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In Situ Conductance and Photoconductance Measurements on Pentacene Thin Films

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Introduction

Pentacene thin films are recognized to have low intrinsic conductivity and become extrinsically doped under exposure to atmosphere [1]. The molecule in those films diffuses readily at room temperature and the film crystallinity is known to finely depend on the temperature, film thickness, and evaporation rate [2]. Evaluating the electrical properties of pentacene thin films is therefore challenging, and great care must be taken with regards to the purity of the sample and the cleanliness of the measurement environment.

Here, we report the two-terminal, lateral conductance and photoconductance measurements of pentacene thin films on single crystal sapphire (0001). Electrical measurements and film growth were performed *in situ* under UHV conditions. The variation in electrical properties with film thickness is discussed in terms of corresponding changes in molecular disorder, charge density, and film growth morphology.

Experimental

Pentacene (purchased from TCI) was sublimed in vacuum three times and once under 30 Pa N_2 gas flow before use. The single crystal sapphire [0001] substrates (from Shinkosha) were annealed at 1000 °C to expose atomically flat terraces, patterned with vacuum-deposited gold electrodes (0.1 mm spacing), and degassed in situ at 150 °C under UHV before use. The substrate temperature was kept at 30 °C during film growth, and the deposition rate was constant at 2.0 ± 0.3 nm min^{-1}. The deposition was performed stepwise to a maximum film thickness of 100 nm. The conductance was recorded in situ during film growth using a Keithley 6487 picoammeter/sourcemeter operating at with a pulsed bias of ±10 V. The photoconductance was evaluated over the range of 400 nm – 1180 nm after each deposition step, using a square pulsed monochromatic light source operated at approximately 0.01 Hz.

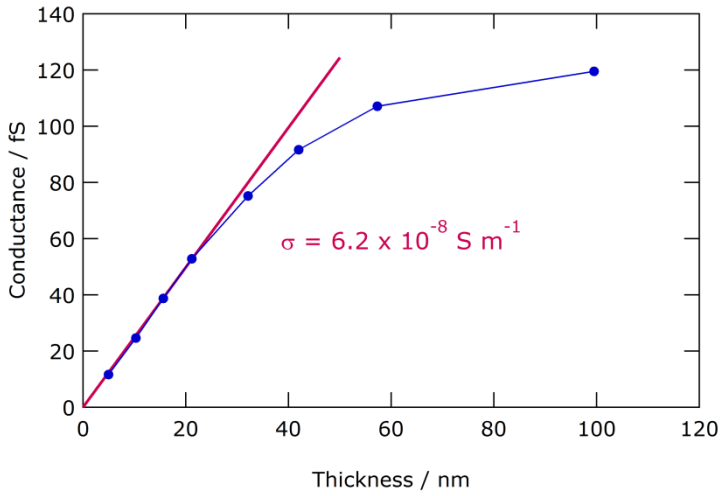

Figure 1. Conductance vs. film thickness plot for pentacene.

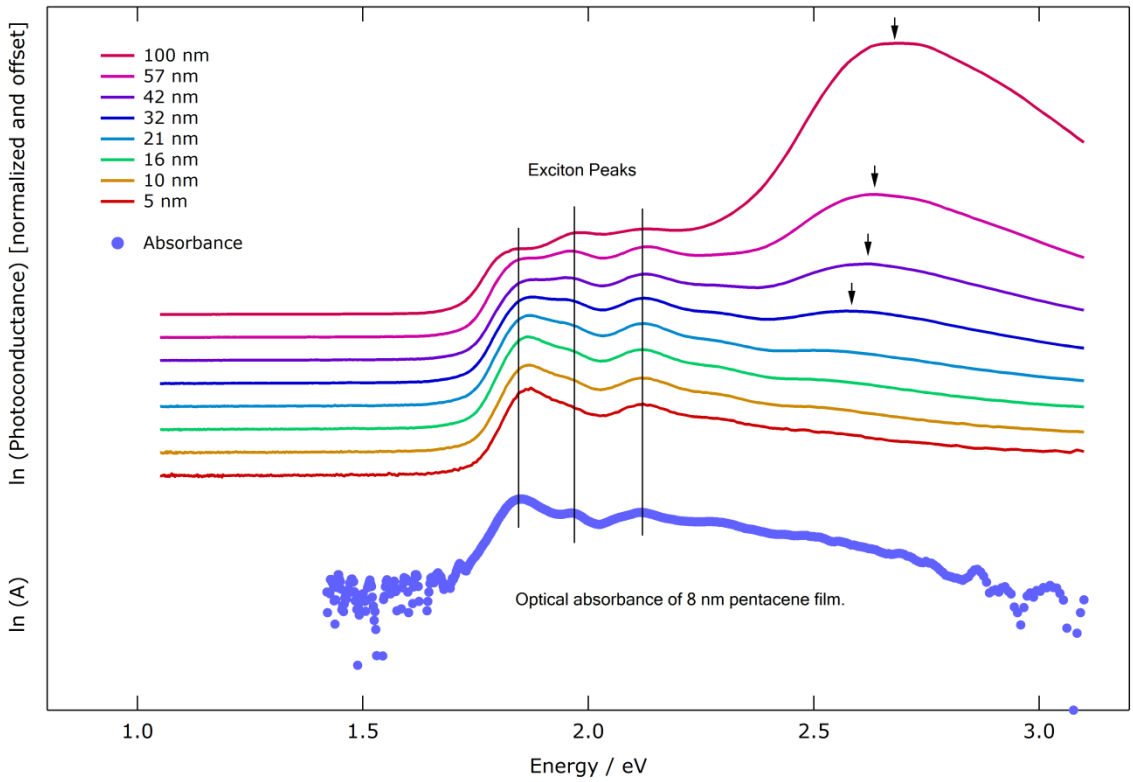

Figure 2. Photoconductivity action spectra for pentacene films having the thickness indicated. For comparison, the typical optical response of a pentacene film is also shown.

Discussion

The conductance of the pentacene film increases linearly with the film thickness from 5 nm up to about 40 nm. The conductivity of pentacene in this thickness region is estimated at 6.2×10^{-8} S m^{-1}. An ohmic *I-V* relationship was confirmed for all films for bias voltages ≤10 V.

The photoconductance spectrum is unchanged from 5 nm to 20 nm, and for these thinner films the features correspond clearly with the optical absorption. The singlet excitons generated by the photoabsorption decay to long lived triplet states with an energy of 0.86 eV [3], and it is the triplet states which are presumed to contribute to the photocurrent. We also observe a feature at 2.6 eV – 2.8 eV which becomes increasingly dominant at higher thicknesses. This peak was previously identified as the HOMO-LUMO gap [4], while we will argue that charge transfer exciton formation is a more reasonable explanation.

References

[1] A. Benor, *et al.*, *Org. Elec.* **8**, 749 (2007).

[2] R. Ruiz, *et al.*, *Chem. Mater.* **16**, 4497 (2004).

[3] C. Jundt, *et al.*, *Chem. Phys. Lett.* **241**, 84 (1995).

[4] D.V. Lang, *et al.*, *Phys. Rev. Lett.* **93**, 086802 (2004).