Spin-Polarized Coherent Tunneling in Fully Epitaxial Magnetic Tunnel Junctions with SrO Tunnel Barrier

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An efficient way to induce a large spin polarization in Si is to take advantage of the spin filtering effect in epitaxial ferromagnet/crystalline oxide tunnel barriers. With this method, we recently demonstrated the creation of a giant spin accumulation in Si using epitaxial Fe/MgO tunnel contacts [1,2] and found that the tunnel spin polarization (*P*) of Fe/MgO on Si can reach up to ~ 90% at 10 K [2]. However, for MgO thicknesses below 1 nm, we observed a rapid drop of the *P* to values below 25 % [2], which might be attributed to the lower crystalline quality of thin MgO layers due to the large lattice mismatch between MgO and Si (22%). This can suppress spin-dependent coherent tunneling transport near the interface and ultimately limit the *P* of the Fe/MgO tunnel contact. A low *P* for thin tunnel barrier thicknesses would be a major obstacle for achieving large magnetoresistance (MR) in a two-terminal Si-based lateral device. From a crystal growth viewpoint, rock-salt type SrO is better lattice-matched to Si than MgO (the lattice mismatch between SrO and Si is 4.9%). Thus, if spin-polarized coherent tunneling through SrO can be achieved, SrO might be a more suitable tunnel barrier for achieving high MR in Si devices. Here, we fabricate magnetic tunnel junctions (MTJs) with an epitaxial SrO tunnel barrier and examine its ability for spin-dependent tunneling by measuring MR effect.

The structure of the MTJ consists of Au (10 nm) / Co (20 nm) / SrO (1.5 nm) / MgO (1.0 nm) / Fe (30 nm) on a MgO(001) substrate. From the scanning transmission electron microscopy (STEM) image of the MTJ (Fig. 1), we observe a fully epitaxial Fe(001)/SrO(001)/MgO(001)/Fe(001) structure without significant diffusion or intermixing among each layer. Magneto-transport measurements reveal high MR ratios up to 90% at room temperature, indicating that spin-polarized coherent tunneling occurs through the epitaxial SrO tunnel barrier. In addition, for equivalent barrier thicknesses, the resistance-area products of the MTJs with SrO are comparable to that of epitaxial Fe/MgO/Fe MTJs. Therefore, SrO presents valuable properties as a novel tunnel barrier for high MR ratio in Si-based lateral devices.

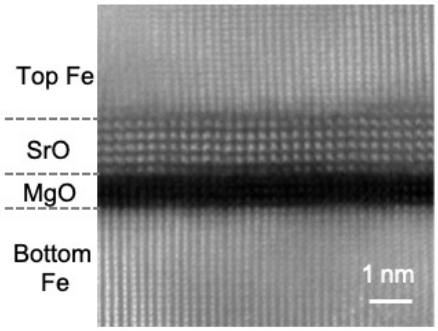

Fig 1. STEM image of Fe/SrO/MgO/Fe MTJ.

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Reference : [1] A. Spiesser *et al.*, Phys. Rev. Appl. **8**, 064023 (2017).
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