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Research Paper Technology

Development Of Silver - Silica Nanocomposite For Novel Humidity Sensing Application

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ABSTRACT

The solgel process was successfully prepared Silver/Silica nanocomposites. In this paper, our aim was to development silver -silica nano composites for novel humidity sensing application using sol gel method. The structure of the sample prepared was studied using Ultraviolet Visible Spectroscopy (UV-VIS), Scanning Electron Microscopy (SEM), High Resolution Transmission Electron Microscopy (TEM).

Keywords : Ag nanoparticles, silica gel, solgel and temperature

Introduction

Synthesis and characterization of nano-sized metallic powders have attracted attention of the materials community due to their promising properties [1-3]. Nanocrystallites depend on the preparation methods; molar ratio of the precursor used and post treatment [2]. In the recent past, nanocrystalline silver oxide/silicates have been synthesized by various methods, e.g. precipitation in high-boiling poyalcohol solutions, inverse micro emlusion, co-precipitation, hydrothermal and solgel auto-combustion [3-7]. The solgel process is a method that is used commercially in many applications, such as forming coatings on window glasses. In addition, it allows higher doping concentrations and a more uniform distribution of metal in the host glass matrix to be achieved [8]. In the present report, we have studied effect of calcinations temperature with prolonged annealing time that mainly supports the development of the silver silicates nanocrystallites in case of silver-containing-silica. The stem of this study is in the results of our earlier report [9], in which, we demonstrated the effect of temperature and time on Nd_2O_3-SiO_2 nanocomposites. The annealing temperature and time dependence of the formation of Nd_2O_3 nanocrystallites as well as their distribution in fused silica matrix were observed. We found that the average size of the silver nanocrystallites in a silica matrix was~50 nm. The Ultraviolet Visible Spectroscopy (UV-VIS), Scanning Electron Microscopy (SEM), High Resolution Transmission Electron Microscopy (HRTEM) data for silver silicates is presented.

Experimental

The principle and basic technique of the solgel process were described in detail in Ref. [9]. Silver oxide/silicates were prepared by mixing high purity reagents $(CH_3CH_2O)Si$ (TEOS) Tetraethoxy silane (Aldrich 99.999), ethanol (Aldrich 99.9995), and deionized water. (0.1-1 wt %) of $AgNO_3$ was introduced in the pre-hydrolyzed solution. Densification of the prepared samples was obtained by annealing in air, at different temperatures (100 and 500^{0}C) and time (1h).

Results

Optical

Fig. 1 shows the UV-VIS spectra of silver nanoparticles prepared with different initial $AgNO_3$ concentrations (0.1 wt % and 1 wt %). The color of the solutions depended on the concentration of added $AgNO_3$ solutions. With increasing the initial $AgNO_3$ concentration, the color of solution changed from yellow to brown. The absorption peak at around 400 nm in Fig. 1 is attributed to the surface plasmon excitation of silver nanospheres, indicating the formation of silver nanoparticles. At low $AgNO_3$ concentrations (0.1 wt %,) a weak absorption maximum of surface Plasmon peaks was observed at 400 nm, showing that silver nanoparticles were produced at a relatively low concentration. With increasing the $AgNO_3$ concentration, the intensity of the maximum Plasmon peak increased, indicating that higher concentrations of silver nanoparticles were formed.

Scanning Electron Microscope

Figure 3.2 (a-b) shows SEM images of Ag-SiO_2 (a) 0.1 wt % Ag-SiO_2 (b) and 1 wt % respectively. From these figures we can see that doping of Ag led to some structural refinement. Ag-SiO_2 revealed some faceted nanostructures with decreased crystallite size in low doping (0.1, wt %) and increase in crystalline size in further Ag doping (1 wt %) which has been already confirmed by UV-VIS analysis. As we see from micrograph with doping Ag incorporated on SiO_2 surface. Ag-SiO_2 seems somewhat porous in nature.

HRTEM Micrographs

Figure 3 (a-b) shows the TEM micrographs of the dispersion of silver nanoparticles in SiO_2 matrix. The nanoparticles with a mean size close to 13 nm were observed in micrograph (a). In the 1wt % Ag-doped SiO_2 sample shown in TEM micrograph 3 (b), nanograins with a mean grain size of around 15 nm were observed. In further high doping of $AgSiO_2$ sample shown in TEM micrograph 3 (b) with a mean grain size of around 20 nm were observed which was also justified by UV-VIS and SEM data. TEM micrograph some flakes of Ag are also shown which is due to the high doping of silver

Conclusions

The solgel process successfully prepared silver-doped silica samples. The samples were characterized by UV-VIS-NIR, SEM, and HRTEM, and the formation of Ag/SiO_2 nanocomposites was confirmed. It is found that the evolution of the system as a function of the annealing temperature and doping percentage is necessary for obtaining a nanoclusters distribution in silica matrix.

