The role of the interface and ferromagnetic alloying on the interlayer exchange coupling

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Interlayer exchange coupling in metallic multilayers between two ferromagnetic (FM) layers across a nonmagnetic (NM) spacer layer is found to oscillate between antiferromagnetic (AFM) and ferromagnetic as a function of the nonmagnetic spacer layer thickness, *d* [1]. The interlayer exchange coupling is widely used in spintronic devices to achieve antiferromagnetic coupling (AFC) between magnetic layers [2].

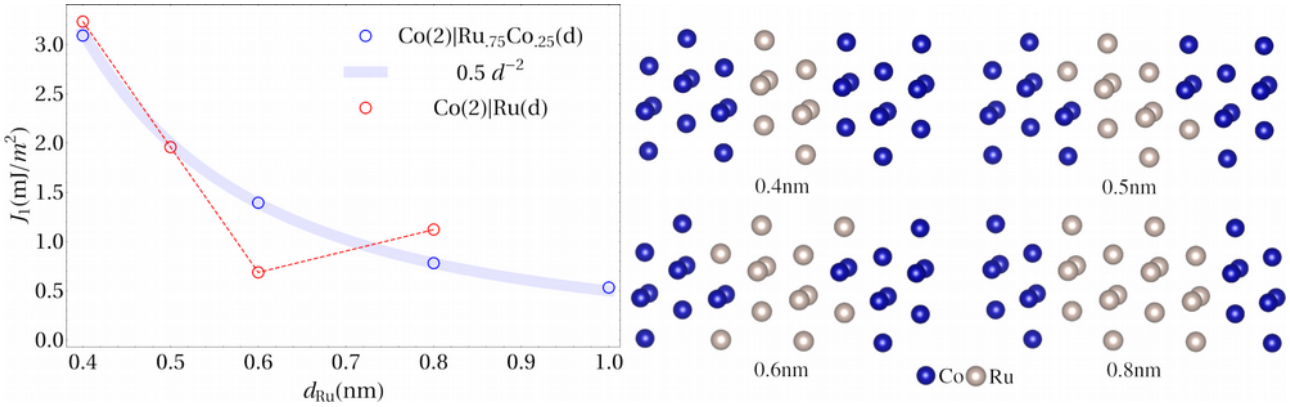

Figure 1: left) Calculated d^{-2} dependence of the damping of oscillations of J_1 with the thickness of Ru spacer *d*. right) Models of Co|Ru interfaces used in calculations to reproduce experimentally observed data.

In metallic FM|NM|FM transition metal multilayers, the antiferromagnetic coupling is achieved across nonmagnetic layers that are only a few atomic layers thick. Thus, during the process of layer by layer deposition a mixing of the FM and NM atoms occurs at the interface between multilayers [3]. During the sputtering process, FM atoms with large kinetic energy can also be deposited into the spacer layer, which will affect the coupling between FM layers.

We have recently performed a systematic study of the AFC of magnetic Co layers across a RuY transition metal spacer layer, where Y = Co and Fe. Co|Ru|Co is important for applications since it has one of the largest reported antiferromagnetic couplings [4]. The oscillation of the bilinear coupling constant, J_1, is damped with the addition of Co to Ru and it decreases as the inverse of the RuCo spacer layer thickness squared. With the addition of Fe into Ru, J_1 increases by a factor of two if 50 at.~% of Ru is substituted for Fe. In addition, we observed that saturation magnetization M_s oscillates with the thickness of the spacer layer with oscillations resembling those of J_1.

In this work we used atomistic simulations based on the Density Functional Theory to understand the role of the FM|NM interface and the substitution of Ru with FM atoms on the AFC in Co|RuY|Co multilayers. Within a simple model of supercells with different collinear spin arrangements we can reproduce the experimental observations of the dependence of J_1 on Co and Fe concentrations in the Ru spacer layer. Within this model we can also explain the damping of the oscillations of J_1, and M_s oscillations with the spacer thickness *d* by the intermixing of Co and Ru atoms at the Co|Ru interface.

References

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