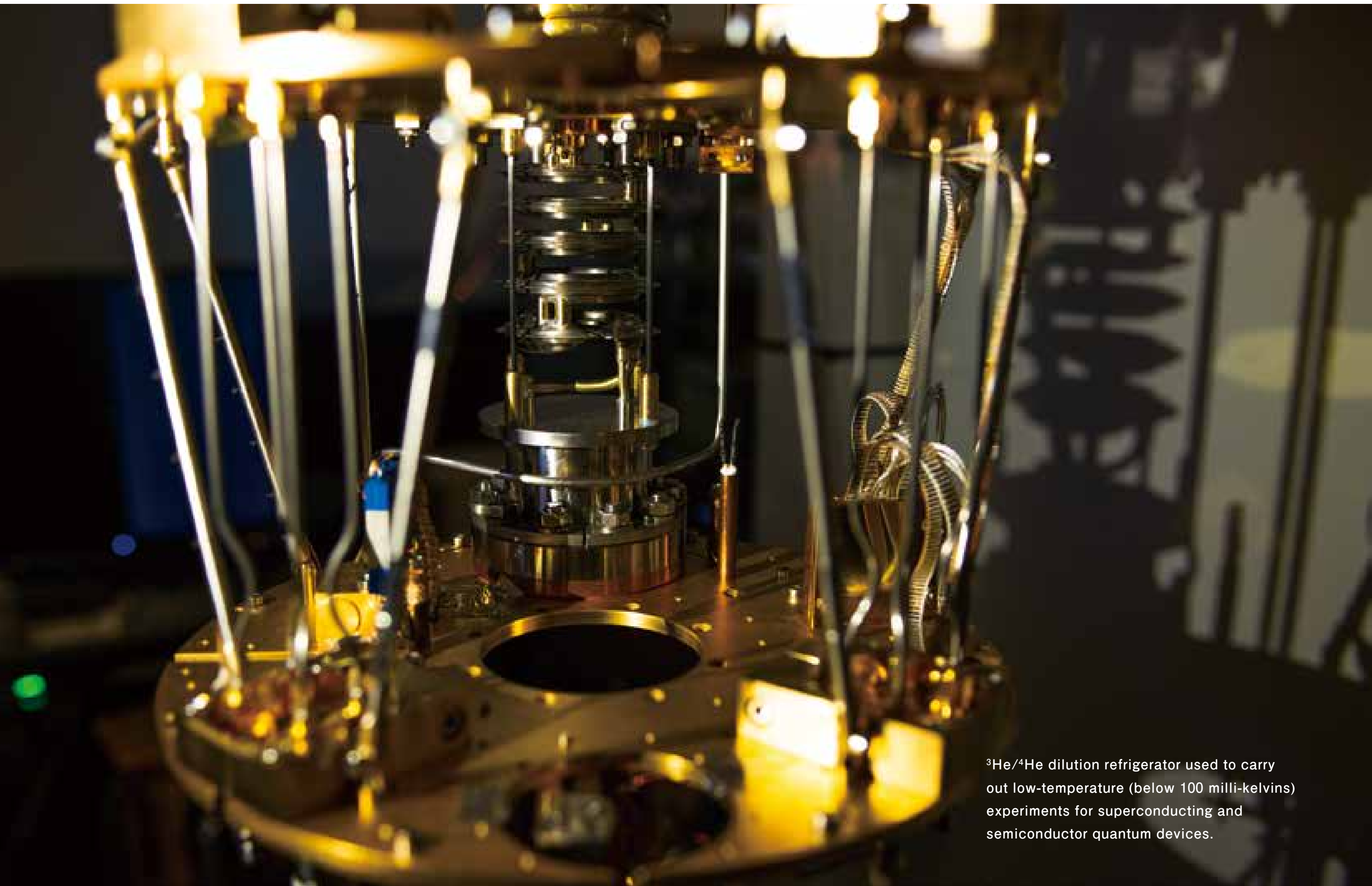
Quantum Solid State Physics Group

Quantum Transport in Hetero- and Nano-structures based on Semiconductor and 2D Materials

