Magnetization dependent rectification in (Ga,Mn)As magnetic tunnel junctions

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Nanoscale devices of diluted magnetic semiconductors form a crossover of semiconductor physics, magnetism and technology of spins (spintronics). Current rectification is one of the basic functinalities in semiconductor devices and we here show that it can be controlled through alignment of magnetization in (Ga,Mn)As tri-layer magnetic tunnel junctions (MTJs) through energy dependence of density of states around the Fermi level. Our devices consist of three (Ga,Mn)As layers (30nm, 5nm, 15nm) with the critical temperature of 40K and GaAs barrier layers (5nm) inserted between the magnetic layers.
The tunneling magnetoresistance (TMR) at 4.2K is 120% in amplitude, showing three step structure, which corresponds to the alignment of magnetizations. With a minor field loop, the alignment of magnetization can be anti-parallel for the top and the bottom layers and then current injections with alternative direction can reverse the direction of the magnetization in the middle layer. The threshold current is as low as 2×10^4A/cm^2. We have found the junctions have small rectification effect up to 8GHz, which is strongly dependent on the alignment of the magnetization. Hence the direction of the rectification as well as the amplitude can be switched by the bi-directional current injections.
The rectification can be explained within the Julliere model with enegy dependence of the density of states. To check this we performed tunneling measurements and obtained positive results.