Utilizing the Chirality Induced Spin Selectivity Effect Through Chiral Carbon Nanotubes to Polarize Current for Spin-Transfer Torque in Spintronic Devices

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Modern day spintronic devices require the use of strong ferromagnets and precise magnetic fields to generate and control spin-polarized current, restricting their efficiency and applications to low-temperature environments where external fields have little impact on the hamiltonian of the spin-state system. Our research objective was to investigate the use of chiral single-walled carbon nanotubes (SWCNTs) as an alternative method to create and manipulate spin polarized current in a routine environment using the chirality induced spin selectivity (CISS) effect. We hypothesized the application of SWCNTs to act as an effective helicity filter and spin polarizer for electrons to then apply their spin transfer torque to a magnetically permeable layer. To test this, we deposited two chiralities of carbon nanotubes onto soft ferromagnetic foil. Constant current was run through the apparatus while a magnetometer was used to measure changes in the surrounding magnetic field. Compared to the control group (mean difference of 1.109 microtesla, SD of 0.746), the metallic chiral group resulted in a much larger mean difference (3.706) with similar SD (0.727). Similarly, the semiconducting chiral group of nanotubes resulted in a larger mean difference (4.160), again with similar SD (0.655). The p-values from both two-sample t-tests were less than 0.0001, indicating statistically significant results. This study showed that carbon nanotubes can act as an effective spin polarizer for current, and the CISS effect in conjunction with giant magnetoresistance allows for a universal magnetic memory storage method. Applications of this research pertain to Magnetoresistive-RAM cells in addition to the development of Spin Field Effect Transistors (SFETs) using the Rashba effect.