Tokyo Tech Research Units

Supra-Integrated Materials Unit

Overview

The creation of new metal, ceramic, plastic, and semiconductor materials is extremely important in scientific, technological, and industrial development. There is infinite potential for new functional materials through the combination of existing materials. To date, however, materials produced through such combinations have been limited to the sum of functions in these existing materials. Since its formation in 2011, the JST-ERATO Iyoda Supra-Integrated Material Project has been aiming to precisely combine different materials at the nanoscale and develop supra-integrated materials with functions exceeding the sum of the functions of the individual materials. With molecular circuitry as one of the project visions, the researchers have been working on a new concept of molecular grid wiring with development of its elemental technologies and algorithms. Today, the Supra-Integrated Materials Unit continues the groundwork laid during the ERATO project, integrating the established elemental technologies, and developing and verifying molecular circuits in order to make them a reality.

Research Unit Leader **Tomokazu Iyoda**

Profile

- 2016 Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2011 Professor, Frontier Research Center, Tokyo Institute of Technology; Professor, Integrated Molecular Engineering Division, Chemical Resources Laboratory, Tokyo Institute of Technology
- 2006 Professor, Integrated Molecular Engineering Division, Chemical Resources Laboratory, Tokyo Institute of Technology
- 2002 Professor, Photofunctional Chemistry Division, Chemical Resources Laboratory, Tokyo Institute of Technology
- 1996 Professor, Department of Applied Chemistry, Graduate School of Engineering, Tokyo Metropolitan University
- 1994 Deputy Leader, Photofunctional Conversion Materials Project, Kanagawa Academy of Science and Technology
- 1991 Research Associate, Chemistry Division, Argonne National Laboratory
- 1984 Research Associate, Department of Molecular Engineering, Graduate School of Engineering, Kyoto University
- 1984 Doctor of Engineering, Department of Hydrocarbon Chemistry, Graduate School of Engineering, Kyoto University
- 1979 Bachelor of Engineering, Department of Hydrocarbon Chemistry, Faculty of Engineering, Kyoto University

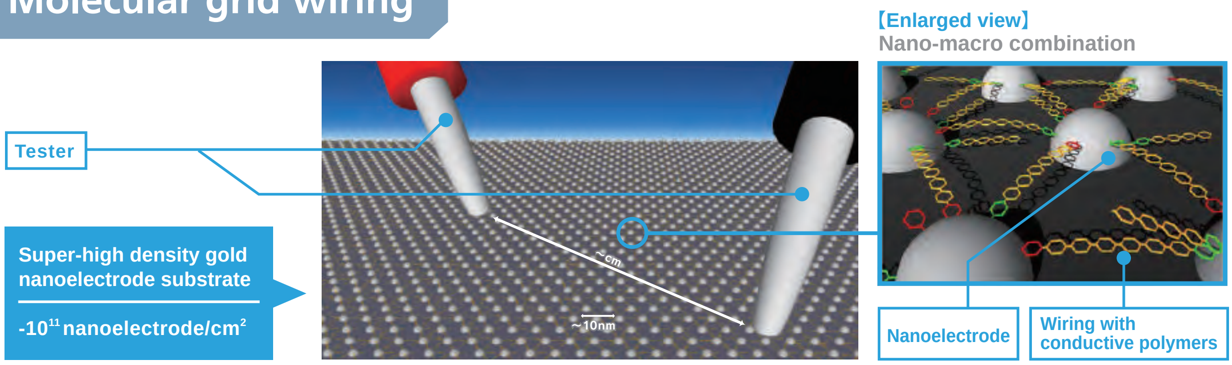
Unit members

- Researcher Takehiro Kawauchi
- Researcher Akihisa Yamaguchi
- Researcher Keiji Nose
- Researcher Takanobu Sanji
- Researcher Tatsuya Nojima