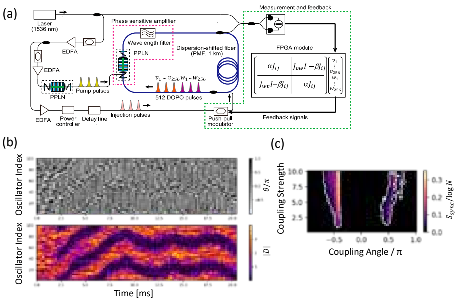
Unconventional charge and spin transport phenomena in quantum devices

Fast Coherent Carrier Dynamics in Electronic Devices

Information processing with coherent electron motion



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

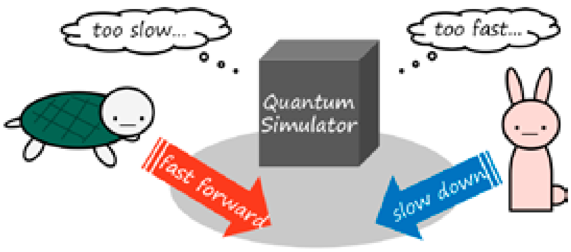


(a) Schematic diagram of photonic neuromorphic oscillators coupled by measurement-feedback.
(b) Experimental results on (upper) time evolution of rotational phase θ of each neuron and (lower) local curvature of the phase $|D|$ in a chimera state.
(c) Theoretical phase diagram of partial synchronization in a complex oscillatory network.

Creating and Detecting Chimera States in Optical Oscillator Networks

The chimera state, a phenomenon where synchrony and asynchrony coexist in an oscillatory system, has attracted much attention from researcher because of its relation to the complex oscillatory dynamics in brain neuronal networks. Here, we made coupled photonic neuromorphic oscillators that emulate certain functionalities of brain neurons and generated a chimera state accompanying spontaneous changes in the functionality of each optical neuron. Furthermore, we developed a data-driven method to detect chimeras hidden in complex oscillatory data by regarding asynchronies as being analogous to vortices. Our results will pave the way for developing an experimental and theoretical platform to study brain function, brain diseases, and neuromorphic information processing.

T. Makinwa, K. Inaba, T. Inagaki, Y. Yamada, T. Leleu, T. Honjo, T. Ikuta, K. Enbutsu, T. Umeki, R. Kasahara, K. Aihara, and H. Takesue, Commun. Phys. 6, 121 (2023).
Y. Yamada and K. Inaba, Phys. Rev. E 108, 024307 (2023), Featured in Physics.

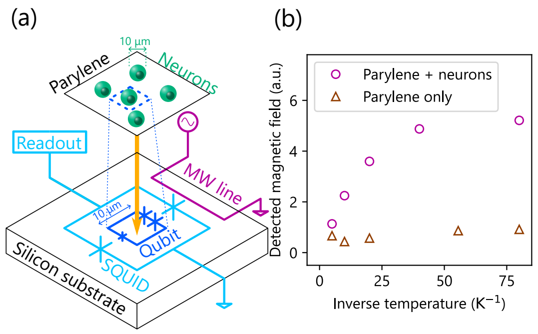


Quantum simulators have limitations on their simulatable timescale, but we can simulate slow dynamics by fast-forwarding it and simulate fast dynamics by slowing it down.

Time Rescaling of Nonadiabatic Transitions

Quantum simulation is a promising technology that enables us to simulate large quantum systems. However, real quantum simulators have limitations on their simulatable timescale. So far, researchers have not been able to simulate slow dynamics because of the short coherence time or fast dynamics because of a lack of a means to control the speed. Here, with the goal of improving the usability of quantum simulators, we developed a method to fast-forward and slow down the dynamics of interest.

