CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)

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Project Number

S1512

Project Title

Magnetoresistance in Co/Al(2)O(3)/Co Granules/Cu Magnetic Tunnel Junctions

Abstract

Objectives/Goals

The objectives were to observe the tunnel junction magnetoresistance (JMR) of magnetic tunnel junctions (MTJs) and thereby investigate the magnetism of Co ranging from the sub-nanoscale granular level to the more familiar thin film level.

Methods/Materials

MTJs of structure 80Å Co/16Å Al2O3/3, 6, 9, 12Å Co/205Å Cu were fabricated by thermal evaporation and JMR was measured at room temperature (RT), 77K, and 4.2K.

Results

Samples consistently exhibited JMR of 0.6% and 1.5% at RT for 9Å and 12Å thicknesses of Co, respectively, and significantly higher ratios of 0.3%, 0.9%, 3.0%, and 2.8% for 3, 6, 9, and 12Å samples at 77K. Bias dependence of the JMR reveals a moderate decrease in JMR with increasing voltage and slight polarization asymmetry, which agrees with results for conventional junctions. JMR tests for 6Å samples at 4.2K reveal higher scattering and lower JMR than at 77K, possibly due to high resistance of Co granules to change of magnetic moment at this temperature. This indicates the blocking temperature (Tb), at which ferromagnetic behavior is "locked in", has not been reached.

Conclusions/Discussion

The shape of JMR curves was characteristic of superparamagnetic materials (Co granules), and increasing concavity was seen at increasing nominal Co thicknesses. Bias dependence tests showed results typical of traditional MTJs, and samples tested at 4.2K reveal a Tb<4.2K, which indicates a low temperature of ferromagnetic stability, a desirable feature for superparamagnetic MTJs.

MTJs in which magnetic material is evaporated as a granular layer at the electrode/insulator interface may have application as a magnetic field sensor due to the reliable dependence of resistance on applied magnetic field up to relatively high magnetic fields.

Summary Statement

The magnetoresistance in magnetic tunnel junctions fabricated with a layer of magnetic material evaporated as a granular layer at the electrode/insulator interface was investigated.

Help Received

Participant in Boston University High School Honors Research Internship Program; conducted research under the direction of Dr. Moodera and staff at the Francis Bitter Magnet Laboratory, MIT.