Figure 1: UV-VIS absorption spectra of the (0.1 wt % and 1 wt %) initial concentrations $AgNO_3$.

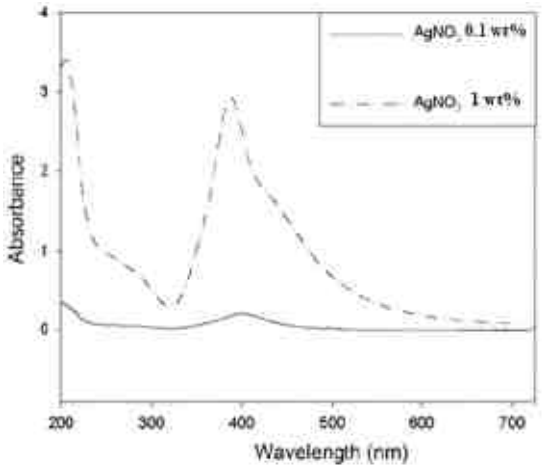
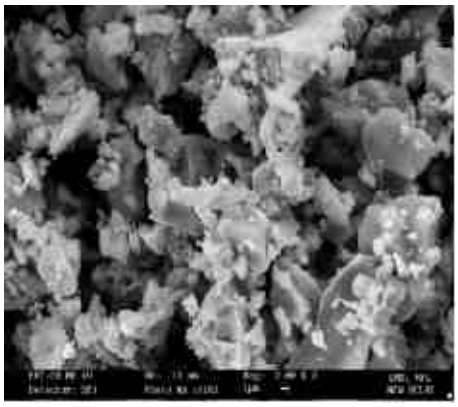


Figure 2: SEM photograph of different amount of $AgNO_3$-doped at (a) 100^{0}C (0.1 wt %), and (b) 500^{0}C (1 wt %), respectively.



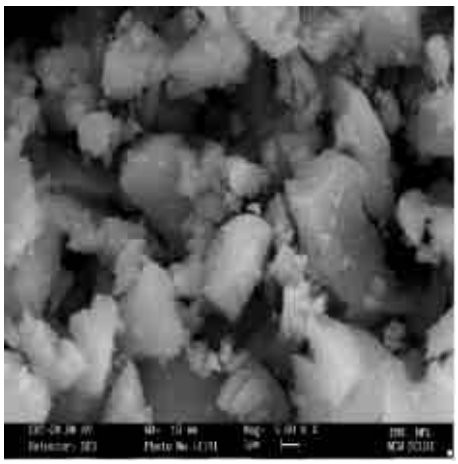
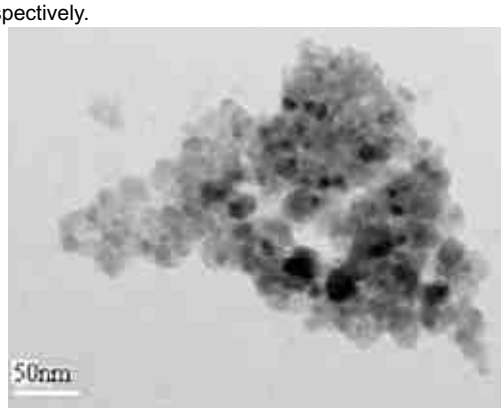
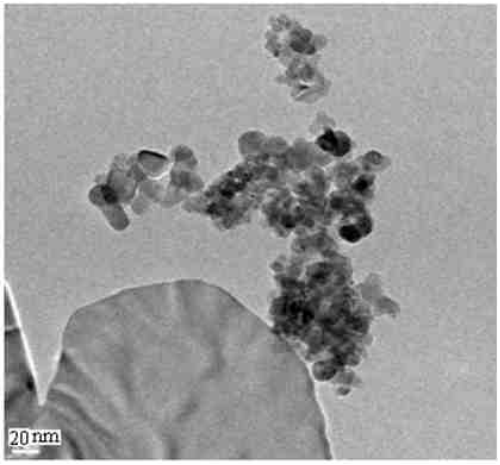


Figure 3 TEM micrographs showing the dispersion of silver in SiO_2 matrix (a) 100^{0}C (0.1 wt %), and (b) 500^{0}C (1 wt %), respectively.





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