ABSTRACT

The work presented in the thesis is mainly concerned with the structural, optical and dielectric characterization of holmium doped silica glass matrices with and without silver nanoparticle co-doping. Structural characterization was carried out using techniques like Fourier Transform Infrared Spectroscopy (FTIR), Thermogravimetric analysis (TGA), X-ray diffraction (XRD) and High-resolution Transmission Electron Microscopy (HR-TEM). The presence of silver nanoparticles was ascertained by XRD analysis and comparison with JCPDS data bank. HR-TEM was used to reveal the icosahedral and spherical morphology of the silver nanoparticle embedded in silica glass matrix.

The optical characterization of holmium doped silica matrix was done using absorption spectroscopy and the peaks corresponding to Ho$^{3+}$ ions were obtained which in turn were used to calculate the Judd-Ofelt (J-O) parameters. Specific parameters such as electric and magnetic dipole line strengths, radiative lifetimes, branching ratio and integrated absorption cross-section for stimulated emission of Ho$^{3+}$ ion in silica matrix were evaluated. Weak fluorescence was observed from $^5S_2 \rightarrow ^5I_8$ (550nm), $^5F_5 \rightarrow ^5I_8$ (647nm) and $^5S_2 \rightarrow ^5I_7$ (761nm) transitions on 460nm excitation. For the samples with silver nanoparticle codoping the band-edge produces a blue shift and also a broad peak appears around 300-350nm due to the energy discretization at the edge due to the production of nanocrystals.
Holmium doped silica matrices were also characterized for their dielectric response nature. It shows low dielectric constant and dielectric loss with high frequency suggesting an enhanced optical quality for the samples with lesser defects. The conductivity curves of Ho\(^{3+}\) doped glass shows an increasing tendency with increase in frequency and found to obey Jonscher’s power law. While on nanoparticle codoping it was observed that successful tuning of dielectric constant values can be brought in.

The surface plasmon resonance (SPR) of silver nanoparticles were observed in the wavelength range 405-420nm. The numerical calculation of SPR of silver nanoparticles with spherical morphology was done on the basis of discrete dipole approximation method (DDA). A comparison with the experimental spectrum confirms the validity of this method. Further, the distinctive features of the SPR like wavelength shift and spectral broadening are explained on the basis of highly localized plasmonic oscillations existing in the matrix. An attempt has also been made to calculate the van der Waals energy between plasmonic silver nanoparticles.

**Key words:** Sol-gel processing, Judd-Ofelt theory, Impedance spectroscopy, Holmium, Silver nanoparticle, Transmission Electron Microscopy, Icosahedral morphology, Cole-Cole parameters, Surface plasmons, van der Waals energy.