A New Route to Next-Generation Spin Based Devices for Quantum Information Processing: Optically Active Fully Organic Room Temperature Ferromagnetic Semiconductors

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Spin-based devices could enable revolutionary applications such as room temperature quantum computation. Ferromagnetic semiconductors showed promise in literature in creating a spin device architecture by aligned spin injection into semiconducting layer. Gould and Molenkamp showed that deposition of a ferromagnetic metal layer could make a prototypical GaMnAs ferromagnetic semiconductor operable at room temperature. However, tuning of band-gap and electron spin polarization in a ferromagnetic semiconductor to create a functional spin device remains very limited due to few ferromagnetic metals to deposit. However, if a ferromagnetic semiconductor were synthesized by a fully organic material then by virtue of solution chemistry an exponential diversification in tuning electronic properties could be achieved. Building on the previous year's research which demonstrated synthesis of organic mesoscopic polyaniline rings ferromagnetic at room temperature, a combinatorial synthesis method was developed to graft organic semiconducting fullerenes to the polyaniline rings. Formation of mesoscopic polyaniline rings atop a single crystalline fullerene-polyaniline junction was characterized by SAED and optical, Raman and Atomic Force Microscopy. PPMS and VSM measurements evidenced ferromagnetic hysteresis loop and I-V measurements in a field effect transistor set-up demonstrated p-n semiconductivity. Upon applied electric field, hysteresis loop was tunable, corroborating the first-ever co-existence of semiconducting and ferromagnetic properties in an entirely organic material. Additionally, time-resolved nanosecond laser spectroscopy of the material showed optically active behavior - exciton formation - suggesting a means of reading spin for quantum information processing.

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