Intrinsic Luminescence of SrF_2 Nanoparticles

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The nanophysics development caused intense research in the field of luminescence studies with the aim to create new luminescent materials that can be used as fluorescent labels for biomedical research[1], nanoscintillators for photodynamic radiotherapy[2], loaders for polymer films for X-rays detection[3], etc. However, the research of interaction between radiation and nanoparticles are required for their practical application. One aspect of this study is the dependence of luminescence intensity on the size of nanoparticles and exciting energy. The optimal size of nanoparticles with suitable scintillation parameters will be established during such studies. The luminescence-kinetic properties of SrF_2 nanoparticles were studied in this work.

SrF_2 nanoparticles were synthesized by chemical co-precipitation. Such the synthesis provides the obtaining of nanoparticles with the small enough sizes $\alpha \approx 20$ nm. In order to obtain SrF_2 nanoparticles of different size, the nanoparticles were annealed at temperatures 200, 400, 600 and 800ºC and their sizes were 30, 45, 65 and 85 nm accordingly.

It was revealed that self-trapped exciton luminescence intensity decreases with decreasing size of nanoparticles, but the rate of decrease depends on the mechanism of luminescence excitation. The smallest sensitivity to the size of nanoparticles is characteristic of excitation in the range of optical exciton creation ($h\nu < E_g$). In the case of excitation in the range of low energy band-to-band absorption transitions ($E_g < h\nu < E_{th}^{ex}$), luminescence is the most sensitive to the nanoparticle size. Under excitation in the range of photon multiplication ($h\nu > E_{th}^{ex}$) luminescence intensity dependence on the size of the nanoparticles is intermediate.

The range of sharp decline of X-ray excited luminescence intensity was revealed, which can correspond to the case when the electronic thermalization length exceeds the nanoparticle size. The sizes of nanoparticles associated with the range of rapid decrease in the X-ray intensity are increased in the series of $CaF_2 \rightarrow SrF_2 \rightarrow BaF_2$. The range of self-trapped exciton luminescence intensity sharp variation can be used for rough estimates of the electron thermalization length.

Main mechanisms of quenching of X-ray excited exciton luminescence of SrF_2 nanoparticles are related to (i) recombination of electrons with surface defects, especially if the size of nanoparticles and electron thermalization length is comparable and (ii) non-radiative decay of excitons due to diffusion to the surface of the nanoparticles.

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