The Enhancement of rare-earth ions luminescence in silicate glass

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Lasers and amplifiers based on glass waveguides doped with rare-earth (RE) ions have a vast potential in various applications, such as material processing, medicine, sensors or defence. The key components of glass-based photonic devices are the optically active ion and host matrix. RE ions such as Er^{3+}or Ho^{3+} are especially perspective due to strong emission around 1.5 μm and 2 μm, since the area beyond approx. 1.4 μm is considered "eye-safer". The co-doping with Yb^{3+} allows effective sensitization by pumping around 980 nm. In the question of host matrix, silica glass remains a perspective option as thanks to its favorable material properties, such as thermal, mechanical and chemical durability, and feasible drawability into optical fiber. However, the photoluminescence of RE ions in pure silica glass is severely limited by the high phonon energy of the silica network and the low solubility of RE ions. To remediate these drawbacks, the silica glass needs to be modified with suitable additives, resulting in the creation of multicomponent silicate glass. Three oxides have emerged as perspective options for enhancing the luminescence of RE ions - germanium oxide (GeO_2) [1], aluminium oxide (Al_2O_3) [2] and zinc oxide (ZnO) [3], which may influence the matrix structure and photoluminescence in various ways, depending on the glass composition and dopant concentrations.

In this work, we aim to investigate the relationship between the matrix structure and photoluminescence properties of RE ions in multicomponent silicate glass. Germano-, alumino- and zinc-silicate glass doped with Er^{3+} or Ho^{3+} ions and co-doped with Yb^{3+} ions were prepared by the melt-quenching method. The structural properties of the glass were analyzed using Raman and NMR (^{27}Al, ^{29}Si, ^{23}Na, ^{67}Zn). The RE ion incorporation was studied by comparing the amount and shape of the NMR signal present in the RE- and La-doped samples. The absorption spectra were analyzed using the Judd-Ofelt analysis. The steady-state and time-resolved luminescence was measured, and the relationship between the matrix structure and the luminescence was analyzed.

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