Organic and Molecular Electronics

Crystals and films of conjugated molecules transport charge and can be used as functional semiconductors in thin film transistors, photovoltaic cells and light-emitting diodes. My research program focuses on understanding connections between structure and electrical transport behavior in organic semiconductors. We are particularly interested in the dependence of electron and hole mobility (the velocity per unit electric field) on molecular structure, crystal packing, intermolecular bonding, and defects in organic crystals and films. A theme of our experimental investigations is the development of methods for measuring transport behavior on length scales spanning nanometers to microns, so that we can accurately characterize the effects of specific structural features on transport. For example, we have used high resolution scanning probe microscopy techniques to measure electrical resistances and potential variations associated with individual grain boundaries in organic semiconductor films. Students are also actively involved in the fabrication and electrical characterization of organic transistors using electron beam lithography and other semiconductor processing equipment in the Microtechnology Laboratory. In collaboration with students and faculty in the chemistry and physics departments, we are actively exploring the synthesis and characterization of novel organic semiconductor materials with enhanced transport properties.

We are also interested in electrical transport through individual molecules. A key issue in molecular electronics is how one "wires up" single molecules or groups of molecules. We use conducting probe atomic force microscopy to contact small numbers of molecules and to test their electrical properties. Questions of interest include how the current-voltage characteristics of these molecular junctions depend on molecular size, bonding and functional group

Research Interests
architecture, and the nature of the metal-molecule contacts.

Selected Publications

"High Toughness, High Conductivity Ion Gels by Sequential Triblock Copolymer Self-Assembly and Chemical Cross-Linking." Gu, Y; Zhang, S; Martinetti, L; Lee, KH; McIntosh, LD; Frisbie, CD; Lodge, TP. J. Am. Chem. Soc., 2013, 26, 9652-9655. DOI: 10.1021/ja4051394.

"Intramolecular Exciton Diffusion in Poly(3-hexylthiophene)." Healy, AT; Boudouris, BW; Frisbie, CD; Hillmyer, MA; Blank, DA. Journal of Physical Chemistry Letters, 2013, 20, 3445-3449. DOI: 10.1021/jz401694j.


"A Pedagogical Perspective on Ambipolar FETs." Kang, MS; Frisbie, CD. Chemphyschem, 2013, 8, 1547-1552. DOI: 10.1002/cphc.201300014.

"Performance and Stability of Aerosol-Jet-Printed Electrolyte-Gated Transistors Based on Poly(3-hexylthiophene)." Kim, SH; Hong, K; Lee, KH; Frisbie, CD. ACS Applied Materials & Interfaces, 2013, 14, 6580-6585. DOI: 10.1021/am401200y.


"Rubrene-Based Single-Crystal Organic Semiconductors: Synthesis, Electronic Structure, and Charge-Transport Properties." McGarry, KA; Xie, W; Sutton, C; Risko, C; Wu, Y; Young, VG; Bredas, J; Frisbie, CD; Douglas, CJ. Chemistry of Materials, 2013, 11, 2254-2263. DOI: 10.1021/cm400736s.

"Effects of Olefin Content and Alkyl Chain Placement on Optoelectronic and Morphological Properties in Poly(thienylene vinylenes)." Speros, JC; Martinez, H; Paulsen, BD; White, SP; Bonifas, AD; Goff, PC; Frisbie, CD; Hillmyer, MA. Macromolecules, 2013, 13, 5184-5194. DOI: 10.1021/ma4009115.


"High-Mobility Transistors Based on Single Crystals of Isotopically Substituted Rubrene-d(28)." Xie, W; McGarry, KA; Liu, F; Wu, Y; Ruden, PP; Douglas, CJ; Frisbie, CD. Journal of Physical Chemistry C, 2013, 22, 11522-11529. DOI: 10.1021/jp402250v.


"Aerosol Jet Printed, Low Voltage, Electrolyte Gated Carbon Nanotube Ring Oscillators with Sub-5 mu s Stage Delays." Ha, MJ; Seo, JWT; Prabhumirashi, PL; Zhang, W; Geier, ML; Renn, MJ; Kim, CH; Hersam, MC; Frisbie, CD. Nano Letters, 2013, 13, 954-960. DOI: 10.1021/nl3038773