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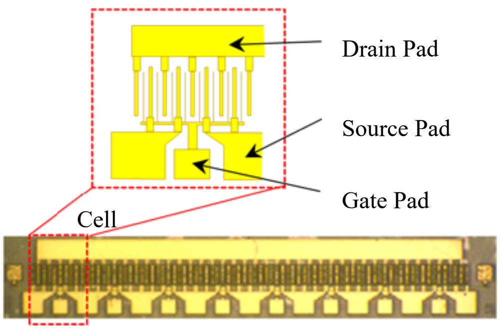
# Mitsubishi Electric Develops World's First Multi-Cell GaN-HEMT Bonded Directly to Diamond Substrate

*Will increase energy efficiency and reliability of microwave electronics in diverse fields*

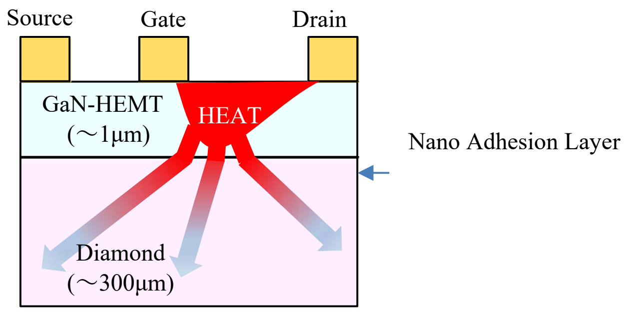
**TOKYO, September 2, 2019** – Mitsubishi Electric Corporation (TOKYO: 6503) announced today that in collaboration with the Research Center for Ubiquitous MEMS and Micro Engineering, National Institute of Advanced Industrial Science and Technology (AIST), it has developed a gallium nitride-high electron mobility transistor (GaN-HEMT) in a multi-cell structure (multiple transistors cells arranged in parallel) bonded directly to a single-crystal diamond heat-dissipating substrate with high thermal conductivity. The direct bonding of a multi-cell GaN-HEMT to a single-crystal diamond substrate is believed to be the world's first.* The new GaN-on-Diamond HEMT will improve the power-added efficiency of high-power amplifiers in mobile communication base stations and satellite communications systems, thereby helping to reduce power consumption. Mitsubishi Electric will refine the GaN-on-Diamond HEMT prior to its commercial launch targeted for 2025.

* According to Mitsubishi Electric research as of September 2, 2019

This research achievement was first announced at the International Conference on Solid State Devices and Materials (SSDM) currently being held at Nagoya University, Japan from September 2 to 5.




New GaN-on-Diamond HEMT
View from above and cell structure




Cross-sectional view of new GaN-on-Diamond HEMT

Mitsubishi Electric handled the design, manufacture, evaluation and analysis of the GaN-on-Diamond HEMT and AIST developed the direct bonding technology. A part of this achievement is based on results obtained from a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

**Key Features**

1) ***World's first GaN-HEMT with multi-cell structure directly bonded to diamond substrate***

Most existing GaN-HEMTs that use a diamond substrate for heat dissipation are created using a GaN epitaxial layer foil from which silicon substrate has been removed and onto which diamond is deposited at high temperature. HEMTs are then fabricated on the diamond substrate of the flattened GaN wafer. However, because the thermal expansion coefficients of GaN and diamond are different, the wafer can warp greatly during the manufacturing process, making it difficult to fabricate large multi-cell GaN-HEMTs.

During this research a silicon substrate was removed from a multi-cell GaN-HEMT that was fabricated with a silicon substrate; the back surface of the GaN-HEMT was then polished to make it thinner and flatter, after which it was bonded directly onto a diamond substrate using a nano adhesion layer. A multi-cell structure was used for the parallel alignment of eight transistor cells of a type found in actual products. Finally, a multi-cell GaN-on-Diamond HEMT—the world's first—was fabricated using a substrate with high heat dissipation made of single-crystal diamond.

2) ***Improved output and power efficiency for expanded radio wave range and energy conservation, compared to an original GaN-HEMT with the same structure on a silicon substrate***

Using a single-crystal diamond (thermal conductivity of 1,900 W/mK) for superior heat dissipation suppresses temperature degradation, decreasing the temperature rise of the GaN-HEMT from 211.1 degrees Celsius to 35.7 degrees Celsius. This improves output per gate width from 2.8 W/mm to 3.1 W/mm as well as raising power efficiency from 55.6 percent to 65.2 percent, thereby realizing significant energy conservation.

**Background**

In recent years, high-power, high-efficiency GaN-HEMTs have been adopted for high-power amplifiers in mobile communication base stations and satellite communications systems, helping to make such equipment smaller, lighter and more efficient. Due to heat generation during high-power operation, however, the output performance inherent in GaNs cannot be realized and their reliability decreases. The newly announced multi-cell GaN-on-Diamond HEMT can achieve high power and high power efficiency for high-power amplifiers, which will help to reduce the power consumption requirements of mobile communications base stations and satellite communications systems.

**Patents**

Pending patents for the technologies announced in this news release number 9 in Japan and 10 outside of Japan.

Completed patents for the technologies announced in this news release number 2 in Japan.

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**About Mitsubishi Electric Corporation**

With nearly 100 years of experience in providing reliable, high-quality products, Mitsubishi Electric Corporation (TOKYO: 6503) is a recognized world leader in the manufacture, marketing and sales of electrical and electronic equipment used in information processing and communications, space development and satellite communications, consumer electronics, industrial technology, energy, transportation and building equipment. Embracing the spirit of its corporate statement, Changes for the Better, and its environmental statement, Eco Changes, Mitsubishi Electric endeavors to be a global, leading green company, enriching society with technology. The company recorded a revenue of 4,519.9 billion yen (US$ 40.7 billion*) in the fiscal year ended March 31, 2019. For more information visit:
www.MitsubishiElectric.com

*At an exchange rate of 111 yen to the US dollar, the rate given by the Tokyo Foreign Exchange Market on March 31, 2019