luminescent nanothermometers for long-term absolute measurements

carlos brites[1], patricia lima[1], nuno silva[1], angel millán[2], vitor amaral[1], fernando palacio[2], luís carlos[1]

[1] department of physics & CICECO, university of aveiro
[2] universidad de zaragoza, spain

Temperature is a fundamental thermodynamic variable, the measurement of which is crucial in countless scientific investigations and technological developments. Thermocouples and thermistors constitute accurate, affordable and easy-to-install experimental probes; however, such traditional thermometers are unsuited to length scales of under 10 microns. This intrinsic limitation has encouraged the development of new non-contact accurate thermometers with micrometric and nanometric precision. At the Universities of Aveiro and Zaragoza we have addressed this issue during the last 4 years and recently we have reported a unique luminescent self-referencing nanothermometer allowing absolute measurements in the 10-350 K temperature range and submicrometer spatial resolution.

The developed thermometer has up to 4.9%·K^{-1} temperature sensitivity (1.5 times larger than the highest value reported previously) and it exhibits high photostability for long-term use. The nanothermometer is a versatile material which can be processed in different forms adapted to the desired application. So far we have processed this nanothermometer in two different forms; i) a thin film coating an integrated circuit trough which we obtain an high resolution (0.1 micron) 2-dimensional temperature mapping and ii) nanobeads composed of maghamite nanoparticles, used as a magnetic-actuated heat sources, covered by a hybrid matrix containing Europium and Terbium chelates. The emission properties change with the temperature making possible to predict the temperature by the analysis of the “colour” of the material.

The synergetic outcomes arising by combining temperature sensing/mapping and superparamagnetism opens the way for new exciting applications, especially in the biomedical field. In particular, such association will provide a unique instrument to map, in a non-invasive way, temperature distributions in biological tissues during heat release, due to the application of an ac field to magnetic nanoparticles (magnetic hyperthermia), this being, with no doubt, a powerful tool for the study of biochemical micro-processes occurring within a cell.