ADVERTISEMENT FEATURE

COMPACT LASERS SET TO DRIVE AUTONOMOUS MACHINERY

The light detection and ranging **SENSORS THAT ALLOW THE AUTONOMOUS MOVEMENT OF VEHICLES AND ROBOTS** will be improved by new photonic-crystal surface-emitting lasers.

"Compared to photonic-crystal surface-emitting lasers, even the best conventional semiconductor lasers today seem like bulky edge-emitting devices with poor beam quality, large beam spread and limited brightness," says Susumu Noda, from Kyoto University.

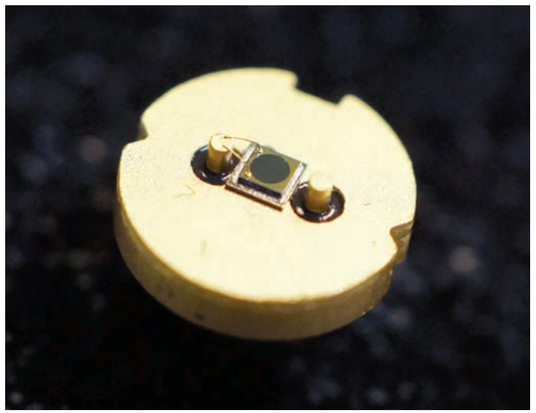
Photonic-crystal surface-emitting lasers (PCSELs) are an emerging semiconductor technology that uses photonic crystals to generate a bright, high-quality beam that emits directly from the top of the crystal surface.

Semiconductor lasers are integral to everything from optical fibre networks and telecommunications, to range-finding, 3D modelling, manufacturing and medicine.

Noda argues that PCSELs should help simplify, reduce in size, and increase the precision and power of these systems, opening up new possibilities in all of these areas.

The group are particularly excited about smaller and more powerful light detection and ranging (LiDAR) systems, which use lasers to measure the distance to solid objects by detecting the time it takes for light to be reflected back from the target. LiDAR is starting to be used extensively to facilitate the mobility of autonomous vehicles and robots, and for 3D imaging. In fact, the autonomous vehicle revolution is only possible because of LiDAR technology, says Noda.

Today, the Center of Excellence (COE) for PCSEL technology, where Noda works, is collaborating with industry partners, including ROHM, Hokuyo Automatic, Brookman Technology and SpaceView, on developing compact, high-performance PCSEL-based LiDAR units for a range of uses. "These projects are really exciting, and we are getting very close to making these technologies a commercial reality," says Noda.



▲ **Industry and academia are collaborating on sensors that use energy- and space-efficient photonic-crystal surface-emitting lasers (pictured).**

BRIGHTER AND TIGHTER

The collaboration between the COE and electronic and optoelectronic parts manufacturer ROHM, which is based in Kyoto, Japan, has produced a powerful, very narrow PCSEL beam with minimal spread, which will allow LiDAR systems to be greatly simplified and miniaturised, says ROHM research engineer, Wataru Kunishi.

THE GROUP ARE PARTICULARLY EXCITED ABOUT SMALLER AND MORE POWERFUL LIGHT DETECTION AND RANGING (LIDAR) SYSTEMS.

Their devices currently have a beam spot size of just 5 centimetres at a distance of 30 metres, without the need for lenses, he explains. These devices boast a brightness of 1 gigawatt per square centimetre per steradian, the unit used to measure angles.

This is more than 10 times brighter than conventional semiconductor lasers, and comparable to much larger lasers, such as industrial gas lasers and fibre lasers. "ROHM is now working with the COE to develop a mass production technology for the nanoscale photonic crystal structures of PCSELs, which will be key to commercialisation," he says, "as well as working on highly robust designs, checking reliability and accumulating data".

ROHM has been developing light emitting devices since the 1980s, Kunishi adds. PCSELs were first demonstrated at Kyoto University in 1999. "As one of the first companies to collaborate with Kyoto University on PCSELs, we have long been working to increase the brightness of the PCSEL to a level where it can be demonstrated in working LiDAR equipment."

