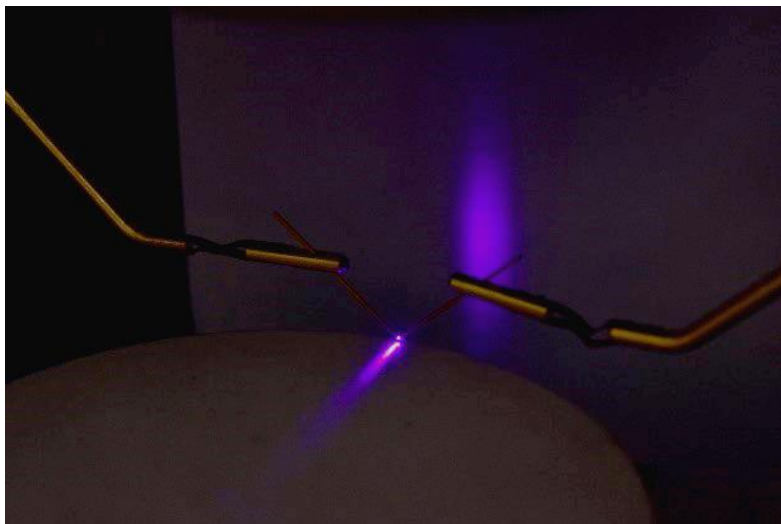


Press Information

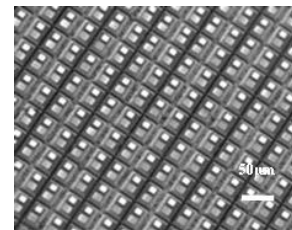
Kyocera Develops New GaN Laser Chip, World's Smallest¹ to be Mass-Produced from Silicon Working Substrate

Company unveils new process to create functioning 100 micron length micro-light sources with higher yield, lower cost — enabling short cavity lasers and micro-LEDs for autonomous driving, AR, and VR applications.

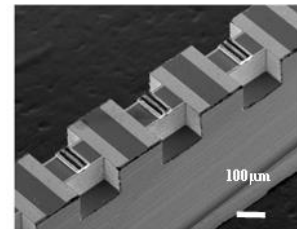
Kyoto/London, 24. November 2022. KYOCERA Corporation has developed a new thin-film process technology for making unique silicon (Si) substrates for gallium nitride (GaN)-based micro-light sources, including short-cavity lasers and micro-LEDs.



100 Micron Long Laser Developed by Kyocera



Micro LED



100 Micron Long Laser

What is a micro-light source?

A “Micro-light source” is a light source with a side measuring less than 100 microns (1/10th of a millimeter). Examples include short-cavity lasers and micro-LEDs. Because they offer key performance advantages, such as higher definition, smaller size, and lighter weight, micro-light sources are considered essential to next-generation automotive displays, wearable smart glasses, communication equipment, and medical devices. The market for micro-LED chips alone

¹ World's Smallest: Among GaN-based edge-emitting lasers formed on silicon substrates. (Source: Kyocera, September 2022).



is expected to reach \$2.7 billion by 2026, a compounded annual growth rate (CAGR) of about 241%.²

Technical challenges in making micro-light sources

GaN-based light-source devices, both micro-LED and laser, have typically been fabricated on sapphire and GaN substrates. Conventional processes involve forming a thin GaN device layer for the light source directly onto the sapphire substrate by heating it to a high temperature (1,000 degrees C or more) in a controlled gas atmosphere. The device layer has to be then removed, or “peeled,” from the substrate to create a GaN-based micro-light-source device. Despite rising demand for smaller devices, however, three separate challenges threaten the ability of this process to achieve miniaturization targets in the near future:

1. Difficulty in peeling the device layer

In case of micro-LEDs, current processes require difficult steps to divide the device layer into individual light sources on the substrate; and then, to separate (or “peel”) the device layer from the substrate. As devices become smaller, the technical challenge of this peeling process can result in unacceptably low yield.

2. High defect density, inconsistent quality

Fabrication of micro-light sources is also problematic because device layers must be deposited onto sapphire, silicon, or other materials with crystal structures that differ from that of the device layer. This creates high defect density and inherent quality control challenges.

