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Tunneling spin polarization in planar tunnel junctions: measurements using NbN superconducting electrodes and evidence for Kondo-assisted tunneling

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The fundamental origin of tunneling magnetoresistance in magnetic tunnel junctions (MTJs) is the spin-polarized tunneling current, which can be measured directly using superconducting tunneling spectroscopy (STS). The STS technique was first developed by Meservey and Tedrow using aluminum superconducting electrodes. Al has been widely used because of its low spin orbit scattering. However, measurements must be made at low temperatures ($<$0.4 K) because of the low superconducting transition temperature of Al. Here, we demonstrate that superconducting electrodes formed from NbN can be used to measure tunneling spin polarization (TSP) at higher temperatures up to $\sim$1.2K. The tunneling magnetoresistance and polarization of the tunneling current in MTJs is highly sensitive to the detailed structure of the tunneling barrier. Using MgO tunnel barriers we find TSP values as high as 90% at 0.25K. The TMR is, however, depressed by insertion of ultra thin layers of both non-magnetic and magnetic metals in the middle of the MgO barrier. For ultra-thin, discontinuous magnetic layers of CoFe, we find evidence of Kondo assisted tunneling, from increased conductance at low temperatures ($<$50K) and bias voltage ($<$20 mV). Over the same temperature and bias voltage regimes the tunneling magnetoresistance is strongly depressed. We present other evidence of Kondo resonance including the logarithmic temperature dependence of the zero bias conductance peak. We infer the Kondo temperature from both the spectra width of this conductance peak as well as the temperature dependence of the TMR depression. The Kondo temperature is sensitive to the thickness of the inserted CoFe layer and decreases with increased CoFe thickness. * performed in collaboration with S-H. Yang, C. Kaiser, and S. Parkin.