Spin-dependent tunneling in $La_{0.67}Sr_{0.33}MnO_3$-based magnetic tunnel junctions with an $LaMnO_3$ barrier

Department of Electrical Engineering and Information Systems, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

°**Tatsuya Matou, Kento Takeshima, Masaaki Tanaka, and Shinobu Ohya**

The perovskite manganite $La_{0.67}Sr_{0.33}MnO_3$ (LSMO) has been widely studied for future spintronic applications because of its half-metallicity and high Curie temperature up to ~370 K. In fact, a large tunneling magnetoresistance (TMR) up to 1900% has been reported in LSMO/ $SrTiO_3$ (STO)/ LSMO heterostructures at 4 K [1]. However, it is known that magnetic dead layers are formed at the interfaces between LSMO and STO and that they strongly deteriorate TMR at higher temperatures. The origin of the dead layers is still unknown. In this study, for understanding the properties of the dead layers, we used A-type *antiferromagnet* $LaMnO_3$ (LMO) as a tunneling barrier for LSMO, as an alternative to the *paramagnetic* STO barrier. In LSMO/ LMO/ LSMO trilayer structures, we can expect that the exchange bias induced by the LMO layer influences the magnetic properties of the interfaces. Thus, investigation of spin-dependent tunneling in LSMO/ LMO/ LSMO heterostructures will give us a new clue to understanding the origin of the dead layers at the interfaces. However, there has been no report of successful detection of TMR in LSMO/ LMO/ LSMO heterostructures [2, 3].

Using a shuttered growth technique of molecular beam epitaxy (MBE), we grew heterostructures composed of LSMO (12 nm)/ LMO (5 nm)/ LSMO (19 nm) on TiO_2-terminated Nb-doped (0.05 wt%) STO(001) substrates at 730°C in an oxygen background pressure $p = 2\times10^{-4}$ Pa with an ozone concentration of 14%. Figs. 1 and 2 show the tunnel resistance, as a function of a magnetic field applied in plane along the [100] direction, obtained for the as-grown sample and for the sample annealed at 730°C with $p = 2\times10^{-4}$ Pa in our MBE chamber for 1 hour, respectively. The sign of the magnetoresistance (MR) (*i.e.* the sign of the jumps of the resistance) was changed from negative to positive by the annealing. Such a negative MR as shown in Fig. 1 has not been reported in TMR devices using LSMO as both top and bottom electrodes. This result suggests that the spin polarization of one of the LSMO electrodes was inverted by the annealing or that the observed MR is attributed to tunneling anisotropic magnetoresistance.

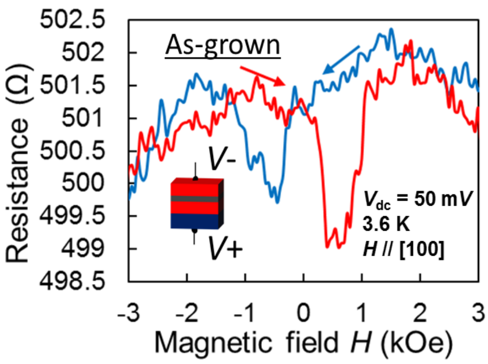

Fig. 1 Tunnel resistance as a function of the magnetic field applied in plane along the [100] direction for the as-grown sample at 3.6 K. Here, V_{dc} is the bias voltage applied to the sample.

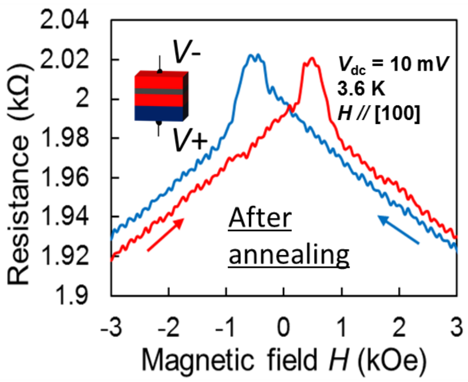

Fig. 2 Tunnel resistance as a function of the magnetic field applied in plane along the [100] direction for the annealed sample at 3.6 K.

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