3. High manufacturing costs

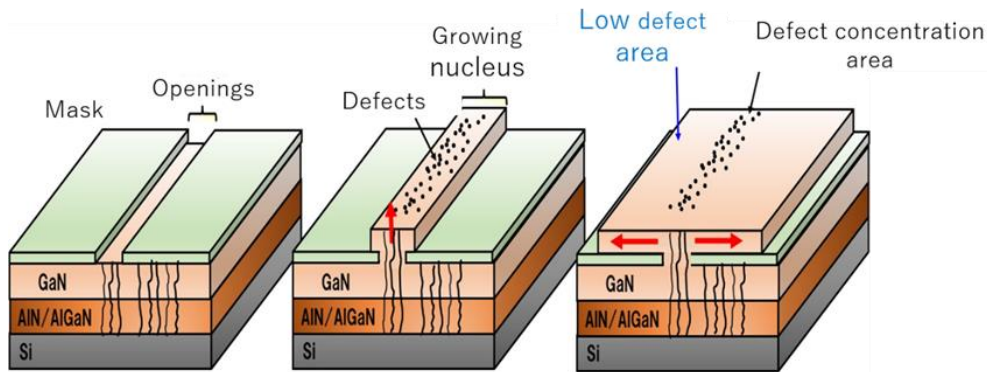
GaN and sapphire substrates are very expensive materials. Although silicon substrates cost less than sapphire, separating the device layer from a silicon substrate is extremely difficult.

New process developed by Kyocera

Kyocera successfully developed the new process technology at the company's Research Institute for Advanced Materials and Devices in Kyoto, Japan. First, we grow a GaN layer on Si substrate which is available in high volumes at a low cost. The GaN layer is then masked with a non-growing material that features an opening in the center. After this, when a GaN layer is formed on the Si substrate, GaN nuclei grow over the opening in the mask. The GaN layer, which is a

² Source: TrendForce “Micro LED Large-Sized Display Chip Market Estimated to Reach 2.7 Billion US dollars by 2026, says TrendForce (August, 2022).

growing nucleus, has many defects at the initial stage of growth; but, by forming the GaN layer laterally, high-quality GaN layers with low defect density can be created, and devices can be fabricated successfully from this low-defect region of the GaN layer.



Advantages of Kyocera's new process

1. Easier peeling of the GaN device layer

Masking the GaN layer with a material that does not grow suppresses bonding between the Si substrate and the GaN layer, greatly simplifying the peeling process.

2. High-quality GaN device layers with low defect density

Since Kyocera's process can deposit low-defect GaN over a wider area than before, consistent fabrication of high-quality device layers is possible.

3. Lower manufacturing costs

Kyocera's new method facilitates successful and reliable separation of the GaN device layer from the relatively inexpensive Si substrate, which will greatly reduce manufacturing costs.

Micro-light source applications

1. Next-generation automotive transparent display

In the future, the advent of autonomous driving will create demand for displays that are brighter, higher-definition, power-efficient, more highly transparent, and lower cost.



Next-generation automotive transparent display

2. Micro-light sources for AR/VR

The market for micro-light sources used in augmented reality (AR) and virtual reality (VR) is expected to expand rapidly. Smart glasses and other products are being developed to facilitate the creation of virtual spaces through the metaverse in VR and “de-smartphoning” in AR. While conventional semiconductor lasers for AR have been miniaturized to as small as 300 microns in length, Kyocera is the first in the world to achieve a size of just 100 microns. We could achieve this size by developing a completely new production process that is an evolution of cleaving method.

This so-called “novel cleaving method” results in a size reduction of about 67% and helps minimize power consumption. Semiconductor lasers with lower power consumption make it possible to reduce the size and weight of the battery, thus improving fit.



AR Glasses



Kyocera will offer a wide range of platform, substrate, and process technologies to bring high-quality, low-cost micro-light sources to market in the near future. We also aim to transform next-generation display and laser markets using this new platform.

For more information on Kyocera: www.kyocera.co.uk

About Kyocera

Headquartered in Kyoto, Japan, KYOCERA Corporation is one of the world's leading manufacturers of fine ceramic components for the technology industry. The strategically important divisions in the KYOCERA Group, which is comprised of 298 subsidiaries (as of March 31, 2022), are information and communications technologies, products which increase quality of life, and environmentally friendly products. The technology group is also one of the most experienced producers of smart energy systems worldwide, with more than 45 years of know-how in the industry. The company is ranked #665 on Forbes magazine's 2022 "Global 2000" listing of the world's largest publicly traded companies.

With a global workforce of over 83,000 employees, Kyocera posted sales revenue of approximately €13,42 billion in fiscal year 2021/2022. The products marketed by the company in Europe include printers, digital copying systems, semiconductor-, fine ceramic-, automotive- and electronic components as well as printing devices and ceramic kitchen products. The KYOCERA Group has two independent companies in the United Kingdom: KYOCERA Fineceramics Ltd. and KYOCERA Document Solutions Ltd.

The company also takes an active interest in cultural affairs. The Kyoto Prize, a prominent international award, is presented each year by the Inamori Foundation — established by Kyocera founder Dr. Kazuo Inamori — to individuals worldwide who have contributed significantly to the scientific, cultural, and spiritual betterment of humankind (approximately €710,000* per prize category).

*Date of Survey: June 15th, 2022

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