Advancement in organic nanofiber based transistors

Jensen, Per Baunegaard With; Kjelstrup-Hansen, Jakob; Tavares, Luciana; Rubahn, Horst-Günter

Publication date: 2014

Document version
Early version, also known as pre-print

Citation for published version (APA):
Advancement in organic nanofiber based transistors
Per Baunegaard With Jensen*, Luciana Tavares, Jakob Kjelstrup-Hansen, Horst-Günter Rubahn
University of Southern Denmark, The Mads Clausen Institute, NanoSyd, Alsn 2, DK-6400 Sønderborg
E-mail: pbwj@mci.sdu.dk

Abstract
The focus of this project is to study the light emission from nanofiber based organic light-emitting transistors (OLETs) with the overall aim of developing efficient, nanoscale light sources with different colors integrated on-chip. The research performed here regards the fabrication and characterization of OLETs using the organic semiconductors para-hexaphenylene (p6P), 5,5'-Di-4-biphenyl-2,2'-bithiophene (PPTTPP) and 5,5'-bis(naphth-2-yl)-2,2'-bithiophene (NaT2). These molecules can self-assemble forming molecular crystalline nanofibers. Organic nanofibers can form the basis for light-emitters for future nanophotonic applications, due to their many interesting optoelectronic properties, such as polarized photo- and electroluminescence, waveguiding and emission color tunability. A simple roll printing technique has allowed us to implement these nanofibers in different types of devices. Multicolor device is obtained by printing two different types of fibers onto the same device. Improvement of charge injection in these devices and thereby a lower driving voltage amplitude has been obtained by implementing a self-assembled monolayer (SAM).

Nanofiber growth and transfer
The organic nanofibers are fabricated under UHV conditions by evaporating the organic molecules (Fig. 1) onto the surface of a freshly cleaved muscovite mica, where the molecules self assemble into nanoscale fibers. One example are p6P nanofibers (Fig. 2). These fibers can be transferred to bottom gate/bottom electrodes substrate to realize a nanofiber-based transistor (Fig. 3).

Light emitting nanofiber transistor
Electroluminescence (EL) is obtained by applying an AC voltage to the gate while grounding the source and drain (Fig. 4). The EL is observed with an Electron Multiplying Charge Coupled Device (EMCCD) - see Fig. 5. EL is seen originating from single or several nanofibers.

Individual nanofiber EL onset voltages
Previously the EL from nanofiber-based transistors was measured for the whole device. Recent investigations show that measuring EL from individual fibers leads to a distribution of onset voltages for the individual fibers (Fig. 6). Here the distributions are shown for three different types of nanofibers: p6P, PPTTPP and NaT2.

Improving device performance by self-assembled monolayers
The EL process is mostly governed by the injection of holes into the organic nanofiber. To optimize the EL process by improving the injection of holes, a self-assembled monolayer (SAM) of polar, alkanethiol-based molecules has been implemented on the Au electrodes. By introducing an oriented dipole layer the effective work function of the electrode can be altered (Fig. 9). One SAM (O-SAM) should increase the injection barrier and the other (P-SAM) should lower the barrier. The results are a bit surprising since both types of SAMs seem to lower the onset voltage for EL both for p6P (Fig. 10) and PPTTPP (Fig. 11) nanofibers, which tells us that the size of the injection barrier is not the only factor in the EL process.

References