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Abstract

Stibnite (Sb_2S_3) is a major mineral of antimony, which occurs as large crystals often with minor encrustations of other minerals. Locally sourced powdered stibnite containing some quartzite (SiO_2) and ferrosilite ($FeSiO_3$) has been used in this work as evaporation source for vacuum deposition of thin film solar cells. The added minerals were left as residue in the crucible and did not incorporate into the Sb_2S_3 thin film. To stibnite powder was added Sb_2Se_3 powder prepared in our laboratory as chemical precipitate. Source mixtures of different weight – by – weight (w/w) ratios gave thin films of chemical composition $Sb_2S_xSe_{3-x}$ and optical band gap (E_g) within 1.38 eV (Sb_2Se_3) – 1.88 eV (Sb_2S_3). Solar cells of SnO_2:F/CdS (100 nm)/Sb_2S_3(250 nm)/C-Ag prepared by using stibnite as evaporation source gave under standard conditions, open circuit voltage (V_{oc}), 0.668 V; short circuit current density (J_{sc}), 6.95 mA/cm^2; and conversion efficiency (η), 1.62 %. For a 2:1 (w/w) mixture of stibnite:Sb_2Se_3, solar cell of $Sb_2S_{2.14}Se_{0.86}$ (E_g 1.61 eV) was obtained with V_{oc}, 0.562 V; J_{sc}, 13.53 mA/cm^2 and η, 4.03 %. For 1:5 (w/w) mixture, solar cell of $Sb_2S_{0.5}Se_{2.5}$ (E_g 1.44 eV) gave V_{oc}, 0.443 V; J_{sc}, 22.31 mA/cm^2 and η, 4.24 %. Electrical conductivity of the $Sb_2S_xSe_{3-x}$ absorber films in the dark increased from 10^{-8} to 10^{-6} Ω^{-1} cm^{-1} and their photoconductivity, from 10^{-6} to 10^{-5} Ω^{-1} cm^{-1} as the composition changed from Sb_2S_3 to $Sb_2S_xSe_{3-x}$ and Sb_2Se_3. Direct use of an abundant mineral as the evaporation source in thin film solar cell technology is a novelty.

Key words: antimony chalcogenide, antimony sulfide selenide, Sb-S-Se, $Sb_2S_xSe_{3-x}$; antimony chalcogenide solar cells, thin film solar cells; solar energy, renewable energy; semiconductor thin films

Highlights:

- Direct use of stibnite ore-mineral of Sb_2S_3 to produce solar cells of 1.6 % efficiency
- Stibnite mineral and Sb_2Se_3 precipitate source-mix used for solar cells of 4.2 % efficiency
- Variable electrical conductivity and E_g 1.38 – 1.61 eV in $Sb_2S_xSe_{3-x}$ from stibnite – Sb_2Se_3