

Fullerene-Oligophenyl bilayers grown by hot wall epitaxy

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Abstract

In this work we report on thin organic films grown by Hot Wall Epitaxy (HWE). This technique allows the epitaxial growth close to the thermodynamic equilibrium. The growing process strongly depends on the choice of the substrate and substrate temperature. We produced para-hexaphenyl (PHP) and PHP/C₆₀ bilayers by HWE and characterized the samples by polarized luminescence and photocurrent measurements.

Keywords: Hot Wall Epitaxy, HWE, Fullerene, C₆₀, Oligophenyl, Hexaphenyl

1. Introduction

In this work we report on thin organic films grown by Hot Wall Epitaxy (HWE). HWE technique allows the epitaxial growth close to the thermodynamic equilibrium, which is essential in the case of van der Waals epitaxy of fullerenes or oligophenyls. The HWE growth technique was usually developed for the deposition of IV-VI semiconducting compounds, but has also been proven to be very powerful for the deposition of high quality films of organic compounds like C₆₀ [2]. The utilization of the HWE apparatus with two growth tubes allows the fabrication of controlled bi- or multilayer devices of different materials. A well known photo-physical phenomenon is the ultrafast photoinduced electron transfer between an a wide class of non degenerated ground state conjugated polymers and C₆₀ [1]. The photovoltaic response of conjugated polymer/C₆₀ bilayer devices depends strongly on the properties of the interface between donor and acceptor.

In this study we produced para-hexaphenyl (PHP see Fig.1) and PHP/C₆₀ bilayers by HWE and characterized the samples by polarized luminescence and photocurrent measurements.

2. Experimental

The HWE system contains in contrast to other high-vacuum growth systems like MBE a closed reactor, so it can be oper-

ated close to the thermodynamical equilibrium. Two quartz tubes with source material (PHP, C₆₀ respectively) at the bottom and the substrate on the top closing it tight are placed with six separated heaters (three for each tube) into a high vacuum system. The advantage of such closed system is the minimization of the loss of source material. Moreover the control of the grow parameters allows the production of high quality crystalline films. In addition, a separate oven was installed in the vacuum chamber, which allowed a pre-heating and annealing of the substrates. The vacuum during film grow was approx. 10⁻⁶ mbar.

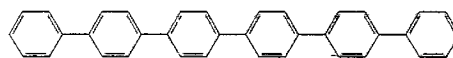


Fig. 1. Structure of para-hexaphenyl

3. Results and Discussion

After purification the PHP and C₆₀ was evaporated onto quartz, mica and ITO-glass. PHP shows a strong luminescence from 390 to 470 nm. The spectra has vibronic peaks at 402 and 440 nm [4], mainly determined by the C=C stretching of the backbone. AFM and light-microscope studies showed that mica enhance the growth of highly ordered films compared to ITO glass or quartz. The film thickness of PHP and C₆₀ films were controlled to be around 80 nm.

The polarized luminescence spectra of PHP films on quartz are shown in Fig. 2 and 3 indicate a preferential orientation

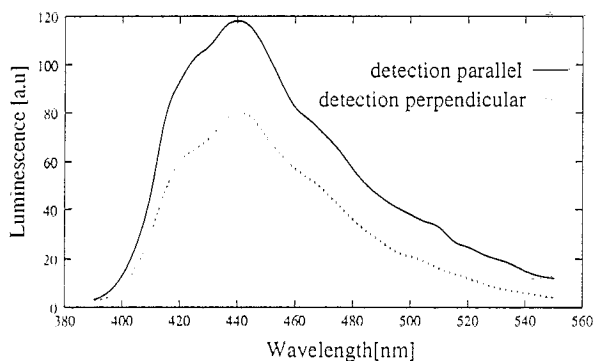


Fig. 2. Polarized luminescence spectra of PHP films grown on quartz. Polarization directions are given relative to the plane defined by the incident beam and luminescence beam. The figure shows the spectra for perpendicular and parallel excitation

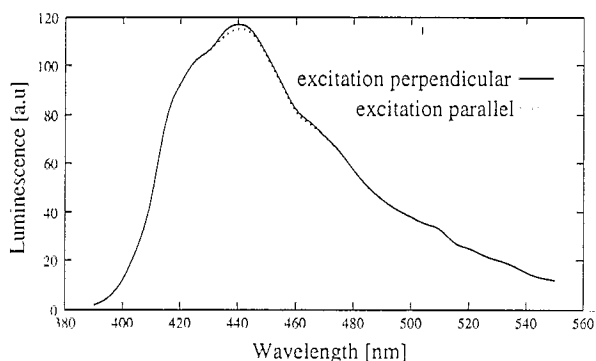


Fig. 3. Parallel and perpendicular detected spectra

of the molecules perpendicular to the surface. Growth conditions were $T_{\text{substrate}}=140^\circ$, $T_{\text{source}}=250^\circ$ resulting in deposition rate of 3 nm min^{-1} . These findings are in agreement with molecular beam epitaxy (MBE) grown PHP films [6].

On C_{60} coated mica-substrates using $T_{\text{substrate}}=90^\circ$, PHP grows epitaxially. The luminescence of PHP films grown on C_{60} is partially quenched as shown in Fig.4. Fig.5 shows the

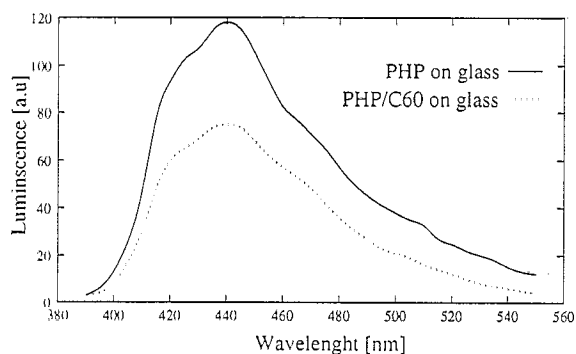


Fig. 4. Luminescence quenching of PHP, PHP/ C_{60} bilayer

geometry of a PHP/ C_{60} bilayer device with ITO/Al contacts. An Oriel xenon lamp spectrally resolved by a monochromator, was used as excitation source. Fig.6 shows the spectrally resolved short current I_{sc}

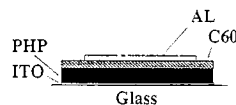


Fig. 5. PHP/ C_{60} bilayer device. Thickness PHP/ C_{60} 80/50 nm respectively

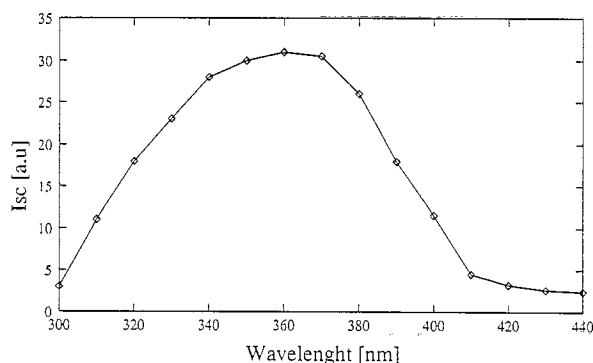


Fig. 6. Short current of a PHP/ C_{60} bilayer device as a function of excitation wavelength. Excitation intensity 1 mW cm^{-2} determined by calibrated Si-Diode

4. Conclusion

We have presented luminescence spectra of PHP, PHP/ C_{60} films on mica and quartz. The polarized luminescence indicate a preferential orientation of the molecules perpendicular to the surface. The quenching of the PHP luminescence on C_{60} indicates the electron transfer to C_{60} . The bilayer devices acts as a photodiode.

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