Inverse tunnel magnetoresistance in Fe_3O_4/MgO/Fe epitaxial Magnetic tunnel junction

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【Introduction】 Since the spin polarization of Fe_3O_4 is predicted as -100% theoretically, it is expected to obtain very large TMR ratio in the magnetic tunnel junction (MTJ) with Fe_3O_4 electrodes. However, the TMR ratio is still small value in previous research. It is considered that one possible cause is the insufficient understandings of the interface magnetism between Fe_3O_4 and barrier layer. In this study, we investigated epitaxial growth and interface state with various crystal orientations, and then fabricated MTJs using Fe_3O_4 electrode.

【Experiment】 The films were epitaxially grown by MBE under ultra-high vacuum with the base pressure of 10^{-8} Pa. To investigate the crystal orientation dependence of epitaxial growth and interface states, NiO(5 nm)/Fe_3O_4(60 nm)/MgO(2 nm) or AlOx(2 nm) was deposited on MgO(001), (110) and (111) substrates, respectively. We employed MgO and AlOx as barrier materials. The surface morphology was observed by RHEED and AFM, and the interface electronic states ware investigated by XMCD. With respect to the TMR, the MTJs of MgO(001)/NiO(30 nm)/Fe_3O_4(60 nm)/MgO (2 nm)/Fe(10 nm)/Au(30 nm) were fabricated and magnetoresistance was measured by two-probe method.

【Result】 From the AFM measurements, the surface roughness of Fe_3O_4(001), (110), (111) were estimated at 0.27nm, 1.30 nm and 1.96 nm, respectively. Since the Fe_3O_4(100) had the flattest surface, we fabricated the MTJs with Fe_3O_4(001) electrode. The MTJs exhibited the TMR ratio of -9.6% at room temperature (290 K) and -56.6 % at 80K as shown in Fig.1. Regarding the temperature dependence, the TMR ratio increased monotonically up to -56.6% at 80 K with decreasing temperature (Fig.2). The XMCD spectra will be also discussed.

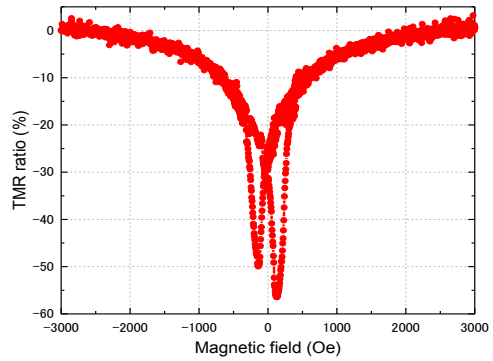

Fig.1 MR curve of Fe_3O_4(001)/MgO/Fe MTJ measured at 80K.

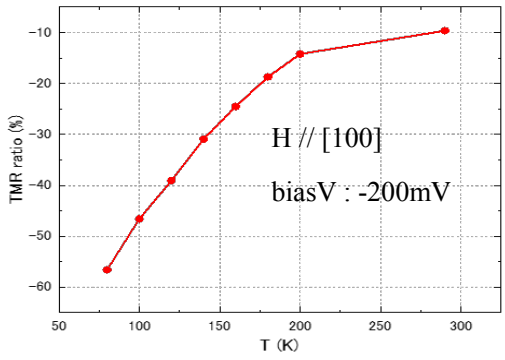

Fig.2 Temperature dependence for TMR ratio of Fe_3O_4(001)/MgO/Fe MTJ.