Switching characteristics of CoFeB-MgO magnetic tunnel junctions in the ns regime

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CoFeB-MgO magnetic tunnel junction with perpendicular easy axis (p-MTJ) is a spintronics device that meets major requirements for practical applications [1]. Understanding of fast magnetization switching in the MTJ by spin-transfer torque (STT) is needed for full understanding of the potential of the MTJ for a variety of usages. In this study, we investigate the STT-switching characteristics in ns regime for the CoFeB-MgO p-MTJs.

A stack, from substrate side, Ta(5)/Pt(5)/[Co(0.4)/Pt(0.4)]$_5$/Co(0.4)/Ru(0.52)/[Co(0.4)/Pt(0.4)]$_2$/Co(0.4)/Ta(0.3)/$Co_{18.75}Fe_{56.25}B_{25}$(1)/MgO(0.8)/$Co_{18.75}Fe_{56.25}B_{25}$(1.6)/Ta(5)/Ru(5) is deposited on a sapphire substrate by dc/rf magnetron sputtering. Circular MTJs with a diameter D ranging from 41 to 82 nm are fabricated on a coplanar waveguide. Magnetization switching probability P is evaluated from 100-time trials for the STT switching by applying voltage pulses with duration τ_p from 1 to 5 ns.

Figure 1 shows the dependence of the switching current I_C, defined as I at which P reaches 0.5, on the inverse of τ_p for the MTJs with D = 41, 61, and 82 nm. The magnitude of I_C increases linearly with τ_p^{-1} in agreement with the expected dependence from a macrospin model [2]. Based on the model, we evaluate the STT efficiency from the slope of I_C-τ_p^{-1} by using the spontaneous magnetization of the corresponding blanket film and the thermal stability factor of devices [3]. The determined STT efficiency is higher than that expected from the tunnel magnetoresistance ratio, suggesting that one needs to go beyond a macrospin based model to understand the I_C versus τ_p^{-1} characteristics observed here.

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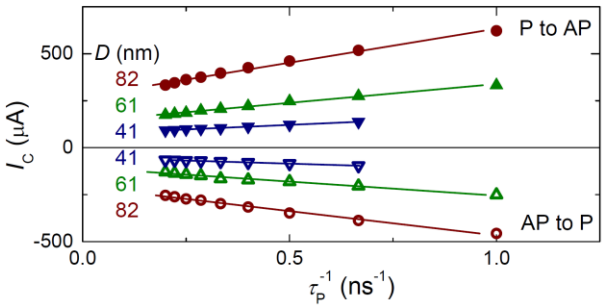

Figure 1: Dependence of the switching current on the inverse of pulse duration τ_p^{-1} for the CoFeB-MgO magnetic tunnel junctions with diameter of 41, 62, and 82 nm.

References

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