Control and characterization of surface and interface in functional oxide thin films

Project Leader
MAKINO Hisao, Dr. Eng.
Associate Professor, Research Institute

Objective

Wide band gap oxide semiconductors have attracted much attention due to the variety of the applications, such as transparent electrodes in optoelectronic devices, light emitting diodes, ultraviolet sensors, and gas sensors. Control of interfaces is an important issue in the development of such oxide based applications. In this project, we explore the control and characterization of substrate/thin film interfaces, interfaces in multilayered structures, and also surfaces of functional oxides thin films.

Project Outline

(1) Nondestructive characterization of interfaces by hard x-ray photoelectron spectroscopy

Hard x-ray photoelectron spectroscopy (HAX-PES) has been known as a powerful tool for the nondestructive investigation of bulk electronic structure, chemical bonding states at interfaces, and depth profiling chemical bonding states [1]. In this project, we investigate the interface between substrates and oxide thin films using a HAX-PES for laboratory use equipped with a Cr Kα x-ray source to develop interface control for the deposition of high quality oxide thin films by ion-plating and magnetron sputtering deposition methods.

(2) Transport property in heavily doped semiconductor oxides

Heavily doped n-type ZnO thin films are promising candidates as transparent electrodes. However, the transport property in such heavily doped polycrystalline thin films is not yet clearly understood [2]. We will investigate transport properties in polycrystalline Ga-doped ZnO films on glass and epitaxially grown films on crystalline substrates. Influences of interface control on the transport properties will be also investigated.

(3) Control and characterization of surface reaction in oxide thin films

The surface of oxides is believed to be stable, but some properties still remain obscure. Stability or reliability of ZnO based materials could be related to surface or grain boundary reactions. Gas sensing properties are also based on surface reactivity. Electronic structure and surface reactions of oxide thin films will be examined using the HAX-PES.

References

[1] J. J. Kim, *et al.*, "Hybridization of Cr 3*d* - N 2*p* - Ga 4*s* in the wide band gap diluted magnetic semiconductor $Ga_{1-x}Cr_xN$" Phys. Rev. B, 70, 161315(R) (2004), K. Kobayashi, *et al.*, "Intrinsic Valence Band Study of Molecular-Beam-Epitaxy-Grown GaAs and GaN by High-Resolution Hard X-ray Photoemission Spectroscopy", Jpn. J. Appl. Phys. 43, L1029 (2004).

[2] T. Yamada, *et al.*, "Ingrain and grain boundary scattering effects on electron mobility of transparent conducting polycrystalline Ga-doped ZnO films", J. Appl. Phys. 107, 123534 (2010), T. Yamada, *et al.*, "Low resistivity Ga-doped ZnO thin films of less than 100 nm thickness prepared by ion plating with direct current arc discharge", Appl. Phys. Lett. 91, 051915 (2007)

Contact

E-mail: makino.hisao@kochi-tech.ac.jp