

Semiconducting Polymers: The Third Generation

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I will focus on the remarkable progress in the science and technology of semiconducting polymers during the past decade. The field has evolved from the early work on polyacetylene (the First Generation material) to a proper focus on soluble and processible materials. The soluble poly(alkyl thiophenes) and the soluble PPVs comprise the Second Generation of semiconducting polymers. The Third Generation polymers can be organized into two sub-groups: (1) highly ordered and crystalline materials such as PDDTT and (2) the ever-growing class of donor-acceptor co-polymers that has emerged in the past few years. Examples of the latter include the bithiophene-acceptor co-polymers pioneered by Konarka and the polycarbazole-acceptor co-polymers pioneered by Leclerc and colleagues. I will summarize progress in the basic physics, the materials science, the device science and the device performance. Examples include the following:

- Control of the energy gap and the absolute energies of the π -electronic structure in semiconducting polymers;
- Demonstration of stable semiconducting polymers;
- Demonstration of relatively high mobility in semiconducting polymers;
- Gate-induced insulator-“metal” transition at high carrier densities with nonlinear transport in agreement with Luttinger Liquid (LL) theory;
- Self assembly of Bulk Heterojunction (BHJ) materials by spontaneous phase separation;
- Improved device performance in Field Effect Transistors;
- Improved device performance in solar cells fabricated from BHJ materials;
- Improved device performance in photodetectors fabricated from BHJ materials.

Although the progress has indeed been “remarkable”, there is both a need for, and an opportunity associated with, the development of higher performance materials made up of high molecular weight and aligned polymer chains with interchain structural order.