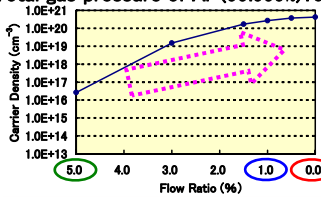


Electronic states of a-In-Zn-O films analyzed by x-ray photoelectron and reflected electron energy loss spectroscopies

It is important to investigate the electronic states of transparent conductive oxide (TCO) films to acquire the directions for electrical property control and device development. In this study, we investigated the electronic states of indium zinc oxide (IZO) films deposited under different oxygen flow ratios. The influence of oxygen flow ratios on the electrical properties of IZO films is discussed on the basis of the results obtained by electron spectroscopies.

1. Samples and analyses

Sample : IZO film /Si sub.
 Oxygen flow ratio (O₂/Ar+O₂) : 0%, 1%, 5%
 Total gas pressure of Ar (99.999%): 0.7 Pa

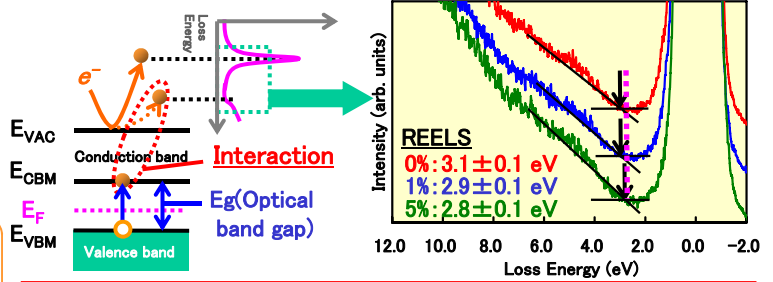


The Carrier density increases with a decrease of the oxygen flow ratio. (1)

(1) T. Ashida *et al.* J. Vac. Sci. Technol. A25(4), 1178(2007).

2. Optical band gap (REELS)

The scattering electron energy loss between the conduction band minimum and the valence band maximum is measured.

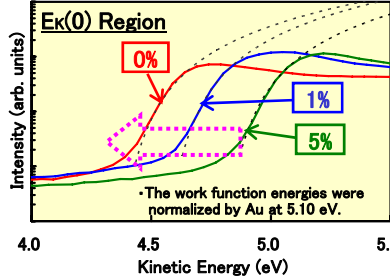
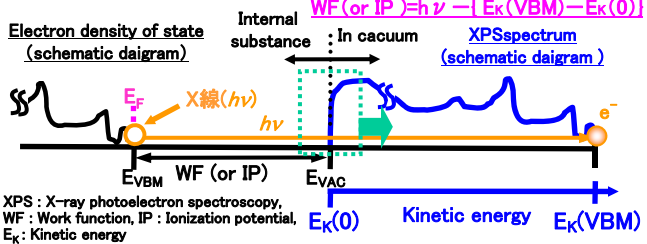


As the carrier density increases, the optical band gap slightly increases.

E_F: Fermi energy, E_{VAC}: Vacuum energy, E_{VBM}: Valence band maximum energy, E_g: Optical band gap, E_{CBM}: Conduction band minimum energy, REELS: Reflected electron energy loss spectroscopy

3. Work function (XPS)

The lowest kinetic energy of photoelectrons is measured.

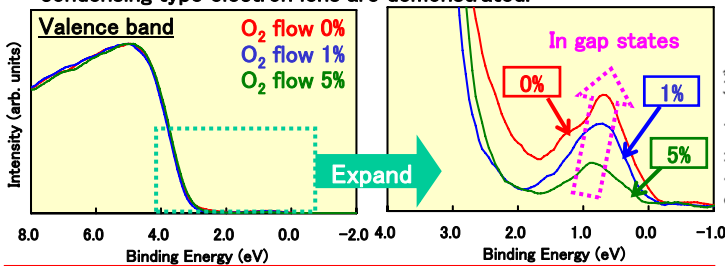


O ₂ flow	WF (eV)
0%	4.4
1%	4.6
5%	4.8

As the carrier density increases, the work function decreases.

4. Valence band region (XPS)

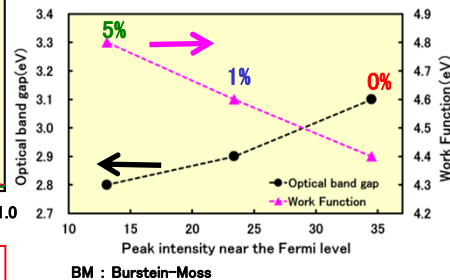
The high sensitivity XPS measurement using a magnetic field condensing type electron lens are demonstrated.



As the carrier density increases, the peak intensity near the Fermi level increases.

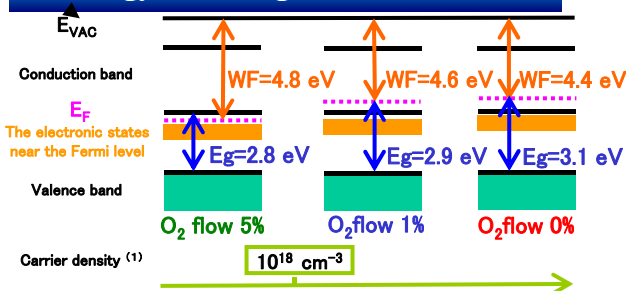
5. Correlation of results

The relationship between electronic states and peak intensity near the Fermi level



As the peak intensity near the Fermi level increases, the optical band gap increases and the work function decreases. Interrelations are related to BM effect

6. Energy band diagram



Extrapolating from carrier density, Fermi level should be located in conduction band at 0% and 1%. Fermi level should be located in band gap at 5%. The relationship between film forming conditions (carrier density) and electronic states was investigated systematically.

It is important to understand energy band diagram for clarification of the electronic property of TCO.

※This study is a result of joint research with Y. Shigesato of graduate school of Science Engineering, Aoyama Gakuin University.

