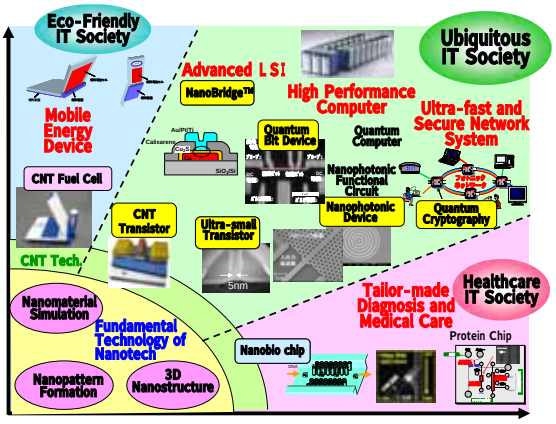
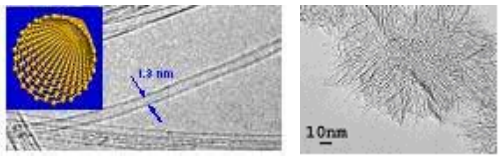
NEC's Nanotechnology

In order to build a convenient IT society, NEC has grappled with nanotechnology R&D, the fundamental technology for advanced IT/Network systems, since the late 1980's, and has made significant accomplishments. These include discovering a carbon nanotube (CNT), and demonstrating proper operation of the world's smallest transistors as well as the solid-state devices for quantum computers. In this exhibit we would like to introduce some of our nanotechnology - future LSI technology, CNT application, IT/network breakthrough, bio IT - and the relationship between nanotechnology and NEC's business.

Technology Fields that will be opened by Nanotechnology



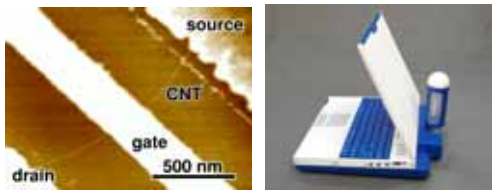


Single-walled Carbon Nanotubes and Nanohorn Aggregate

1. Carbon Nanotube Applications

The carbon nanotube (CNT), discovered in 1991 by NEC's Dr. Sumio Iijima, is a promising nanomaterial whose application is highly anticipated in a variety of fields such as electronics.

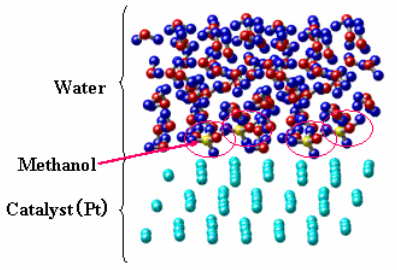
NEC has made transistors using CNTs as conducting channels and has clearly shown the possibility of high-speed operation of CNT transistors. Carbon nanohorns, a kind of carbon nanotube, are an optimal material to serve as a support for platinum catalyst particles for fuel cells because they have complex surfaces and are chemically stable and conductive. NEC has succeeded in the development of fuel cells and has demonstrated the operation of laptops with the world's best output power density.



AFM image of CNT transistor and Laptop with CNT Fuel Cells. (A part of these works is supported by NEDO, and the other part is in collaboration with JST.)

2. Nanomaterial Simulation

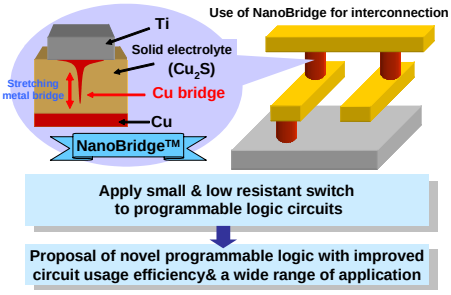
Based on the quantum mechanics, we can predict reaction paths and properties of materials, and can reduce experimental runs that need time and cost and cause environmental pollutions. Nano-material simulation is a powerful tool to investigate nano-scale phenomena, which are, however, hard to be observed experimentally. We are currently simulating nano-phenomena being related to the fuel-cell technologies and the nanotube devices. The nano-material simulations will evolve in Material IT in the future with increasing computational power based on NEC's HPC technologies.



Simulation of electrochemical reaction of direct-methanol at the interface of catalysts and water. (This work is in collaboration with Nano-carbonproject by NEDO

3. NanoBridge™ Devices

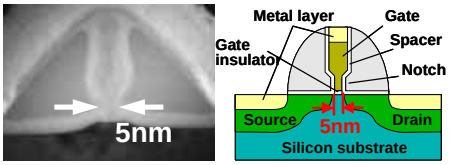
NanoBridge is a kind of switching device that has a solid electrolyte layer sandwiched by two metal electrodes. The switching is caused by creation and annihilation of nanoscale metal bridges based on electrochemical reaction and metal-ion migration in a solid electrolyte. Applying NanoBridges to programmable logic circuits significantly improves the logic circuit usage efficiency ten times, extending the range of application.



