Ph.D_Abstract

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Title of Thesis: Electrical and Opto-Electronic Devices Based on $SnSe_2$ Thin Films

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Abstract

$SnSe_2$ is a semiconductor with unique and interesting properties such as band gap with layer thickness dependence. Theoretically, it has been predicted that the band gap can be varied between 1.2 and 2.04 eV. This range of band gap enables it to absorb a wide range of electromagnetic radiations suitable for various opto-electronic and other sensing device applications. Single or few layers of this material have been developed by various techniques such as mechanical exfoliation using scotch tape method for applications in photodetectors, gas sensors and phototransistors. In the first part of this work, we have grown $SnSe_2$ thin films of varying thicknesses on a soda lime glass substrate by DC magnetron sputtering of Sn metal target followed by selenisation and have provided experimental demonstration of the band gap engineering of layered $SnSe_2$ thin films. We have shown that for films < 50 nm thick, the band gap is ~ 2.04 eV, whereas the band gap is approximately ~ 1.2 eV, similar to that of bulk, for a 1200 nm thick film. The observed variation is consistent with the theoretically predicted layer thickness-dependent band gap of $SnSe_2$. We fabricated photoconductors on the thin films and found that 400-1200 nm thick samples are responsive to IR radiation of wavelength 1064 nm, while thinner films of less than 140 nm thick were irresponsive to IR but responsive to white light. We estimated the average response and recovery time constants as ~7.76 and ~2.5 s at biases of 5 and 10V, respectively. In an attempt to improve the time constants, we fabricated a hetero-structure based on n-$SnSe_2$ thin film and commercially available p-PEDOT:PSS. Interestingly, the device powers itself without any external bias. Due to strong built-in potential at the interface, the response and recovery time constants improved to ~1.33 and 1.22 s. The time constants were improved further by increasing the mobility at the interface and reducing the depletion width by fabricating a p-Si/n-$SnSe_2$ hetero-structure. The observed response and recovery time constants were ~ 57/34 μs with the device operating even under zero-bias condition. Finally, we studied the temperature-dependent (100-350K) electrical transport properties of $SnSe_2$ thin film of band gap of ~ 1.2 eV prepared on soda lime glass substrate. After extracting material parameters, we demonstrated the implication of this study in temperature sensing.