Tohoku and Sony develop first 100W blue-violet ultra-fast pulsed semiconductor laser

High-capacity optical disc storage and nano-fabrication targeted.

Professor Hiroyuki Yokoyama of Tohoku University's New Industry Creation Hatchery Center (NICHe) and Sony Corp's Advanced Materials Laboratories in Japan have jointly developed a blue–violet indium gallium nitride (InGaN)-based ultra-fast pulsed semiconductor laser with peak output that is 100 times that of the highest output for existing conventional blue–violet pulse semiconductor lasers (Appl. Phys. Lett. vol 97, issue 2, 021101).

The new all-semiconductor-laser picosecond pulse light source has an emission wavelength of 405nm (in the blue–violet region of the spectrum), and can generate ultra-fast single-transverse-mode optical pulses as short as 3ps in duration, with a repetition frequency of 1GHz, without the use of any pulse compression. The generation of clean optical pulses without sub-pulse components from the proprietary mode-locked laser diode (MLLD) and the reduction in amplified spontaneous emission in the accompanying semiconductor optical amplifier (SOA) by incorporating a flare waveguide structure resulted in effective amplification of optical pulses to produce peak output power of more than 100W (see Figures 1 and 3).

The new high-output, ultra-fast pulsed semiconductor laser light source is capable of using the two-photon absorption (TPA) nonlinear optical process, which occurs only due to high-intensity optical pulses

Although there have previously been ultra-high-output laser devices combining solid-state lasers and a second-harmonic-generation unit for high functionality and high-value chemical research applications, the light source was bulky, and a specialist technician was required to ensure stable operation of the laser. It is expected that the new system, incorporating semiconductor laser diodes, can have a much wider range of applications through enabling the size of components such as the light source to be drastically reduced (see Figure 2).

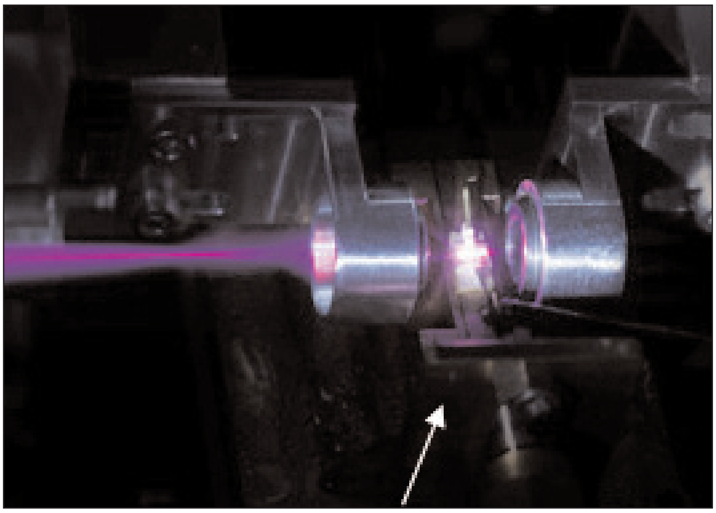

Figure 1. Beam emitted by blue–violet ultra-fast pulsed laser (arrow indicates SOA).

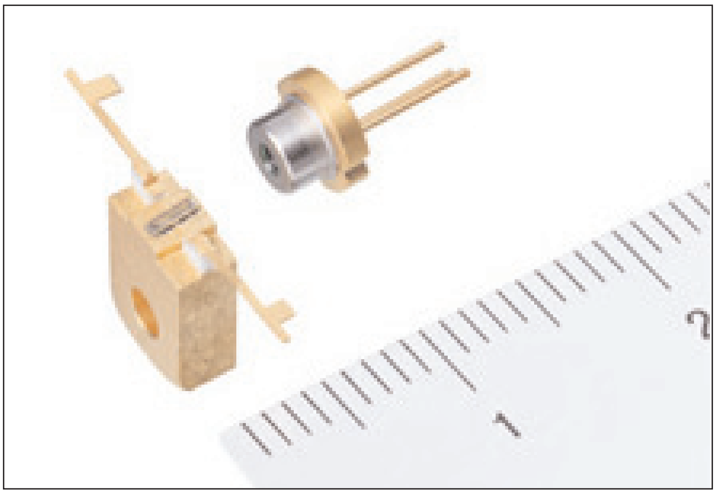

Figure 2. The new blue-violet laser (right) and SOA (left).

