

## Conjugation of TEM-EDX and optical spectroscopy tools for the localization of Yb<sup>3+</sup>, Er<sup>3+</sup> and Co<sup>2+</sup> dopants in laser glass ceramics composed of MgAl<sub>2</sub>O<sub>4</sub> spinel nano-crystals embedded in SiO<sub>2</sub> glass.

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### Streszczenie

The main goal of this work is to conjugate two independent techniques of TEM-EDX and optical spectroscopy, which is rare, for the localization of Yb<sup>3+</sup> and Er<sup>3+</sup> rare earth ions and Co<sup>2+</sup> transition metal ions as dopants in a compact self-Q-switched microchip laser glass ceramic composed of MgAl<sub>2</sub>O<sub>4</sub> spinel nano-crystals of 10–20 nm size embedded in SiO<sub>2</sub> glass. The use of the TEM-EDX technique associated with both the elemental mapping of each dopant and the direct visualization of the heavier rare earth ions has led to the result that Er<sup>3+</sup> and Yb<sup>3+</sup> rare earth ions are preferentially located in the spinel nano-crystals. Regarding the low Co<sup>2+</sup> concentration this technique was not accurate enough for characterization and finally we have used absorption spectroscopy to probe the main presence of Co<sup>2+</sup> ions in the spinel nano-crystals. The use of Yb<sup>3+</sup> ions as structural probes allows the identification of the 0-phonon broad line at 977 nm as both that of the disordered glass and that of the spinel inverted phases. A new Yb<sup>3+</sup> radiationless center has been pointed out by the presence of a strong absorption line at 970 nm which has been assigned to the strongly perturbed area of the spinel nano-crystallite surface. This dopant characterization is worthwhile to be shown as a special case where characterization of rare earth and transition metal ions needs the use of both TEM and spectroscopic techniques.

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