Elektrooptische Charakterisierung dünner Schichten mesogener, organischer Halbleiter

Electrooptical characterization of thin layers of mesogenic, organic semiconductors

Abstract

This work deals with the preparation of organic light emitting diodes (OLEDs) and organic photovoltaic devices (OPVs) from mesogenic derivatives of the compounds perylene, pyrene, tetralone, triphenylene, and hexabenzocoronene. For this purpose, systems for reproducable preparation of thin organic and metallic films were developed and built. Thermal evaporation- and "spin-coating"-processes were introduced and optimized. This way, samples were fabricated that typically consisted of 3 to 5 layers, each of which had a thickness of less than 100 nm.

The prepared OLEDs and OPVs were characterized electrically and optically. Many of the measuring systems used for this, were developed within this work so that they are now ready for routine use.

Moreover, methods were presented, which can be used for the electronic characterization of organic materials. These methods are for example ultraviolett-photoelectron-spectroscopy (UPS), time-of-flight measurements (TOF) and cyclic voltammetry (CV).

The investigated compound perylene-tetraethylester shows the best results when used in the OLED-preparation. The current-voltage measurement of a single-layer setup with a layer-thickness of 45 nm results in a diode characteristics with a threshold-voltage for electroluminescence of about 4 V. The maximum efficiency appears at 13 V with a value of about 0.1 lm/(W·sr). At 15 V and a current-density of 25 mA/cm^2 a maximum luminance of 100 Cd/m^2 is reached.

Also the derivatives of pyrene, triphenylene and tetralone are qualified to fabricate single- or double-layer OLEDs. However the properties of these samples (concerning luminance and efficiency) do not reach the maximum values measured at perylene-tetraethylester-samples. Concerning lifetime of the OLEDs a setup with the layers [ITO / Baytron-P® / Pyrene-tetrahexylester / Al] showed the best properties. It emitted light for more than 5 hours under loboratory-atmosphere.

OLEDs emitting all three basic-colours were prepared with the different materials investigated: red (perylene-tetraester, perylene-imide), green (pyrene-tetraester), blue (triphenylene-triester, tetralon-cyclotrimers). Suitable combination of different emitting materials led to a light-emission with a mixed colour, which appeared to be "white".

First results in the field of organic solar-cells show that, again, the perylene-tetraethylester is a suitable compound, if it is combined with a donor for electrons. For this, Hexa-*peri*-Hexabenzocoronene (HBC) was used. The most promising properties were measured at a setup with the layers [ITO / HBC-C_{10} / Perylene-C_2 / Al], in which 3,7-dimethyloctyl-substituded HBC was used. In the case of optimum operation parameters such a solar-cell provides 0.41 V and an output-power of 5 mW/m^2. Excited with monochromatic light of the appropriate wavelength, maximum external quantum-efficiencies of 0.15 % can be reached. This value decreases to $2.2 \cdot 10^{-4}$ % when white light is used.