NEWS RELEASE

Hamamatsu Photonics has developed a high power QCL module that applies a unique QCL beam combining technology to deliver an output power of 2 watts at a wavelength of 8.6 μm, making it ideal for laser micromachining of fluoropolymer resins.

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Hamamatsu Photonics have developed a high power QCL module that delivers an average output power of 2 watts at a wavelength of 8.6 micrometers (1 micrometer or μm is one-millionth of a meter). This high power QCL module was created by applying our unique beam combining technology, with quantum cascade lasers (QCL)*1 , developed based on new heat dissipation technology. This QCL module combines mid-infrared light beams emitted from two QCLs to boost the output power to a level ideal for micromachining of fluoropolymer resins, such as polytetrafluoroethylene (PTFE) that are used for high frequency device substrates, and a vast range of vehicles and transportation machinery. Other potential applications for this QCL module include medical treatment and healthcare.

This new module was designed and developed as part of a project called “Development of Advanced Laser Processing with Intelligence Based on High-Brightness and High-Efficiency Next-Generation Laser Technologies” supported by NEDO (New Energy and Industrial Technology Development Organization), a major national research and development agency in Japan. We are planning to exhibit this QCL module at the NEDO booth at the OPIE ’21 (OPTICS & PHOTONICS International Exhibition 2021), Japan’s largest optoelectronics exhibition which will be held at the Pacifico Yokohama (Nishi-ku, Yokohama, Japan) for 3 days from Wednesday 30 June to Friday 2 July 2021.

*1. Quantum cascade laser or QCL is a semiconductor laser light source utilizing a quantum structure for the light-emitting layers to produce high output power in the mid-to-far infrared region.

■Key features

◇QCL module has an average output power of 2 watts at a wavelength of 8.6 μm.
- Succeeded in developing a high power QCL module that applies our unique beam combining technology to efficiently combine mid-infrared light beams emitted from two QCLs.
- Boosts the output power to 2 watts which is approximately 100 times higher than previously available products.

◇QCL wavelength is selectable from either 8.6 μm, 6.1 μm or 4.6 μm.

◇Fiber output unit was also designed with actual use in mind.
- Guides mid-infrared light from the QCL module to the machining area.

◇Ideal for micromachining of fluoropolymer resins that easily absorb mid-infrared light.

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Development background

With the current trend toward higher speed and capacity of communication equipment, fluoropolymer resins such as PTFE are becoming more widely used for high frequency device substrates since signal deterioration is less likely to occur in these fluoropolymer resins. A great deal of progress is also being made using these fluoropolymer resins in car bodies and parts to reduce the weight of vehicles and transportation machinery. This trend will increase the need for harnessing laser machining technology that works on a practical level, capable of precise micromachining of PTFE and similar fluoropolymer resins. At present, mid-infrared lasers suitable for micromachining of these resins are limited to carbon dioxide (CO_2) lasers with 10.6 μm wavelength. This means there is a high demand for mid-infrared lasers with wavelengths different from currently available lasers that will allow them to micromachine fluoropolymer resins that absorb these different wavelengths.

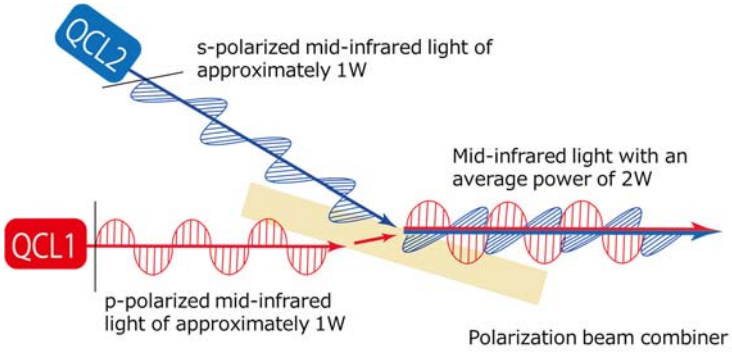
We have already designed and manufactured QCL products that emit mid-infrared light of wavelengths from 4 μm to 10 μm and have an output power of several dozen milliwatts (mW). We also market and sell these QCL products for environmental gas measurement applications. Laser machining applications usually require higher power. The QCL has a structure of stacked light-emitting layers and its output power can be boosted by increasing the number of stacked layers, yet it also requires a higher drive voltage that in turn leads to generating a greater amount of heat. Since this reduces the output efficiency and also shortens the device service life, the problem of how to boost QCL output power has been a major issue.

