Ultrasmall transistor-based light sources

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

Publication date:
2012

Document version
Submitted manuscript

Citation for published version (APA):

Terms of use
This work is brought to you by the University of Southern Denmark through the SDU Research Portal. Unless otherwise specified it has been shared according to the terms for self-archiving. If no other license is stated, these terms apply:

- You may download this work for personal use only.
- You may not further distribute the material or use it for any profit-making activity or commercial gain.
- You may freely distribute the URL identifying this open access version.

If you believe that this document breaches copyright please contact us providing details and we will investigate your claim. Please direct all enquiries to puresupport@bib.sdu.dk

Download date: 16. Jul. 2020
Motivation

The focus of this Ph.D. project is to study the light emission from nanofiber based organic light-emitting transistors (OLETs) with the overall goal of developing efficient, nanoscale light sources with different colors integrated on-chip.

The research performed here regards the fabrication and characterization of OFETS using the organic semiconductor para-hexphenylene (p6P) and 5,5’-Di4-biphenyl-2,2’-bithiophene (PPTTPP). These molecules have fluoresced when excited optically: photoluminescence (PL) and electrically: electroluminescence (EL).

Organic nanofiber: Fabrication and integration

The organic nanofibers are fabricated under ultra high vacuum conditions. This fabrication involves evaporating the organic molecules onto a freshly cleaved of muscovite mica, where the molecules self assemble into nanoscale fibers.

Previous work has shown how these fibers can be transferred to bottom gate/top electrode transistor substrates in order to realize a nanofiber-based transistor. See Figure 1.

The p6P molecule is a linear chain of six phenylene groups. See Figure 2. Organic p6P nanofibers fluoresce highly polarized blue light when excited by UV light. See Figure 3.

The PPPTTPP molecule consist of two thiophene groups flanked by four phenylene groups. See Figure 4. Organic PPPTTPP nanofibers fluoresce strongly polarized green light when exited by UV light. See Figure 5.

Photoluminescence

Excited by UV-light the p6P fluoresce in the blue part of the spectrum. An example of such a spectrum is shown in Figure 6. The spectrum contains several peaks corresponding to transition between vibronic states in the p6P molecule.

Excited by UV-light the PPPTTPP fluoresce in the green part of the spectrum. An example of such a spectrum is shown in Figure 7. The spectrum contains several peaks corresponding to transition between vibronic states in the PPPTTPP molecule.

Electroluminescence

For both p6P and PPPTTPP fibers electroluminescence has been observed. During the EL experiments the OLET are kept under vacuum conditions and the EL is observed (in black an white) with an Electron Multiplying Charge Coupled Device (EMCCD). In order to obtain EL an AC voltage is applied to the gate of the OLET while the drain and source electrode are grounded. See Figure 8.

Conclusion and further investigations

The coal of obtaining multicolors (in this case blue and green) seems possible within a very near future. If EL is obtained from both types of fibers on the same substrate it should be possible to separate the luminescence by using short- and longpass filters. Figure 11 shows the photoluminescence from p6P and PPPTTPP fibers together with the transmission of a shortpass filter (cut-off: 500nm) and a longpass filter (cut-on: 500nm). Here it seen how optical filters can separate light from the two types of fibers. This is assuming that the electroluminescence spectrum coincides with the photoluminescence spectrum of both fibers. This has been demonstrated for p6P.

Another aspect of the nanofiber based OLETs is the low efficiency with which the devices. Attempts to improve this could involve a self-assembling monolayers between nanofibers and the electrodes of the transistor. This have in some cases been shown to improve charge injection. Another improvement could originate from a change of gate dielectric medium.

References


Ultrasmall transistor-based light sources

Per Baunegaard With Jensen*, Luciana Tavares, Jakob Kjelstrup-Hansen, Horst-Günter Rubahn
University of Southern Denmark, Mads Clausen Institutte, NanoSyd, Alsion 2, DK-6400 Sønderborg

The research performed here regards the fabrication and characterization of OFETS using the organic semiconductor para-hexphenylene (p6P) and 5,5’-Di4-biphenyl-2,2’-bithiophene (PPTTPP). These molecules have fluoresced when excited optically: photoluminescence (PL) and electrically: electroluminescence (EL).