11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

Study of Charge Transport in Polyvinyl Alcohol Organic Matrix/Cadmium Sulphide Particles Composite Material

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Abstract – A statistical model of a resistor network is proposed to describe the electrical properties, of polyvinyl alcohol (PVA) and PVA/CdS composite. The model takes into account the polydispersivity of the insulating PVA matrix as well as charge transport processes in the CdS particles. The conductance between two neighboring sites of the PVA was determined by well-known Miller-Abrahams formula. The conductance between sites of CdS particles was determinate by Drude's Formula. The hopping conduction in the polymeric matrix dominates the transport mechanisms at the low frequency range, while in the high frequencies the electrons conduction in cadmium sulfide are dominant.

In recent years, due to number of practical applications in the field of organic electronics devices and of micro and nanotechnologies, the electrical conduction in polymers has been investigated by many researches to understand the mechanism of charge transport in these materials. The difficulty to distinguish and to quantify the different processes of carriers transport lies in the complexity of the morphologic structures of these materials.

In present work an attempt has been made to study the electrical transport properties of pure PVA film and PVA/CdS film by a statistical model of resistor and capacitor network (Figure 1). Polyvinyl alcohol has excellent film forming, high tensile strength and flexibility. It is a dielectric with low conductivity and hence is of importance to microelectronic industry [1].

The composite films were synthesized by the hydrothermic method in a weight proportion of 90/10, starting from a homogeneous solution of polyvinyl alcohol (PVA), carbon dissulfide (CS_2) and cadmium chloride ($CdCl_2$) that was heated to 120°C for 8 hours and after that cooled until the room temperature. Field Emission Gun (FEG) micrographs showed the CdS particles have average diameter of 0,5 µm (Figure 1). The complex conductivity in PVA/CdS films was measured by an impedance analyzer of Hewlett Packard HP Model 4192A, in the frequency range from 10^2 to 10^6 Hz.

The model, developed in FORTRAN 90 language, takes into account the polydispersiveness of the material as well as intrachain and interchain charge transport processes from both PVA and PVA/CdS films. The real and imaginary parts of the conductivity were determined using a transfer-matrix technique [2].

The conductance calculation between two neighboring sites in the CdS particles is given by Drude's formula and for conductance between two neighboring sites of polymeric matrix is given by Miller-Abrahams formula. For real component of the conductivity indicates a change in the conduction process in frequencies above 10^5 Hz due to the presence of CdS semiconductors particles. The theoretician-experimental adjustment indicates that the intermolecular conduction at low frequencies (below 10^3 Hz) dominate the transport mechanisms by charges hopping in the polymeric matrix sites. On the other hand, at high frequencies (above 10^5 Hz) the electrons conduction in cadmium sulfide should be dominant.

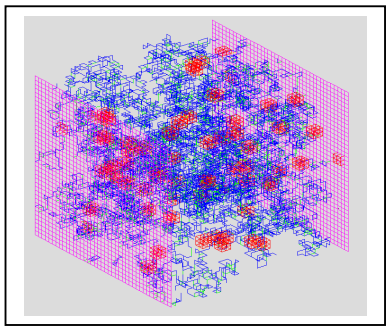

Figure 1: Simulation PVA/CdS composite structure (90/10) formed by a cell of 40x40x40 sites.

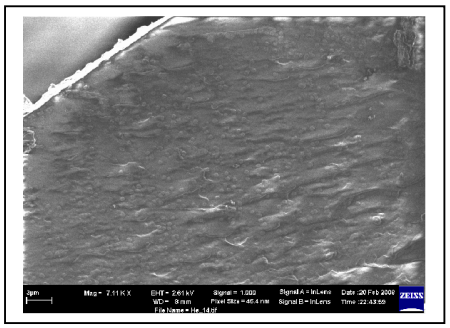

Figure 2: Field Emission Gun (FEG) micrograph shows the CdS particles with average diameter of 0,5 µm.

References

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[2] B. Derrida, et. al., Journal of Statistical Physics, 36, (1984) 31-42.