Photoelectrochemical Characterization of High-Ga Content CIGS2 Thin Films

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This paper presents a study of photoelectrochemical characterization of $CuIn_{1-x}Ga_xS_2$ (CIGS2) thin films with Ga content, x, of 0.3–0.5. Flat band potential, doping density N_D, and bandgap have been determined using photocurrent spectroscopy. CIGS2 thin film samples on Mo-coated glass substrates with Ohmic contacts were mounted on an electrode tip coated with silver paint. A three-electrode system was used with platinum mesh as the counterelectrode, a saturated calomel electrode (SCE) as reference electrode, and the sample as working electrode. Variation of capacitance-voltage at different frequencies was measured in a buffer solution with a computer controlled Impedance Gain-phase Analyzer module SI1260 connected to an Electrochemical Interface SI1287 of Solartron. Photocurrent spectroscopy was carried out in a buffer solution with a 250 W Oriel tungsten halogen quartz lamp, monochromator, a chopper, optical filters, a lock-in amplifier SR530, and Potensiostat VersasStar II of EG and G.

The current-voltage curves showed a low cathodic current density. Capacitance measurements were carried out in the region of near zero current at frequencies between 5-100 kHz. Typical Mott-Schottky plots ($1/C^2$ vs. V) at 10KHz for the samples showed a linear relationship in a voltage range from 0 to –0.7 V (vs. SCE) at different pH values (Figure 1). Also, the flat band potential (the flat band is the potential where there is no field in the semiconductor) was found to shift positively with decreasing pH. The pH dependence of the flat-band potential was linear, with a slope of approximately 60 mV/pH for the case of sample. This indicates that the band edges are almost the same to the redox potential of hydrogen evolution and oxygen evolution at different values of pH.

Direct bandgap was determined by extrapolating to zero the plots of photocurrent current versus energy of the incident light. Ga-content, x, was determined by electron probe microanalysis (EPMA). The bandgaps for the samples with Ga-content, x, of 0.31 and 0.36 were found to be ~1.707 eV, and ~1.78 eV respectively (Figures 2 and 3). This showed an almost linear increase of the bandgap with increasing gallium content from the value of ~1.53 eV for $CuInS_2$.

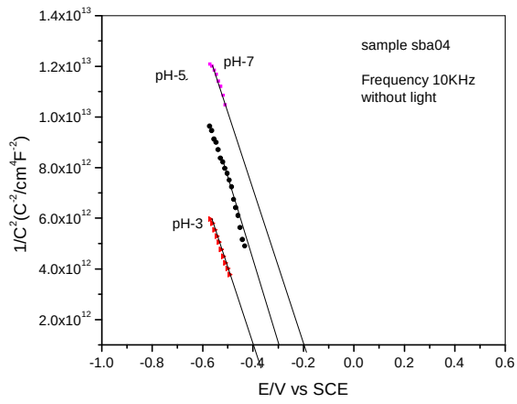

Fig. 1. Mott-Schottky plots ($1/C^2$ vs. V) at 10KHz for CIGS2 sample SBA04

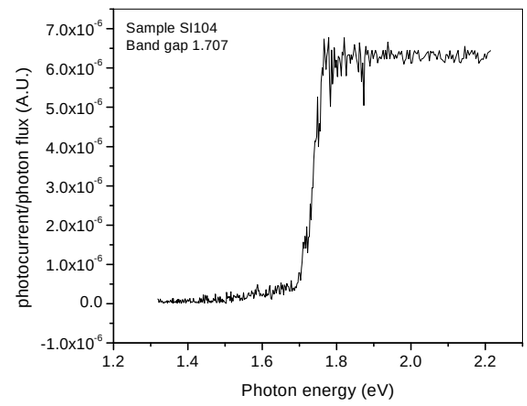

Fig. 2. Photocurrent current versus energy of the incident light for CIGS2 sample SI104

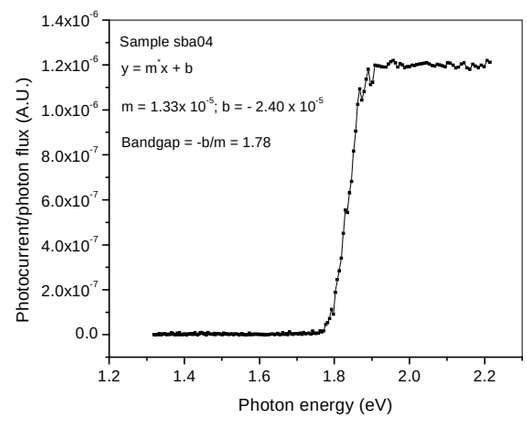

Fig. 3. Photocurrent current versus energy of the incident light for CIGS2 sample SBA04