Effect of Au NPs on the Spectral Modification of Er-doped Zinc Sodium Tellurite Glass

Abstract

Optimizing of the spectroscopic features of rare earth (RE) doped inorganic glasses via tuneable growth of metallic nanoparticles (NPs) is demanding in plasmonic based nanophotonics. We report the gold (Au) NPs assisted sizeable enhancements in Er3+ luminescence in zinc-sodium tellurite glass. Glasses of the form 70TeO2-20ZnO-10Na2O-(x)Er2O3-(y)Au (x = 0.0 and 1.0 mol%; y = 0.0-0.6 mol% in excess) are synthesized via melt-quenching method and thoroughly characterized. Au concentration dependent variations in the physical and spectroscopic properties of glasses are determined. XRD data confirms the amorphous nature of all samples. UV-Vis-NIR spectra reveal seven absorption bands corresponding to the transitions from ground state (4I15/2) to 4I13/2, 4I11/2, 4I9/2, 4F9/2, 2H11/2, 4F7/2 and 4F5/2 excited states of Er3+. TEM micrograph manifests the existence of non-spherical Au NPs with average size of 8.6 nm. Prominent surface plasmon band of Au NPs is evidenced around 629 nm. Furthermore, Au NPs display a SPR mediated strong absorption in the visible region. Room temperature visible down-conversion emission (under 425 nm excitation) reveal three significant peaks centred at 532 (moderate green represent 2H11/2 → 4I15/2 transition), 550 (weak green represent 4S3/2 → 4I15/2 transition) and 588 nm (strong green represent 4S3/2 → 4I15/2 transition). Glass containing 0.4 mol% of Au exhibiting the highest luminescence intensity is ascribed to the NPs local field enhancement and energy transfer between RE ions and NPs. Variations in the physical properties of glass are explained in terms of the alteration in structures and ligand interactions with Au NPs present in the glass network. The intense field amplification discerned in the vicinity of Au NPs is attributed to the charge accumulation at the surface of the NPs. Surface plasmon resonance (SPR) of Au NPs and energy transfer (ET) from NPs to Er3+ ions are primarily attributed for the observed spectral modification. It is established that our glass composition displaying such significant enhancement may be beneficial for the development of up-converted solid state lasers and other plasmonic devices.