New strategies for optical pressure and temperature sensors

Abstract:
Matter under extreme conditions of pressure (P) and/or temperature (T) is the subject of multidisciplinary studies involving physics, chemistry, materials science, biology or geology. High P and low/high T conditions can be induced in a solid with the help of a diamond anvil cell for optical, vibrational, electrical, structural and/or magnetic studies. The determination of P-T within the hydrostatic chamber is a key issue that requires calibrated standards. Thanks to the transparency of diamonds to visible light, indirect in situ calibration can be performed by taking advantage of the high sensitivity to P and/or T changes of some rare earth (RE) emission lines in solids. For pressure sensing applications, the shielding of 4f electrons of the RE in crystals produces very sharp emission lines in the optical range. Less standardized is the method for measuring the exact temperature of the sample in the hydrostatic chamber. One technique is based on the existence of two emission levels of a RE ion close enough in energy to be considered in quasi-thermal equilibrium and whose relative population depends on T. In this work we present different combinations of rare earth ions in different materials and nanomaterials that have been successfully tested as optical P- and/or T- sensors, along with the role of the host and the RE concentration.