Sintering of $Y_3NbO_7:Eu^{3+}$ compound: correlation between luminescence and SPS effect

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Highlights

- Luminescence proof of two different coordination environments
- Phase split during sintering
- Non expected lack of miscibility
- Relationship between SPS conditions and Nb:Y ratio

1. Introduction

Emitting materials and all solid state lasers are widely used in the field of optical applications and materials science as a source of excitement, instrumental measurements, medical applications, metal shapingé New ways to obtain optical materials are being used in the present thanks to the developments in fast sintering processes, making possible to highly densify refractive materials. The application of these techniques in order to obtain transparent laser materials is promising, and satisfying efficiencies have been already recorded [1-4]. The Spark Plasma Sintering is an outstanding and versatile sintering technique with many advantageous features as for example: to control the grain growth (micro-nanostructure), avoid diffusion effects, the use of short sintering cycles and high densification rates.

In this work, we studied the cubic Y_3NbO_7 matrix because is an interesting host being capable of incorporating a high proportion of rare earth doping elements, without charge compensation requirements. The oxygen vacancies are tolerated between 21-28% of niobium over cations (Nb/(Nb+Y) ratio [5].

2. Methods

The Eu^{3+} doped Y_3NbO_7 powders were synthesized using the Sol-Gel route [6] and then sintered in a Syntex Dr. Sinter model SPS-515S machine at 1600ºC and under 100MPa in vacuum atmosphere. The photoluminescence properties were analyzed using a Fluorolog 3 Horiba spectro-fluorimeter equipped with a 450 W xenon lamp, an excitation double monochromator, an emission double monochromator, and at thermoelectrically cooled photomultiplier tube. Low-temperature measurements were collected with an Oxford cryostat connected to the previous equipment. X-ray diffraction (XRD) experiments were performed using a PANalytical XôPert PRO MPD with Bragg-Brentano geometry and equipped with a germanium (Ge) monochromator to obtain Cu Kα1 (λ= 1.54059Å) radiation. The collected patterns were refined using the Rietveld method. Structural studies were carried out by electron diffraction on a JEOL 2100 transmission electron microscope on SPS sintered crushed pellet samples.

3. Results and discussion

The characterization by luminescence shows the existence of several distorted environments of the doping element in the studied defective fluorite-type host lattice. In the X-ray diffraction patterns, the observed diffraction peak split at higher angles correspond to two different fluorite types. The electron diffraction patterns show the presence of satellite reflections besides the ones corresponding to the fluorite (*Fm*-3*m*) cell and inhomogeneity between grains belonging to the same pellet. As a result, the two spectral signatures of Eu^{3+} ions can be attributed to the location of europium ions into two fluorite type host lattices [6].

Figure 1. $Y_3NbO_7:Eu^{3+}$ samples sintered by SPS, before (black specimen) and after (lighter specimens) post-annealing.

4. Conclusions

The obtained ceramics are composite pellets in which two different compositions in the solid solution range are stabilized, probably due to the fast and high crystallization rates of the phase. This result shows an unexpected lack of miscibility in the phase diagram highlighting the fact that the final composition is driven by the SPS conditions and the ratio between niobium and yttrium elements.

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Keywords

ñSPSò ñphase splitò ñluminescenceò