T. Hatomura, SciPost Phys. 15, 036 (2023).

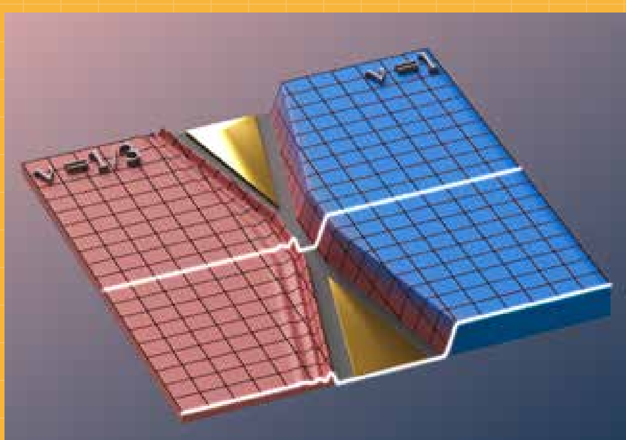


(a) Overview of magnetometry system using a superconducting flux qubit for measuring electron spins in biomaterials.
(b) Temperature dependence of the magnetic field generated by ferric ions in neurons and in a reference sample.
The figures were created by modifying the original paper under CC BY 4.0.

Electron Spin Detection in Biomaterials by Using a Superconducting Flux Qubit

We detected ferric ions in neurons with a spatial resolution at the single-cell level by using a superconducting flux qubit as a sensitive magnetometer. This method can also be used in quantitative analysis, as the detected signal intensity is directly related to the number of electrons of the ions in the sample. In addition, we identified the species or valence of ions by using electron spin resonance spectroscopy. This method paves the way for imaging distributions of atoms in tissues at the single-cell level.

H. Toida, K. Sakai, T.F. Teshima, M. Hori, K. Kakuyanagi, I. Mahboob, Y. Ono, and S. Saito, Commun. Phys. 6, 19 (2023).



Fractional-integer quantum Hall junction

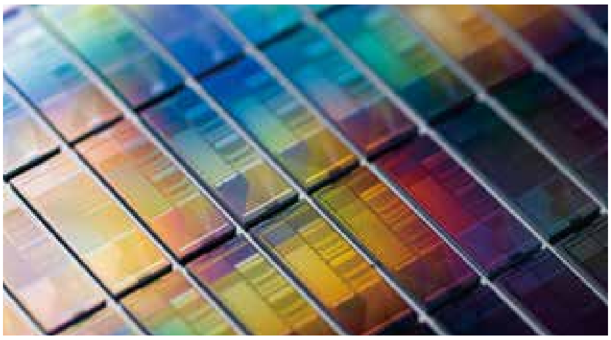
Charge-neutral-mode Transport in Fractional Quantum Hall Edge State

Edge transport in topological systems has potential applications in quantum information processing and in novel devices because of its robustness to perturbations. In particular, researchers are interested in fractional quantum Hall states owing to the presence of fractionally charged quasiparticles. Here, we demonstrated the emergence of a charge-neutral mode in systems with strongly coupled $\nu = 1/3$ fractional and $\nu = 1$ integer edge channels. Our study provides fundamental knowledge for understanding quantum transport in various topological systems.

M. Hashisaka, T. Ito, T. Akiho, S. Sasaki, N. Kumada, N. Shibata, and K. Muraki, Phys. Rev. X 13, 031024 (2023).

Nanophotonics Center

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.

Research Themes

- **Extreme enhancement of light-matter interactions by using photonic crystals and plasmonics**
- **Integrable nanophotonic devices with extremely small energy consumption**
- **Novel optical platforms using nanomaterials and nanophotonics**
- **Nanophotonic computations with photonics-electronics convergence**

Research Center for Theoretical Quantum Information

Research Center for Theoretical Quantum Information

Overview

The research center was established in October 2023 by expansively reorganizing the Research Center for Theoretical Quantum Physics, in order to further strengthen the theoretical research on quantum information science by facilitating interdisciplinary collaboration among researchers in diverse layers in the realm of quantum information. We are aiming to become a "compass" of quantum information that points to the correct direction in which the progress of quantum information technology, ranging from hardware to middleware and applications, should head by describing the future of information technology.

