Luminescent Sulfophosphate Glass Doped with Plasmonic Nanoparticles: Optical and Spectral Features

Zeinab Ebrahimpour[1]*, Fahimeh Ahmadi[2], Asghar Asgari[2,3]

[1]*INFN-Laboratori Nazionali di Frascati, Via E. Fermi 54, 00044 Frascati, Italy.*
[2]*Research Institute for Applied Physics and Astronomy, University of Tabriz, Tabriz 51665-163, Iran;*
[3] *School of Electrical, Electronic and Computer Engineering, University of Western Australia, Crawley,*

The lanthanide (Ln^{3+}) ions doped sulfophosphate glass systems are promising candidates to be used in different fields, including fiber-optics, waveguide lasers, optical detectors, solar concentrators, and solid-state lasers. The variable and weak interactions between metaphosphate (PO^{3-}) and sulfate (SO_4^{2-}) ions are a great feature for rare earth ion incorporation and give these glasses a high luminescence efficiency with the least non-radiative losses. By adding different modifier oxides, such as alkaline earth oxides, the interaction between PO^{3-} and SO_4^{2-} can be greatly improved. It could result in a disturbance in the glass system and consequently facilitate the creation of non-bridging oxygen (NBO) groups [1].

At an optimum Sm^{3+}/Er^{3+} dopant concentration, emission increases by combining the remarkable properties of rare-earth ions and sulfophosphate glass, such as energy transfer between the erbium and samarium ions. For further improvement of the emission properties, incorporation of plasmonic nanoparticles such as TiO_2 and Ag into the RE-doped glass system has been reported as an effective way to overcome the low emission cross-section of the systems. Spectroscopic techniques represent a unique combination to investigate the structural and optical features concerning the incorporation of Sm^{3+} and Er^{3+} ions in solphophosphate glasses, as well as the role of plasmonic nanoparticle incorporation to modify the optical emission properties of such systems [2–5].

In this contribution, the spectroscopic as well as optical properties of Sm^{3+}/Er^{3+} doped glass, including titania and silver nanoparticles, are presented. Erbium (Er3+) and samarium (Sm^{3+}) ions doped magnesium zinc sulfophosphate glass systems containing TiO_2 NPs were synthesized using the melt-quenching technique and characterized for the influence of varying TiO_2 ion contents on their spectral properties. UV-Vis-NIR spectra revealed the occurrence of several absorption bands corresponding to the transitions from the ground state to various excited states of the ions. An enhancement in the PL emission intensities in the presence of TiO_2 or Ag NPs were observed. Such enhancement was attributed to the local field effect stimulated by the surface plasmon resonance (SPR) of plasmonic NPs and the energy transfer mechanism among Ln^{3+} ions and the NPs.

References

[1] G. Kaur, M. Kumar, A. Arora, O. Pandey, K. Singh, Influence of Y_2O_3 on structural and optical properties of SiO_2–BaO–ZnO–xB_2O_3–(10-x)Y_2O_3 glasses and glass ceramics, *J. Non-Cryst. Solids* **357** (2011) 858–863.
[2] F. Ahmadi, Z. Ebrahimpour, "Titania nanoparticles embedded Er^{3+}-Sm^{3+} co-doped sulfophosphate glass: Judd-Ofelt parameters and spectroscopic properties enhancement," *J. Alloy. Compd.,* **843**, (2020) 155982.
[3] F. Ahmadi, Z. Ebrahimpour, A. Asgari, and R. El-Mallawany, "Role of silver/titania nanoparticles on optical features of Sm^{3+} doped sulfophosphate glass," *Opt. Mater.,* **105**. (2020).
[4] F. Ahmadi, Z. Ebrahimpour, A. Asgari, and S. K. Ghoshal, "Insights into spectroscopic aspects of Er^{3+} doped sulfophosphate glass embedded with titania nanoparticles," *Opt. Mater.,* **111**, (2020) 110650.
[5] Ebrahimpour, Z., Cabrera, H., Ahmadi, F., Asgari, A., & Niemela, J.. Sulfophosphate Glass Doped with Er3+ and TiO2 Nanoparticles: Thermo-Optical Characterization by Photothermal Spectroscopy. *Photonics* **8** (2021) 115.