Magnetization switching driven by spin-orbit torque in exchange-biased magnetic tunnel junctions

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The magnetization switching by spin-orbit torque provides an alternative route to operate magnetoresistive random access memory (MRAM) devices [1]. The key elements of this approach are the transverse spin current generated by in-plane charge current in ferromagnet/ heavy metal structures and the magnetization switching driven by the spin current. The switching of the magnetic layer is, in many cases, proved by the anomalous Hall effect while the magnetization switching in full magnetic tunnel junction (MTJ) structure is scarcely reported because of the difficulties in the fabrication process [2,3]. Here we report the spin-orbit-torque driven switching of in-plane magnetic layer in exchange-biased MTJs. The MTJ layer stack consists of Ta/ CoFeB/ MgO/ CoFeB/ Ru/ CoFe/ IrMn/ Ta/ Ru. The stack is patterned into nano-scale MTJs having three-terminal geometry, and the junction size is 200 nm × 80 nm. By flowing current in the bottom Ta layer, it is possible to switch the bottom CoFeB free layer while the top CoFeB layer is pinned by the synthetic antiferromagnetic structure. The magnetization switching is monitored by measuring tunnel magnetoresistance of the MTJ. We have analyzed the relation between the critical switching current and external magnetic field by measuring magnetoresistance switching curves with varying in-plane current and external magnetic fields. It is shown that the CoFeB free layer is switched by an in-plane current of 2.0 mA even without external magnetic fields. This experimental result obtained with the exchange-biased MTJ raises prospect for the spin-orbit-torque MRAM devices.

References

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[2] S. Fukami et al, Nat. Nanotechnol. 11, 621 (2016).
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