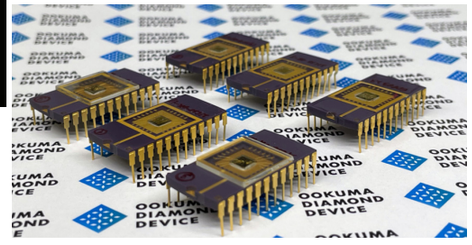
Left: An image of a diamond, not related to the final diamond semiconductors.
Below: Synthetic-diamond semiconductors developed by Ookuma Diamond Device Co., Ltd., designed for decommissioning nuclear reactors, thanks to their ability to operate in extremely hot and highly radioactive environments.



DIAMOND SEMICONDUCTORS:

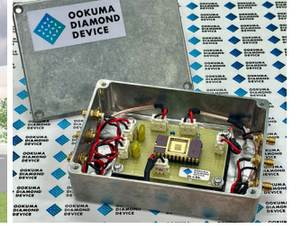
TURNING CRISIS INTO INNOVATION WITH ULTIMATE DEEP TECH

Thanks to advancements in analog semiconductor materials, a Japanese company is on the brink of launching diamond semiconductors—hailed as the "ultimate" semiconductors—into real-world applications for the first time. By leveraging unique expertise gained from the Fukushima Daiichi Nuclear Power Station accident, this innovation aims to overcome decommissioning challenges and revolutionize industries from satellite communications to next-generation high-speed networks.

Beyond the well-known semiconductors—those used in PCs, smartphones, and other information-processing devices for tasks like computation and memory—there are also semiconductors designed to amplify, convert, and transmit signals related to physical phenomena, such as electricity, temperature, light, and communications. These are known as analog semiconductors for their capability to handle continuously varying analog signals. Their importance has grown significantly in recent years, as they are vital for signal processing in all kinds of equipment including communication devices, sensors, and automobiles. The development of higher-performance analog semiconductors is accelerating rapidly, driven by the increasing data demands of generative AI and autonomous driving, as in satellite communications, and other operations in harsh environments.

Particularly promising for this purpose are diamond semiconductors, which use synthetic diamonds produced from methane gas, a greenhouse gas with a significant impact on global warming, second only to carbon dioxide. Unlike conventional materials such as silicon or gallium nitride, diamond semiconductors offer exceptional properties, including high thermal conductivity, superior high-frequency performance, and enhanced power efficiency, as well as resistance to extreme environments like high temperatures and radiation.

Since the 1980s, researchers have attempted to develop diamond-based semiconductors, but faced significant challenges in commercializing due to technical difficulties and the lack of viable markets. However, this changed when a prototype device was successfully developed by Ookuma Diamond Device Co., Ltd., a startup founded jointly by Hokkaido University and the National Institute of Advanced Industrial Science and Technology (AIST). The company plans to begin constructing the world's first factory for diamond semiconductors in early 2025, with operations expected to commence by the end of 2026.



Left: An artist's rendering of the semiconductor manufacturing plant planned for construction in Okuma Town, Futaba District, Fukushima Prefecture. Construction will begin in early 2025, with operations slated to commence by the end of 2026.
Right: Ookuma Diamond Device will use the planned facility to manufacture diamond semiconductor devices for decommissioning work at the Fukushima Daiichi Nuclear Power Station. Shown here is a prototype of the world's first such device, specifically made for debris removal.

A pivotal moment in the semiconductor's development was the shutdown of the Fukushima Daiichi Nuclear Power Station (NPS), caused by the tsunami following the Great East Japan Earthquake on March 11, 2011. When the unprecedented and challenging mission arose of retrieving fuel debris for the reactors' decommissioning, a research project was launched in 2012 to develop diamond semiconductors capable of operating in the harsh environment of the wrecked NPS, laden with radiation.

The initiative brought together the technical expertise of such organizations as the AIST, the Japan Atomic Energy Agency (JAEA), Hokkaido University, and the High Energy Accelerator Research Organization (KEK). Their goal was clear: to develop a critical approach monitoring system using diamond semiconductors that could withstand elevated temperatures and high radiation levels, providing detailed data, including neutron dose on fuel debris, and thereby facilitating safer and more efficient planning for the debris removal.

"Having a clear practical goal allowed us to prioritize yield (the ratio of usable products) in our design, giving us a significant technological advantage during our decade of research," explained HOSHIKAWA Naohisa, CEO and founder of Ookuma Diamond Device.

The company was the first in the world to establish a vertically integrated system for manufacturing diamond semiconductors, covering everything from substrate design to assembly of the amplifier, the final product. Hoshikawa, together with KANEKO Junichi, an associate professor at Hokkaido University and a former visiting researcher at JAEA specializing in decommissioning research, and UMEZAWA Hitoshi, a senior researcher at AIST, spearheaded the company's founding in 2022 to lead mass-production efforts. The name "Ookuma" is derived from Ookuma (Okuma) Town in Fukushima Prefecture's Futaba District, home to Fukushima Daiichi NPS and the planned mass-production facility, in a nod to the company's commitment to supporting Fukushima's recovery.

"The trend of increasing information processing—driven by the spread of technologies such as autonomous driving and generative AI—is irreversible. The market for diamond semiconductors is bound to grow significantly," said Hoshikawa. Also on the horizon are future applications in aerospace, defense, and next-generation communications.

March 2025 will mark 14 years since the Fukushima Daiichi nuclear accident. Hoshikawa reflected, "Reconstruction goes beyond merely eliminating the negative impacts of the nuclear accident and dialing the clock back to zero; it involves creating new industries and transforming the experience into something positive. If we can help overcome the negatives of the nuclear accident through diamond semiconductors, the technology that has emerged from the accident will take humanity a step forward. That is what we are striving for." ●

The Ookuma Diamond Device team. Company CEO HOSHIKAWA Naohisa sits third from the left in the front row, with KANEKO Junichi to his right and UMEZAWA Hitoshi to his left.