CONDUCTION AND ELECTROLUMINESCENCE FROM ORGANIC CONTINUOUS AND NANOFIBER THIN FILMS

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Organic nanofibers and thin films made from para-hexaphenylene (p6P) molecules exhibit a range of extraordinary properties with application potential, such as the ability to emit intense blue light after either UV excitation or electron and hole injection, while the semiconducting properties enable field-effect transistor (FET) applications. Organic nanofibers have been shown to act as optical waveguides and random lasers, while chemical functionalization of the molecular building blocks can be used to tailor the nanofiber optoelectronic properties for a given application [1]. Connection to electrodes makes the probing of their electrical properties possible [2] and represents an important step towards the realization of a nanoscale organic light-emitting device.

The nanofibers are grown by physical vapour deposition of p6P onto a specific growth substrate, where the organic molecules self-assemble into a discontinuous thin film, made of straight, mutually parallel and crystalline, fiber-like nanostructures [3]. Following the growth process, the nanofibers are transferred to a pre-fabricated device substrate by gentle stamping, which does not destroy the otherwise fragile van der Waals bonded molecular crystals. The device substrate consists of an interdigitated array of gold electrodes placed on a 200 nm thick layer of silicon dioxide on highly doped silicon as shown in fig. 1. The underlying silicon acts as a backgate electrode in a FET configuration. In order to allow for quantitative evaluation of the effect of crystalline nanofiber growth on the electric and electroluminescence properties of the resulting device, thin film devices have also been fabricated by deposition of the p6P molecules directly on the device substrate. This procedure leads to a non-singlecrystalline thin film with arbitrarily oriented molecular absorbers and emitters.

The devices have been characterized both in terms of their electrical transport properties and their ability to emit light. Both the nanofiber and the thin film devices exhibit a clear influence of the backgate voltage on the current-voltage characteristics. Biasing such organic semiconductor devices in a FET configuration with an AC signal applied to the backgate electrode enables efficient injection of both carrier types into the organic material and thereby results in emission of light through radiative electron-hole recombination [4]. In this paper, parameters for distinctive blue light emission and for charge transport from continuous thin film devices (fig. 1) as well as from discontinuous nanofiber arrays are discussed.

References:

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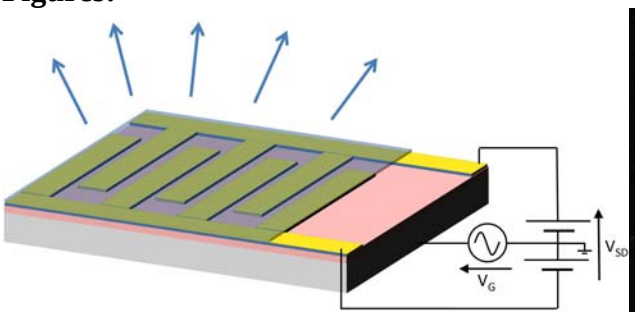
Figures:



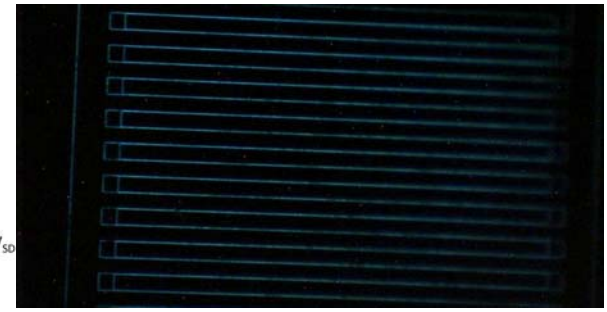


Figure 1 (left): Device structure consisting of a silicon substrate with a 200 nm silicon dioxide layer and an interdigitated array of gold electrodes upon which the organic material is placed. (Right): Blue light is observed from the device upon application of a DC source-drain voltage and an AC gate voltage.