Bilayer Light-Emitting Electrochemical Cells for Signage and Lighting Applications

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Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av filosofie licentiatexamen framläggs till offentligt förvar i N430, Naturvetarhuset, den 19e februari, kl. 09:00.
Avhandlingen kommer att förvaras på engelska.

Betygsnämnd:
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Abstract

Artificial light surrounds us in a manifold of shapes. It is mainly utilized for illumination, but also for graphical communication of complex and evolving messages and information, among other things. It can be generated in different ways with incandescent lamps and fluorescent tubes constituting two common examples. Organic solid state light-generation technologies, which boast advantages such as solution processability, thin and flexible form factors, and large versatility, are modern additions to the field. But regardless of the means of generation, whenever light is to be used to communicate information, as signage or displays, it needs to be patterned. Unfortunately patterning is often complicated and expensive from a fabrication point of view, or renders the devices inefficient. To bridge the gap between present technologies and the need for low-cost and low-complexity patterned light emitters, it is important to develop new device architectures and/or fabrication procedures.

In this thesis we show that patterned light emission can be attained from solution processable bilayer light-emitting electrochemical cells (LECs), in which the bilayer stack comprises an electrolyte and an organic semiconductor as the first and second layer, respectively. We investigate a subtractive direct-write approach, in which electrolyte is displaced and patterned by the contact motion of a thin stylus, as well as an additive inkjet-patterning technique. Both result in electroluminescent patterns, e.g., light-emitting sketches and microscopic signage with high pixel density. But they can also build macroscopic patterned regions with homogeneous emission depending on the design of electrolyte features. Using an in-operando optical microscopy study we have investigated the operational physics and some limiting factors of the bilayer LECs. More specifically we find that the electrolyte film homogeneity is a key property for high optical quality, and that the emitting region is defined by the location of the interfaces between electrolyte, anode, and organic semiconductor. We observe that the cationic diffusion length is less than one micrometer in our employed organic semiconductors, and rationalize the localized emission by cationic electric double-layer formation at the cathode, and the electronically insulating electrolyte at the anode.

To date, the presented luminescent signage devices feature high-resolution patterns, in both pixelated and line-art form, and show great robustness in terms of fabrication and material compatibility. Being LECs, they have the potential for truly low-cost solution processing, which opens up for new applications and implementations. However, these first reports on patterned bilayer LECs leave plenty of room for improvements of the optical and electronic characteristics. For instance, if the optoelectronic properties of the devices were better understood, a rational design of microscopic electrolyte features could provide for both more efficient LECs, and for more homogeneous light emission from the patterned regions.

Keywords

Organic electronics, Light-emitting electrochemical cell, Signage, Display, Luminescent line art, Inkjet printing, Direct-write printing