

The crystal structure and magneto-transport properties of $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$ films

[○]Asaka Tsujie¹, Andrea Fernandez², Lora Veneracion², Takashi Yanase³, Toshihiro Shimada³, Taro Nagahama³

(1.CSE Hokkaido Univ., 2.Philippines Diliman Univ., 3.Eng. Hokkaido Univ*)

E-mail: tsujie1995@gmail.com

[Introduction] NiCo_2O_4 is ferrimagnetic material, which has a inverse spinel type structure and has high Curie temperature, so it is expected to be spintronic material operated at room temperature. In addition, previous studies have reported that NiCo_2O_4 thin films prepared by PLD showed perpendicular magnetic anisotropy and good electrical conductivity depending on the degree of cation site disorder ^[1]. Therefore, NiCo_2O_4 has possibility to be applied to spin filter or MTJs. In this work, $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$ thin film was deposited by MBE method and its crystal structure and magneto-transport properties were investigated for the purpose of applying $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$ to spintronic devices with perpendicular magnetization.

[Experiment] We fabricated $\text{MgO}(001)$ substrate / $\text{MgO}(20 \text{ nm})$ / $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$ (24 nm) / AlO (2 nm) thin films by MBE. The $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$ thin film was deposited in an oxygen radical atmosphere of $4.0 \times 10^{-4} \text{ Pa}$ and then annealed for 30 minutes. To investigate the structure, RHEED, AFM, XRD and STEM were used. SQUID and MOKE were used for characterization of magnetic properties. In addition, the thin film was processed into a Hall-bar shape, then the electrical conductivity was measured by the four-terminal method.

[Result and Discussion] The RHEED pattern of $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$ deposited at $T_s=100^\circ\text{C}$ is shown in Fig.1 .Clear streak pattern was observed, indicating that $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$ was epitaxially grown at lower temperature than previous studies ^[1]. From the XRD profiles, peaks assigned for MgO substrates and NiCo_2O_4 films were confirmed, which suggested that $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$ had a spinel structure and it grew epitaxially in the [001] orientation. Fig. 2 shows an AFM image of surface of the $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$ thin film. The RMS was 0.1146 nm. Such a very flat surface has an advantage for application for devices. With respect to the magnetic properties, as the result of MOKE at room temperature, no hysteresis was observed in perpendicular magnetic field. Details of magneto-transport properties will be also discussed at the conference.

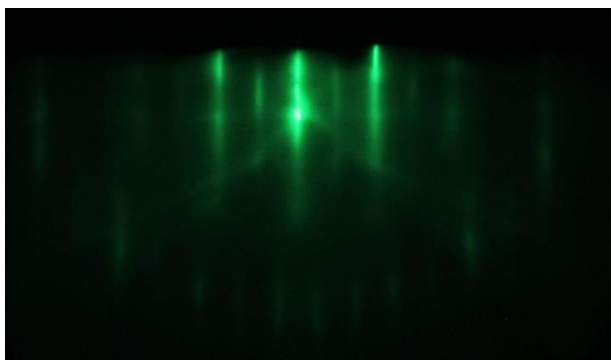


Fig.1 RHEED pattern of as-grown $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$

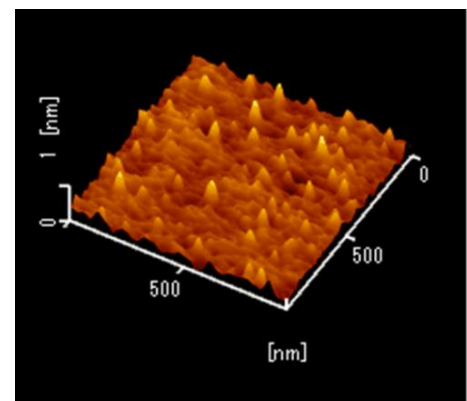


Fig.2 AFM image of surfaces of $\text{Ni}_x\text{Co}_{3-x}\text{O}_4$

[1] Yugandhar Bitla et al., *Sci.Rep*, **5**, 15201 (2015)