FABRICATION AND CHARACTERIZATION OF ANTIMONY SELENIDE THIN FILM SOLAR CELLS

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Antimony selenide (Sb_2Se_3) has recently gained a world-wide interest as low-cost photovoltaic (PV) material. Earth-abundant and low toxicity composition, in addition to high light absorption coefficient, suitable band gap for single-junction solar cell application and technologically amiable – low crystallization temperature and single phase make this material very attractive for sustainable PV.

Although Sb_2Se_3 has been studied half a century ago, only recently it spurred a much wider interest with intent to use as light absorber. Sb_2Se_3 is a highly anisotropic material with a ribbon-like structure forming so called quasi-one-dimensional crystal. This leads to much more complicated semiconductor physics, defect chemistry and optical properties than in, for instance, cubic crystals. Because much of the attention is dedicated to the deposition of polycrystalline thin films and solar cell fabrication, there is a knowledge gap in basic fundamental properties of this material, such as photoluminescence. Photoluminescence is a powerful method to estimate radiative recombination processes and reveal fundamental limits for PV material. In this work, we focus on investigating optical properties of Sb2Se3 single crystal. Optical transitions were studied using transmission, reflectance and photoreflectance spectroscopies, whereas radiative emission was investigated by photoluminescence spectroscopy. We found that Sb_2Se_3 is an indirect semiconductor, has a split off valence band and exhibited at least three different radiative recombination mechanisms. More importantly, dominant PL peaks did not show strong stoke-shift which indicated absence of radiative energy loss near band edges. Such lossless radiative emission is highly desirable in PV material.

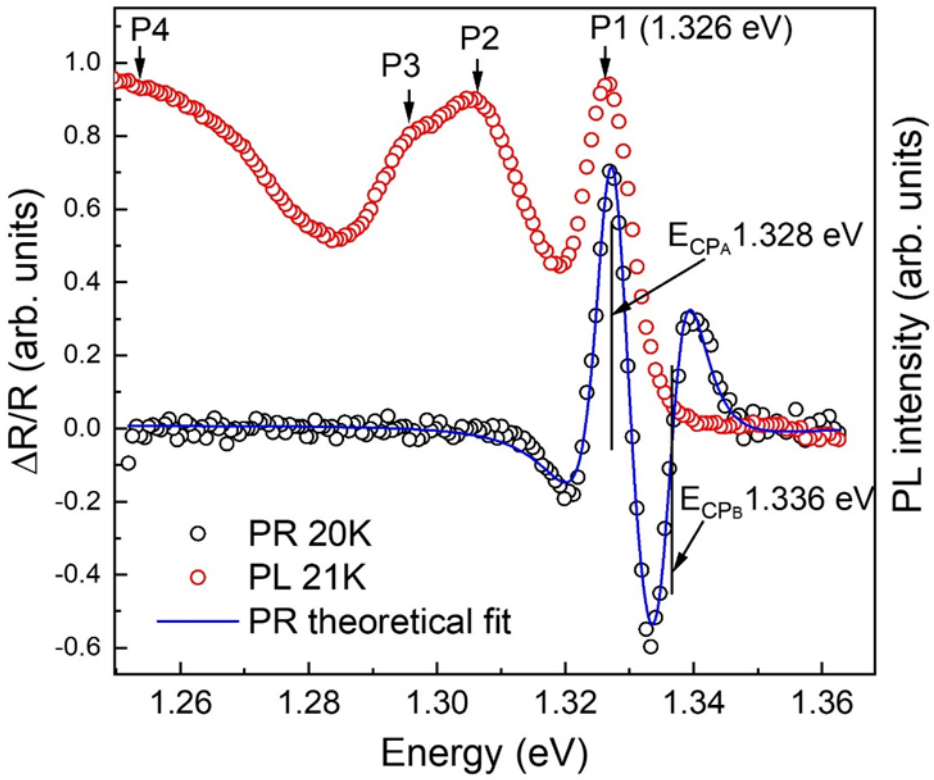

Fig. 1. Photoluminescence (PL) and photoreflectance (PR) spectra of Sb_2Se_3 single crystal at 20 K temperature, showing four distinct PL peaks and two critical points in electronic band structure.