# Room temperature cw lasing of Tm:$LuVO_4$ near 1.9 µm

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The orthovanadates with the general formula $TVO_4$ (T: trivalent lanthanide ion Ln, Y or Sc) are oxide compounds which crystallize in the zircon ($ZrSiO_4$) structure. They are interesting for high power laser technology because their thermal conductivity is comparable to that of YAG but the cross sections and the spectral bandwidths of the "active" rare-earth dopants are larger and suitable for diode pumping. Continuous-wave (cw) Tm-laser operation has been demonstrated so far only with the $YVO_4$ and $GdVO_4$ "passive" hosts. The successful growth of Tm:$LuVO_4$ was reported only recently [1] and these authors established that the absorption cross section for the $^3H_6 \rightarrow {}^3H_4$ transition near 800 nm is substantially larger than for Tm:$GdVO_4$. Here we report the basic spectroscopic properties of Tm:$LuVO_4$ relevant for laser operation on the $^3F_4 \rightarrow {}^3H_6$ transition near 1.9 µm and, for the first time to our knowledge, cw room temperature laser operation of Tm:$LuVO_4$ both under Ti:sapphire and diode laser pumping. Quasi-cw operation with 25% duty cycle was previously reported [2].

Tm:$LuVO_4$ with 3 at. % Tm in the melt was grown in the ***a***-direction by the conventional Czochralski technique. A 2-mm thick uncoated sample was first studied under Brewster angle in an astigmatically compensated X-type cavity with Ti:sapphire laser pumping at 796.7 nm. The maximum output power of 174 mW obtained at 1926 nm for $T_{OC}$=3% corresponds to an optical efficiency of 16.3%. The relatively high threshold (around 460 mW) is an indication of reabsorption losses and higher than optimum dopant concentration. Stable oscillation was obtained only for the σ-polarization where the crystal absorption under lasing conditions was roughly 70%. The pump absorption for the π-polarization was higher but the output power was lower and in the absence of cooling slowly decayed with time.

The same uncoated 2-mm thick Tm:$LuVO_4$ sample was studied with diode pumping in a nearly hemispherical 50 mm long cavity. The diode laser pump module contained a single 50 W commercial bar and only simple adapted beam shaping optics was used for the pump beam which was unpolarized. At the maximum output power used its wavelength was 800 nm (FWHM of 2 nm). The nearly circular pump spot had a diameter of about 125 µm. The Cu-crystal holder was provided with water cooling to maintain room temperature. The reabsorption effect was stronger in the case of diode pumping and the oscillation wavelength was longer (Fig. 1). The laser naturally selected the σ-polarization which confirms the higher gain for this polarization in agreement with the calculated gain cross sections. The maximum output power of 564 mW achieved with $T_{OC}$=1.5% (Fig. 1) corresponds to an optical efficiency of 7%.

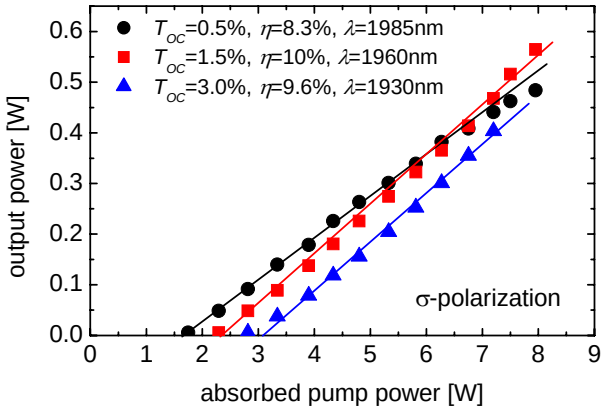


Fig.1: Output power versus absorbed pump power for the diode laser pumped Tm:$LuVO_4$ laser and three output couplers. The slope efficiencies ($\eta$) and the oscillation wavelengths ($\lambda$) are indicated in the figure.

In conclusion, cw lasing of Tm:$LuVO_4$ at room temperature was achieved for the first time near 1900 nm reaching output powers above 500 mW with diode pumping.

1. M. Higuchi, T. Shimizu, T. Takahashi, T. Ogawa, Y. Urata, T. Miura, S. Wada, and H. Machida, J. Cryst. Growth **283** (2005) 100.
2. P. Cerny, J. Oswald, J. Sulc, H. Jelinkova, Y. Urata, and M. Higuchi, ASSP 2006, CD-ROM Digest, paper WB20.