Research Themes

- **Cryptographic techniques using quantum information, post-quantum cryptography**
- **Quantum algorithms and quantum communication protocols**
- **Quantum computer architecture, fault-tolerant quantum computer technologies, quantum repeaters**
- **Theoretical physics aimed at quantum information processing**

Bio-Medical Informatics Research Center

Bio-Medical Informatics Research Center

Overview

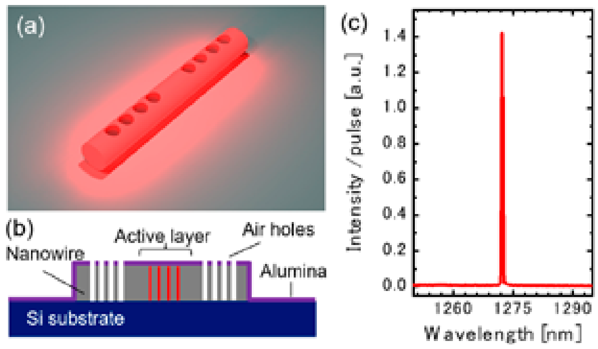
The Bio-Medical Informatics Research Center (BMC) was established in July, 2019 as a research organization in which related NTT laboratories collaborate with the goal of creating data-driven medicine using ICT and AI. The BMC engages in basic and applied research on AI analysis of medical and health data, genome information and behavior information, real-time biomonitoring in daily life, biomimetic nanodevices, and new biocompatible materials. In addition, it promotes innovations in medical and health fields in cooperation with partners at medical institutes and Medical & Health Informatics Laboratories (MEI Lab), NTT Research Inc.

Research Themes

- **Personalized medicine by AI analysis of personal medical data (precision medicine)**
- **Cardiac modeling and rehabilitation activities supported by AI-tele stethoscope and hitoe® ECG measurement**
- **Lifestyle-related disease management based on noninvasive blood glucose sensor and core body temperature sensor**
- **Fabrication of implant materials and artificial neural networks that complement biological functions**

Nanostructure-implemented Semiconductor Nanowire Lasers

Nanowire (NW) lasers are promising devices that can be integrated into optical circuits. However, room-temperature continuous operation of NW lasers has not been demonstrated yet as the injected carriers cause heating problems. It is necessary to incorporate a cavity structure in the NW to improve the optical confinement and reduce the lasing threshold. Here, we established a technique to directly implement a nanocavity on a NW by using a focused ion beam (FIB). Damage to the active layer caused by FIB Ga ions was a critical issue, but we succeeded in suppressing the damage by forming an alumina film as a hard mask.

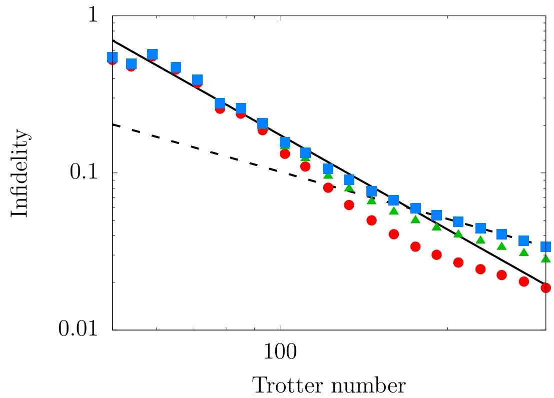


(a)Nanostructure-implemented nanowire laser
(b) Cross-sectional view of the nanowire
(c) Lasing spectrum

M. Takiguchi, G. Zhang, S. Sasaki, K. Tateno, C. John, M. Ono, H. Sumikura, A. Shinya, and M. Notomi, Nanotechnology 34, 135301 (2023).

Scaling of Errors in Digitized Counterdiabatic Driving

Counterdiabatic driving is a method of obtaining an adiabatic state without requiring adiabatic conditions. It is a potential means of overcoming a drawback of quantum adiabatic algorithms. A digital implementation of counterdiabatic driving was recently reported. We found that digitization errors of counterdiabatic driving show better scaling than the conventional expectation. Our findings enhance the usefulness of digitized counterdiabatic driving.

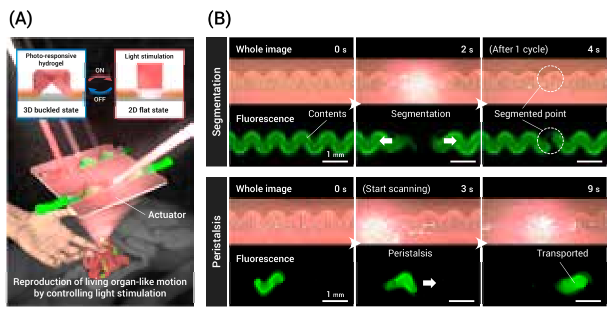


Amount of digitization errors versus number of digitization steps. Better scaling (solid line) than conventional expectation (dashed line) appears for small numbers of steps.

