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Abstract

Raman and Luminescent Thermometers for Determining Local Temperatures at the Nanoscale †

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The ability to control and understand the temperature at the nanoscale is fundamental for manipulating physical, chemical, and biological processes.

Nanothermometry is a crucial aspect of scientific and technological applications ranging from electronics to biological systems. The development of well-defined protocols for precise temperature determination is essential for advancing research and applications in nanotechnology. Accurate nanoscale temperature measurements involve the integration of various strategies, including the design and fabrication of new materials, the implementation of detection techniques, and the testing of prototypes for real-world applications.

The utilization of optical techniques, such as fluorescence and Raman spectroscopy, enables the efficient characterization of different materials. The ability to synthesize and test materials using these techniques allows researchers to identify the most suitable and sensitive nanothermometry materials. This is particularly important when prototype devices are developed for biomedical applications, where biocompatibility and non-invasiveness are essential.

This presentation will focus on Raman and luminescent nanostructures. The Raman active material is TiO_2, anatase, while lanthanides, such as Yb3+ and Er3+, are used as luminescent materials; they are both characterized by a signal strongly dependent on the local temperature.

Anatase nanoparticles are synthetized by MW-assisted (MW) and solvothermal procedures, while core@shell nanoparticles are realized by MW-assisted co-precipitation of $CaCl_3$, $YbCl_3$, and $ErCl_3$ and sol–gel methods. Fluorescence and Raman measurements were conducted on sample powders in the visible and n-IR ranges. The sample, maintained at a defined temperature via a temperature controller, underwent laser beam focalization through a microscope. The signals were then collected through a triple monochromator and a liquid nitrogen-cooled CCD camera. Preliminary findings indicate the feasibility of obtaining reliable temperatures for characterizing the local temperature using fluorescence and Raman techniques.

The preliminary results indicate a reliable and accurate temperature characterization, paving the way for further advances in nanothermometry and its applications in diverse fields, including biomedicine.

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