# In Situ XRD Investigation on Phase Transformation of CIGS Alloyed Compound during Heat Treatment

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Despite of 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 had highly potential among theses solar cells, but the costs of thin-film CIGS solar cells fabricated by the vacuum process (co-evaporation, sputtering) was high. Therefore, the cost reductions by establishing non-vacuum processes for manufacturing thin-film CIGS solar cells become a major task.

Fabrication of CIGS alloyed compound with chalcopyrite phase colud be achieved by the knowledge obtained from the phase transformation and formation mechanism. However, the formation mechanism colud be studied by in–situ XAS; the structure parameter corresponding to the chemical environment colud be extracted, such as : local coordination of absorbing atom, bond distance these information led us to establish the formation mechanism of CIGS alloyed compound in the synthesis system. The phase transformation of synthesis sample under heat treatment colud be studies by in-situ XRD.

The synthesized ternary precursor by solvo-thermal method (CGS and CIS) were packed into capillary tube (shown in Figure.1). The precursor were heated with the heating rate 10 $^oCmin^{-1}$ by heating gun and collected data for each 10 min from 30$^o$C to 600$^o$C.

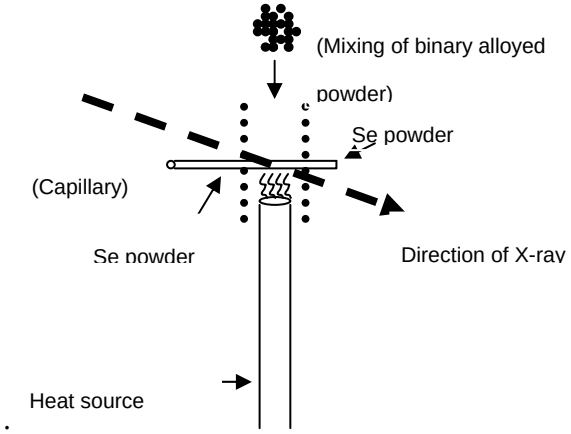


**Figure 1.** Seheme of in-situ XRD experiment under heat treatment

The XRD pattern indicated that mixed ternary powder at 150 $^o$C had (112), (220), (312), (400) and (316) orientations. The peaks of (316), (400) orientation were disappeared and the (112), (220) and (312) were shifted toward higher angles with the increasing temperature due to the migarion of Ga atom into CIS lattice caused the lattice expansion. Finally, at 600$^o$C, the chalcopyrite phase of CIGS was obtained

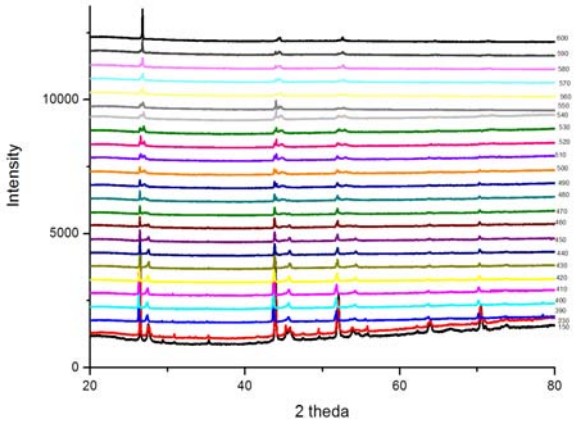


**Figure 2.** In-situ XRD pattern of phase transformation of mixed CGS and CIS alloy compound under heat treatment.