Rare Earths Optical Sensors

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Abstract

Matter under extreme conditions of pressure (P) and/or temperature (T) is the subject of multidisciplinary studies involving physics, chemistry, material science, biology, or geology [1,2]. High-P and low/high-T conditions can be induced on a solid with the help of a diamond anvil cell in order to perform optical, vibrational, electrical, structural or magnetic studies. The P-T determination inside the hydrostatic chamber is a key question that requires calibrated standards. Thanks to the transparency of the diamonds to visible light, an in situ, indirect calibration can be done taking advantage of the high sensitivity to changes of P and/or T of some emission lines of rare earth (RE) in solids [1-3]. For pressure sensors applications, the shielding of the 4f-electrons of the RE in crystals produces very sharp emission lines in the optical range. In this sense, the luminescence in systems such as Nd^{3+}-doped garnets have been tested in the near-infrared range studying the pressure shifts of the $R_{1,2} \rightarrow Z_5$ lines of the $^4F_{3/2} \rightarrow {}^4I_{9/2}$ transition [3]. Less standardized is the method to measure the exact temperature of the sample in the hydrostatic chamber. One technique is based on the existence of two emitting levels of a RE^{3+} ion close enough in energy to be considered in quasi-thermal equilibrium and whose relative population depends on T [4]. Luminescence of Nd^{3+} and Er^{3+} in different materials (glasses, microspheres, glass-ceramics and nanomaterials) have been tested as P- and T-sensors, analyzing the role of the host and the concentration of RE ions.

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