Nanoelectronics

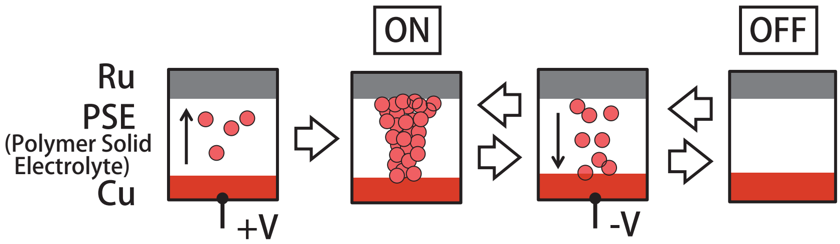
Low-power FPGA based on NanoBridge® technology

〈A new principle-based LSI developed using the TIA nanoelectronics platform〉

Summary NEC and AIST have been engaged in the practical development of FPGA products (NB-FPGA) based on a new principle, called atom switch (NanoBridge®), in the Super cleanroom (SCR) in AIST, which is the main base of the TIA nanoelectronics platform. The NB-FPGA is low in power consumption and can be used for a wide variety of products. NEC has started a sample shipment of NB-FPGA products.

What is NanoBridge® ?

NanoBridge® is a resistive change switch using ionic conduction and an electrochemical reaction of Cu ions in a solid electrolyte.



FPGA based on NanoBridge® technology

A field-programmable gate array (FPGA) is a reconfigurable circuit, in which a user can reconfigure the circuit as desired. The current mainstream FPGA uses static random-access memory (SRAM) to hold circuit information.

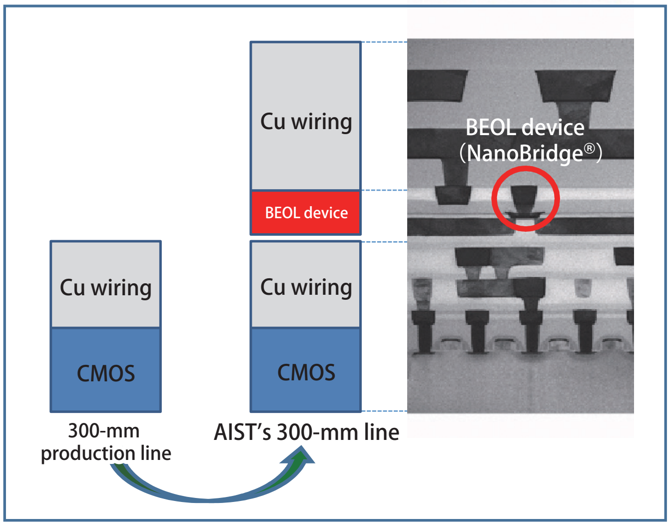
NEC's NB-FPGA maintains circuit information using a metallic bridge switch (NanoBridge® technology). It does not require power to maintain the switch state (on/off), and has a radiation hardness with an error rate that is less than 1/100. This switch is so small that the size of the chip is reduced to one-third of the size of a conventional one and the electrical efficiency increases ten-fold due to the small parasitic capacitance of the switch. Thus, NB-FPGA has low power consumption and is a highly reliable, reconfigurable circuit.

History of development

- The development started from the discovery of a phenomenon by a group of NIMS, in which the transfer of atoms in a solid electrolyte can be controlled at the atomic scale. It was followed by an invention of an atom switch and a subsequent basic research in FY2002–FY2005, which revealed its operational mechanism and superior functionality.
- Whereas conventional semiconductor devices work by the control of electron transfer, atom switch-based devices control the transfer of atoms, which are larger than electrons, based on devices in the nanometer scale. A JST program (second term: FY2005–FY2009) examined the constituent materials and the device structure of an atom switch consisting of two electrodes separated by a gap of several nanometers filled with a solid electrolyte, and examined the fundamentals of its integration with Si-LSI.
- In the NEDO project, "Ultra Low Voltage Device Project for Low-Carbon Society (FY2010–FY2014)," the development of atomic switch devices with commercialization in mind, the development of circuits and the verification of their functionalities, the integration with large-scale LSI, and studies on reliability were performed. A technique to form the atom switch (BEOL device) in the wiring process is important for the commercialization of the device. In this project, a technique of laminating atom switches and upper-layer wiring was developed using a pilot line for 300-mm wafers installed in the SCR in AIST on CMOS wafers produced in mass-production plant not part of AIST.
- In a project started in FY2016, the practical development of a product (NB-FPGA) for the FPGA aboard artificial satellites and for application to communications equipment has been performed.

