FIRST LASER ACTION OF A 4*%at.* $Tm:Y_3ScAl_4O_{12}$ CERAMIC MATRIX

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We report the first laser emission of a 4 at.% $Tm:Y_3ScAl_4O_{12}$ ceramic fabricated by solid-state reaction combined with vacuum sintering method. The role played by Sc^{3+} ions on the laser performance is studied.

Keywords: Ceramic laser materials, Tm:YSAG ceramic laser

1. Introduction

The interest on mixed garnet ceramics has definitely grown over the last decade as disordered crystal structures resulting from the mixing of the two o more different compositions could induce a spectral broadening as well as a spectral shift of the both absorption and the emission bands of several activators (Yb^{3+}, Tm^{3+}, exc.).

We investigated the spectroscopic properties and the laser action of 4*at.%* $Tm:Y_3ScAl_4O_{12}$ (*i.e.* YSAG) ceramics. In particular, we studied the effect of Sc^{3+} ions on the energy levels of the Tm^{3+} ions.

2. Fabrication technique and experimental setup

The samples were fabricated by solid-state reaction combined with the vacuum sintering method. Several sintering temperatures were used (from 1650°C to 1820°C for 30 h). The phase composition was identified by X-ray diffraction while the relative densities were measured by the Archimedes drainage method. The lifetime of the Tm^{3+} in the YAG was measured. Absorption and emission cross-sections were calculated by acquiring the transmittance and the fluorescence spectra at room temperature. The laser properties of the high-optical quality sample was tested in a V-shape laser cavity pumped by a fiber-coupled laser diode at 790 nm.

3. Results and Discussion

The transparency of the samples increases with the sintering temperature; the ceramic sintered at 1800°C for 30 hours shows homogenous microstructure and excellent optical properties, showing a transmittance as high as 79.3% at 2 µm. By comparing the absorption and emission spectra of the 4*at.%* Tm^{3+} doped YSAG and YAG ceramics we observed a disappearance and degeneration of some absorption and emission peaks in the middle infrared region; this behaviour is addressed to the presence of Sc^{3+} ions, which affects the energy levels of the Tm^{3+}.

Concerning the laser performance, we measured a maximum laser output power of 0.54 W with a corresponding slope efficiency of 4.8%. We note it is the first time that the laser action of a Tm:YSAG ceramics is reported in literature.

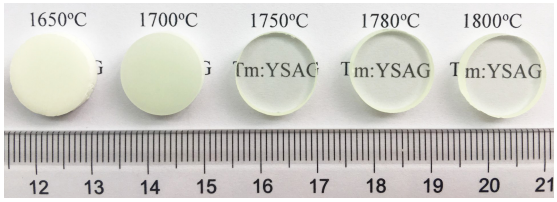

Fig. 1 Picture of 4*at.%* Tm^{3+}-doped YSAG ceramics, sintered at different temperatures.

7. Conclusion

We have investigated the spectroscopic and laser behavior of 4*at.%* Tm doped YSAG ceramics. The highest-optical quality sample shows the highest value of transmittance never before reported in the literature, at least to the best of our knowledge. It is demonstrated that the presence of Sc^{3+} ions affects the Tm^{3+} energy levels. Concerning the laser performance, it is the first time that laser action of Tm-doped YSAG ceramic is achieved.

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