Switching the In-Plane Magnetization in Gd-Based Spin Valves Using Optically Excited Spin Currents

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The discovery of magnetization manipulation using laser pulse-induced spin currents generated by laser-induced demagnetization [1] has attracted significant attention for its potential application in future magnetic memories, as it enables magnetization reversal within a few hundred femtoseconds [2]. Previous studies have primarily focused on collinear spin valve structures composed of GdFeCo/Cu/ferromagnetic (FM) layer, where the Gd sublattice in GdFeCo predominantly generates the spin currents, and the aim is to switch the ferromagnet's magnetization via the spin current pulse [3,4]. Most research has concentrated on magnetization reversal in perpendicularly magnetized spin valves [5]; however, this configuration does not allow for the disentanglement of the impact of layer thickness on the reversal process since these ultrathin layers exhibit a Curie temperature (T_C) that varies significantly with film thickness.

In this talk, I will present findings from experiments using a similar structure with in-plane magnetic anisotropy, which allows us to isolate the effects of T_C and FM layer thickness on magnetization switching of the FM layer. The results show that ***(1)*** a higher T_C in the FM layer requires a larger laser fluence threshold for complete reversal. Furthermore, ***(2)*** for samples with a fixed T_C, an increase in FM layer thickness also demands a higher laser fluence threshold. Beyond a certain thickness, multiple pulses are necessary to switch the entire FM layer. I will also discuss ***(3)*** the maximum thickness at which full switching is achieved, depending on the Gd concentration in the spin current source layer, GdCo. In summary, this switching behavior can be explained by the need for substantial demagnetization of the FM layer upon the arrival of the current pulse. These findings improve our understanding of magnetization reversal induced by ultrafast spin current pulses and contribute to the design of energy-efficient magnetic memory devices [6].

References

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Figures

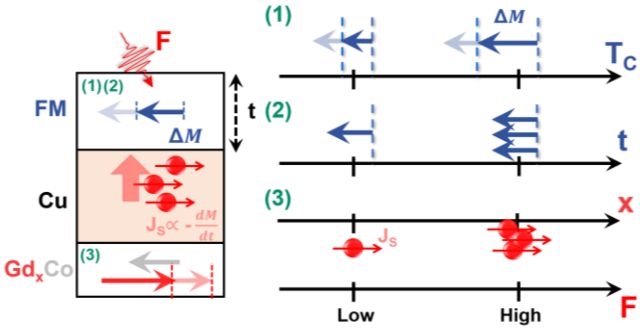

Figure 1. Schematic illustrating the parameters studied in this in-plane magnetized ferromagnet (FM)/Cu/GdCo spin valve structure, including the FM Curie temperature (T_C), FM layer thickness (t), and Gd concentration (x) in the current source GdCo alloy. This study aims to investigate the factors influencing the switching of the FM layer. It is concluded that the criterion for observing switching is that the angular momentum loss (J_S, referred to as optically excited spin currents) from the Gd sublattice must exceed the remaining magnetization (ΔM) in the FM layer, both of which are dependent on the laser fluence (F).