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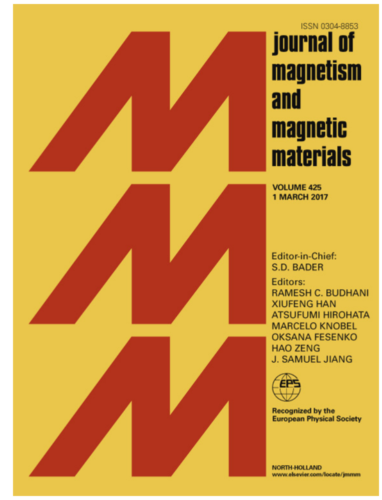

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Pawan Tyagi, Edward Friebe

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Large Resistance Change on Magnetic Tunnel Junction based Molecular Spintronics Devices

Pawan Tyagi[1,2*] and Edward Friebe[1]

University of the District of Columbia, Department of Mechanical Engineering, 4200 Connecticut Avenue NW Washington DC-20008, USA[1]
Email: ptyagi@udc.edu*
University of Kentucky, Chemical and Materials Engineering Department, 177 F Paul Anderson Hall, Lexington, KY-40506, USA[2]

Abstract: Molecular bridges covalently bonded to two ferromagnetic electrodes can transform ferromagnetic materials and produce intriguing spin transport characteristics. This paper discusses the impact of molecule induced strong coupling on the spin transport. To study molecular coupling effect the octametallic molecular cluster (OMC) was bridged between two ferromagnetic electrodes of a magnetic tunnel junction (Ta/Co/NiFe/AlOx/NiFe/Ta) along the exposed side edges. OMCs induced strong inter-ferromagnetic electrode coupling to yield drastic changes in transport properties of the magnetic tunnel junction testbed at the room temperature. These OMCs also transformed the magnetic properties of magnetic tunnel junctions. SQUID and ferromagnetic resonance studies provided insightful data to explain transport studies on the magnetic tunnel junction based molecular spintronics devices.

Key Words: Molecular spintronics; magnetic tunnel junctions; magnetic molecules;

Introduction: Connecting magnetic molecules between two ferromagnetic electrodes open the flood gate of opportunities for observing the new phenomenon and making novel devices [1, 2]. Initial studies focused on sandwiching molecules between two ferromagnetic leads [3]. In a more popular approach molecules were placed in a nanoscale-gap on a metallic electrode [4]. However, these two approaches have been extremely difficult to mass produce robust molecular spintronics devices [5]. With conventional approaches, it is challenging to conduct a variety of magnetic studies to explore the true effect of molecules on the magnetic properties of the molecular spintronics devices [6]. To date most of the experimental studies have only focused on the transport studies- no direct magnetic measurements were performed [3, 4, 7]. To overcome the limitations of the conventional molecular spintronics devices magnetic tunnel junctions (MTJ), produced by sandwiching an insulator between two ferromagnetic electrodes, were utilized as the testbed [5, 6, 8]. Under this approach, an MTJ with the exposed side edges can enable the covalent bonding of desired molecular channels onto the two ferromagnetic electrodes along the junction perimeter [5]. These molecules can be single molecular magnets [9], porphyrin [10], single ion molecules, and DNA [11]. This approach is equally capable of utilizing alkane like simple molecules with low spin-orbit coupling and Zeeman splitting. The MTJ based molecular spintronics device (MTJMSD) approach enabled us to study the impact of paramagnetic molecules on the spin transport and magnetic properties of MTJs. This paper discusses experimental studies conducted before and after transforming an MTJ into MTJMSD. We report the observation of paramagnetic molecule induced dramatic changes in spin transport of an MTJ. We also report complementary SQUID and magnetic resonance studies exploring the underlying mechanism behind the impact of covalently bonded molecular channels between two ferromagnets of an MTJ testbed.

Experimental details: To produce MTJ for MTJMSD, a bilayer ferromagnetic electrode was deposited by sequentially depositing ~ 3 nm tantalum (Ta), 5-7 nm cobalt (Co) and 5-3 nm NiFe