

Center for Molecular Spintronics

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The emerging field of spintronics (spin-electronics) envisions devices based on spin-polarized (α or spin “up”/ β or spin “down”) carrier transport for new materials that propel the next generation of ultra-miniature computational and information-storage technologies. Commercial spintronic sensors are excellent for very high-density magnetic hard-disk drives; however, translation of this technology into widespread, efficient semiconductor/metal devices has not yet occurred because interface chemistry and fabrication issues unique to magnetically-doped inorganic semiconductors are not adequately understood. To surmount critical problems associated with all-inorganic spintronic devices, *molecular* spintronics uses “designed” magnetic moments, low-cost processing and mechanical flexibility of molecular materials for spintronics applications.

The fundamental device processes to be understood in spintronics are: **spin injection**, **spin transport**, and **spin manipulation**. Electrical spin injection into an organic material from a ferromagnetic (FM) electrode involves transfer of charge from near the Fermi level of a ferromagnetic electrode into molecular orbital-derived states of the organic. The existence of a “conductivity mismatch”⁸ at the metal-organic interface suggests that this process should be extraordinarily inefficient in general. However, experiments have demonstrated that this is not a major impediment and can be overcome in large part by molecule-electrode orbital mixing. Clearly, significant coupling at the metal-molecule interface is necessary for efficient spin injection. However, extraordinarily strong coupling leads to surface reactions that are detrimental to spintronic functionality.

Phase I results of the CCI *Center for Molecular Spintronics* will be presented, including:

- a) **magnetically/electronically switchable molecules** (e.g., valence tautomers and spin-crossover compounds) **alter current flow** in concert with the molecule’s spin state *and exhibit a spin-valve effect*;
- b) **theoretical predictions show new device capabilities and functions owing to switchable molecules that facilitate spin-polarized injection and enhance detection**;
- c) local electronic spectroscopy (scanning tunneling spectroscopy, STS) of films containing tris(8-hydroxyquinolino)aluminum(III) (Alq₃) and iron(II)phthalocyanine (FePc) model complexes shows that **spin injection can be controlled at the molecular level** by interfacial orbital mixing (hybridization).