T. Hatomura, New J. Phys. 25, 103025 (2023).

Biomorphic Actuation with Light-driven On-chip Hydrogel Actuators

Actuators using photoresponsive hydrogel can be used to smooth the movements of devices made of soft materials in a way that mimics living organisms. The challenge has been to increase the response speed and displacement. In this study, we fabricated an actuator with performance comparable to that of a living organ. The actuator has a thin and porous design that increases the response speed and an on-chip buckling mechanism that amplifies the displacement. With a luminal structure that closely resembles living organs, this actuator is capable of complex motions (segmentation and peristalsis) similar to those of the intestinal tract. We believe that this development will contribute to the creation of organ chips.



(A) Schematic illustration of behavior of light-driven on-chip hydrogel actuator
(B) Demonstration of segmental movement (upper) and peristaltic movement (lower) controlled by light stimulation

R. Takahashi, A. Tanaka, and M. Yamaguchi, Adv. Funct. Mater. 33, 2300184 (2023).

NTT Fellow

December 31, 2023

Shingo Tsukada

Research Subject

Medicine, Physiology, Biomedical Interface & Data Analysis

Hiroshi Yamaguchi

Research Subject

Nano-mechanics in Semiconductors

Masaya Notomi

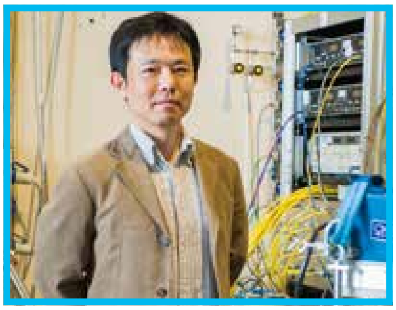
Nanophotonics Center Project Manager

Research Subject

Photon Manipulation in Photonic Nanostructures

Senior Distinguished Researcher

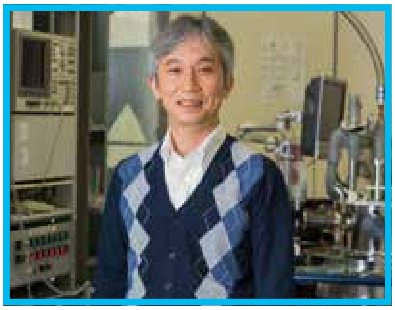
Koji Muraki



Research Subject

Electron Correlation in Semiconductor Nanostructures

Akira Fujiwara

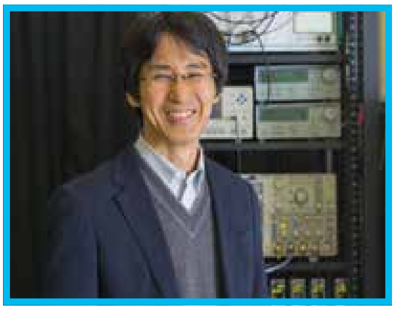


Research Subject

Ultimate Electronics Using Semiconductor Nanostructures

Hiroki Takesue

Quantum Science and Technology Laboratory Executive Manager



Research Subject

Quantum Communication Experiments in Telecommunication Band
Coherent Ising Machine

Hideki Yamamoto

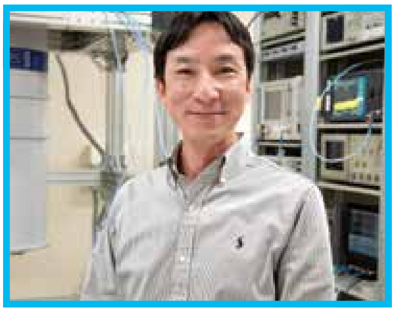
Multidisciplinary Materials Design and Science Laboratory Executive Manager

Research Subject

Design and Thin-film Synthesis of Novel Superconductors and Magnetic Materials with Elucidation of the Underlying Physics

