New Advances in Rare Earth Luminescent Pressure and Temperature Sensors

Víctor Lavín [1], Marcin Runowski [1,2], Przemysław Woźny [2], Teng Zheng [3], Ulises R. Rodríguez-Mendoza [1], Inocencio R. Martín [1]

[1] Departamento de Física, IUdEA, IMN and MALTA-Consolider Team, Universidad de La Laguna, Apartado de Correos 456, 38200 San Cristóbal de La Laguna, Santa Cruz de Tenerife, Spain

[2] Faculty of Chemistry, Adam Mickiewicz University, ul. Uniwersytetu Poznańskiego 8, 61-614 Poznań, Poland

[3] School of Information and Electrical Engineering, Zhejiang University City College, Hangzhou, Zhejiang, China

E-mail: vlavin@ull.edu.es

Over last few decades, rare earth (RE)-doped materials have been studied extensively due to their excellent luminescence properties and multiple applications in photonic and optoelectronic devices. Recently, there has been growing interest in the use of RE-doped materials as optical pressure (P) and/or temperature (T) sensors, primarily due to their high electrical passiveness, negligible electromagnetic interference and wide dynamic range. RE optical P-T sensors are based on an indirect measurement taking advantage of the luminescent properties of the optically active ion using laser excitation [1].

A calibration of the relative intensities of the green emissions from the $^2H_{11/2}$ and $^4S_{3/2}$ thermally-coupled multiplets to the $^4I_{15/2}$ ground state of Er^{3+} ions in $Y_3Ga_5O_{12}$ garnet crystal were calibrated within temperature range from 292 K up to 1000 K [2]. We also have shown the possibility of highly sensitive and accurate determination of very high temperature (up to above 1000 K) via luminescence thermometry of YVO_4:Yb^{3+}−Tm^{3+} nanoparticles (<100 nm) for industrial applications [3].

Taking advantage of the excellent pressure-sensing properties of the Sm^{2+} ion in the SrB_4O_7 crystal, we demonstrate an enormous enhancement of 60 times in its emission intensity when Eu^{2+} ions are also incorporated [4]. We have also designed a series of Ce^{3+}-activated $Ca_2Gd_8Si_6O_{26}$ phosphors with an abnormal enhancement of emission intensity under compression [5]. In addition, a series of Eu^{2+}-doped $Sr_8Si_4O_{12}Cl_8$ microspheres show one of the highest pressure-sensitivity ever reported [6].

Finally, a Eu^{2+}/Sm^{2+} divalent lanthanide-co-doped dual-center system in SrB_4O_7 phosphors [7] has been used as a bifunctional ratiometric sensor of temperature and pressure. We have also succeeded to optically monitor the lowest pressure values in a vacuum region (from $\approx 10^{-5}$ to 10^{-2} bar), utilizing the light-induced and pressure-governed heating–cooling of the YVO_4:Yb^{3+}-Er^{3+} material [8].

References

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