

Magnetic, electro-transport, and structural properties of Co ion-implanted ZnO single crystals

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In recent years, dilute magnetic semiconductor (DMS) materials have attracted much attention for potential application in spintronics devices⁽¹⁾. ZnO is a II-V compound semiconductor with a wide band gap energy ($E_g = 3.35$ eV) and is interesting from the viewpoint of forming a transparent ferromagnetic materials⁽²⁾. We have investigated the magnetic, electro-transport, and structural properties of Co ion-implanted ZnO single crystals by using high resolution x-ray diffraction (HRXRD), superconducting quantum interference device (SQUID) magnetometer, physical properties measurement system (PPMS), and fluorescence x-ray absorption fine structure (XAFS) measurements using synchrotron radiation. We prepared 0.5 mm thick ZnO (0001) single crystals, and 80 KeV Co⁺ ions with a dose of 3×10^{16} cm⁻² were implanted into ZnO at 350°C. The implanted samples were post-annealed at 700~900°C by rapid thermal annealing (RTA) in N₂ atmosphere for 5 min to recrystallize the samples. Considerable lattice damage was observed in analyzing of x-ray diffraction and it was recovered after annealing. X-ray diffraction results show the presence of Co impurities phase in the samples annealed at 700-900°C. Magnetization measurements indicate ferromagnetic behavior with hysteresis loops at 5K. The temperature dependence of the magnetization taken in zero-field-cooling (ZFC) and field-cooling (FC) condition exhibits the main features of superparamagnetic system showing blocking temperature (T_B). After annealing the films, T_B increased with increasing annealing temperature. Transport measurements of resistivity as a function of temperature reveal a typical semiconducting behaviors and show conduction via variable range hopping (VRH). Co K-edge x-ray absorption near-edge structure, extended x-ray absorption fine structure revealed the coexistence of oxidized and metallic Co in the film. Observed results of the structural properties collectively imply that the presence of ferromagnetic Co clusters leads to ferromagnetism in Co ion-implanted ZnO single crystals.

[참고문헌]

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