Photon avalanche assisted thermometry

Description for the general public

Growing interest in luminescent thermometry which can be observed during last two decades results from the new possibilities of temperature determination given by this technique. Taking advantage from the fact that the shape of emission spectra changes with temperature no physical linkage between sensor (nanocrystals) and readout system (photodetector) is needed. Therefore luminescent thermometry enable in vivo temperature determination of cells and tissues becoming an useful tool i.e. for in-real time temperature readout during photo-induced hyperthermia treatment of cancer. Nowadays scientific work are devoted to the enhancement of the sensitivity of luminescent thermometers in order to improve the quality of temperature readout.

The aim of the project is to investigate and understand the influence of the temperature on the photon avalanche process in the nanocrystalline, lanthanide (Nd^{3+}, Tb^{3+}, Eu^{3+}, Pr^{3+}). doped fluorides, oxides and phosphates. Within the framework of the project either the synthesis of nanocrystals of narrow particle's size distribution or complete characterization of photon avalanche process in a function of temperature will be provided. Our own preliminary results indicates that upon certain conditions of optical excitation (energy of the exciting photons not in resonance with ground state absorption but in resonance with excited state absorption, and strictly defined excitation power) it is possible to generate photon avalanche emission. Moreover conducted research reveals that the threshold power of photon avalanche process is strongly temperature dependent. After exceeding the threshold excitation power emission intensity increases rapidly. Therefore highly sensitive luminescent thermometer can be designed which bases on the ratio between emission intensity upon resonant and nonresonant excitation. The main advantage of this type of luminescent thermometer is related with the fact that the temperature will be determined basing on a emission intensity of a single band. It is especially important because most of the luminescent thermometers used up to date based on the relative emission intensity of two bands what brings difficulties in spectral separation of each of the bands. The influence of the temperature on the photon avalanche process was not described in details up to date. Therefore the aim of the project is to investigate and understand the influence of the size of the nanocrystals, dopant concentration, the nonradiative depopulation rate and the phonon energy of the host material on the thermal characteristic of photon avalanche process. Conducted research will enable to build of the theoretical model of the photon avalanche process in lanthanide doped nanocrystals. Such model will give possibility for intentional designing of highly sensitive luminescent thermometers based on photon avalanche process.