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Glasses and Ceramics as Templates for Generating Nanostructures and Novel Properties

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Silica glasses containing substantial amounts of modifying oxides have considerable void spaces within their structure . These systems have therefore been exploited to generate different kinds of nanostructures e.g., nanoparticles,core-shell structures and nanowires. Similarly, ceramic structure like mica have well-defined crystal channels. The latter have been used to prepare nanowires or nanosheets. In this lecture the author will discuss some examples in which the above strategies of material synthesis have been applied. Copper core-copper oxide shell nanostructures with diameters ~6 nm were grown within a gel-derived silicate glass containing copper ions[1]. Electrical conductivity of the nanocomposites was several orders of magnitude higher than that of the parent glass. An interfacial amorphous phase gave rise to this behaviour. Electrical conduction was ascribed to a small polaron hopping mechanism. Silver metal core–silver oxide shell structure with nanometer dimensions were generated in a silicate glass by first precipitating silver particles of ~ 6nm diameter by an electrodeposition process and subsequently subjecting the material to an oxidation treatment[2]. Detailed analysis of the optical absorption spectra led to the conclusion that there is a metal non metal transition for particles having diameters less than ~ 2.5 nm. Similar results were obtained in the case of copper core- copper oxide shell nanostructures grown within a silicate glass[3]. Core-shell structure of Fe-Fe_3O_4 system was also produced within a gel derived silica glass which exhibited a four order of magnitude change in electrical resistivity when the relative humidity was changed from 25%to 95% [4]. Silver and copper nanowires respectively were grown within a silicate glass by the application of an electric field. These nanowires were found to consist of arrays of metal nanoparticles. The latter gave rise to nano-junctions between large and small particles which behaved as metal–semiconductor junctions. A diode like voltage current characteristic was observed in these nanocomposites.[5] Silver nanowires were grown by electrodeposition within gel–derived silica glasses containing pores having diameters in the nanometre range. After suitable treatment to these nanowires these exhibited single electron tunnelling property[6]. Silver nanowires were grown within the channels of fluorophlogopite mica crystals precipitated within a suitably chosen glass composition. The nanocomposites exhibited giant dielectric permittivity ($\sim 10^7$) which were explained on the basis of Gorkov-Eliashberg and Rice–Bernasconi model[7]. Na-4mica structure was used to grow CdS nanowire[8]. The former was also used to prepare films of $BaTiO_3$ with a thickness of 1.2 nm. These films did not show any ferroelectric behaviour which was consistent with recent theoretical prediction[9]. [1] D.Das and D.Chakravorty , Appl. Phys. Lett. 76, 1273 (2000). [2] K.Chatterjee,S.Banerjee and D . Chakravorty, Phys. Rev. B66, 085421 (2002). [3] K.Chatterjee, D.Das and D.Chakravorty, J.Phys .D : Appl. Phys. 38 451 (2005) [4] B.N.Pal ,S.Basuand D.Chakravorty, J. Appl. Phys. 97, 034311 (2005). [5] A.Dan,B.Satpati,P. V.Satyam and D.Chakravorty, J.Appl. Phys. 93, 4794 (2003). [6] S.Bhattacharyya,S.K.Saha and D.Chakravorty, Appl. Phys. Lett. 77, 3770 (2000). [7] P.K.Mukherjee and D.Chakravorty, J. Mater. Res. 17 3127 (2002). [8] P.K.Mukherjee and D.Chakravorty, J. Appl. Phys. 95, 3164 (2004). A.Dan,P.K.Mukherjee and D.Chakravorty, J. Mater. Chemistry 15, 1477 (2005)..