BRIGHT UV-C LUMINESCENCE OF $Lu_{1-x}Sc_xPO_4$ SOLID SOLUTIONS

Dmitry Spassky, Irina Kudryavtseva, Vitali Nagirnyi

Institute of Physics, University of Tartu, Estonia

e-mail of presenting author: dmitry.spasskiy@ut.ee

Compounds with bright luminescence in the UV spectral region attract attention due to the possibility of their application in photocatalysis, photochemistry and medicine [1-5]. Phosphors emitting in the UV-C spectra region (200-280 nm) are of particular interest for application in medicine. UV-C radiation has disinfectant properties due to overlap with the bactericidal efficiency curve. Moreover, UV-C radiation can be used to destroy superficial cancer cells without negatively affecting deeper tissues. Recently we demonstrated that solid solutions $Y_{1-x}Sc_xPO_4$, are characterized by intense luminescence in the UV-C range with high thermal stability, decay times of $\sim 10^{-7}$ s and a quantum yield of up to 34% [6]. A distinctive feature of solid solutions is the ability to change properties with composition, which allows both fine-tuning of luminescent properties and obtaining properties that are not characteristic of the compounds that are the constituents of the solid solution. Here we extend our studies of efficient UV-C phosphors and present the results on the luminescent properties of undoped solid solutions $Lu_{1-x}Sc_xPO_4$.

The studied samples crystallize in the zircon-type structure and form a continuous series of solid solutions. The lattice parameters gradually decrease with x value. Intense luminescence in the UV-C region has been observed, which is associated with the radiative relaxation of excitons self-trapped at the 2p O and 3d Sc states. The spectral position of the luminescence band depends on the Lu/Sc ratio, shifting from 5.94 eV at x = 1 to 5.4 eV at x = 0.1. The quantum yield increases for the solid solutions with intermediate x values peaking for a solid solution with x = 0.2. The temperature stability of UV-C luminescence increases with decreasing scandium content in the solution, and the threshold temperature of the onset of quenching exceeds 300 K for solutions with $x < 0.8$. The participation of 3d Sc states in formation of the conduction band and their influence on the processes of energy migration of electronic excitations has been analyzed. Based on a joint analysis of the experimental data and numerical simulation results, it was supposed that clustering of scandium cations occurs during the formation of solid solutions. The formation of clusters promotes deep localization of excitons, which is expressed in high temperature stability and quantum yield of UV-C luminescence. The obtained results show that $Lu_{1-x}Sc_xPO_4$ solid solutions can be considered as bright temperature-stable UV-C phosphors for various applications.

References

1. X. Wang, Y. Chen, F. Liu, Zh. Pan, *Nature Com*., 2020, vol. 11 p. 2040.
2. B. Caillier, J. Caiut, C. Muja, et al., *Photochem and Photobiology*, 2015, vol. 91, pp. 526–532.
3. G.V. Belessiotis, P.P. Falara, I. Ibrahim, A.G. Kontos, Materials, 2022, vol. 15, p. 4629.
4. Sh. Miwa, Sh. Yano, Yu. Hiroshima, et al., *J. Cell. Biochem.*, 2013, vol. 114, pp. 2493–2499.
5. H. Kimura, C. Lee, K. Hayashi, et al., *J Cell Biochem.,* 2010, vol. 110, pp. 1439–1446.
6. D. Spassky, A.N. Vasil'ev, V. Nagirnyi, et al., *Materials*, 2022, vol., 6844.