Area: 3 Thin-Film Compound Semiconductor PV

TEMPERATURE-DEPENDENT ABSORPTION SPECTRA OF Cu_2SNS_3 THIN FILMS

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Cu_2SnS_3 (CTS), which is composed of Earth-abundant and non-toxic elements, has been reported to have a direct band gap and a high optical absorption coefficient, which makes it a promising material for solar cells. Recently, CTS-based thin-film solar cell with power conversion efficiency of 4.8%[1] has been demonstrated. Although CTS-based device fabrication and CTS thin film synthesis have been extensively reported, there has been insufficient investigation of the fundamental properties of CTS. An understanding of the optical and electronic properties of CTS is important to further improve the power conversion efficiency of CTS-based thin-film solar cells. Here, we report temperature-dependent absorption spectra from transmittance and reflectance measurements of CTS thin films with different metal contents.

The CTS thin films were prepared by sulfurization of thermally co-evaporated ternary sulfide precursors on glass substrates. The sulfide precursor films were then annealed at 570°C for 5 min in an atmosphere of 3 vol% H_2S in N_2. The Cu/Sn ratios of three prepared samples determined to be Cu/Sn composition ratios of 1.92 (Cu-poor), 2.02 (near stoichiometric), and 2.23 (Cu-rich) by electron probe microanalysis. The S/metal ratio for all samples was approximately 0.86.

A Xe lamp was used as the light source for transmittance and reflectance measurements. The sample was mounted on a cold finger in a closed-cycle helium cryostat and the temperature was controlled from 6 to 300 K. The transmission and reflectance light were analyzed using a polychromator (f = 163 mm) with a 150 mm^{-1} grating combined with a Peltier-cooled InGaAs array detector.

Figure 1 shows the absorption spectra of all samples at 6 K. For the Cu-rich and near-stoichiometric samples, increased absorption was observed at 0.93, 1.03, and 1.07 eV. These absorption spectra consist of overlapping band-to-band and exciton transition peaks. In this study, these band-to-band transitions are denoted the A-band, B-band, and C-band from the low energy side. For the Cu-poor sample, no exciton transitions were observed. In addition, the absorption spectra of the Cu-poor and near-stoichiometric samples exhibited a larger amount of absorption tailing than the Cu-rich sample. Fig. 2 shows temperature-dependent absorption spectra for the Cu-rich sample. Here, the exciton transitions corresponding to the A-, B-, and C-bands are referred to as the A-exciton, B-exciton, and C-exciton, respectively. The A-exciton, which had the most intense peak, was observed at temperatures as far as 220 K.

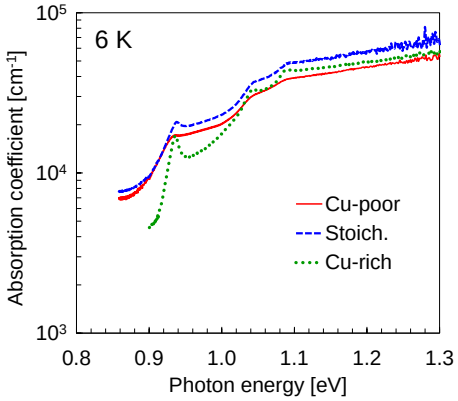

Fig. 1. Absorption spectra for all samples measured at 6 K.

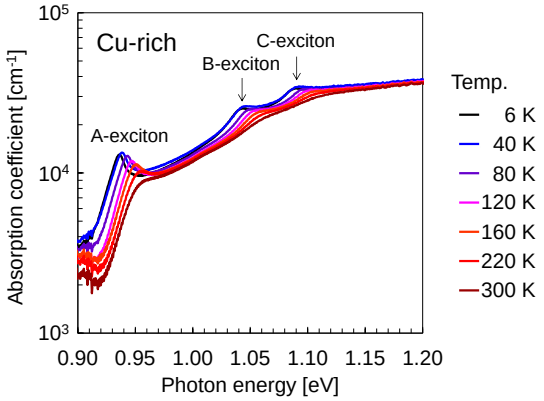

Fig. 2. Temperature-dependent absorption spectra of the Cu-rich sample.

References

[1] J. Chantana *et al.*, Sol. Energy Mater. Sol. Cells **168**, 207 (2017).

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