Shiro Saito

Quantum Optical Physics Research Group Leader

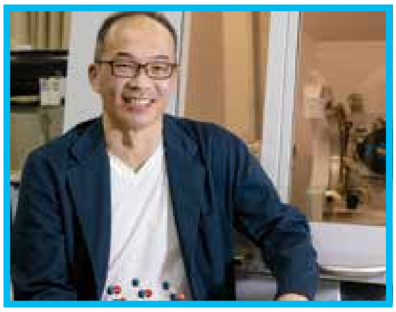


Research Subject

Quantum Information Technologies Based on Superconducting Quantum Circuits

Yoshitaka Taniyasu

Thin-Film Materials Research Group Leader
Low-Dimensional Nanomaterials Research Group Leader



Research Subject

Research on Functional Materials for Green Innovation

Distinguished Researcher

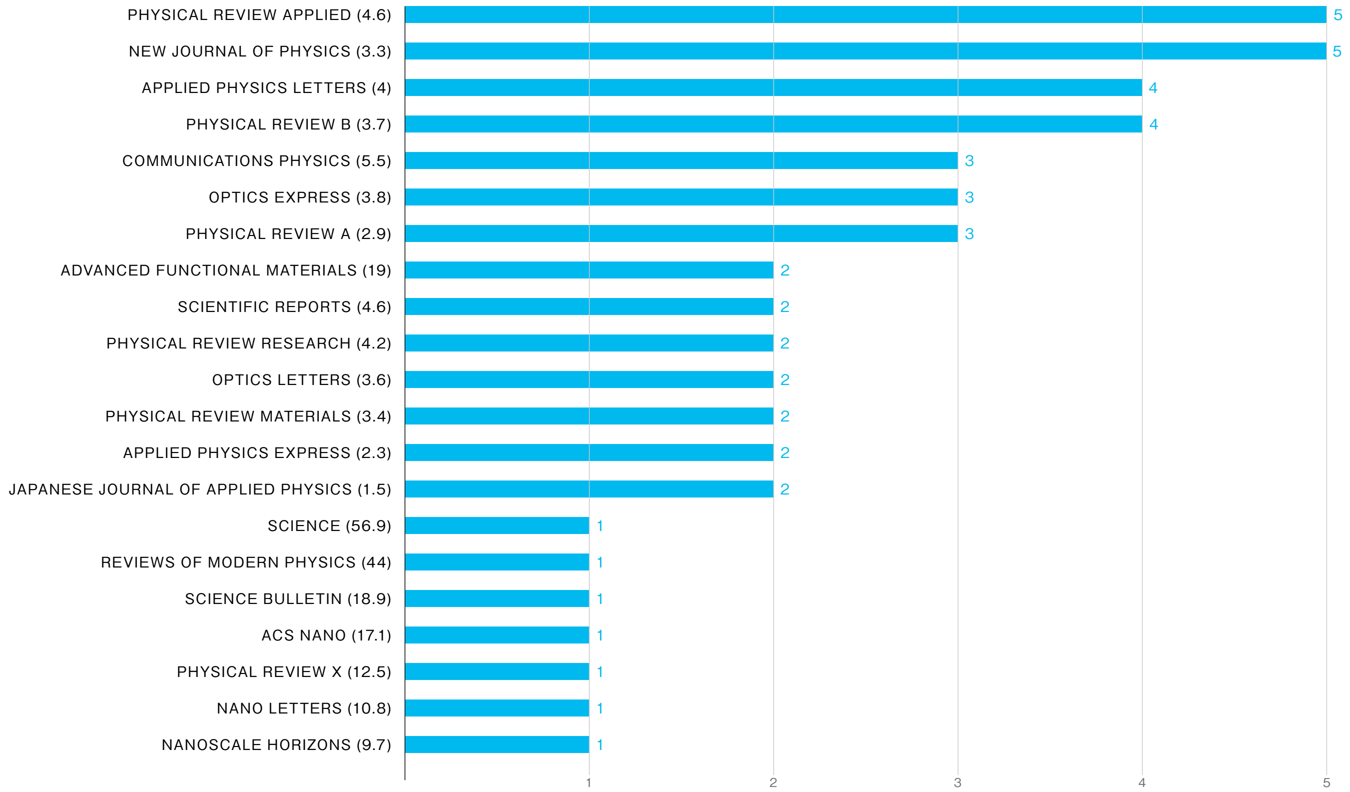
Norio Kumada
Katsuhiko Nishiguchi
Imran Mahboob
Haruki Sanada
Koji Azuma
Takahiro Inagaki
Gento Yamahata
Hajime Okamoto

