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Physical properties of Mn-doped ZnO films with oxygen vacancy

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Diluted magnetic semiconductors (DMSs) have attracted a great deal of attention because of the possibility of incorporating magnetic degrees of freedom in traditional semiconductors. Especially, since Dietle predicted that p-type Mn-doped ZnO has room-temperature ferromagnetic properties, many researchers have tried to fabricate ZnO-based DMS because the intrinsic properties of ZnO are useful for numerous application such as ultraviolet light-emitting devices, wide-bandgap high-power devices, and invisible field-effect transistor. In order to understand the magnetic ordering in Mn-doped ZnO, it is necessary to investigate the correlation between carrier concentration and magnetism. Hence, in this study, we fabricated the Mn-doped ZnO film on a Si wafer using the UHV co-sputtering method in a well-controlled oxygen partial pressure during the film growth, and investigated their physical properties.

The crystalline structure and the chemical composition of the films were determined by x-ray diffraction and Rutherford backscattering spectroscopy (RBS), respectively. Their magnetic properties were measured by using a superconducting quantum interference device magnetometer. The Hall measurements were carried out to determine the carrier mobility and the carrier concentration at room temperature. The hysteresis curves show that the films, prepared in an oxygen pressure of 2.2×10^{-7} Torr, exhibit the ferromagnetic behavior with a low coercivity ($\sim$50 Oe) at room temperature and a T_C above 350 K. On the other hand, the films at an oxygen pressure higher than 1.2×10^{-6} Torr turn out to be nonmagnetic. The carrier concentration was decreased with increasing the oxygen vacancy which was determined by RBS in the oxygen-resonance mode.