The Design of High Mobility Semiconducting Polymers

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The evolution of organic electronics is now poised to enter the commercial phase, with the recent market introduction of the first prototypes based on organic transistors fabricated from solution. Understanding the impact of both the organic semiconductor design and processing conditions, on both molecular conformation and thin film microstructure has been demonstrated to be essential in achieving the required transistor electrical properties to enable these devices. Polymeric semiconductors offer an attractive combination in terms of appropriate solution rheology for printing processes, mechanical flexibility for rollable processing and applications, but their electrical performance requires further improvement in order to fulfil their potential. Thienothiophene polymers have been shown to exhibit highly organized microstructures with crystalline domains of the order of hundreds of nanometers. This unusual degree of ordering is attributed to both the organization of the side chains and the conformation of the conjugated backbone plane. Side chain ordering is determined by the local free volume and periodic spacing of the side chains. Further optimization of this class of polymer through modification of the molecular energy levels will be carried out in order to minimise the influence of ambient humidity and oxygen on long term electrical device performance. Promotion of this highly organized and oriented morphology, shown in more detail in Figure 1, was achieved through both thermotropic and lyotropic liquid crystalline phase aggregation and alignment. Charge carrier mobilities of over 1 cm^2/Vs have been recorded with this class of polymer.

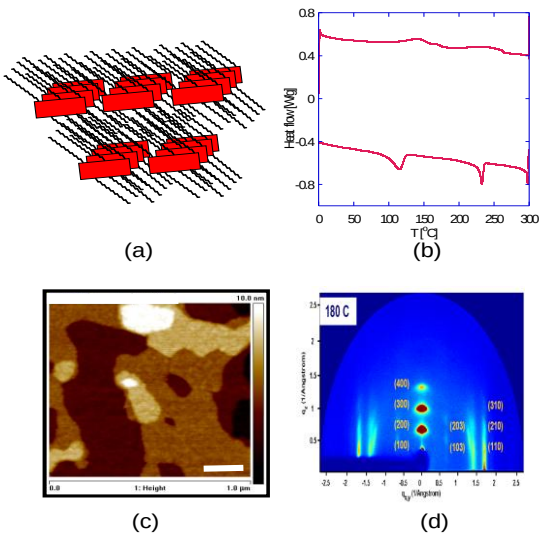

Figure 1. (a) thienothiophene polymer microstructure, where the bars represent the pi-stacked polymer backbones, and the lines depict the interdigitated alkyl side chains; (b) DSC graph illustrating the multiple phase transitions; (c). AFM images of annealed films. Scale bar corresponds to 200 nm ; (d) Two-dimensional x-ray scattering at grazing incidence of an annealed film of PBTTT C12.