COMPACT, HIGH-PERFORMANCE LIDAR

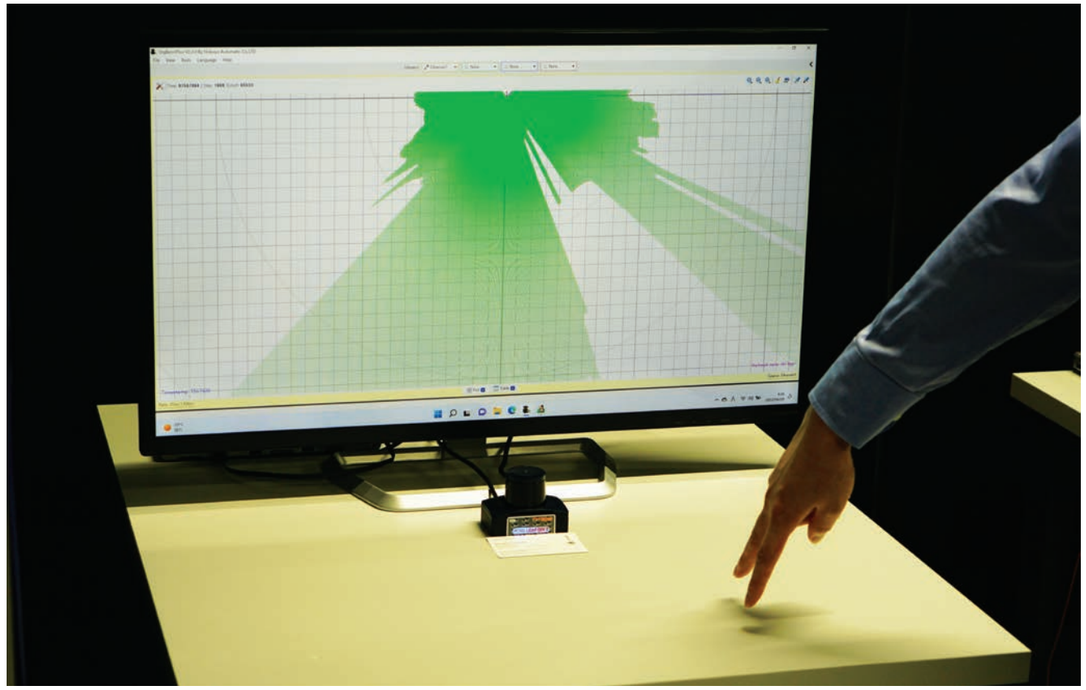
With LiDAR PCSEL technology reaching brightness levels viable for commercial performance, the COE is collaborating with advanced optical sensors manufacturer Hokuyo Automatic, headquartered in Osaka, Japan, on designing these next generation PCSEL-based LiDAR systems.

"Hokuyo produces LiDAR for self-driving industrial robots," explains, Naohiro Shimaji, general manager of Hokuyo Automatic's R&D department. These types of LiDAR systems involve scanning of the surrounding physical environment with a laser beam that uses a rotating assembly.

Conventional systems are bulky, the size of a football or larger, says Shimaji. By eliminating redundant optics and achieving high power in a small device, Hokuyo's latest LiDAR system, made in collaboration with the COE, is the size of a baseball, and further miniaturization is expected.

"Sensors for robots that work in logistics warehouses need to be small and have high resolution. PCSELs have many new and ideal features that can be exploited, including very narrow beam divergence and a circular beam shape, elimination of optical components and their precision alignment requirements, and a high-quality beam at high output," he explains.

He believes "all lasers used in LiDAR will soon be replaced with PCSEL technology".



▲ **One company has made a baseball-sized light detection and ranging system for self-driving robots. It scans its surroundings on a rotating assembly.**

FLASH AND SCAN

One of the most promising features of PCSELs is the ability to direct a beam by activating different individual elements in an PCSEL array, says Tomoyuki Akahori, chief engineer with semiconductor imaging company, Brookman Technology, which is based in central Japan.

This means that a device without moving parts can have a beam that can be directed across a wide arc, raising the prospect of solid-state LiDAR devices, which would be more compact, light, hardy, and use less energy.

Using a PCSEL array also makes it possible to 'flash' all the laser elements at once to obtain an instant 3D snapshot across a field of view. This feature, combined with scanning, creates new application opportunities for LiDAR technology.

Brookman Technology had been developing a flash type 3D LiDAR, but was facing one key challenge; black objects were difficult to detect by flash alone.

"By collaborating with the COE, we recently created a completely new LiDAR that combines flash and scanning PCSEL array chips, solving the black object problem and also enabling a dramatic reduction in device size," says Akahori.

"We are now working to further improve the new LiDAR system by adding automatic recognition and tracking of black objects," says Yoshiyuki Mineyama, formerly of Brookman Technology, and now the CEO and chief engineer of SpaceView, a hardware-system start-up company developing cameras and imaging systems. "We are creating LiDAR technology that we've never seen before," says Mineyama.

Noda says the COE is now focused on establishing an ecosystem for exporting PCSELs and its related technologies globally, while continuing to expand the functionalities of PCSELs for various technologies, including sensing, manufacturing, communications, medicine and entertainment. He hopes that PCSELs will be available all over the world in the near future." ■

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