Structural and electrical characteristics of P3HT during film formation

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Poly(3-hexylthiophene) (P3HT) is considered a promising candidate for organic field effect transistors (OFETs) due to relatively good semiconducting properties. However, charge transport mechanisms are still not fully understood. Up to now, most studies were addressing structural and electrical properties in separate experiments and in already prepared, i.e. solid films (see e.g. [1, 2]).

Recently we have successfully realized in situ investigations of a correlation of the structure and the electrical properties [3]. The experiments were performed at the PETRA III beamline P08 at the energy of 15 keV. The solidification process of P3HT solution in chloroform was monitored in terms of structural and electrical properties by grazing incidence X-ray diffraction and source/drain current measurements at fixed voltage, respectively. A schematic representation of the setup is shown in figure 1.

P3HT was dissolved in chloroform and dropped onto Si/SiO$_2$ substrates with gold source/drain electrodes. The (100) diffraction peak which is associated with alkyl side chains and the (020) which represents the $\pi$-stacking distance were detected with a MYTHEN line detector as a function of time. Figure 2 shows time-resolved correlations of the (100) peak and the current response at the fixed voltage of 10 V from the same conducting polymer channel.

Figure 1: Experimental setup for in situ P3HT droplet investigation under applied voltage (according to [3])
The measurements revealed that the source/drain current typically increases in two steps with the current peaking a few seconds before the Bragg peak intensity reached its final constant level. We suggest a two step solidification process similar to the two step gelation process proposed by Koppe et al. [4]. Our findings support the idea that the overall network connection within the polymer film rather than solely crystallinity is a key parameter for good conductivity.

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References