MICROCHIP LASERS |

Microchip Laser Nears 2-MW Output

Researchers at the Institute of Molecular Science (Okazaki, Japan) have developed a microchip laser using a saturable Q-swtich capable of producing 1.7 MW.

Diode-pumped, solid-state lasers (DPSSL), including microchip lasers, have much to recommend them. Not only are they compact and highly efficient, but they also offer a long life compared to flash-lamp pumped, gas and dye lasers. But for the purposes of Takunori Taira's research, DPSSLs high beam quality and accumulation of energy are perhaps the most significant source characteristics. "Our objective with the project was to increase the pulse brightness in a microchip configuration," Taira says.

The team picked a passive Q-switched laser because it needs neither high voltage nor high-frequency power supplies, Taira says, making the system safer to handle. In addition, its advantages include compact size, low cost, and portability.

Taira's team used a diode end-pumped high-brightness Nd^{3+}:YAG microchip laser that was passively switched by a Cr^{4+}:YAG saturable absorber (SA). Taira's research revealed that SAs do not reach complete saturation; instead, there is a residual loss, which Taira accounts for by assigning T_o to the initial transmission before saturation and T_f to the final transmission when the laser oscillation is completed in the SA.

"In order to investigate the key parameters that determine the characteristics of the laser," Taira says, "we calculated the rate equations of the passively Q-switched laser. As a result, we found that the pulse energy increases when the reflectivity of the output coupler decreases, when the initial transmission of SA decreases, and when the effective area of the resonator mode at the laser medium increases."

As noted above, the team started with a diode end-pumped passively Q-switched Nd^{3+}:YAG laser. The cavity was formed between the end face of the laser medium—which was a 5-mm-long Nd^{3+}:YAG crystal (1.4 at %)—and the output coupler—a flat mirror with 56% reflectivity. The SA was constituted by CR^{4+}:YAG crystals with initial transmission T_o of 30%, 65%, and 80%, with a 30-µm

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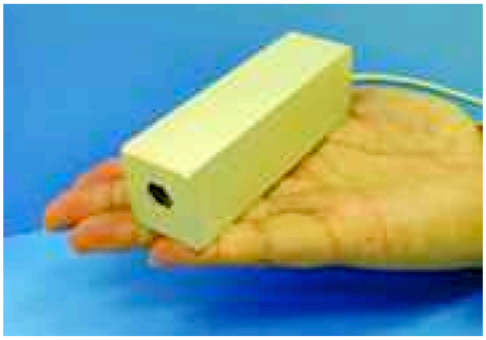
cavity length. The pump source was a fiber-coupled diode laser with a core diameter of 400 µm, numerical aperture of 0.22, and a center wavelength of 806 nm. The diode laser was pulsed at 100 Hz to control the repetition frequency of the passively Q-switched laser.

"During our experiments, we found that the pulse energy increased and the pulse width decreased as the initial transmission of SA was reduced," Taira explains. "We then conducted a theoretical analysis to find an explanation for this phenomenon, and arrived at the equation T_f = exp. (0.043 × In T_o – 0.098). We found that the experimental values were well in agreement with those calculated, as well."

With this improvement, Taira's team achieved a laser pulse energy of 0.95 mJ, a pulse width of 480 ps (1.7 MW peak power), a beam quality of M^2 = 1.05 for a pump peak power of 30 W (450-ms pulse width), initial transmission of SA T_o = 25%, and a cavity length of 20 µm at the repetition rate of 100 Hz. "Our results were excellent for this kind of small laser," Taira says. "We were able to package the optical head of the passively Q-switched Nd:YAG laser in a box only 3 × 3 × 10 cm."

Kodo Kawase of the Nagoya University (Nagoya, Japan) Department of Quantum Engineering says, "One important feature of Taira's Q-switched laser is its single-frequency oscillation. We found it ideal for generating sharp-spectrum, single-frequency terahertz waves in our own experiments."



Taira and his research team succeeded in creating a very compact high-power Nd:YAG laser.

"Tightly focused spots with high energy density are a must for laser microfabrication," says Yoshihiko Matsuoka of the National Institute of Advanced Industrial Science and Technology (Tsukuba, Japan). "Taira and his team have achieved a high-quality, high-brightness, compact, stable laser source. Hereafter, we think a microchip laser such as Taira's may be used as a power application for microfabrication." —*Charles Whipple*