In addition, the new high-output, ultra-fast pulsed semiconductor laser light source is capable of using the two-photon absorption (TPA) nonlinear optical process, which occurs only due to high-intensity optical pulses. When light from the laser beam is concentrated on the lens, it creates chemical and thermal changes in the vicinity of the focal spot that are narrower than even the focal spot's diameter. It is expected that application of these properties will be possible in a wide range of

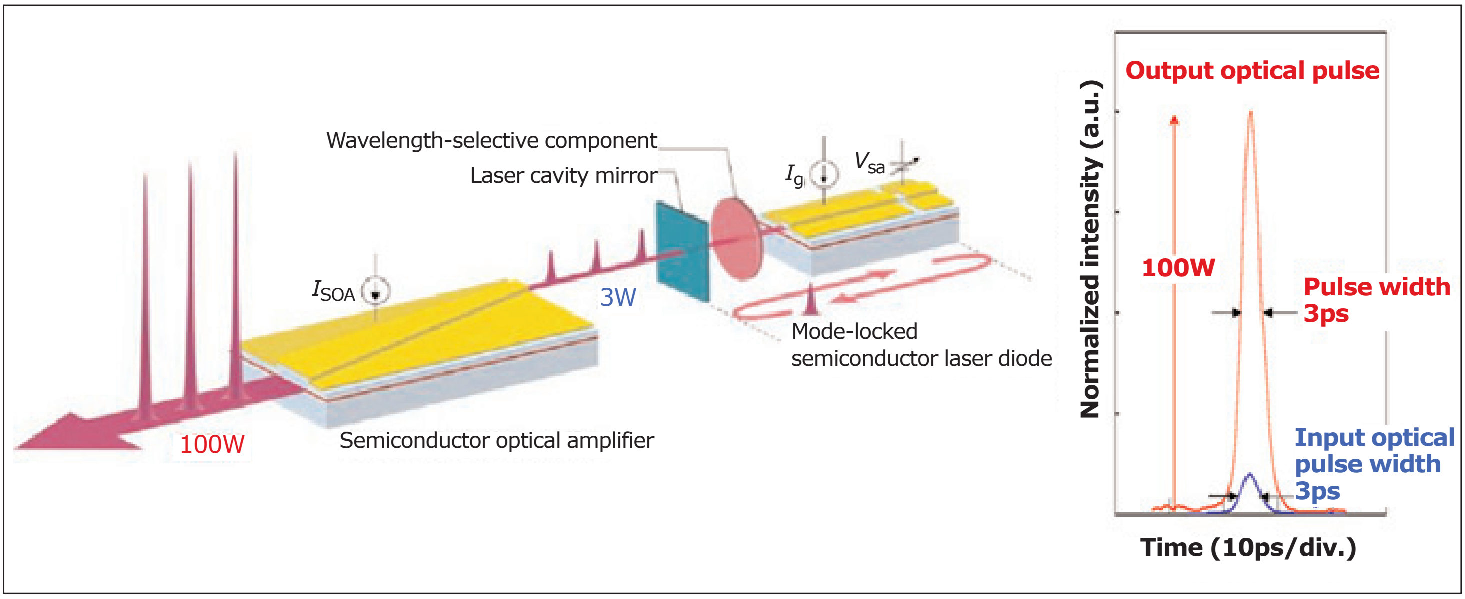

Figure 3. Blue-violet ultra-fast pulsed semiconductor laser system (left) and temporal waveforms of light using streak camera measurement (right): wavelength 405nm (GaN-based laser); peak optical output 100W or more; repetition frequency 1GHz; pulse width 3ps.

fields such as three-dimensional (3D) nano-fabrication of inorganic/organic materials of the order of nanometers, and next-generation large-capacity optical disc storage.

Sony says that it has tested the principles for applying the technology in next-generation large-capacity optical disc storage by creating void marks with a diameter of about 300nm at intervals of 3μm on the interior of plastic material, and then successfully read these marks using the laser beam (see Figure 4).

