Hybrid organic-inorganic perovskites as high-sensitive luminescent thermometers

Temperature is one of the most important physical parameter which affects the dynamics and viability of natural systems and is important in many fields of natural science. The technique of non-contact luminescence-based thermometry offers a lot of advantages compared to traditional contact thermometers. The advantage of the new technique is non-invasive measurement, fast response, high sensitivity, the ability to use in dynamically changing conditions and working even in a strong electromagnetic field. Mainly three temperature detection methods based on (i) spectral shift of emission band, (ii) variation of the emission intensity of a single transition or two independent transitions, and (iii) the kinetics of the lifetime of the emitting levels are used. The intensity of emission depends on a couple of factors such as materials inhomogeneity, excitation sources and type of detector. All of these factors can lead to inaccurate or unrepeatable measurements. Therefore, the most common used temperature read-out is based on the ratio of relative intensities of two different emission bands. This method minimizes the influence of troublesome external factors, therefore is commonly called as a self-calibrating or dual-emitting luminescence thermometry.

Metal-organic frameworks (MOFs) are promising materials for non-contact luminescence thermometry. For our investigation we chose hybrid organic-inorganic compounds adopting perovskite-like architecture with the general formula ABX_3, in which A is organic cations (mostly protonated amine), B represents a metal cations and X is small organic linkers (formate, cyanide, hypophosphite, dicyanamide ion, etc.). In perovskite structure, cation B and organic linker create a three-dimensional framework, while the organic cations are accommodated inside the created pores.

Due to their unique physical properties, such as ferroelectricity, multiferroicity, as well as dielectric, magnetic and luminescent one, these compounds have been intensively studied during the last few years. However, up to now only a few materials for non-contact thermometry have been based on Eu^{3+} and Tb^{3+} ions emission. For our investigation Cr^{3+} has been chosen as an optical active ion because its emission is very sensitive even for very small changes in the crystal field strength. Chromium ions, which are located in intermediate ligand field or near it, exhibit two different type of emission corresponding to spin allowed $^4T_{2g} \rightarrow {}^4A_{2g}$ transition and a forbidden one from the ^2E_g excited level to $^4A_{2g}$ ground state. The energy of ^2E_g and $^4T_{2g}$ levels can be modulated by crystal field strength and metal-oxygen distance.

We think that our innovative project will help to answer a number of questions: how substitution of one element in the structure will affect the order of organic cations in the material, the bond strength, the crystal field strength, the relative intensity of the Cr^{3+} emission bands, the luminescence kinetics and the temperature detection. We are going to explain the mechanisms of the temperature-dependent processes and correlate them with structural-related factors.

We are sure that our innovative research will be groundbreaking in the luminescent thermometry field based on organic-inorganic MOF compounds and will direct new routes in studying of those compounds. Moreover, we are convinced that our inventive idea is opening a new chapter in the field of the MOF family compounds. We anticipate that this innovatory approach will have a significant and immediate impact on the entire discipline in the coming years.