Functional thin film laboratory in Kochi University of Technology

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Development of the material with the new functionality as well as innovation of conventional electronic device technology are desired to settle the environment and energy problems and build the sustainable society. The oxide semiconductor, which is expected as electronic material of the next generation, is also watched as the new functional materials, because the various physical properties are indicated. In this laboratory, we are controlling the physical properties of the oxide thin films and are aiming at improvement of the function and creation of a new multi-functional devices using environmentally harmonious metal oxide thin films.

Research theme under investigation

(1) Transport property in heavily doped semiconductor oxides thin films

Heavily doped n-type ZnO thin films are promising candidates as transparent electrodes. However, the transport property of charge carriers in such heavily doped polycrystalline thin films is not yet clearly understood. We will investigate transport properties in polycrystalline ZnO-based thin films on glass and epitaxially grown films on crystalline substrates. Influences of interface control on the transport properties will be also investigated. These years we have studied improvement electrical conductivity of Al-doped ZnO thin films on glass substrates using ultrathin Al top layer and bottom layer combination with thermal annealing process. Details on the mechanism of the improvement and further possibility of improvement and limitation have been explored.

(2) Control and characterization of surface reaction in ZnO thin films for multi-functional applications

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. These years we have investigated control of crystallographic polarity, that is Zn-polar surface and O-polar surface of polycrystalline ZnO thin films by using some interfacial layer between glass and oxide thin films. UV light sensing properties and gas sensing properties of ZnO-based thin films have been under investigation. The influences of mechanical bending on such functionality has been also investigated. Since such functionality is strongly related surface reaction and/or reactions at grain boundaries, chemical bonding and electronic states near the surface region will be examined.

(3) Nondestructive characterization of buried interfaces by HAXPES

Hard x-ray photoelectron spectroscopy (HAXPES) has been known as a powerful tool for the nondestructive investigation of bulk electronic structure, chemical bonding states at buried interfaces, and depth profiling chemical bonding states because of high energy excitation resulted in much deeper probing depth compared to that of common XPS. We investigate buried interfaces, like as between substrates and oxide thin films, between passivation layer and oxide thin films, using a HAXPES 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 magnetron sputtering deposition methods. X-ray irradiation damage on inorganic oxides thin films have been under investigation.

Experimental facilities:

- Custom made laboratory-based hard X-ray photoelectron spectroscopy (HAXPES) system equipped with a wide acceptance angle electron analyzer (Scienta Omicron EW4000), monochromatic Cr Kα (5.4 keV) and Al Kα (1.5 keV) X-ray sources (ULVAC-PHI) and a dual beam charge neutralization system consists of a Ar ion gun and low energy electron gun (ULVAC-PHI)

- Magnetron sputtering deposition system connected to the laboratory-based HAXPES system through ultra-high vacuum chamber

- Magnetron sputtering deposition system equipped with a load-lock chamber enabling substrates to enter into the deposition chamber without breaking vacuum; Two cathodes for DC and RF super imposed DC power, one cathode for RF power; Heating substrates

- Resistance heating vacuum evaporation equipment for metal electrodes

- UV ozone treatment system

- Plasma treatment system

- Hall effect measurement system available in measurement temperature between 15 K and 300 K

- Annealing furnace in pure gas environment

- Optical spectroscopy system for photoluminescence measurement

- Fiber optic miniature spectrometers used for monitoring plasma process

- UV-VIS-MIR spectrophotometer for transmission and reflection measurements

- Shared use equipment: Thin film X-ray diffraction measurement system; Secondary electron microscopy; Atomic force microscopy; Spectroscopic ellipsometry; Thermal desorption spectroscopy, and so on