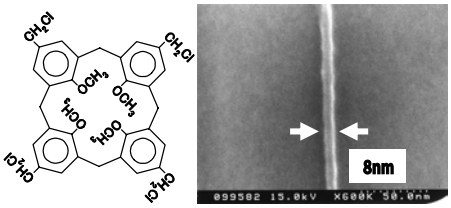
Application of NanoBridge to programmable logic. (A part of this work is in collaboration with NIMS and JST, and the other part is supported by NECEL.)

4. Nanoscale Transistor

Today, silicon transistors are used almost everywhere, as the key processing device, embedded in various kinds of equipments. By nature, higher speed, lower power, and increased functionality can be achieved by decreasing the size of the transistors.NEC fabricated a 5-nm-gate world-smallest transistor and successfully confirmed the transistor operation at room temperature. This small transistor is expected to be realized around 2020. NEC also succeeded to develop the high-resolution electron beam resist (Calixarene) for the precise fabrication of such minute devices. NEC investigates the possibility of future LSI through the investigation of nanoscale transistor.



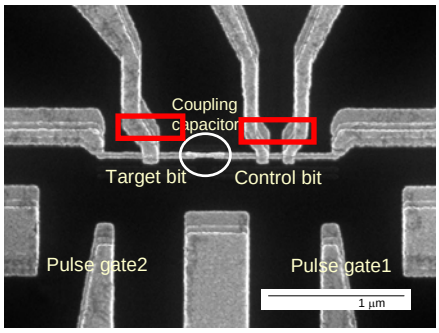
Photograph and figure of 5-nm-gate transistor.



Calixarene resist and its 8-nm pattern. (This work is in collaboration with TOKUYAMA Co.)

5. Basic Device for Quantum Computers

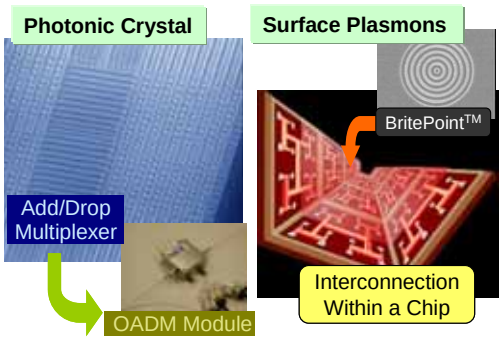
Quantum computers will be able to calculate vast amounts of data that cannot be processed by present computers. NEC has developed a device using the superconducting tunnel junction as the basic element for quantum computers and was the first in the world to succeed in solid-state quantum bit operation. NEC has recently demonstrated operation of a two-quantum-bit gate in collaboration with RIKEN.



Scanning-electron micrograph of coupled qubits. (This work is in collaboration with RIKIN.)

6. Nanophotonic Devices

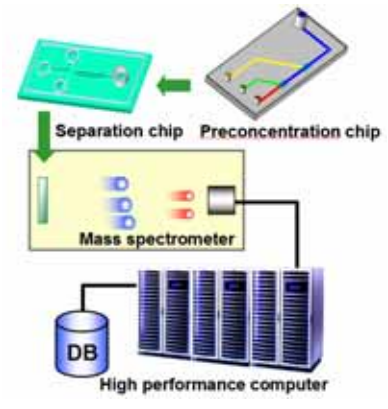
Nanoscale control of photons realizes extremely small and low power consumption optical devices. NEC has developed optical add/drop multiplexers (OADMs) with photonic crystals under collaboration with Tohoku Univ. for use in wavelength division multiplexing (WDM), and demonstrated the transmission experiment for the first time with the OADM modules. NEC also succeeded to create strong nano-scale near-field light (BritePoint^{TM}) by using surface plasmon technology, which is a much-in-the future for optical-interconnections within a chip. These nanophotonic technologies are useful for the integration of system devices for the IT/networks in the ubiquitous era.



Nanophotonic devices for IT/network systems. (A part of this work is supported by NEDO, and the other part is supported by MEXT.)

7. Nanobiochips / Integrated Proteome Informatics

High through-put protein assay with a small amount of samples and information technology for analyzing the output of the assay are essential for effective drug discovery or early detection of disease. In order to realize these, NEC is developing novel analyzing methods by combination of a nanobiochip technology and an information technology. The nanobiochip technology enables the high-speed analysis of protein samples that have been difficult to analyze with conventional technologies.



Protein-analysis system based on nanobiochips. (This work is supported by NEDO.)