Bias Control of the Out-Of-Equilibrium Interlayer Exchange Coupling with Application to Magnetic Switching

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We demonstrate, using computer simulations and a non-equilibrium Greens function approach, that the sign of the out-of-equilibrium interlayer exchange coupling (ooeIEC) of an epitaxial multi-layer system changes in the presence of an external electrical bias. The system consists of a single, resonant tunnelling or amorphous insulator barrier connected to an exchange coupled ferromagnetic (FM) tri-layer with non-magnetic conducting spacer. Current flow is perpendicular to the layer interfaces and we take the magnetic moments of the FM's to lie in a plane parallel to the layer interfaces.

Under certain conditions we find a strongly non-linear dependence of the spin current on bias which can result in the exchange coupled tri-layer switching between parallel and antiparallel configurations. Furthermore, for an appropriately chosen system with CoCu FM tri-layer, it can be shown that the magnitude of the applied bias can be approximately 0.25-0.5 eV, several orders of magnitude smaller than that required by spin-transfer torque (STT) alone.

We believe that this could act as an energy efficient and highly scalable mechanism for magnetic switching which does not require a large charge current density. There are potential applications to magnetoresistive random-access memory (MRAM) which, due to its non-volatility and high read/write speeds, is one of the principal contenders for a universal memory.