May 18, 2021

Completion of the world's largest manufacturing facility for gallium nitride (GaN) substrates

The Japan Steel Works, LTD.
Mitsubishi Chemical Corporation

The Japan Steel Works, LTD. (JSW; Head Office: Shinagawa-ku, Tokyo , President: Naotaka Miyauchi) and Mitsubishi Chemical Corporation (MCC; Head Office: Chiyoda-ku, Tokyo, President: Masayuki Waga) have completed construction of a demonstration facility for mass production of gallium nitride (GaN) single-crystal substrates in the premises of the Muroran Plant of Japan Steel Works M&E, Inc. (Muroran Plant) in collaboration. We will conduct verification tests for mass production of 4-inch GaN single-crystal substrates throughout FY2021, and start market supply early FY2022.

1. Background

GaN is a material used to create ultra-high-efficiency devices, employing its enhanced efficiency and durability. In addition, it is expected to have an environmental benefit since the material can reduce CO_2 emissions with a drastic reduction of power consumption. Promising applications of GaN not only include blue LEDs but the fields listed below as well:

① High-power and high-intensity light source
GaN is expected to be applied to high-intensity and high-power lasers, high-efficiency illumination, and new-generation displays.

② Telecommunications
GaN will contribute to 5th Generation Mobile Communication System (5G) such as high-frequency devices and optical communication devices that can instantaneously transmit and receive large amounts of data, and even to post-5G. GaN, with a higher processor frequency than currently prevailing silicone substrates, can also contribute to power saving of servers and base stations.

③ Power semiconductor
In recent years, demands for power semiconductors that allow the downsizing of devices and instruments in particular have been increasing. While silicone substrates currently predominate, demands for high-voltage power semiconductors that can attain higher-current operations are rising more than ever.

2. Past approaches for technological development

JSW manufactures autoclaves (pressure vessels) for producing synthetic crystals and has sold 415 autoclaves in Japan, with 100% market share, and 24 autoclaves overseas in total. One of its affiliates has been manufacturing synthetic crystals for 30 years and distributes a number of optical components mainly to domestic camera manufacturers.

With the technology to manufacture high-quality GaN substrates based on Hydride Vapor Phase Epitaxy (HVPE) and compound semiconductor processing technology, Mitsubishi Chemical is developing GaN substrates with its unique Super Critical Acidic Ammonia Technology (SCAAT™) in order to achieve higher productivity.

The two companies had been developing the technology to manufacture large-diameter, high-quality, and low-cost GaN substrates in collaboration with Tohoku University, and have established a joint research system for crystal growth and properties evaluation in cooperation with Amano Laboratory, Nagoya University.

In 2017, both companies successfully developed the low-cost manufacturing technology for transparent GaN substrates with minimal crystal defects at a pilot facility constructed in the Muroran Plant and confirmed uniform crystal growth on 4-inch substrates. The newly-developed manufacturing process is called 'SCAAT™-LP', and is a new manufacturing technology using low-pressure acidic ammonothermal technology*1 that features approx. half the pressure conditions of conventional SCAAT™ to achieve future mass production.

3. For the future

At the just-completed large-scale facility, we will conduct demonstration experiments using 'SCAAT™-LP' in order to materialize mass production of 4-inch GaN substrates. Based on these experiments, we will establish a stable supply system of GaN substrates and will develop 6-inch substrates that can be applied to power devices that have increasingly been demanded in recent years. Utilization of GaN substrates is considered promising for various applications ranging from power devices to optical and radio energies.

We are dedicated toward contributing to a minimum energy society with enhanced fuel efficiency and power generation efficiency by supplying high-quality GaN substrates that are regarded as essential material to support future society.

Some results were obtained during the grant projects*2 for the New Energy and Industrial Technology Development Organization (NEDO).

<Overview of demonstration facility>

- Location: Muroran Plant of Japan Steel Works M&E, Inc. (4 Chatsucho, Muroran-shi, Hokkaido)
- Total area: 266 m^2
- Major equipment: Large autoclave units, heaters and controllers, ammonia supply/absorption equipment, high-purity gas purifiers

<Overview of JSW>

- Company name: The Japan Steel Works, LTD.
- Address: 1-11-1 Osaki, Shinagawa-ku, Tokyo
- Founded: November 1, 1907
- Capital: 19,737 million JPY
- Line of business: Industrial machinery business, material and engineering products business

<Overview of Mitsubishi Chemical>

・Company name: Mitsubishi Chemical Corporation
・Address: 1-1-1 Marunouchi, Chiyoda-ku, Tokyo
・Founded: August 31, 1933
・Capital: 53,229 million JPY
・Line of business: Functional products, raw materials, etc.

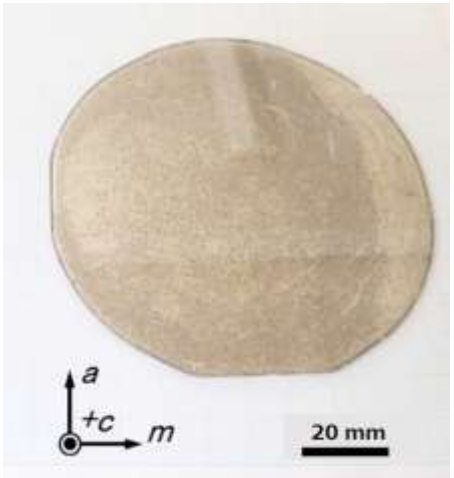
*1 Low-pressure acidic ammonothermal technology

This technology consists of a solvothermal method in which a solute that is not solved at ordinary temperature and pressure is solved in a high-temperature and high-pressure supercritical fluid and recrystallized on a seed crystal by utilizing the difference in solubility depending on the temperature gradient in the furnace. Acidic mineralizers such as ammonium halide (NH_4X, X=Cl, Br, I) are used as mineralizers to promote dissolution of GaN in supercritical ammonia. They facilitate crystal growth at relatively low-pressure conditions (approx. 100MPa, about half of conventional technology), thus materializing a large-scale manufacturing facility suitable for the mass production of large-diameter GaN substrates.

*2 Grant projects of NEDO

FY2017 to FY2019: "Next generation power electronics project for achieving low carbon consumption society"

FY2020 to FY2021: "Strategic innovation program for energy conservation technologies"



GaN crystals grown at the demonstration facility

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