The experimental results have been achieved through the integration of Sony's semiconductor laser diode expertise with Tohoku University's fundamental ultra-short pulse laser technology (Tohoku is promoting a joint research program for industry–academic collaboration based on materials and devices).

Tohoku and Sony aim to develop the fundamental technology further to achieve even higher output and multi-functionality, while developing practical applications to make the systems more compact and stable. ■

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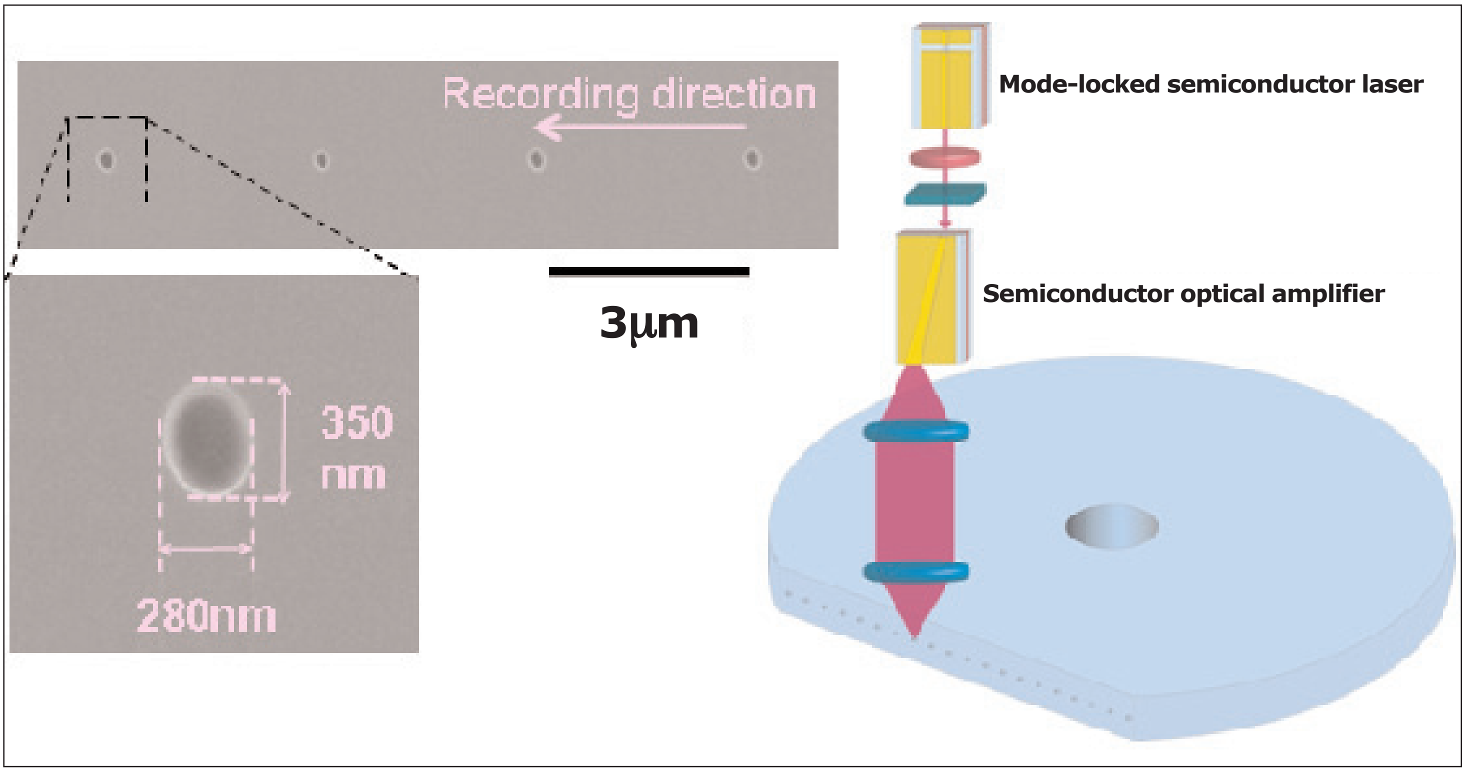

Figure 4. Testing the principle of optical disc storage using an experimental laser.