Raman spectroscopy of double activated YTaO₄:Eu³⁺,Tb³⁺

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Raman spectroscopy is very sensitive to the structure and bond order of metal oxides, especially in the region of metal-oxygen stretching modes, because many of the Raman frequencies depend on the bond order in the structure. In this study, we investigate both non-activated host lattice YTaO₄, as well as double activated by Eu³⁺ and Tb³⁺.

Yttrium tantalate phosphors were prepared by solid state reaction method from homogeneous mixture consisting of Y₂O₃ (99.9%) and Ta₂O₅ (Optipur). The oxide precursors for the host lattice, Eu₂O₃ and/or Tb₄O₇, are used in the activator system and Na₂SO₄ (99%) as flux. The mixtures were homogenized with a ball mill, in acetone medium, and dried at 70°C. The phosphor samples were baked at 1200°C for 4 h and slowly cooled to room temperature. Finally, the samples were water washed, dried and then sieved.

Raman spectra were measured in the spectral range 100-1000 cm⁻¹ with the in Via Reflex Raman Microscope, using a He–Ne laser (632.8 nm). This spectral range usually contains bands due to metal–oxide bonds and/or lattice vibrations.

In the Raman spectra, more associated with lattice vibrations and symmetrical bonds, small amount of activator can be observed in additional peaks. We observed ν₁, ν₂, ν₃ and ν₄ vibration modes from the host lattice YTaO₄ (Fig.1.a) predicted by Blasse.¹

Raman bands appearing at 818 and 300 cm⁻¹ are due to Ta–O symmetric modes of the TaO₅ structure, and Raman bands appearing at 662 and 417 cm⁻¹ are due to Ta–O antisymmetric modes. The phonon energies below 250 cm⁻¹ are assigned to external vibrations.

We have observed four new peaks around 446, 484, 542 and 592 cm⁻¹ in the spectrum from the double activated YTaO₄ by 2.5 % mol Eu³⁺ and 2.5 % mol Tb³⁺ (Fig.1.b).

We assumed that these new peaks are related

Fig.1. Raman spectra of the M’-YTaO₄ (a), M’-YTaO₄:Eu³⁺,Tb³⁺ (2.5 mol%) (b), M’-YTaO₄:Eu³⁺ (5 mol%) (c), and M’-YTaO₄:Tb³⁺ (5 mol%) (d).
to europium, because after separated activation by 5% mol Eu$^{3+}$ (Fig.1.c) and 5% mol Tb$^{3+}$ (Fig.1.d), only YTaO$_4$Eu$^{3+}$ shows the same peaks.

No additional peak is observed when yttrium tantalate is doped only by terbium and the Raman spectra of YTaO$_4$Tb$^{3+}$ (Fig.1.d) is identical with spectra YTaO$_4$ (Fig.1.a).

Raman spectra from YTaO$_4$ activated only by Eu$^{3+}$ from 0.5 up to 20 %mol confirms our assumption about new peaks (Fig.2). Moreover, the intensity of these peaks is proportional to europium concentration, while the intensity of vibration modes from the host lattice YTaO$_4$ at 818 cm$^{-1}$ ($\nu_1$) does not change. The nature of these peaks is discussed.

Acknowledgements

This work was supported by Korea Science and Engineering Foundation (KOSEF) through NRL (Program No. M1040000045-04J0000-04510) and NCRC grant (No. R15-2008-006-00000-0) funded by Ministry of Education, Science and Technology in Korea. This work was also supported by Photonics 2020 research project through a grant provided by the Gwangju Institute of Science and Technology in 2008.

Reference