Features of the silver nanoparticles formation in the bulk and on the surface of the fluoride phosphate glasses.

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Abstract

Noble metal nanoparticles exhibit unique optical properties, such as resonant absorption and scattering of light, not found in bulk metal. Collective coherent excitations of the free electrons in the conduction band, also known as Surface Plasmon Resonance (SPR), are responsible for the strong absorption and scattering of light by the particles. These resonant properties have been employed in surface enhanced Raman spectroscopy, bio sensing, fluorescence enhancement, catalysis, photovoltaics and optoelectronic. The present work aims to study the formation of the Ag- structures in fluorine phosphate glasses. Nanoscale silver molecular clusters and metal nanoparticles embedded in fluoride phosphate glass were produced by Na↔Ag ion exchange and subsequent heat treatment in an air atmosphere. We report on photoluminescence, optical absorption and transmission electron microscopy of fluoride phosphate glass after the ion-exchange process and heat treatment. It was deduced that during ion-exchange first stage of the particle formation could be identified: (i) reduction of ionic silver by reduced atmosphere of the glass (ii) formation of the small molecular clusters Agn n=2-4 with high luminescence and (iii) formation of the large molecular clusters Agn n=11-70 with blue shifted plasmonic band (λ=325-340 nm). Heat treatment at temperatures near and below glass transition temperature resulted in two SPR bands belonged to large molecular clusters and metal nanoparticles (λ =405 nm). Electron microscopy investigation revealed the completion of silver particles in near-surface regions with high silver concentration induced by thermally assisted diffusion: (i) formation of single-crystalline particles with sizes 1-5 nm in the interior of the glass and some number of the large NP- agglomerates of the small NPs on the surface. The aim of this study is to get a knowledge of the influence of the heat treatment on the optical properties of silver centers, introduced by silver ion exchange into the fluoride phosphate glass synthesized in the strong reduced conditions.

Keywords: Optical properties, silver nanoparticles, fluoride phosphate glass

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