Transport property of Fe$_3$O$_4$ thin films

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【Introduction】Magnetite(Fe$_3$O$_4$) is predicted to be a half-metallic ferromagnetic material, which has 100% spin-polarization near the Fermi level [1]. It also has a high Curie temperature of 860K, therefore the Fe$_3$O$_4$ has attracted much interest as a spintronics material. Many researchers have investigated the TMR devices with Fe$_3$O$_4$ to realize large TMR ratio, however, such large MR has not been reported yet. Regarding a magnetic property, the magnetization processes of the Fe$_3$O$_4$ films are not sensitive to the magnetic field. The external field of several tesla is necessary to saturate the magnetization of Fe$_3$O$_4$ thin films. Although the reason is not clear so far, the anti-phase boundary is proposed to give rise to such effects. In this study, we fabricated high-quality Fe$_3$O$_4$ epitaxial film and investigated the transport and magneto transport properties in detail.

【Experiment】Sample was fabricated by an MBE system. The sample structures were MgO(100) substrate / MgO / NiO / Fe$_3$O$_4$. The NiO film was formed by reactive deposition at $T_{sub}$ of 300$^\circ$C in an O$_2$ radical atmosphere. The Fe$_3$O$_4$ film was formed by reactive deposition at $T_{sub}$ of 300$^\circ$C in an O$_2$ atmosphere, and then annealed at $T_a$ of 600$^\circ$C for 30 minutes in an O$_2$ atmosphere. Partial pressure of O$_2$ was 4×10$^{-4}$Pa. The thickness of Fe$_3$O$_4$ film was varied from 5 to 30 nm, and the epitaxial growth was observed by RHEED. Microfabrication of the sample was carried out by photolithography, and temperature dependence of the resistance of Fe$_3$O$_4$ films were measured by four-terminal method.

【Results】The RHEED pattern of Fe$_3$O$_4$ film on MgO(100) substrate is shown in Fig.1. A clear streak pattern was observed, meaning a high-quality epitaxial film was obtained. In Fig.2, the temperature dependence of the resistance for Fe$_3$O$_4$ thin films (5 and 10 nm) are shown. It exhibited electric conductivities at 300 K, and the resistance increased in low temperature. Clear Verwey transitions were not observed.

【Reference】