

Magneto-transport Properties in Magnetic Tunnel Junctions with a Single-crystalline LiF Tunnel Barrier

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In the process of investigating magnetic tunnel junction (MTJ), great efforts have been made to develop crystalline tunnel barriers. To date, giant magnetoresistance (MR) ratios have been observed at room temperature (RT) in epitaxial MTJs with oxide barriers. Lithium fluoride (LiF) would be a suitable candidate for a single-crystalline tunnel barrier because of its small lattice mismatch ($\Delta a/a$) with bcc-Fe ($\sim 0.4\%$) when the LiF unit cell is turned by 45° with regard to the Fe unit cell. Furthermore, a recent *ab initio* calculation for the epitaxial Fe(001)/LiF(001)/Fe(001) structures has predicted very high MR ratios up to 2400% [1]. However, only a few studies on the LiF-based MTJ have been reported [2]. Here, we report on structural and magneto-transport properties of Fe/LiF/Fe MTJs.

The MTJ film was grown by molecular beam epitaxy. The structure of the MTJs is Au (10 nm)/Co (10 nm)/Fe (5 nm)/LiF (3 nm)/Fe(30 nm) /MgO (10 nm) buffer layer on MgO(001) substrates. The films were patterned into tunnel junctions ($3 \times 12 \mu\text{m}$) using a conventional micro-fabrication technique.

Crystallographical studies such as transmission electron microscopy observations revealed that the LiF tunnel barrier is single-crystalline having LiF(001)[100] \parallel bottom Fe(001)[110] crystal orientation, which is constructed in the same manner as the MgO(001) on Fe(001). Also, the in-plane $\Delta a/a$ between the LiF barrier and bottom Fe was estimated to be quite small, and was about 0.5%. However, the observed MR ratio was low ($\sim 6\%$ at 20 K), and showed a significant decrease with increasing temperature ($\sim 1\%$ at RT as shown in Fig.1). The results imply that indirect tunneling and/or thermally-excited carriers in the LiF, in which the current basically is not spin-polarized, play a major role in the electrical transport in the MTJ.

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Reference

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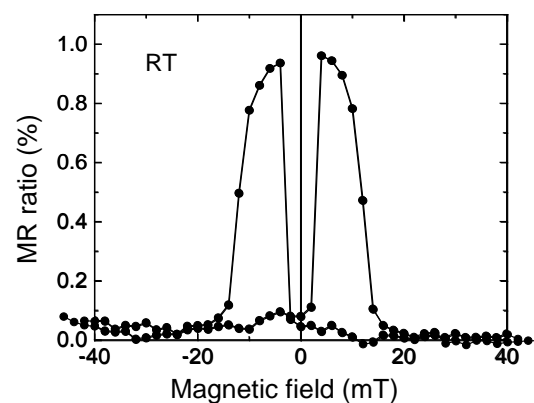


Figure 1 MR curve of the Fe/LiF/Fe MTJ at RT.