Associate Distinguished Researcher

Yuki K. Wakabayashi

Publication List

The total number of NTT Basic Research Laboratories papers published in international journals in 2023 is 69 with an average impact factor of 6.259. The 2022 impact factor of those individual journals are shown in ( ).



Number of Presentations

138
(39 Invited talks)

Number of Patents

50

List of Award Winners

Support Center for Advanced Telecommunications Technology Research (SCAT) Chairman Award, 2022.

Research and Development of Quantum Key Distribution Over Optical Fiber **Toshimori Honjo**

Electronics Society Activity Testimonial

Contribution as a Co-chair of the 12th QIT Steering Committee **Koji Azuma**

The Young Scientist Award for an Excellent Article

"Designing Superlattices of Cuprates and Ferrites for Superconductivity" ACS Applied Electronic Materials, 4 (2022) 2672 **Ai Ikeda**

The 53rd Young Scientist Presentation Award at The Japan Society of Applied Physics

MHz-repetition-rate Generation of 1.7-cycle Intense Pulses Using an 80W Yb:KGW Laser
Takuya Okamoto

High Performance Computing Infrastructure Consortium, 2023 HPCI Software Awards [Development Category Award] Encouragement Award

SALMON (Scalable Ab-initio Light-Matter simulator for Optics and Nanoscience)
Shunsuke Yamada, Yuta Hirokawa, Kenji Iida, Jun-ichi Iwata, Shinji Noda, Tomohito Otobe, Shunsuke Sato, Yasushi Shinohara, Takashi Takeuchi, Mizuki Tani, Mitsuharu Uemoto, Kazuhiro Yabana, Atsushi Yamada

JSAP Fellow

Exploration of Novel Properties of Photonic Crystals and Application to Integrated Nanophotonics **Masaya Notomi**

The 70th Spring Meeting of the Japan Society of Applied Physics Young Researcher Best Presentation Award

Biomimetic Actuation Leveraging on-chip Buckling Deformation of Photoresponsive Gels **Riku Takahashi**

Young Scientist Award of the Physical Society of Japan

Pioneering Terahertz Spectroscopy Techniques for Investigating Ultrafast Local and Nonlocal Responses **Katsumasa Yoshioka**

The Japan Society of Mechanical Engineers, Sports and Human Dynamics Division, Excellent Presentation Audience Award

Score Prediction Using Postural Tremor During Aiming in Archery **Takayuki Ogasawara**

35th International Microprocesses and Nanotechnology Conference (MNC 2022) Most Impressive Presentation Award

Room-temperature Single-electron Sensor for AC Signals beyond an RC Time Constant ～ Energy Transfer via a non-leakage DRAM in non-equilibrium ～
Katsuhiko Nishiguchi, Akira Fujiwara, Kensaku Chida

35th International Microprocesses and Nanotechnology Conference (MNC 2022) Most Impressive Poster

High-overtone Bulk Acoustic Resonator with Epitaxial AlN Layer Grown on n-SiC
Megumi Kurosu, Daiki Hatanaka, Ryuichi Ohta, Keiko Takase, Hiroshi Yamaguchi, Yoshitaka Taniyasu, Hajime Okamoto

