Accelerated ultrafast demagnetization of an interlayer-exchange-coupled Co/Mn/Co trilayer

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Antiferromagnetic (AFM) films are often used to tune the magnetic properties of adjacent ferromagnetic (FM) films, clusters, or adatoms. While AFM/FM bilayers have been studied extensively in the past with respect to their static magnetic interactions, less is known about their ultrafast magnetization dynamics. Here we report on the influence of the spin structure of an AFM Mn spacer layer on the magnetization dynamics of adjacent FM Co layers after excitation by an ultrashort infrared laser pulse. In the epitaxial Co/Mn/Co thin-film system on Cu(001), a combination of direct exchange coupling through the spin structure of the AFM layer, orange-peel coupling and Ruderman–Kittel–Kasuya–Yosida (RKKY)-type coupling results in a Mn-thickness-dependent oscillatory interlayer coupling between the two Co layers across the Mn layer [1]. By growing the Mn layer as a wedge, different coupling regimes are accessed. We use resonant soft-X-ray magnetic circular dichroism in reflectivity (R-XMCD) to probe the magnetization dynamics in a pump–probe experiment. We observe an accelerated demagnetization in the case of antiparallel alignment of the magnetizations of the two Co layers for antiparallel direct exchange coupling through the AFM Mn spin structure (9.5 ML Mn thickness, Fig. 1) as well as for parallel alignment in the case of parallel direct interlayer exchange coupling (11 ML Mn thickness), while parallel alignment in the case of antiparallel interlayer coupling leads to a slower demagnetization. Applying ab initio time-dependent density functional theory (TD-DFT) calculations we identify this behavior to originate from the optically induced intersite spin transfer (OISTR) effect [2] as the dominant mechanism, opening an additional decay channel by spin-selective transfer of electrons from occupied Co states into unoccupied Mn states. Depending on the alignment of both ferromagnetic layers with respect to the sign of the interlayer coupling by direct exchange through the Mn layer, the Mn spin structure is either collinear or twisted, resulting in OISTR or no or less OISTR, respectively.

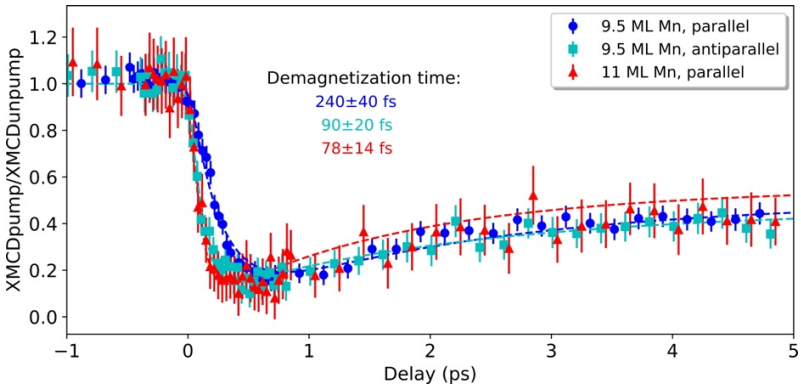

Figure 1. Ultrafast demagnetization of the Co/Mn/Co trilayer for different Mn thicknesses and parallel or antiparallel magnetization of the two Co layers. At 9.5 ML Mn thickness, the interlayer coupling by direct exchange through the antiferromagnetic Mn spin structure is antiparallel, while it is parallel at 11 ML.

References

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