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Antiferromagnetic coupling strength between Co films across NiRu, CoRu, and FeRu

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Antiferromagnetic coupling (AFC) has plays an important role in many magnetic thin film structures used in applications such as sensors, hard drives, and solid state memories. AFC is achieved in FM/NM/FM structures where two ferromagnetic layers (FM) are separated by a non magnetic (NM) spacer layer. Coupling of FM films across NM is RKKY like and oscillates between antiferromagnetic and ferromagnetic (FC) with the change of NM layer thickness. Here we investigate the coupling strength in Co/XRu/Co (X= Ni, Co, and Fe) trilayer structures as a function of the XRu layer thickness. Ru spacer layer is known to generate the largest AFC between Co films. Our result found that the coupling strength in Co/XRu/Co depends on the magnetic element added into the Ru. Furthermore. AFC increases 1.3 times in respect to AFC in Co/Ru/Co if the optimal concentration of Fe is added to Ru.

Our sample structure consisted of a Ta(3 nm)/Ru(10 nm) seed layer to obtain proper [0001] growth orientation, followed by the Co(2 nm)/XRu(d)/Co(2 nm) trilayer, where d is the XRu thickness, and Ru(3 nm) capping layer is used to minimize oxidation of the magnetic layers. All samples were deposited on Si substrates at room temperature using magnetron sputtering in 1.8mTorr of Argon. Out of plane X-ray diffraction measurements show that Co, Ru and XRu films are highly textured with full-width- at- half- maximum (FWHM) of rocking curve below 3.5 degrees. The coupling strength of these trilayer structures were determined from magnetization versus field dependence, M(H), in fields up to 7 T, using SQUID magnetometer. In Co(2 nm)/XRu(d)/Co(2 nm) demagnetizing dipolar field in Co films is much larger than the uniaxial magnetocrystalline anisotropy field forcing the magnetization to lie in plane. Thus, in our M(H) measurements the magnetic field was applied parallel to the film surface. The M(H) data are fit using a micromagnetic model. The model has only two fitting parameters the exchange stiffness within each Co layer that was kept constant, and RKKY coupling strength, JRKKY, across XRu spacer layer.

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