Materials Synthesis and Process Engineering for Flexible Electronics

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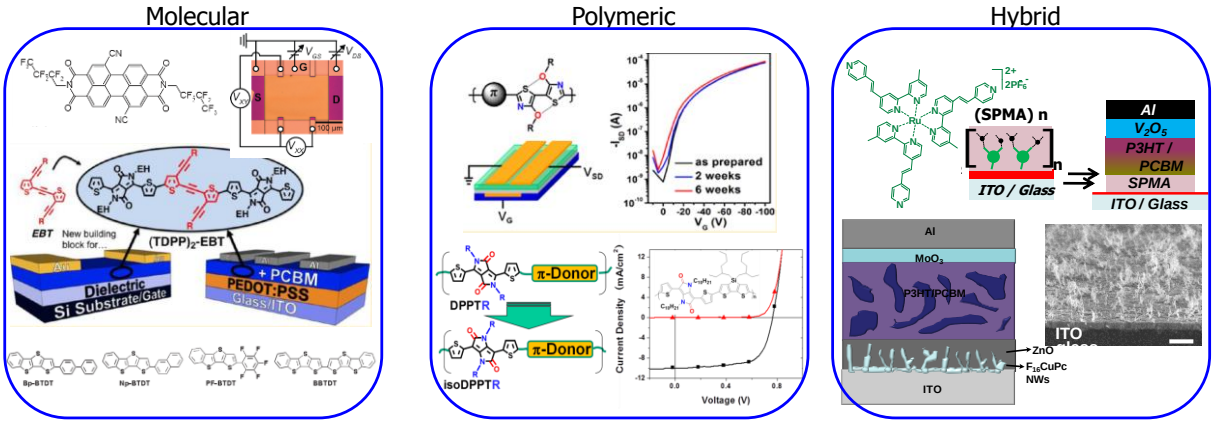
Printed electronics is a new technology envisioning the fabrication of electronic devices using solution processable materials and printing methodologies. In this presentation I will describe the materials synthesis, development, and process engineering enabling the fabrication of unconventional electronic and opto-electronic devices, such as transistors, circuits and solar modules, all on flexible foils using several new materials.[1-3] Materials development include new synthetic, green routes to semiconducting polymers. Examples of unconventional electronic materials include organic small molecular and polymeric semiconductors, metal chelates and complexes, and hybrid organic-inorganic metal oxides. Thus, we will show the fabrication of polymer based complementary circuits with excellent performance (field-effect mobilities ~ 1-6 cm^2/Vs), flexible amorphous oxides TFTs (field-effect mobilities ~ 5-40 cm^2/Vs) as well as polymeric donor-fullerene solar cells with efficiencies approaching 11% in inverted architectures.



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Limitations of energy level tuning at inorganic/organic semiconductor heterojunctions

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The combination of inorganic and organic semiconductors may enable new routes for high performance light emission or light-to-electrical-energy conversion devices. Inorganic semiconductors feature high charge carrier mobility and support high excitation densities, while organic semiconductors exhibit strong light-matter coupling and their energy gap can be tuned over wide ranges. Quite naturally, one of the prime challenges to optimize inorganic/organic heterojunctions is taming the interface. For the exemplary inorganic semiconductors ZnO and GaN, already the preparation of reliable pristine surfaces is demanding, due to unique and crystal face dependent termination. However, a positive feature is the rather low reactivity towards conjugated molecules, as evidenced here for a few blue light emitting molecular materials. To tune the "intrinsic" energy level alignment at the interface of a given material pair, the work function of the inorganic semiconductor surface can be modified with appropriate monolayers of molecular donors or acceptors, so that the organic levels are re-aligned accordingly. One mechanism that limits the range of level tuning is Fermi-level pinning at the frontier levels of the organic semiconductor. Here, the impact of molecular orientation, interfacial conformation, and degree of disorder as key parameters is exemplified. On the inorganic side, the energy and density of surface states turns out to play a crucial role for how the work function can be tuned with molecular donors and acceptors. Finally, heterojunctions comprising intrinsic versus p-doped organic semiconductors are discussed.