Invited Paper

"Complications in Organic Transistor Characterization"

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Organic semiconductors have been studied as candidates for unique functionality electronics for over 30 years. Tunability of electrical properties by molecular design and natural flexibility make these materials attractive for use in flexible, stretchable, and bio-compatible electronics. Progress has been made in designing materials and devices to address challenges in creating product ready devices, such as increased photovoltaic efficiency, the commercialization of organic LEDs, and increasing mobility in transistors, but challenges still arise in designing and characterizing devices for high current applications. Due to weak electrical bonding between molecules or polymer chains, charge transfer in organic semiconductors is very sensitive to small changes in environment, conformation of the molecule, and thermal fluctuations in molecule position. Effective mobility that changes with gate bias and diode-like low voltage characteristics are two common problems in organic transistors which can arise from poor charge injecting contacts and disorder in the semiconductor bulk. Addressing charge transport problems in organic field effect transistors will affect both the design of materials for future applications and the development of circuit models which accurately address the unique charge transfer physics of these van der Waals bound materials.

In this talk, I will present several case studies of organic transistors where interfaces and molecular order strongly affect final current-voltage (I-V) characterization and parameter determination. In order to elucidate the origin of non-ideal behavior, we combine AC impedance with traditional DC I-V characterization to separate the effects of the contacts from the channel. Our results show variations in the ideality of IV curves with polymer ordering (Fig. 1), and changes in the effective device mobility with gate voltage due to gated Schottky contacts. These non-ideal I-V characteristics raise questions as to the true mobility and threshold voltage extraction, and illustrate difficulties which arise from applying traditional semiconductor models to the characterization of novel materials.

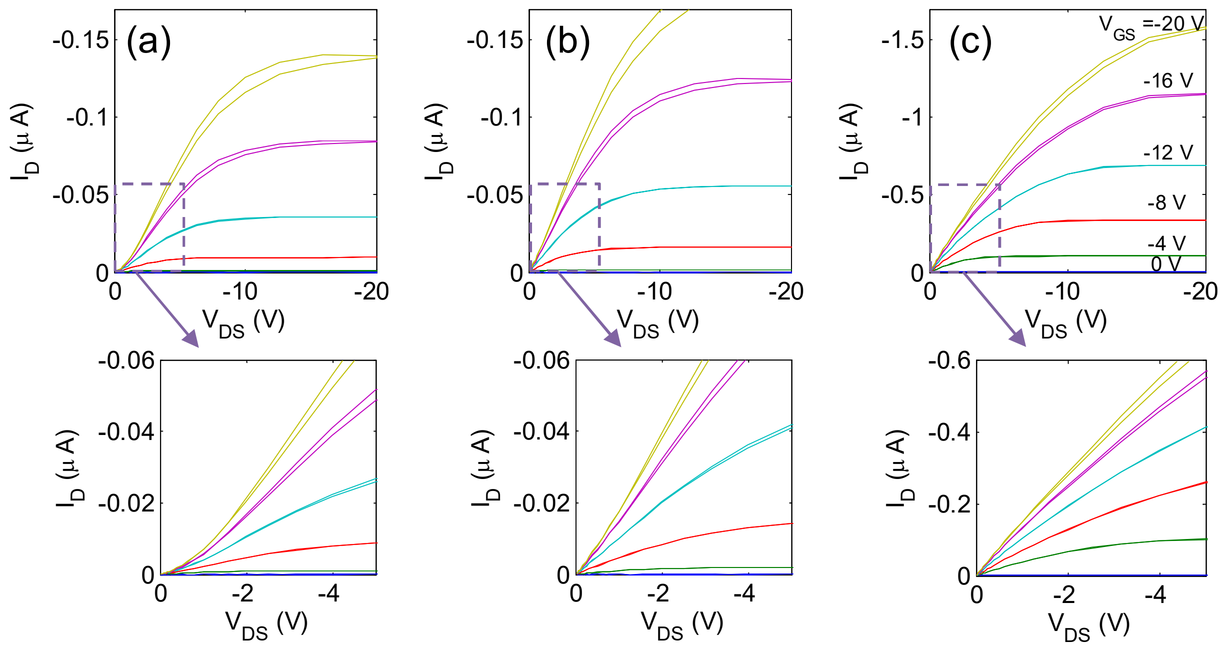

Figure 1: Changes to the ideality of I-V characteristics as a function of polymer ordering in three organic field effect transistors. As polymer ordering is increased from (a) to (c), current increases and low drain voltage characteristics become increasingly linear, and therefore closer to agreement with traditional field effect transistor characteristics.