


FY2015

Creation of the Functional Materials on the Basis of the Inter-Element-Fusion Strategy and Their Innovative Applications

What is inter-element-fusion, this innovative idea that overturns the conventional wisdom for metallurgy?

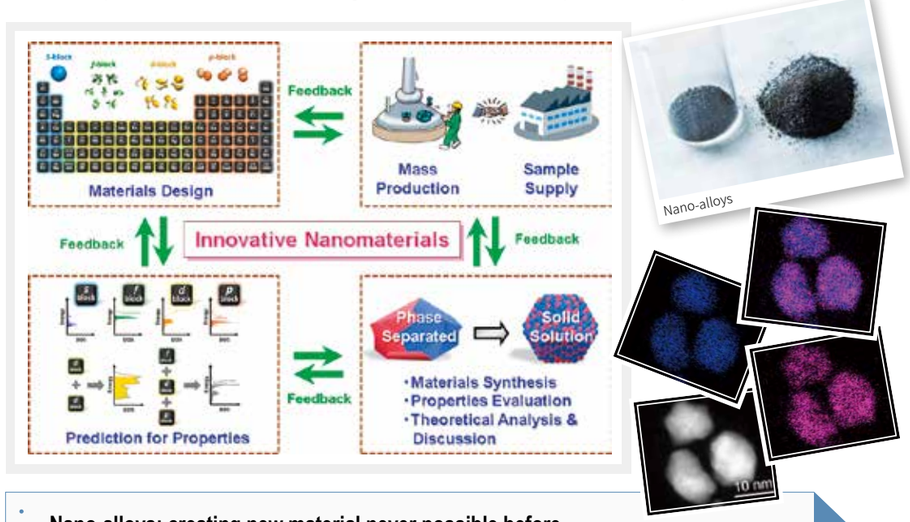
Humankind has combined elements with different characteristics to develop materials with excellent properties. We are advancing research on **inter-element-fusion** that creates new materials by mixing immiscible metallic elements in the bulk state, at the atomic level.

Focusing on the element rhodium,* an expensive element used as a catalyst, we have succeeded in mixing at the atomic level palladium and ruthenium, which are on either side of rhodium on the periodic table, to develop a novel alloy (nano-alloy material) that can replace rhodium at about a third of the cost. We also found that this novel alloy offers a superior property; namely how its catalytic activity is higher than natural rhodium, resulting in its reaction proceeding at temperatures lower than previously. Although its durability still needs to be investigated, its current performance is expected to be good enough to be used for exhaust gas purification.

* A type of rare metal. It is widely used as industrial catalyst, for decomposition of nitrogen oxide in exhaust gases and for conversion of hazardous carbon monoxide to carbon dioxide.

Building a mass production system for this novel nano-alloys and making them available to industry

In the ACCEL project, we will be able to use previous research to theoretically predict physical and chemical properties of the new materials that are made through inter-element-fusion, enhancing the accuracy of its structural design with this new concept. In addition, we will demonstrate that it is possible to create new materials with desired properties. Moreover, by establishing the technology for the mass production of these new materials and providing prototype samples to industry in a range of fields, we shall seek out the path to commercialization, aiming to contribute to the development of society and industry.



Nano-alloys: creating new material never possible before

To combine immiscible metals, we applied the preparation method of nanoparticles through chemical reactions rather than the “metallurgical” method of melting and mixing. Once the mixture solution dissolving two metal ions is mixed into the reducing agent using a vaporizer, the metal ions in the water droplets are instantaneously transformed into metal atoms, resulting in the formation of a nano-alloy in which both metals are randomly mixed. This method enables the creation of completely new materials.

Research Director

Hiroshi Kitagawa

Professor, Graduate School of Science, Kyoto University

More than ten years ago, during the development of hydrogen-storage alloys to be used for fuel cells, my student found that palladium and platinum were being mixed at the atomic level, something which had never been considered possible. This gave me the idea behind inter-element-fusion. I also thought that mixing two elements lying on either side of the target element on the periodic table would create a material that has properties equivalent to the target element, and started research on finding a material that could replace rhodium. This experience made me aware of the importance of not giving up (staying hungry) and not being a slave to convention (staying foolish).

The ACCEL project will clarify the mechanisms of inter-element-fusion, and reveal what kind of synthesis creates the desired new materials. With the help of the Program Manager, Dr. Okabe, who is active at the forefront of catalytic research & development, I am engaged in research with a strong sense of purpose, and my aim is to commercialize the results acquired from top-level science.

The real value of a scientist is tested by whether something new can be created. The application of inter-element-fusion will maximize the potential capacity of every element on Earth.

Program Manager

Akihiro Okabe

ACCEL Program Manager, Japan Science and Technology Agency

I conducted joint research with Prof. Kitagawa before this ACCEL project, when I felt that inter-element-fusion is a breakthrough technology that is not limited to just a specific research field, but can be widely applied to many areas of society.

In this ACCEL project, I play the role of deciding what should be investigated to commercialize our new material to replace rhodium, and connecting our research activities with the needs of end users. They do not always require 'integrity' in materials to make practical use of them. I am a corporate researcher and thus able to understand what they need in a product. That expertise allows me to make specific proposals to satisfy users’ needs.

In the future, we aim to provide new materials for a wide range of fields, from the chemical industry to health care, contributing to the creation of many different business opportunities. Through these actions, we will build a structured system for generating new materials.

The real value of inter-element-fusion is in its expansion capabilities. With a balance between a structured system and commercialization of our materials, I will offer a variety of new materials to a wide range of fields.

Inter-element-fusion technology, a sort of “modern-day alchemy” that creates new materials and achieves the stable supply replacing rare materials, will act to support future chemical industries.

PROFILE HIROSHI KITAGAWA

1991: Completed coursework, Graduate School of Sciences, Kyoto University; Institute for Molecular Science and Japan Advanced Institute of Science and Technology; 2003: appointed Professor, Graduate School of Science, Kyushu University; 2009: appointed to current post. Fields of expertise: Solid state chemistry, coordination chemistry, inorganic chemistry, and nano science. Ph.D. (Science).

PROFILE AKIHIRO OKABE

1998: M.S. (Applied Chemistry), School of Engineering, The University of Tokyo. Joined Mitsui Chemicals, Inc. Engaged in R&D for catalysts, responsible for development, with much experience in industry-academia projects. Ph.D. (Engineering)