IOP Trusted Reviewer Status

Takuya Hatomura

NTT Basic Research Laboratories

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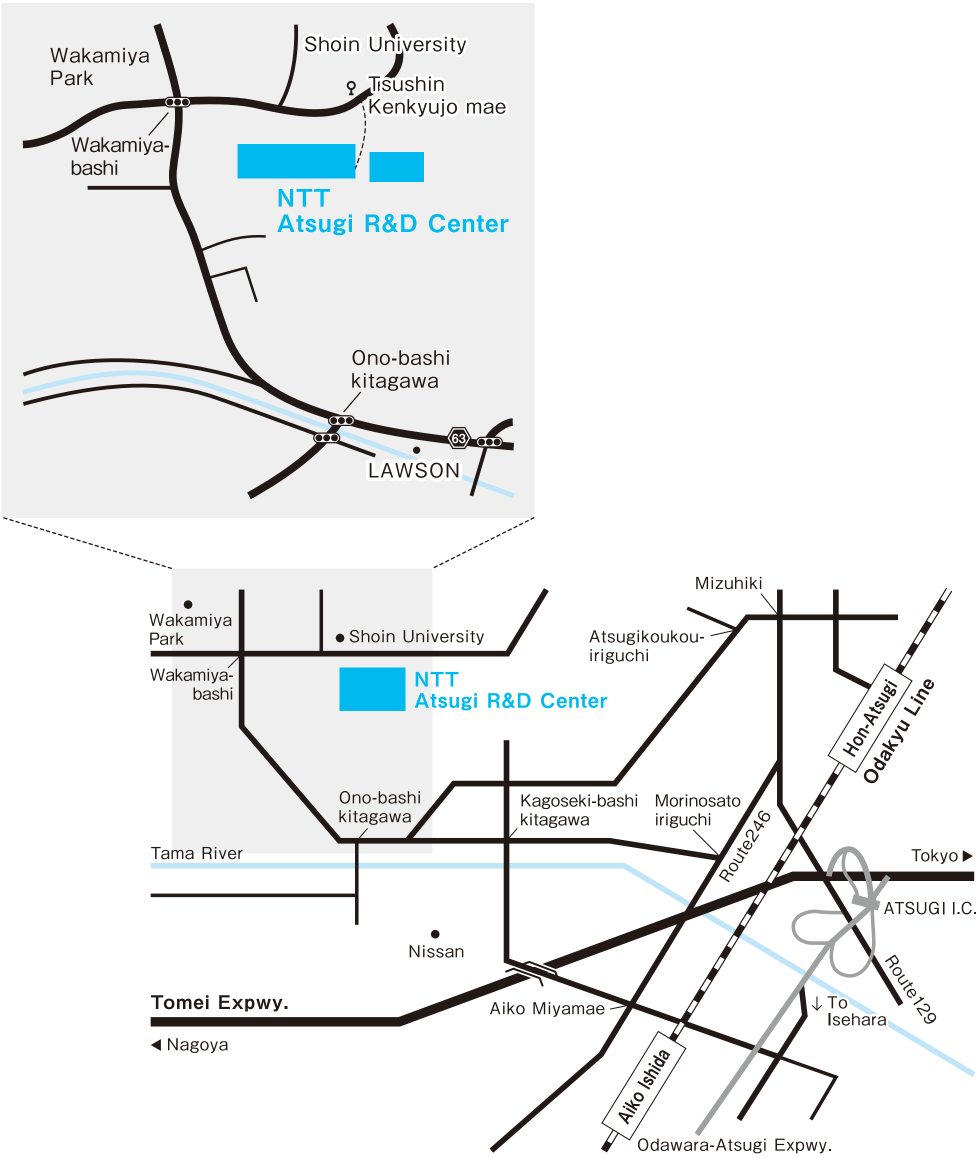

Access

By train and bus

"Aiko-Ishida" station on Odakyu Line (About 50 minutes from Shinjuku by Rapid Express / Express)
North Exit Bus Depot 4
20 minutes bus ride on "愛17 Morinosato" route; get off at "Tsushin Kenkyujo-mae" bus stop.
20 minutes bus ride on "愛18 Shoin Daigaku" route; get off at "Tsushin Kenkyujo-mae" bus stop.
20 minutes bus ride on "愛19·21 Nissansenshingijyutsukaihatsu center" route; get off at "Tsushin Kenkyujo-mae" bus stop.

"Hon-Atsugi" station on Odakyu Line (About 50 minutes from Shinjuku by Rapid Express / 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 2,000yen) or 20 minutes from "Hon-Atsugi" station on Odakyu Line (around 3,000yen)

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.