Structural Characterization of the Absorption Layer of CIGS Thin Film Solar Cells

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Despite the significant advances made so far in solar energy conversion technology, the crystalline silicon-based photovoltaic (PV) modules still had a problem of high manufacturing cost; hence, the development of the low-priced PV modules became an important issue. The thin-film Cu(In,Ga)Se_2 (CIGS) solar cells with high photovoltaic conversions show high potential among various types of solar cells, but the costs of thin-film CIGS solar cells fabricated by the vacuum process (e.g. co-evaporation or sputtering) was relatively high. Therefore, the cost reduction by developing non-vacuum processes for manufacturing thin-film CIGS solar cells becomes a major task.

In the present work, water-based oxide ink was prepared in a stoichiometric Cu/In/Ga ratio of 1.0/0.7/0.3. After coating onto a soda lime glass/Mo substrate using the doctor blade technique, the coated layer was calcined at 430°C followed by reduction in H_2 atmosphere at 500°C. Final selenization was carried out using Se vapor at 450-550°C in a reducing atmosphere to convert the metal precursor layer to a $Cu(In_{1-x}Ga_x)Se_2$ film. X-ray diffraction (XRD) and X-ray absorption spectroscopy (XAS) were employed for structural characterization of the resultant film. XRD measurement was carried out by using the in-house Cu $K\alpha$ source, while X-ray absorption spectra were recorded at NSRRC BL01C1 (for In *K*-edge) and BL17C1 (for Cu, Ga, and Se *K*-edges).

Figure 1 shows the XRD pattern of the $Cu(In_{1-x}Ga_x)Se_2$ film. It was found that the $Cu(In_{1-x}Ga_x)Se_2$ film possesses a crystal structure identical to that of $CuInSe_2$. Fig. 2, on the other hand, presents the radial distribution function (RDF) of each constituent element and the corresponding fitting results. It is interesting to note that only the nearest neighboring atoms were observed in the RDF. Such evidence might indicate the occurrence of EXAFS cancellation in higher coordination shells. Accordingly, the $Cu(In_{1-x}Ga_x)Se_2$ film is speculated to have a quasi-crystal structure.

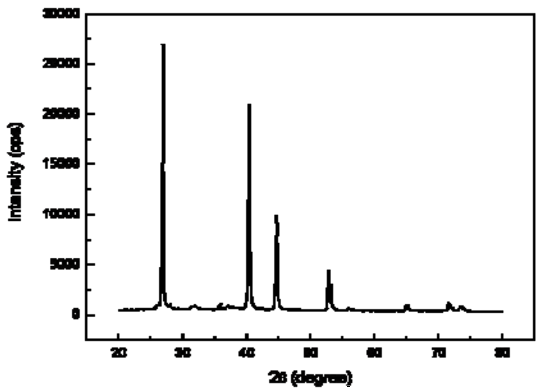

Fig. 1: X-ray diffraction pattern of the $Cu(In_{1-x}Ga_x)Se_2$ film. The peak at ~40° (2θ) arose from the molybdenum back electrode.

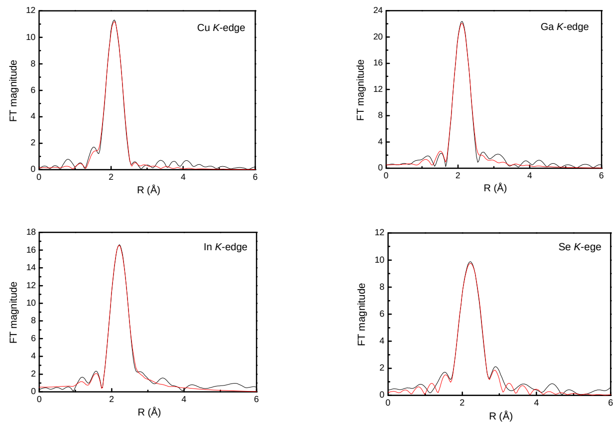

Fig. 2: Fourier transformation of k^3-weighted EXAFS data at Cu, Ga, In, and Se *K*-edges. Black line denotes the experimental data, and red line the computer-fitting result with only the first-shell contribution being considered.