Influencing Ferromagnetic Behavior of Gadolinium Films by Proximity Coupling

Joshua Feig\textsuperscript{1,2}, Dr. Yota Takamura\textsuperscript{2}, Dr. Juan Pedro Cascales\textsuperscript{2}, Dr. Jagadeesh Moodera\textsuperscript{2,3}

\textsuperscript{1}Half Hollow Hills High School East, Dix Hills, NY 11746; \textsuperscript{2}Francis Bitter Magnet Laboratory, \textsuperscript{3}Physics Department, MIT, Cambridge, MA 02139

Computing technologies are growing in power while shrinking in size. With traditional silicon-based computer chips reaching their scaling limit, the next step could be quantum computing, which uses an electron’s to spin represent data. However, in order for this to be successful, electron spins must be able to be controlled and detected with pinpoint precision, which can be accomplished through tailored thin film ferromagnetic materials. A material’s ferromagnetic properties can be modulated by changing its thickness or boundary conditions. We explored this phenomenon in Gadolinium (Gd)/Molybdenum (Mo) and Gd/Aluminum (Al) bilayers. Gd was chosen as the ferromagnetic material due to its Curie temperature ($T_c$) of 292K. Mo and Al were chosen as boundary materials based on their atomic numbers. Each sample (AlN/Gd/Mo/Al$_2$O$_3$ and AlN/Gd/Al/Al$_2$O$_3$) was deposited onto Si/SiO$_2$ substrate at room temperature using the ultrahigh vacuum sputtering technique. Mo and Al thicknesses were fixed at 1 nm, while Gd was varied from 2 to 10 nm. Resistance vs. temperature and anisotropic magnetoresistance measurements were carried out to observe ferromagnetic properties in the Gd/Mo and Gd/Al bilayers. Gd’s $T_c$ changed from 292K in bulk to as low as 260K by reducing its thickness to 2 nm. Additionally, the samples with Mo had lower $T_c$’s than their respective Al counterparts. In addition to providing new insights, the successful manipulation of Gd’s ferromagnetic properties shows promise for the use of ferromagnetic materials in future information storage and processing.