

CW Yb:LuVO₄ Laser Produces More Than 1 W

New material is promising in diode-pumped applications.

The vanadate crystals YVO₄, GdVO₄ and LuVO₄ are good host materials for diode-pumped neodymium-doped lasers because they have large absorption and emission cross sections, have broad bandwidths and naturally lase in a single polarization.

Experiments with ytterbium-doped YVO₄ and GdVO₄ also have yielded positive laser results, and now scientists at Max Born Institut für Nichtlineare Optik und Kurzzeitspektroskopie in Berlin and at

Shandong University in Jinan, China, have reported equally positive results with Yb:LuVO₄.

The investigators grew their Yb:LuVO₄ by the Czochralski technique from a melt with 1.5 percent ytterbium doping. Because the ionic radius of ytterbium is very close to that of the lutetium it replaces in the crystal lattice, the ytterbium concentration in the crystal was 1.56 ± 0.01 atomic percent, nearly identical to the concentration of the melt.

They measured the spectroscopic

properties of Yb:LuVO_4 and then observed laser oscillation in the material under pumping with a Ti:sapphire laser and a diode laser. They found, spectroscopically, the spontaneous lifetime was $256 \mu\text{s}$, roughly the same as ytterbium in the other vanadate hosts. The absorption and emission cross sections were strongly

polarization-dependent, as in all vanadates. Surprisingly, a trend observed in neodymium-doped vanadates, namely that the cross sections increase going from GdVO_4 to YVO_4 to LuVO_4 , appears not to be present in the ytterbium-doped vanadates.

For the Ti:sapphire-pumped laser experiments, the scientists placed a

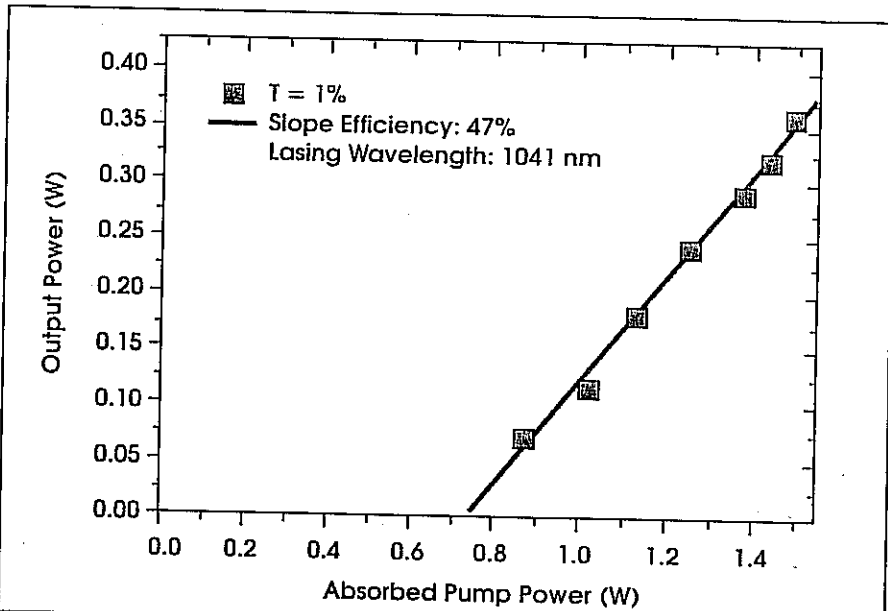


Figure 1. Under Ti:sapphire pumping, the Yb:LuVO_4 laser achieved 360 mW at a slope efficiency of 47 percent. T = transmission of output coupler. Images ©OSA.

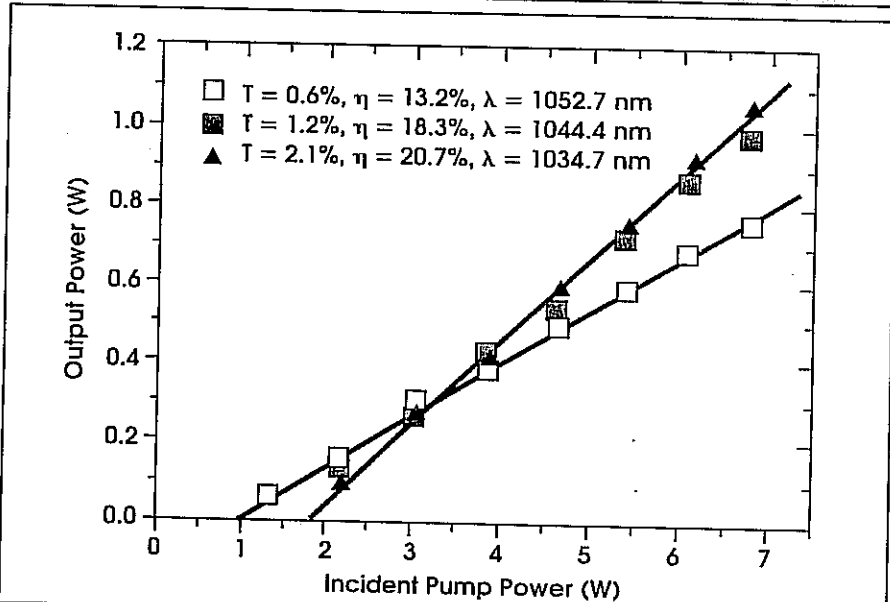


Figure 2. When pumped with a 981-nm diode laser, the Yb:LuVO_4 laser generated 1.05 W with a slope efficiency of 20.7 percent. T = transmission of output coupler; η = slope efficiency; and λ = output wavelength.

2-mm-thick, uncoated piece of Yb:LuVO₄ in a three-mirror resonator at Brewster's angle. The 985-nm pump light entered the resonator through the folding mirror and was focused to an ~22- μ m Gaussian waist at the crystal. From an absorbed pump power of 1.5 W, the laser generated 360 mW at 1041 nm (Figure 1). At this point, the laser's optical efficiency was 24 percent and its slope efficiency, 47 percent.

The results are similar to those obtained by others with Yb:GdVO₄ and Yb:YVO₄, but the threshold for Yb:LuO₄ observed in this case was somewhat higher. The investigators attribute this to higher-than-optimal ytterbium doping in their sample.

For the diode-pumping experiments, they used the same 2-mm-thick sample but placed it in a two-mirror, hemispherical resonator. They focused the 981-nm pump light

through the flat mirror to an ~40- μ m spot on the crystal. The highest output was 1.05 W, obtained with a 2.1 percent output coupler (Figure 2). The laser's optical efficiency was 15.4 percent, and the slope efficiency was 20.7 percent.

The 2-mm piece of Yb:LuVO₄ employed in the laser experiments was mounted on a copper holder but otherwise was uncooled. Nonetheless, no saturation or rollover was evident at the upper reaches of the input/output curves.

The scientists expect that significantly higher power could be obtained by actively cooling the laser crystal, by antireflection-coating it and by matching the pump light more closely to the laser crystal's absorption peak. □

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