Future development

In the Innovative satellite technology demonstration program, the NB-FPGA will be installed aboard an artificial satellite, which will be launched in 2018 to verify the practicality and reliability of the device. The NB-FPGA will also be applied to communication equipment to demonstrate its low power consumption and will be incorporated into IoT equipment.



■TIA projects:

- Ultra Low Voltage Device Project for Low-Carbon Society (FY2010–FY2014)
- Development of One Million LUT Atom Switch FPGA (FY2016)

MEMS Open research facilities

Nanoelectronics

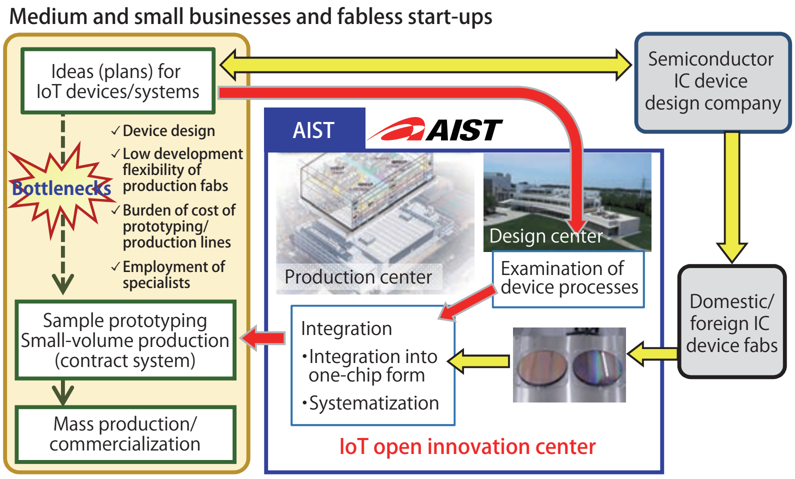
Center for design and prototyping of IoT devices

Accelerating R&D by using the open research facilities in AIST

Equips with the designing tools for IoT devices
Supports the prototyping of advanced IoT devices
Supports the entry of various businesses into the IoT industry

Background and purposes

- AIST provides designing tools for IoT devices (e.g., new-generation Technology CAD) and advanced equipment for prototype device fabrication to form a platform that is open to external use.
- AIST supports the entry of businesses not only from the electronics industry but also from other industries interested in IoT, such as industrial equipment, food, medical and biotechnology, and health care, to the IoT domain.
- Medium and small businesses and start-ups, which find it difficult to own expensive semiconductor manufacturing equipment or to hire trained specialists to operate it, can use our open research facilities.



Concept of open innovation center for R&D of IoT technology

Overview of the platform

- IoT equipment was newly introduced in addition to AIST's existing open research facilities (SCR, IBEC including NPF, MEMS).
- The process of prototype fabrication by using three-dimensional high-density packaging technology including modularization for assembling different functionalities and laminating wafers was strengthened.
- The fabrication of prototypes based on the idea of IoT devices/systems. Subsequent mass production or commercialization will be supported.
- The newly introduced IoT equipment will be available in FY2018.

Edge trimming machine

Wafer bonding system

Examples of available equipment

Available facilities, equipment, and techniques

- Constructing developmental lines for the prototyping process of Si semiconductor devices using 300-mm wafers and for three-dimensional laminated packaging process
- Additionally integrating devices made with new materials or devices having new structure with Si devices on 300-mm wafers fabricated in external fabrication facilities
- Prototyping of silicon photonics devices on a 300-mm device prototyping line
- Prototyping of nanostructured devices using electron beam lithography
- Development of MEMS integrating process/evaluation techniques using 200/300-mm wafers
- New-generation TCAD technology for devices made with new materials or devices based on new principles

Examples of newly introduced equipment

Fourteen types of equipment including i-line Lithography Stepper, Deep Etch System, Chemical Vapor Deposition System, Cu Plating System, Chemical Mechanical Polishing System, Wafer Bonding System, Wafer Thinning System, Spectroscopic Ellipsometer, and Surface Inspection System.

This platform participates in a NEDO project, Open Innovation Hub for IoT Device Development (FY2016–FY2017).

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