Currently near-infrared (NIR) radiation is widely used in science and industry area. But human eye and most of measuring equipment has a low sensitivity to it or can’t detect it at all. Existing NIR sensors don’t satisfy present requirements because they work is slowly, they have low resolution and damaged by high density of optical radiation. NIR visualizers and Infrared Quantum Counters (IRQC) based on crystals doped with rare-earth ions (REI) avoid all these problems.

Actually study of crystals doped with REI as material for IRQC is carrying out for many years [1], but mostly they just came down to observation of up-conversion effect only, so still almost no works, where all factors, which influence on this effect, has been studied. Obtaining of parameters of up-conversion transitions is very urgent for practical applications.

Crystal Lanthanum fluoride (LaF3) is most attractive matrix for using as base of IRQC, because it has low phonon energy. It also has great mechanical and optical properties. LaF3 has very wide window of transparency (up to 8µm), good radiation resistance, it is non-hygroscopic and thermally stable. As activator ions for it there are need ions with narrow energy states and RE ions in particular Pr3+ ions are good candidates for this purpose.

For studying influence concentration of Pr3+ ions on efficiency of IRQC there are few reasons. On the one hand the f-f transitions are forbidden and they have low probability, and hence low absorption of photons and weak luminescence. Thus, absorption of crystal samples increases with the increasing of activator ions concentration and luminescence intensity should increases too. Hence crystal can be used more efficiently. But on the other hand another important process occurs. It is cross-relaxation process which is quenching of luminescence [2]. But strong cross-relaxation can lead to photon avalanche effect [3], as the similar process take place in the avalanche photodiode. Thus, last process can have a positive impact on sensitivity of IRQC.

Results are presented of studies of influence concentration of Pr3+ ions on up-conversion channels in LaF3:Pr3+ crystal. Crystal samples of LaF3 with various concentrations of Pr3+ ions were grown by Bridgman-Stockbarger method in fluorinating atmosphere in the laboratory of crystal growth of Kazan Federal University. Energy level diagram of Pr3+ ions in LaF3 crystal has been obtained from polarized absorption spectra which were measured in spectral range from IR to visible at room temperature. Diagram was used for analysis of various transitions after excitation to high located f-configuration Pr3+ ions. Registration of luminescence spectra at different energy excitation has allowed separating direct luminescence transitions and up-conversion transitions. Registration of same dependences of luminescence spectra versus concentration of Pr3+ ions in LaF3 crystal has allowed determining effect and cross-section of cross-relaxation process. Thus dependences of cross-relaxation process and up-conversion parameters on concentration of Pr3+ ions in LaF3 crystal were obtained.

Knowledge of these parameters will allow creating more effective IRQC.

Literature: