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Optical and electrical properties of TeO_2-ZnO insulators with silver nanoparticles for microelectronic applications

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Abstract – This work presents optical and electrical properties of TeO_2-ZnO glasses with silver nanoparticles (NPs) for microelectronic applications. The investigation of tellurite glasses containing NPs is of large interest because the optical and electrical properties of such composites can be controlled by appropriate thermal treatment. The nucleation of silver and gold NPs in tellurite glasses was demonstrated recently. Tellurite glasses have high refractive linear index (~2.0), large transmission window (from visible to the mid infrared region) and low phonon energy (around 700 cm^{-1}).

This work presents optical and electrical properties of TeO_2-ZnO glasses with silver nanoparticles (NPs) for microelectronic applications. The investigation of tellurite glasses containing NPs is of large interest because the optical and electrical properties of such composites can be controlled by appropriate thermal treatment [1]. The nucleation of silver and gold NPs in tellurite glasses was demonstrated recently [2,3]. Tellurite glasses have high refractive linear index (~2.0), large transmission window (from visible to the mid infrared region) and low phonon energy (around 700 cm^{-1}) [1].

TeO_2-ZnO vitreous targets were prepared with the starting composition 85.5TeO_2 -14.5PbO (in wt%). The doping specie is $AgNO_3$ (0.5 - 8 wt%). The reagents were melted in platinum crucible at 800°C for 2h, quenched in air in heated brass mold, annealed for 2h at 325°C, and then cooled to room temperature inside the furnace. The samples were submitted to different heat-treatment times at 325°C during 2, 24 and 48 hours in order to reduce the Ag^+ ions to Ag and to nucleate silver NPs. The amount of NPs increases with the increase in the annealing time. A 200kV transmission electron microscope (TEM) was used to investigate the nucleation of NPs; their composition was verified by electron diffraction measurements. Absorption spectra were recorded from 300 to 850nm using a commercial spectrophotometer. Alternate Current (AC) electrical impedance measurements were performed in the frequency range from 40Hz up to 30 MHz at room temperature (20°C) to estimate the effect of the presence of NPs.

Figure 1 shows the relative electrical permittivity (e_r) versus Ag concentration at 1MHz; the increase in concentration reduces e_r. The pure glasses have a high e_r, around 19, that make them suitable for applications with insulators used in MOS capacitive memories. Figure 2 shows e_r versus heat treatment time at 1MHz. The samples with 1 and 8 wt% of $AgNO_3$ present a decrease in the e_r with the heat treatment; for the samples with 4 and 6 wt% we observe an increase of e_r.

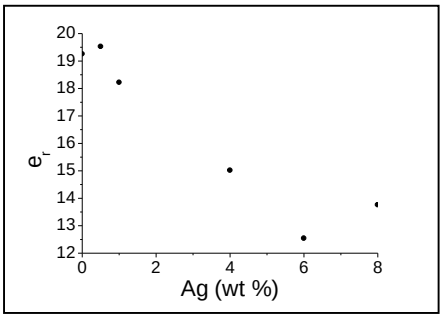

Figure 1: Electrical permittivity versus Ag concentration, for samples heat treated during 2 hours, f = 1MHz.

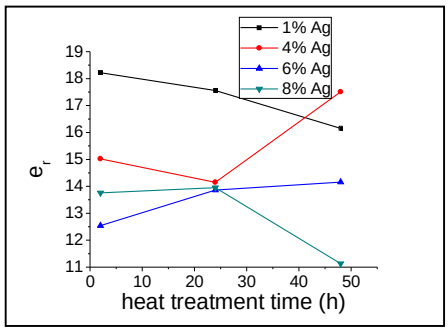

Figure 2: Electrical permittivity versus heat treatment time, f = 1MHz.

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