Wrocław, 13.12.2021 r.

Institute of Low Temperature and Structure Research
Polish Academy of Sciences

ABSTRACT OF DOCTORAL DISSERTATION

Synthesis and investigation of spectroscopic properties of luminescent thermometers doped with Eu^{3+} and Nd^{3+} ions based on excited state absorption

MSc Eng. Karolina Trejgis

Supervisor: Dr. hab. Łukasz Marciniak, professor of ILTSR PAS

As is well known, temperature is one of the most essential physical quantities for understanding physical phenomena, chemical reactions or biological processes. Therefore, its precise determination is crucial for the detailed understanding or controlling of certain phenomena. One of the newest and unconventional tools for temperature readout are luminescent thermometers. Temperature measurement with their application is based on the analysis of changes in spectroscopic properties of a phosphor, which acts as a thermometer, in response to changes in temperature of its environment. A particular advantage of this technique is the capacity for remote temperature measurement and the ability of imaging not only the surface, as in the case of thermovision cameras, but also in the volume of the material, so that the luminescent thermometer can be used even in very demanding conditions, which can also include biological environments. Among the various types of luminescence thermometers, i.e., based on the analysis of various spectroscopic parameters, those analyzing the intensity ratio of two emission bands have until recently been the most widely studied. However, due to the dispersive dependence of the extinction coefficient of the medium in which the phosphor is located, the environment may

Wrocław, 13.12.2021 r.

affect the intensity of each of the analyzed bands differently. Consequently, there is no calibration curve for them, suitable in different media, which results in unreliability of the results and their dependence on the medium under investigation. The solution is delivered by single emission band analysis, which is provided by the newest single-band ratiometric approach. Ratiometricity is realized by using two excitation beams while analyzing a single emission band. Furthermore, the excitation wavelengths are chosen in such a way as to activate two differently temperature-dependent processes, i.e., ground state absorption (GSA) and excited state absorption (ESA). Due to the contrasting trend of changes in the emission intensity excited through these two processes, these thermometers should possess a high relative sensitivity to temperature changes and a temperature resolution of <0.1K. Nevertheless, the intensity of luminescence upon ESA excitation is a nontrivial issue and depends on many factors that may cause population or depopulation of the level from which it occurs. Therefore, in order to intentionally design a luminescent thermometer with high temperature sensitivity, it is necessary to perform a series of studies considering various parameters in order to completely understand the phenomena occurring and to optimize the parameters. These efforts have been carried out in this dissertation taking into account factors such as interionic interactions determined by the concentration of optically active ions, the influence of phosphor size and surface effects, the impact of host phonon energy, and the type of optically active ions.

Acknowledgements

This work was supported by National Science Center Poland (NCN) under project No. DEC-2017/27/B/ST5/02557.