FY2014

Fundamentals and Applications of Diamond Electrodes

Using familiar diamonds as electrodes

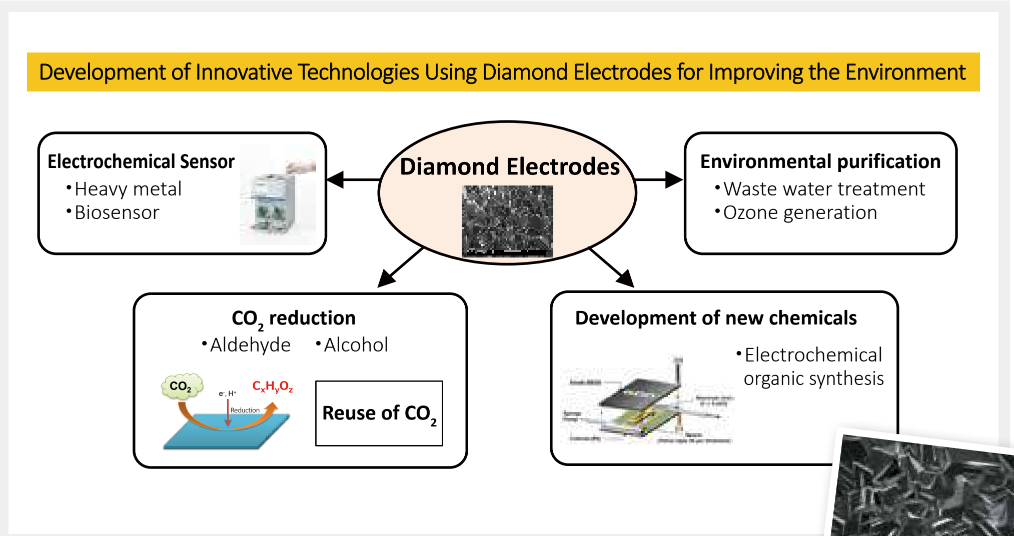
Everyone knows what diamonds are, but this time we found a new use for them other than jewelry or industrial uses. Diamond is an insulator. However, when doped with boron, it turns into a conductive material. And so we are developing diamonds with high boron content and their use as electrodes. These diamond electrodes are noted for not using rare metals and for being able to be manufactured relatively easily.

Our previous research has revealed the fundamental characteristics and functions of diamond electrodes used as electrochemical electrodes. It also showed their utility in a range of different applications, including successfully developing high-performance sensors, achieving organic synthesis, and producing useful materials using carbon dioxide (CO_2).

Improving electrode performance and finding ways to expand applications

This ACCEL project aims to establish design guidelines for diamond electrodes and to search out applications to maximally utilize their performance. Market and competition research will be conducted at an early stage to demonstrate the availability of the applications and to develop the appropriate electrochemical application systems.

In moving ahead with our R&D, we will actively engage with users' needs while working to increase area, with the goal of building diamond electrodes into a baseline technology that will contribute to the development of a range of applications.



Diamond electrodes

Diamond electrodes are prepared by introducing source materials (carbon and boron) into plasma generated using microwaves and by depositing diamond onto a silicon substrate. They look black because of the fine irregularities of the diamond particle surface and because of the boron in them. They are physically stable and characteristically cause particular kinds of reactions that never happen in conventional electrodes. Being carbon-based, they have excellent biological compatibility.

Diamond electrode

Research Director

Yasuaki Einaga

Professor, Faculty of Science and Technology, Keio University

Diamond, a material everyone has heard of, is fascinating thanks to the successive discoveries that are being made of its many exciting characteristics.

Diamond electrodes have a wide range of applications. For example, in CO_2 reduction they can effectively produce formaldehyde, which is used as a raw material for chemical products, at room temperatures and under ambient pressures. There was a huge reaction to this research, and I feel a great sense of responsibility, but also a sense of satisfaction. The electrodes produce extremely small noise currents, so can become excellent high-accuracy sensors. We succeeded in accurately monitoring neurotransmitters in the brain and stomach pH in mice.

In the ACCEL project, we will use our research results to clarify the mechanism in terms of material science and develop large-area, high-performance electrodes. Along with Mr. Tsukahara, our program manager, who will provide the path to the commercialization, I would like to contribute to a way of manufacturing that benefits society while being attuned to the needs of our society.

As research on diamond electrodes has a short history and many unknowns remain in the field, there is a huge amount of excitement and joy in discovering new phenomena.

Program Manager

Nobuhiko Tsukahara

ACCEL Program Manager, Japan Science and Technology Agency

I have been in charge of the management of intellectual property for Prof. Einaga for some time, and, as understanding of the diamond electrodes deepens in society, I have come to realize their potential to become useful in a range of industries. While I am sometimes puzzled by the fact that the research time span of a university is longer than a company, I hope to be able to help commercialize the technology.

In the ACCEL project, I am responsible for presenting the research results to companies to discover its needs, forecasting its applications to social needs, and also manufacturing or experimenting with the products. In terms of the creation of useful materials through the reduction of CO_2, at the current stage, large-scale manufacturing at an industrial level requires infrastructure development and industrial cooperation. A sensor to measure heavy metal has been already commercialized and is widely used. I will look for applicability to all types of areas, from drug development to environmental purification areas like water treatment, waste water purification, and ozone generation.

It is the program manager's role to find out how to apply these "magical electrodes," with their potential to make the impossible possible, to society as useful products.

This technology is expected to be useful in all aspects as a base technology for society that will greatly contribute to solving issues of the global environment and energy.

PROFILE YASUAKI EINAGA

1999: Ph.D. (Engineering), The University of Tokyo; 1999-2001: The University of Tokyo; 2001: Keio University; in current post since 2011. Research into new nano-materials demonstrating magnetism and superconductivity with photo-functions added, and new functional materials such as electrically conductive diamond electrode.

PROFILE NOBUHIKO TSUKAHARA

1979: M.S. (Engineering), Waseda University. Joined Sony Corporation; worked for Keio University. Has been responsible for development processes, with expertise in industry-academia collaboration from the university side for patent management and coordination of contracts with companies.