Brief look at the product

The high power QCL module we have developed provides an average output of 2 watts at a wavelength of 8.6 μm ideal for micromachining of fluoropolymer resins such as PTFE that easily absorb mid-infrared light.

We manufactured the high power QCL module by forming a thick gold film with high thermal conductivity on the surface of the QCL, polishing it with high precision and making good contact with a heatsink via our unique assembly technique to enhance the heat dissipation of the QCL. This suppresses the effect from heat while increasing the number of light-emitting layers up to 3 times that of previous products, and so boosts the QCL output power to 1 watt or more. By employing optical components created based on our optical design technology, and using our unique beam combining technology to efficiently combine mid-infrared light beams emitted from two QCLs that are polarized*2 at a different angle, we succeeded in developing this high power QCL module that provides an average output power of 2 watts at a wavelength of 8.6 μm. The two QCLs mounted in this QCL module can be replaced to emit mid-infrared light with a wavelength of 6.1 μm or 4.6 μm, depending on the resin materials to be laser-machined. To make it easier to use the QCL module, we have also developed a fiber output unit that guides and irradiates mid-infrared light from the QCL module onto the target machining area.

*2. Polarized light is light where all waves vibrate on the same plane relative to the direction of propagation.



The newly developed polarization beam combiner is used to boost output power by spatially combining mid-infrared light with different polarization angles emitted from two QCLs.

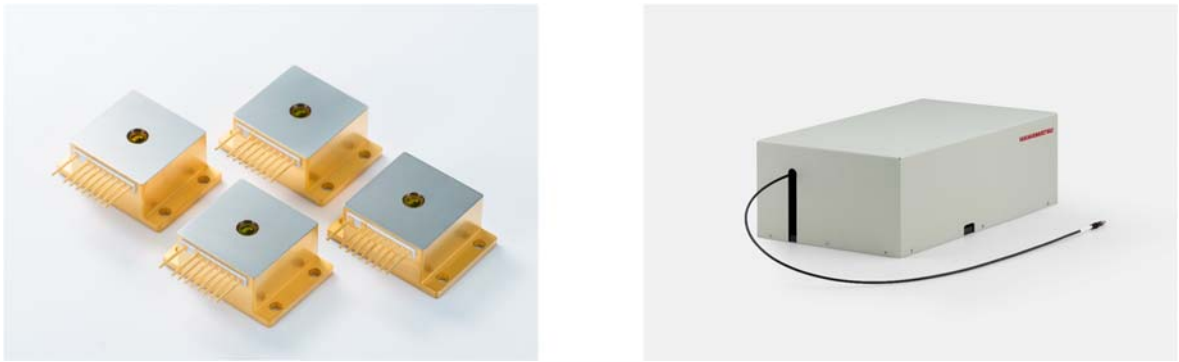
How the QCL module boosts the output power

The QCL module we developed is capable of laser micromachining on difficult to machine resin materials such as PTFE, that are increasingly being used for high frequency device substrates, and for vehicles and transportation machinery. This QCL module also appears to be promising for applications in the medical treatment and healthcare field, as it utilizes mid-infrared light of the specific wavelength that is easily absorbed by the target biomolecules to be irradiated and it minimizes thermal damage to the adjacent areas.

We will be collaborating with universities, public research institutes and companies involved with laser machining, while continuing demonstrations and experiments, to improve the performance of this QCL module and place it on the market as a product. We will also expand the underlying technologies for micromachining lasers that support our laser business.

About the project

Future manufacturing sites are expected to improve production efficiency even further by harnessing artificial intelligence. These circumstances make laser machining, which is easy to digitally control, ever more important. However, laser machining technology including cutting, welding and bonding still face challenges in terms of satisfactory machining accuracy and power consumption. Although applications that make use of ultraviolet to visible light and near-infrared light in laser machining are making progress, applications using mid-infrared light are still limited. This project aims to establish high-precision and high-efficiency laser machining that utilizes mid-infrared light.



External view of the newly developed QCL and fiber out unit

● **Main specifications**

Item	Specifications	Unit
QCL	Operating temperature: 10 to 20°C QCW drive duty: 30 to 50%	-
Laser Wavelength	8.6, 6.1, 4.6	μm
Average optical output	2	W
External dimensions(W×D×H)	245 × 250 × 105	mm

External view of the QCL module