Materials Science & Engineering Doctoral Defense

Investigation of Properties of Amorphous and Liquid State Chalcogenide Barriers

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abstract

Liquid state materials can self-heal and are not susceptible to damage from high energy radiation unlike their solid state counterparts. Liquid state semiconductors have been recently proposed as the choice of material for direct conversion of high energy radiation. Se is a naturally occurring material which is a semiconductor in crystalline, amorphous and liquid states. To operate a liquid state energy conversion device using Se requires understanding the fundamental electronic properties of liquid Se and its electrical characteristics.

This research focuses on growth and characterization of trilayer junctions made using amorphous As_xSe_{1-x}, Cl doped As_xSe_{1-x} films. Zr, Al, ITO were used as the bottom electrode and Pt, Au were used as ohmic contacts. A layer of SiO_2 was deposited on the Se films to allow them to be heated to a high temperature to enable operation in the liquid state.

The experimental results of the electrical characteristics of Zr/As_xSe_{1-x}/Au trilayer devices indicated that the trap limited Space Charge Current was the dominant electrical transport in the field range of 3000V/cm – 10000V/cm. The current at high fields (>10^4 V/cm) increased rapidly with applied field as a result of carrier emission from localized states and is consistent with transport by the Poole-Frenkel mechanism. A permanent transition to a high conductance state (~10^{-3} S) was observed after exposure to very high electric fields (~4×10^5V/cm).

The heavily doped Cl (>1000 ppm) As_xSe_{1-x} films showed a distinctly different behavior from the As_xSe_{1-x} system with no evidence of trap limited space charge limited current (SCLC) from low to high fields. The devices showed high resistivity and no permanent transition to high conductance state at fields close to 4×10^5 V/cm.

The metal/As_xSe_{1-x}/metal devices in amorphous, liquid and crystalline states were characterized by using the first principles framework of transport. A model used to predict the efficiency of direct conversion of radiation to electrical energy was developed using the principle of solar cells. The factors that affect the efficiency of conversion of radiation energy using metal/As_xSe_{1-x}/metal devices were evaluated.

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