Effect of Hydrogen on the Characteristics of ZnO thin films

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Zinc oxide (ZnO) is a versatile material which has been used in a variety of thin film devices, including surface acoustic wave devices, transparent conducting electrodes in solar cell, varistor, cantilevers, thin film gas sensors, and as film bulk acoustic resonator (FBAR). The wide range of applications is a result of the fact that ZnO is both a piezoelectric and an electro-optic materials, and a semiconductor which possesses a wide optical band gap (3.3 eV). In resent years, a great deal of effort has been devoted to the investigation of hydrogen in semiconductors as well as hydride forming metals (e.g. Zr, La and Ti). Research has been driven not only by technological requirements of state-of-the-art applications, but also by the lack of a fundamental understanding on the role of hydrogen in those materials. Among any configurations, several notable results have been reported from observations on hydrogen in a compound semiconductor ZnO.

ZnO thin film that used by surface acoustic device was required preferred orientation of c-axis, high resistivity and uniform surface morphology. Also, ZnO thin film was required high conductivity for optical device and sensor. In order to these, heat treatment after deposition and control of charge carrier concentration and of microstructure by adding to special element. Because of different requirements according to application field, it is important that deposition condition of ZnO thin film effect crystallinity, microstructure and electrical and optical properties. From these reasons, we studied to understanding the effects of hydrogen on basic characteristics such as structural, electrical and piezoelectric properties.

ZnO films were deposited on Pt/Ti/SiO_2/Si and quartz by radio frequency (rf) magnetron sputtering of a zinc oxide target in gas mixture argon, oxygen and 0~24 vol% hydrogen mixture. Figure 1. shows XRD patterns of ZnO films deposited on Pt/Ti/SiO_2/Si according to amount of hydrogen. As hydrogen concentration increased in the gas mixture, the vanishment of (002) peaks, is accompanied by the creation of (101) and (100) peaks, which correspond to energetically more unstable planes inclined to the substrate.

Figure 2. shows SEM images of ZnO films deposited on Pt/Ti/SiO_2/Si according to amount of hydrogen. Typical columnar structure and circular shaped grains appeared none hydrogen, but increasingly collapsed columnar structures with elongated textured were obtained above 4 vol% hydrogen. The resistivity of ZnO films decreased sharply in the range of 0~24 vol% hydrogen and exhibited a minimum (6.0×10^2 μ Ω -cm) for 24 vol% hydrogen.

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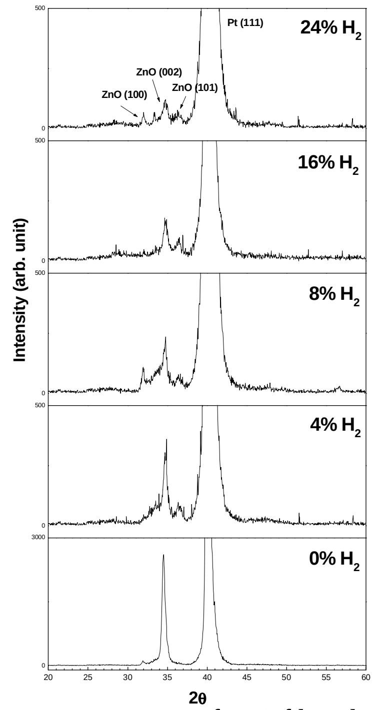

Figure 1. XRD patterns of ZnO films deposited on Pt/Ti/SiO_2/Si according to amount of hydrogen

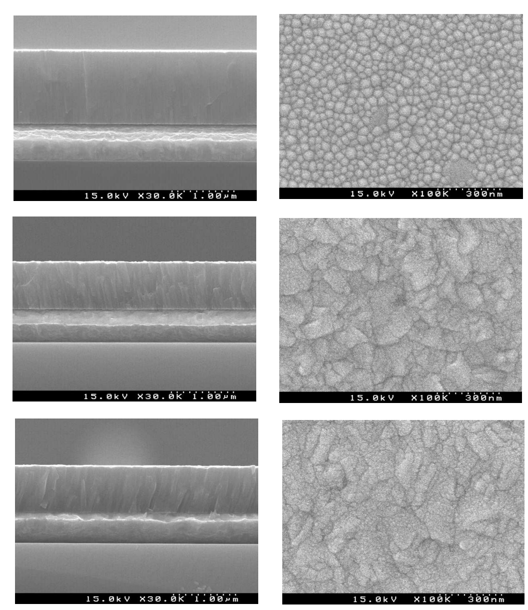

Figure 2. SEM images of ZnO films deposited on Pt/Ti/SiO_2/Si according to amount of hydrogen