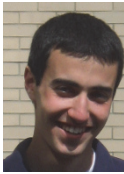


mLogic Fabrication and Testing



David
Bromberg



Matt Moneck



Vincent
Sokalski



En Yang



Larry Pileggi



Jimmy Zhu

Magnetoelectronics is an emerging area in the low energy design space. Our approach, mLogic, is based on a novel spin transfer torque-driven magnetic tunnel junction (STT-MTJ) device with electrically-insulated read and write paths. These devices can be configured into digital (and in some cases, analog) circuits with energy performance that rivals other technologies. Fabrication of the device involves the optimization of three distinct components: the STT write path, the MTJ read path, and an electrically-insulating magnetic material that couples these two paths.

A variety of film structures were deposited to test domain wall motion (DWM), including CoPd, CoCrPt, CoFeB, and CoNi. Nanowires of width ranging from 50 nm to 250 nm were patterned for each material. Kerr microscopy was used to observe and characterize DWM; in this setup, image contrast is a function of magnetization orientation, and so domains can be visualized as black or white. Current pulses down to 25 ns in width were applied to drive wall motion. Fig.1 demonstrates successful magnetization reversal in a 250 nm wide nanowire, with a 50 ns pulse of $J \approx 10^8$ A/cm² and a bias field of 75 Oe. Optimization of materials is ongoing. CoFeB/MgO/CoFeB tunnel junctions, the primary read path components, were deposited, patterned, and measured with a probe tester in a varying DC field to obtain the tunnel magnetoresistance switching ratio (TMR). Fig. 2 demonstrates TMR above 140% for our test structures, indicating a switching ratio of about 2.5 to 1. This is nearly as high as the best achieved TMR for these materials, and well within range for mLogic circuits to operate. Initial measurements of a naturally-oxidized FeCo film, a candidate for the coupling layer, indicate the material is intrinsically insulating and strongly couples magnetic layers on either side. The next major phase of research is to integrate the write path, read path, and coupling components together.

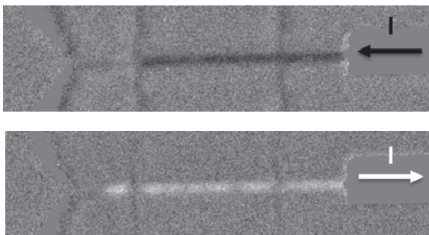


Fig. 1: Kerr microscope image of DWM.

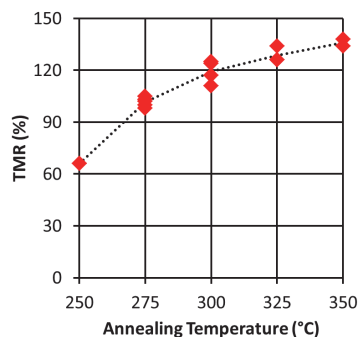


Fig 2: MTJ switching ratio vs. annealing temperature.