Research goals

Creating molecular circuits requires four elemental technologies: ultra-high density gold nanoelectrode array substrates, surface-initiated/terminated polymerization wiring with electroconductive polymers between nanoelectrodes, algorithms for single molecular conductivity from macroconduction characteristics of molecular grid wiring, and an optical counting system of the wired molecules. The ERATO project established such elemental technologies, which the Supra-Integrated Materials Unit now applies in the verification of molecular grid wiring. Utilizing precise polymerization, the unit works on polymerization wiring in which polymerization starts from individual nanoelectrode surfaces and reaches the neighboring nanoelectrodes. The unit confirms that molecular grid wiring functions as an interface to assess single molecular conductivity in an accurate, integrated, and reproducible manner. Molecular grid wiring is an expandable methodology capable of highly sensitive, low-dispersive detection of extremely small signals from single molecules, and has both engineering and transdisciplinary applications. As an example, sensing the mutual interaction between extremely small target and grid wiring molecules at a high level of sensitivity makes it possible to quickly measure target molecules in complicated targets with multiple components such as blood tests. It is clear that the application of this methodology to medical and health care will be highly beneficial.

Molecular grid wiring



Integrated research requires sensitivity, mobility, and creativity that are free from the conventional framework

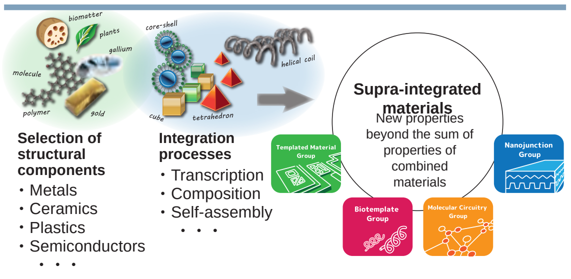
Q Why was this research unit established?

The ERATO project has been promoting research in four core groups. The Template Materials Group sought to discover functions through the creation of transcription complexes of self-assembled nanostructures. The Biotemplate Group sought to discover functions utilizing biotemplate technology based on biological microstructures. The Molecular Circuitry Group developed elemental technology to create molecular circuits, and the Nano-Junction Group designed and searched for functions in dissimilar material interfaces. Each group has achieved results that have created new value in supra-integrated materials. The Supra-Integrated Materials Unit continues to advance the technical findings from the Molecular Circuitry Group of the ERATO project and utilizes the flexible organizational structure of the unit to intensively verify these findings on a large scale. In addition, the unit promotes research to establish new methodologies for the creation of new supra-integrated materials. The unit continues to actively disseminate research findings and strives to return benefits to society.

Q What are the strengths of this research unit?

The strengths of the Supra-Integrated Materials Unit are in multidisciplinary research. Integrated research beyond the boundaries of material chemistry, nanoscience, polymer chemistry, surface chemistry, and the mathematical sciences requires sensitivity, mobility, and creativity that are free from the conventional framework. The proper specializations, technologies, and processes matched with the right target materials will produce new methodologies and results in a synergistic manner. Each technology is a result of individual efforts, and the integration of these efforts makes big projects possible. The unit's big advantage is its highly effective coordination of both individuals and teams.

Supra-integrated materials overview



Q What is the path to achieving the unit's goals?

The basic concept of molecular diodes was proposed in 1974. Since then, creating integrated circuits at the molecular level has been the biggest challenge. Although the potential capabilities of molecular materials were known, we did not know how to proceed before discovering how to best integrate advanced individual technologies in a well-balanced way. These technologies include generation and control of nanoscale metals, precise synthesis of molecules and polymers, and layout and bonding of electrodes with molecules and polymers.

We have accumulated and integrated molecules and materials, and have acquired outstanding results for the past five years in the ERATO project. Currently, we have elemental technology that is unique in the world, and the unit is preparing for its verification. The Supra-Integrated Materials Unit will verify molecule grid wiring through controlled mutual operation of elemental technology and work toward completion with high reproducibility and reliability.

Contact us

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March 2016