Growth and characterization of spinel-type magnetic semiconductor $ZnCo_2O_4$ by reactive magnetron sputtering

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We report the synthesis of cubic spinel $ZnCo_2O_4$ thin films and the effects of the oxygen partial pressure in the sputtering gas mixture on electrical and magnetic properties of the $ZnCo_2O_4$ films. Furthermore, we present a bipolarity of sputtered spinel $ZnCo_2O_4$ films by tuning of the sputtering gas mixture and the conduction type dependence of ferromagnetism. Zinc cobalt oxide films were grown on SiO_2 (200nm)/Si substrate by reactive magnetron co-sputtering method using Zn and Co metal target in a mixed O_2/Ar atmosphere. From X-ray diffraction measurements, we found that the crystal structure of zinc cobalt oxide films grown under an oxygen rich condition (the partial pressure ratio O_2/Ar = 9/1) changes from the wurtzite-type of $Zn_{1-x}Co_xO$ to the spinel-type $ZnCo_2O_4$ with the increase of the Co/Zn sputtering ratio, D_{Co}/D_{Zn}. In addition, the (111)-preferred growth was shown by X-ray diffraction patterns for a fixed sputtering ratio, D_{Co}/D_{Zn} of 2.0. We note that the electrical properties including conduction type and carrier concentration of the highly oriented films were varied by oxygen partial pressure ratio : *n*-type and *p*-type for oxygen partial pressure ratio below 70 % and above 85 %, respectively. Lastly, the conduction type dependence of magnetic properties of the $ZnCo_2O_4$ films were discussed by the analysis of magnetization data measured from the superconducting quantum interference device. A ferromagnetic coupling was observable in *p*-$ZnCo_2O_4$, whereas an antiferromagnetic interaction was found for *n*-$ZnCo_2O_4$ film.

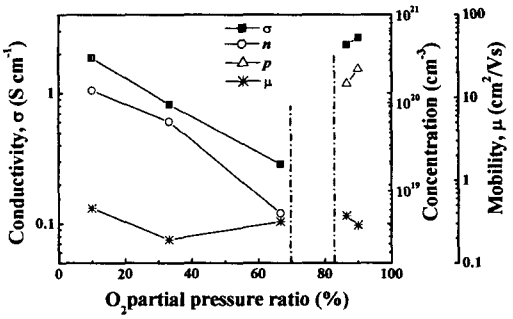

Fig 1. Electrical conductivity (σ), carrier concentration (*n*, *p*), and mobility (μ) in cubic spinel $ZnCo_2O_4$ films for various O_2 partial pressure ratio.