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Characterization of deep defects in Cu(In,Ga)Se_2 by transient photo-capacitance method

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Introduction Cu(In_{1-x},Ga_x)Se_2 (CIGS) is a promising material for realizing thin-film solar cells of low cost and high efficiency. Although the highest efficiency of CIGS solar cell has exceeded 20% at low Ga content around 0.3 (Ga/III ratio) [1], however, efficiency of higher Ga/III CIGS is still much lower than theoretically prediction [2]. Deep defects which locate near the mid-gap of CIGS bandgap is an possible candidate for this problem [3]. Here, a sub-bandgap optical absorption method called tranisent photo-capacitance (TPC) spectroscopy [3] was employed to characterize deep defects.

Experimental

CIGS films with Ga content (Ga/Ga+In) of 0.3～0.8 were grown by a three-stage process using a molecular beam epitaxial (MBE) system. The photo-capacitance measurements have been carried out at low temperature (60K) by using a Boonton 72B capacitance meter (ac frequency=1 MHz). During the photo capacitance measurements, a halogen lamp was used as the sub-bandgap monochromatic probe light source (wavelength 700~1800 nm).

Results

Fig. 1 shows the TPC spectrum measured at 60 K for CIGS with various Ga content. A fitting of the sub-bandgap spectrum considering the optical absorption model [4] indicates that a deep defect around 0.75-0.8 eV with a Gaussian distributed density of state from the valence band and an exponential bandtail exists for all measured CIGS samples, the position of which has no significant relationship with Ga/III as indicated from Fig.1. It seems the defect signal intensity increases with increasing Ga/III ratio. The above bandgap signal of CIGS with Ga/III ratio 0.80 shows distinctive feature than others which may show some unique information about the band structure and more research will be carried out in the future.

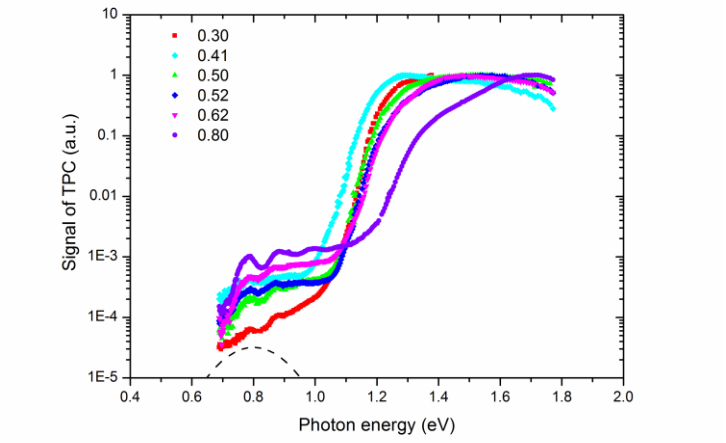

Fig. 1 TPC spectrumof CIGS with various Ga/III ratio

Conclusions

By using TPC method, a deep defect around 0.75-0.8 eV from the valence band maximum (VBM) was determined for all measured CIGS samples, the position of which has no significant relationship with Ga/III. The defect signal intensity seems to increase with increasing Ga/III ratio.

Reference

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