Ionization potentials and electron affinities of amorphous Cd-In-Ga-O

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Band alignment of semiconductor is one of the most significant parameters to design the semiconductor devices such as thin film transistor in flat panel displays, solar cells and laser diodes. When we fabricate semiconductor device, their device have to be designed based on the suitable band alignment, meaning that ionization potential (I_p) and electron affinity (χ) and band gap should be taking into account. Among various semiconductors, we are going to focus on the amorphous oxide semiconductors (AOSs) which have several advantages such as high carrier mobility compare with amorphous Si, low processing temperature, wide range tunability of their physical properties by varying their compositions, and *etc*.

In this study, we fabricate amorphous Cd-In-Ga-O films to demonstrate the tunability of I_p and χ, independently. The films were fabricated by radio frequency magnetron sputtering system connected with ultraviolet photoelectron spectroscopy (UPS) vacuum chamber: I_p can be measured by UPS without exposing samples to atmospheric contamination. Mixed powders of CdO, In_2O_3 and Ga_2O_3 were employed as sputtering targets. Electrical properties such as carrier type, carrier concentration (N), and electron mobility (μ) were evaluated by Hall measurement using the van der Pauw method.

Fig.1 (a) and (b) show I_p and χ of amorphous Cd-In-Ga-O system, respectively: I_p and χ are energy difference from the vacuum level to the valence band maximum (VBM) and the conduction band minimum (CBM), respectively. I_p values were increased by increasing Cd concentration. On the other hand, χ values were changed by tuning In:Ga ration but keeping Cd concentration. As a result, the energy positions of the VBMs and CBMs of amorphous Cd-In-Ga-O system, which are I_p and χ, respectively, could be independently controlled by tuning Cd:In:Ga ratios. Carrier concentrations of amorphous Cd-In-Ga-O films were decreased from ~10^{20} to ~10^{16} cm^{-3} by increasing Ga concentration because Ga could suppresses generation of oxygen vacancy, which might origin of carriers in this system.

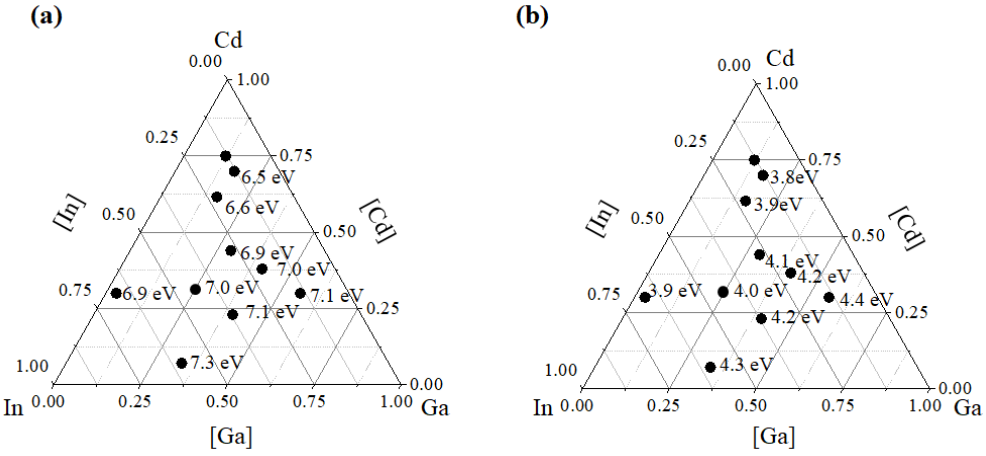

Fig.1 Ionization potential (I_p) (a) and electron affinity (χ) (b) of amorphous Cd-In-Ga-O films.