FY2013

"Photonic Crystal Surface-Emitting Semiconductor Laser" - Towards Realization of High Power and High Brightness Operation

Molding light with photonic crystals for high-power lasers

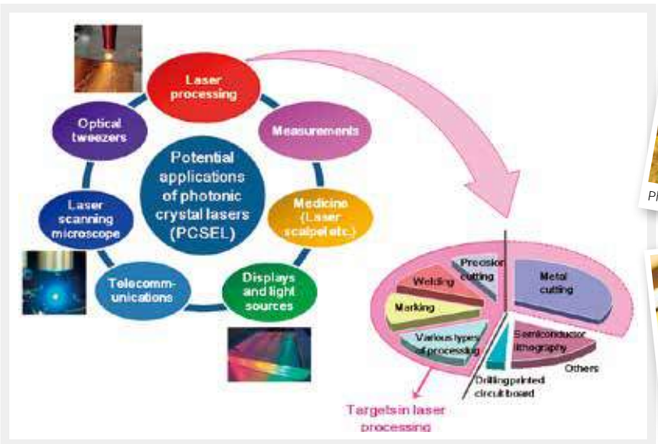
Lasers are used in manufacturing in areas such as optical recording for DVDs and metal processing. While compact semiconductor lasers are low in cost, high in energy efficiency, and easy to control and handle, their maximum output power, beyond which their beam quality is seriously degraded, is extremely small compared to the gas lasers that are common in industry. Consequently, they have not been used in manufacturing with heavy demands, such as metal or material processing that requires high power.

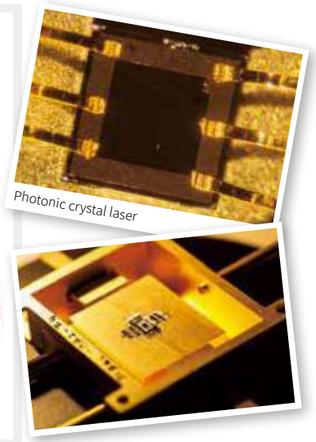
We have invented an artificial optical nano-structure called a photonic crystal, and are trying to use it to realize a photonic crystal laser that provides high power and high functionality while still enjoying the advantages of semiconductor lasers. Our previous research has demonstrated the possibility of achieving a high powered laser by making the light on the entire emitting surface be in phase.

Combining high-power lasers to achieve even more power

In the ACCEL project, we aim to increase the output power of the photonic crystal laser, which currently is just one watt per element, to up to ten watts per element. We will also develop a high-power module that produces 100 watts by combining modules of 10-watt lasers. Recently, we have discovered that the output can be increased further by making double holes in the photonic crystal.

Using these methods, we aim to come up with a compact, high-performance, and high-output laser processing technology, one that has been difficult to achieve using existing semiconductor laser technology.





Photonic crystal laser

The photonic crystal used for this laser has holes opened precisely every several hundreds of nanometers. This special structure reflects light like a mirror to confine light within the crystal. The photonic crystal laser produces strong light by stacking this photonic crystal layer on the active layer that emits light, emitting a high-density beam perpendicular to the crystal surface.

Research Director

Susumu Noda

Professor, Graduate School of Engineering, Kyoto University

In a semiconductor laser, enlarging the light emission area increases power, but drastically impairs the beam quality, distorting its wavelength, phase, and travel direction. We found out that light is kept in phase over a very broad area using the unique resonance function of photonic crystals called "band-edge resonance." Installing this in the proper position in the laser element created a high power laser beam of around one watt.

In the ACCEL project, we aim to increase the power, with 10 watts as our target, by solving and verifying the problems we face one by one. Specifically, we will research designs with refined photonic crystal structures, as well as the nanotechnologies required to implement these designs. Through this research, we would like to increase the competitive strength of Japanese laser technology internationally. In addition, we will train researchers through the innovation of new technology.

If this laser from Japan achieves 100 or 1000 watts of output power as a single device in the future, I expect that it will revolutionize laser technology.

Program Manager

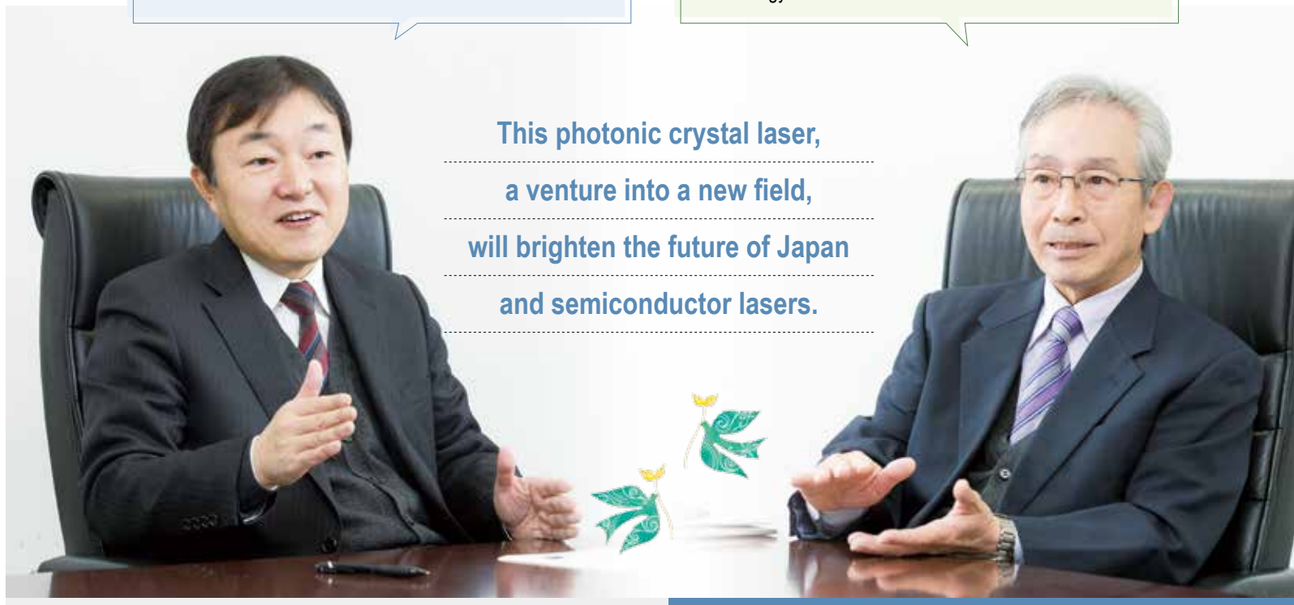
Shigenori Yagi

ACCEL Program Manager, Japan Science and Technology Agency

I have noted this research as one of the frontiers of physics from the time when I was developing a CO_2 laser at a company, and have been impressed with their progress and results. As the Program Manager, I would like to verify and present the technical feasibility of the photonic crystal laser and promote application-oriented strategic research management.

In the ACCEL project, I will collaborate with three companies to promote R&D, discover potential needs through market research and hearings with users, and develop this technology so that it can be used for processing, as well as for medical and measurement uses. In addition, with a help of a think tank, I will look for ways in which less than 10 watts of power can deliver sufficient performance, and promote its commercialization. The real power of a technology is only truly demonstrated when it replaces the existing universally used technology. The photonic crystal laser has ample potential for this.

The photonic crystal laser is a prime example of Japan's original/innovating technology. I shall communicate its practical achievements to ensure it becomes a major technology worldwide.



This photonic crystal laser, a venture into a new field, will brighten the future of Japan and semiconductor lasers.

PROFILE SUSUMU NODA

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