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AIR WATER

News Release

December 15, 2022
Air Water Inc.

A cubic SiC material with a high thermal conductivity that outperforms copper, silver, and even thin-film diamond was first demonstrated using Air Water's proprietary technology ~ Published in the international academic journal "Nature Communications" ~

A research team made up of Air Water, Osaka Metropolitan University, Tohoku University, University of Illinois, and Georgia Institute of Technology confirmed that the cubic SiC material (3C-SiC) based on the Air water's proprietary technology showed a higher thermal conductivity than copper, silver, and even thin-film diamond. Air Water is pleased to inform you this result has been published in the authoritative international academic journal "Nature Communications".

1. An overview of SIC business in Air Water

Air Water has developed the original, unique technology for growing high-quality cubic SiC (silicon carbide) crystals on Si (silicon) substrates. Since 2012, Air Water has been engaged in the production and sale of large-diameter (maximum, 200 mm diameter) SiC on Si substrates utilizing this unique proprietary technology. Compared to growing on a Si substrate, GaN (gallium nitride) can have better crystallinity and a thicker layer when grown on SiC on Si substrate. Air Water has also demonstrated that SiC on Si substrate was suitable for bonding with high-performance semiconductor materials such as diamond.

2. About "Cubic SiC"

It is well known that SiC has multiple polytypes of crystals with different atomic arrangements, such as hexagonal and cubic crystals. The main feature of Air Water's SiC on Si substrate is cubic crystals, also known as '3C-SiC'. Since cubic SiC materials can be grown on Si substrates, it is possible to manufacture large-diameter substrates at a lower cost than diamond crystals, which are representative of highly heat-dissipating semiconductor materials. Combining cubic SiC with other semiconductor materials can significantly contribute to the realization of various high-power and high-frequency devices that require substantial heat dissipation.

3. Achievement of this joint research

In this joint research, we verified that Air Water's high-quality, wafer-scale cubic SiC free-standing substrate has a thermal conductivity that exceeds the physical properties of copper, silver, and hexagonal SiC. Furthermore, Air Water's cubic SiC thin films were found to have record thermal conductivity, higher than diamond thin films of the same thickness. The results of this study show that Air Water's cubic SiC possesses unparalleled high purity and high crystal quality, which leads to the world's first demonstration of the ideal thermal conductivity inherent in 3C-SiC crystals.
This result was published as an online bulletin in the authoritative international academic journal "Nature Communications" published by Nature Publishing Group at 12:00 on Thursday, November 24, 2022.
See here for details of the results.

University of Illinois: https://mrl.illinois.edu/news/solving-the-puzzle-cubic-silicon-carbide-wafer-demonstrates-high-thermal-conductivity-second-only-to-diamond

<Background and target of the study >

Currently, in the field of power electronics, higher voltages and larger currents are required for semiconductor devices due to the expansion of automotive applications. For the substantial development of radio-frequency (RF) device technology, the size of the die needs to be shrunk. Because of that, the amount of local heat generated inside

high-power and high-frequency devices is steadily increasing, which created a strong demand for a semiconductor material with high heat dissipation characteristics.
Diamond is a well-known standard semiconductor material with high heat dissipation, but its high cost and small diameter substrate are obstacles to wide commercialization. In addition, other than diamonds, there have only been reports of semiconductor materials with a lower thermal conductivity than copper and silver, primarily used as heat dissipating materials.
Cubic SiC has been considered to have high thermal conductivity due to its simple crystal structure. However, no experimental evidence has been provided to address the high thermal conductivity of cubic SiC compared to its theoretical value. Moreover, the reported thermal conductivity of cubic SiC is lower than that of hexagonal SiC.
In this study, the research team first demonstrated a cubic SiC material which has higher thermal conductivity than copper, silver, hexagonal SiC, and thin-film diamond by combining excellent Japanese and US analysis technology with Air Water's proprietary crystal growth technology.
The verified high thermal conductivity is clarified in this study to be primarily due to the crystal's high purity and quality. From the results, the Air Water 3C-SiC material can be used not only as a base substrate for GaN semiconductors, which we have been working on but also as a heat dissipation material.

[Contact for inquiries]
SIC Division, Air Water Inc.
2290-1, Takibe, Toyoshina, Azumino, Nagano, 399-8204, Japan
Telephone: +81-263-71-2510 E-mail: info-sicgan-h@awi.co.jp