Scientists demonstrate new wavelength shift with diode-pumped continuous-wave Yb:CALGO laser

May 22 2020, by Zhang Nannan

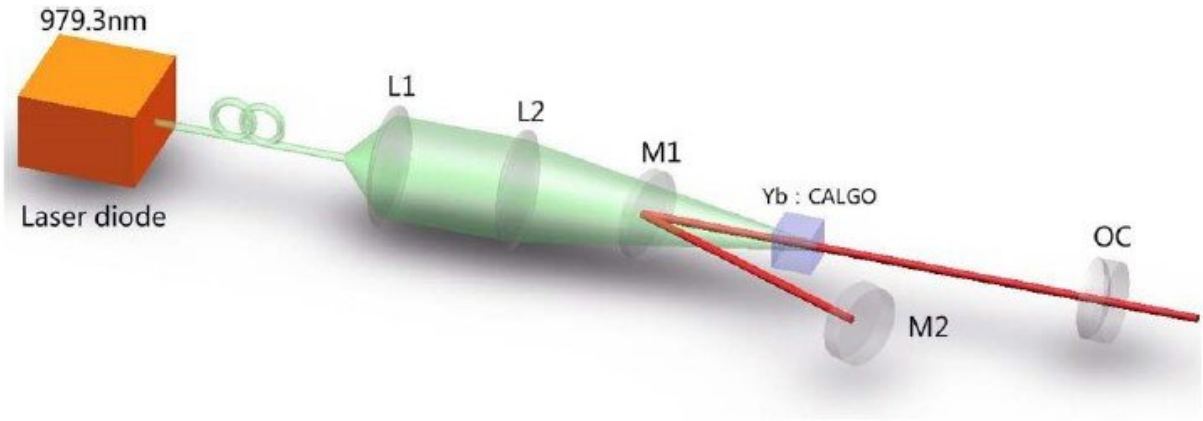

Fig. 1. Schematic setup of the CW Yb:CALGO laser. Credit: SIOM

In 1960, Maiman's first demonstration of the ruby laser initiated the beginning of the laser era. Solid-state lasers still comprise one of the most rapidly developing branches of laser science and has improved amazingly during last six decades while the gain media with good characteristics is essential for realizing a highly efficient solid-state laser.

It is now widely recognized that Yb^{3+}-doped crystals have significant potential in the development of directly diode-pumped high-power and

ultrafast lasers. Among them, the Yb^{3+}-doped $CaGdAlO_4$ crystal (Yb:CALGO) performs well, with high thermal conductivity and the broadest and flattest emission spectra of all the Yb_3^+-doped materials. Therefore, studying the laser performances of Yb:CALGO is of great significance for high-peak-power ultrashort pulse generation.

In a recent study, researchers from the Shanghai Institute of Optics and Fine Mechanics of the Chinese Academy of Sciences have made new progress in the research of a diode-pumped continuous-wave Yb:CALGO laser. The findings were published in *Applied Optics*.

In the experiment, a diode-pumped continuous wave Yb:CALGO laser with an output power of 11W and a slope efficiency of 19.8% was demonstrated. The effects of crystal temperature on wavelength emission were investigated. The crystal temperature was controlled by changing the pump power. The output wavelength obviously shifted to the longer wavelength for output couplers with different transmissions as the temperature of the crystal increased.

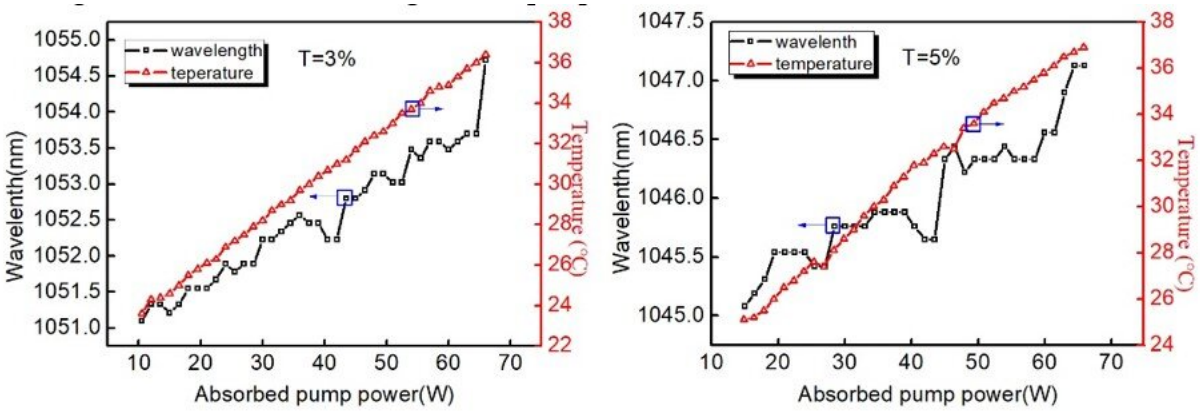

Fig. 2. Output wavelength and temperature of crystal versus the pump power. Credit: SIOM

The researchers found that, for T =3% output coupler, the out wavelength shifted range from 1,051.10 nm to 1, 054.72 nm, as the temperature of crystal changed from 23.6 degrees Celsius to 36.4 degrees Celsius. And for T =5% output coupler, the out wavelength shifted from 1, 045.08 nm to 1, 047.13 nm, and the temperature of crystal changed from 25.1 degrees Celsius to 36.9 degrees Celsius. For T =3% output coupler, an experiment at the fixed pump power was also carried out.

The crystal temperature was altered through cooling water. When the temperature of the crystal increased from 32.2 degrees Celsius to 38.2 degrees Celsius, the output wavelength shifted from 1,052.23 nm to 1,052.80 nm. The wavelength shift with temperature in the CW Yb:CALGO laser could be explained with a temperature-dependent model. The rise in temperature increased the population density in the upper levels of ground manifold, according to Boltzmann distribution.

Consequently, when the laser operated above a certain temperature threshold, the previous two energy levels could no longer meet the condition of the population inversion. However, the population inversion still existed between the excited level and upper ground level. As a result, the population inversion would vanish for the shorter laser wavelength and a longer wavelength would dominate.

Due to the much more complicated Stark splits of ground manifold and excited manifold of Yb:CALGO, a series of output wavelength were observed with the changing temperature.

This wavelength shift phenomenon would be especially important for intracavity optical parametric oscillator and might be favorable for some special purposes, including tunable lasers for certain wavelengths and any other wavelength-sensitive researches.

More information: Xiao Du et al. Wavelength shift with a diode-pumped continuous-wave Yb:CALGO laser, *Applied Optics* (2020). DOI: 10.1364/AO.385337

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