Fabrication and characterization of lead selenide thin film as X-ray sensors, photovoltaic devices and microwave resonators

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Abstract

In this work thin film of $p-$PbSe are coated onto n-Si thin crystals to perform as a multifunctional devices. The devices are fabricated by the thermal evaporation technique under a vacuum pressure of 10^{-5} mbar. Structural and morphological analyses have shown the preferred growth of cubic phase of lead selenide resulting in a large lattice mismatched structure at the $n-$Si/$p-$PbSe (SP) interfaces. The construction of the energy band diagram also indicated the presence of a valance band offset of 0.57 eV at the SP interfaces. These two effects together resulted in a significant photovoltaic effect presented by large short circuit photocurrent density of the SP devices. In addition the SP devices performed as good X-ray sensors responsive to an X-ray ($\lambda = 1.5405$ Å) beam of low and high power tested in the range of 0.1-35.0 W. Moreover SP layers treated as microwave cavities displayed negative capacitance (NC) effect in the frequency domain of 1.2-1.8 GHz. The NC effect is controlled by two Lorentz oscillators being dominant at resonance frequencies of 0.7 and 1.2 GHz. It is found that the SP microwave cavities exhibit cutoff frequency values exceeding 10 GHz when the driving frequency is mounted at 1.2 GHz. This feature make the SP cavities suitable for use in wireless 5G technology applications as signal filters. The ability of the SP layers to perform as photovoltaic devices, X-ray sensors and microwave cavities nominates them for use as multifunctional devices suiting modern technology needs.

Keywords: Si/PbSe X-ray sensors; photovoltaic devices; 5G technology; wireless communications