

Crystal growth, structure, spectroscopy, and lasing of $\text{NaLu}_{1-x}\text{Yb}_x(\text{WO}_4)_2$

X. Han, J. M. Cano-Torres, A. García-Cortés, C. Cascales and C. Zaldo

Instituto de Ciencia de Materiales de Madrid, Consejo Superior de Investigaciones Científicas,
c/ Sor Juana Inés de la Cruz 3, Cantoblanco, E-28049 Madrid, Spain

X. Mateos, S. Rivier, U. Griebner and V. Petrov

Max-Born-Institute for Nonlinear Optics and Ultrafast Spectroscopy, 2A Max-Born-Str., D-12489 Berlin, Germany

F. J. Valle

Instituto de Cerámica y Vidrio, Consejo Superior de Investigaciones Científicas,
c/ Kelsen 5, Cantoblanco, E-28049 Madrid, Spain

Tetragonal double tungstate $\text{NaT}_{1-x}\text{Yb}_x(\text{WO}_4)_2$ crystals emerged in the past year as efficient hosts for tunable Yb^{3+} lasers.^{1,2} A tuning range larger than 60 nm was achieved for $T=\text{Gd}$, promising for sub-50 fs mode-locked pulses. The previously studied hosts, $T=\text{La}$ and Gd , have congruent melting character and were grown by the Czochralski method. Since $\text{NaYb}(\text{WO}_4)_2$ melts incongruently there should be some upper x_{MELT} limit for congruent melting of $\text{NaT}_{1-x}\text{Yb}_x(\text{WO}_4)_2$ compounds. For the above two hosts it is $x_{\text{MELT}} \approx 20$ mol %. Higher Yb doping or alternative hosts with incongruent melting require different growth methods. In this work we used $\text{Na}_2\text{W}_2\text{O}_7$ flux and the top seeded solution growth method to prepare $\text{NaLu}_{1-x}\text{Yb}_x(\text{WO}_4)_2$ single crystals with $x_{\text{MELT}}=0, 0.1$ and 0.5 .

From single crystal x-ray diffraction we conclude that these crystals have the $I\bar{4}$ space group symmetry. The refined formula for $x_{\text{MELT}}=0.5$ is $\text{Na}_{0.99(2)}\text{Lu}_{0.54(4)}\text{Yb}_{0.47(4)}(\text{WO}_4)_2$. Yb^{3+} occupies two non equivalent crystallographic sites (also shared by Na and Lu) with occupancy factors 0.16 ($2d$ -site) and 0.31 ($2b$ -site). This multiple occupancy of the same crystallographic sites by Na, Lu and Yb cations contributes to the Yb^{3+} linewidths. At 300 K, the maximum absorption cross section for the π -polarization, $\sigma_{\text{GSA}}=2.1 \pm 0.1 \times 10^{-20}$ cm^2 at $\lambda=974.1$ nm, is slightly higher than for the σ -polarization, $\sigma_{\text{GSA}}=1.9 \pm 0.1 \times 10^{-20}$ cm^2 . The 300 K photoluminescence spectral profile is similar for both polarizations at longer wavelengths up to ≈ 1100 nm. Laser operation was achieved at 300 K in a Z-shaped optical cavity using an uncoated sample of $\text{NaLu}_{1-x}\text{Yb}_x(\text{WO}_4)_2$ with $x_{\text{MELT}}=0.1$ under Brewster angle and without special cooling. Preliminary results with Ti:sapphire laser pumping are shown in Figure 1. The 0.94 mm thick sample absorbed roughly 60% of the pump radiation for the three output couplers used. A slope efficiency of $\eta=51.6$ % was obtained for an output coupler transmission of $T_{\text{OC}}=5\%$ and σ -polarization. The maximum output power achieved with $T_{\text{OC}}=1\%$ was 282 mW for an absorbed power of $P_{\text{abs}} \approx 1.1$ W, however, at $P_{\text{abs}} > 900$ mW, roll-off of the output power dependence occurred. This was attributed to thermal effects because using a chopper the same slope efficiencies as those shown in the figure were obtained for peak powers up to $P_{\text{abs}} \approx 1.1$ W.

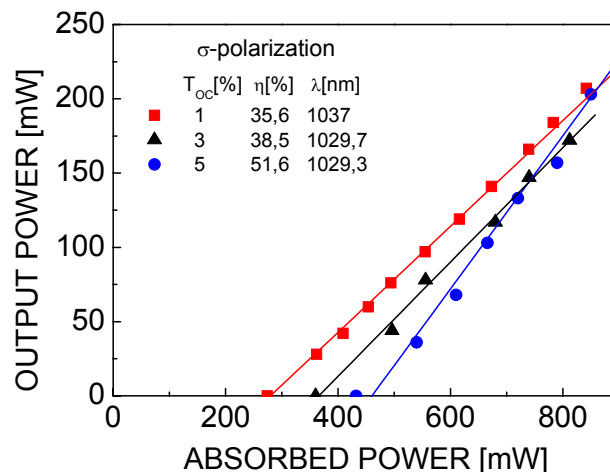


Figure 1. Continuous-wave laser performance of $\text{NaLu}_{0.9}\text{Yb}_{0.1}(\text{WO}_4)_2$ at room temperature. $\lambda_{\text{PUMP}}=974.9$ nm.

¹ M. Rico, J. Liu, U. Griebner, V. Petrov, M. D. Serrano, F. Esteban-Betegón, C. Cascales, C. Zaldo, Optics Express 12, 5362, 2004

² J. Liu, J. M. Cano-Torres, C. Cascales, F. Esteban-Betegón, M. D. Serrano, V. Volkov, C. Zaldo, M. Rico, U. Griebner, and V. Petrov, Phys. Stat. Sol. (a) 202, R29, 2005.