High-Pressure Study of YVO_4 Nanoboxes

F.J. MANJÓN[1], O. GOMIS[2], S. RAY[1], S. F. LEÓN-LUIS[3], U.R. RODRÍGUEZ-MENDOZA[3], V. LAVÍN[3], A. SEGURA[4], D. MARTÍNEZ-GARCÍA[4], and Ch. FERRER-ROCA[4]

[1]*Instituto de Diseño para la Fabricación y Producción Automatizada, MALTA Consolider Team, Universitat Politècnica de València, Camí de Vera s/n, 46022 València (Spain*), *e-mail*: *fjmanjon@fis.upv.es*[1]

[2]Instituto 2Instituto de Centro de Tecnologías Físicas, MALTA Consolider Team, Universitat Politècnica de València, Camí de Vera s/n, 46022 València (Spain)

[3]Instituto de MALTA Consolider Team and Departamento de Física Fundamental y Experimental, Electrónica y Sistemas, Universidad de La Laguna, E-38200 San Cristóbal de La Laguna, Santa Cruz de Tenerife (Spain)

[4] Instituto de Ciencia de Materiales de la Universidad de Valencia, MALTA Consolider Team, Universitat de València, C/. Dr. Moliner 50, 46100 Burjassot, València (Spain)

***Abstract* – YVO_4 nanoboxes doped with Eu ions (4 at%) have been studied by means of X-ray diffraction, Raman and photoluminescence measurements under high pressure. Photoluminescence measurements in nanoboxes provide evidence that Eu ions locate at different symmetry sites in the nanoenvironment than in bulk crystal. On the other hand, Raman scattering measurements under pressure provide evidence that YVO_4 nanoboxes undergo a monoclinic distortion of the zircon structure prior to their phase transition towards the scheelite structure at high pressure.**

***Index Terms* – high pressure, vanadates, X-ray diffraction, Raman scattering, photoluminescence.**

YVO_4 is a very interesting material which finds an extensive use in material science and technology due to its outstanding optical properties. YVO_4:Nd^{3+} is used in industrial diode pumped solid state lasers [1]. The improvement of luminescence properties in nanosized and pressure-treated materials has opened an enormous working field in phosphors [2] and the study of rare-earth ions in the nano-environment of ABO_4 compounds is important for the development of phosphors with enhanced luminescence efficiency by combining the promising optical properties of rare-earth ions and nanoparticles [3,4].

Bulk YVO_4 crystallizes in the zircon structure (space group S.G. #141) and it undergoes two pressure-induced phase transitions: a first one towards the scheelite structure (S.G. #81) above 7.5 GPa [5,6] and a second one towards the fergusonite structure (S.G. #15) above 23 GPa [7]. Knowing the phase transitions in nanocrystals could give a better insight into the relation between compositional, structural and optical properties in order to design better phosphors or even provide novel nanocrystal phases which could be retained in metastable way, like diamond, at ambient conditions with enhanced optical properties with respect to parent materials.

We have synthesized Eu-doped YVO_4 nanoboxes with zircon structure and 25 ± 5 nm lateral size. Nanoboxes have been characterized by X-ray diffraction, Raman scattering, and photoluminescence under pressure up to 18 GPa. The pressure behaviour of nanocrystals has been compared to that of bulk material [2,5-7]. We have found that the zircon-to-scheelite phase transition occurs at a much higher pressure in nanocrystals as compared to the bulk and that Eu ions show a different photoluminescence spectrum in nanocrystals than in the bulk likely due to the occupation of different symmetry sites by Eu ions in nanocrystals. Additionally, a possible intermediate monoclinic phase resulting from the distortion of the zircon phase and occurring between the zircon and scheelite phases could be present in nanocrystals unlike in the bulk as recently suggested to occur in zircon-type chromates [8].

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