Nano-structuring of Conjugated Polymer Based Structures by Focused Ion Beam

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In the current study, principally, the compatibility of Focused Ion Beam (FIB) applications with conjugated materials and conjugated polymer based organic optoelectronic devices, in terms of gains and drawbacks was investigated. As already known, dual-beam FIBs enable many opportunities for the characterization, structuring and modification of many different materials and structures [1]. However, it should be noted that conjugated polymers suffer from inevitable beam damage during electron/ion exposure in dual beam instruments [2]. Thus, first of all, to realize the degree of damage which is introduced by electron/ion beams, various sets of irradiation experiments were performed on Polyfluorene (PF) and Poly(3-hexylthiophene) (P3HT) thin films. For the polymer degradation analysis, Raman Spectroscopy, Electron Energy Loss Spectroscopy (EELS), Atomic Force Microscopy (AFM) and Kelvin Probe Force Microscopy (KPFM) were utilized. Raman spectroscopy was an appropriate means to examine the degradation behavior of these polymers as far as it was caused by a loss of conjugation. The fine-structure of the carbon K ionization edge investigated by EELS provided useful information about the changes in the electronic structure, whereas with the AFM valuable knowledge about beam induced changes of roughness, layer thickness, and potentials inside the materials could be obtained.

Furthermore, electron and ion beams have been used for nano-scale structuring applications, including platinum deposition to fabricate contacts and conducting paths, manipulation of nano-sized polymer colloids and also formation of specially shaped FIB-cuts to create nano-scale devices from prefabricated structures. Another emphasis was directed towards changing the optoelectronic properties of light-emitting conjugated polymers by using beam degradation processes (Figure 1). In the frame of this work, PF, Me-LPPP and MEH-PPV thin films on silicon and transparent substrates were selectively irradiated using different electron and ion doses and examined for the alterations in the optoelectronic properties of the corresponding materials using photoluminescence (PL) and electroluminescence (EL) microscopy. Finally, the measurements pointed out the possibility to turn beam degradation into a beneficial way for light-emitting conjugated polymers, in terms of tuning the emission color by varying the degree of irradiation.

Moreover, using the facilities of dual beam instrument, novel nano-devices functioning similar to optoelectronic device structures were developed. The concept was based on using a single conjugated polymer colloid (MEH-PPV and Me-LPPP) instead of the active layer of the device (Figure 2). The prototyping was simply carried out by dislocating the colloid into a channel which was ion milled and situated between metal electrodes, avoiding beam damage as much as possible. Concerning the current work, the use of dual

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beam systems for the development of novel devices on a nano-scale seemed to be quite encouraging, especially in terms of in-situ prototyping convenience.

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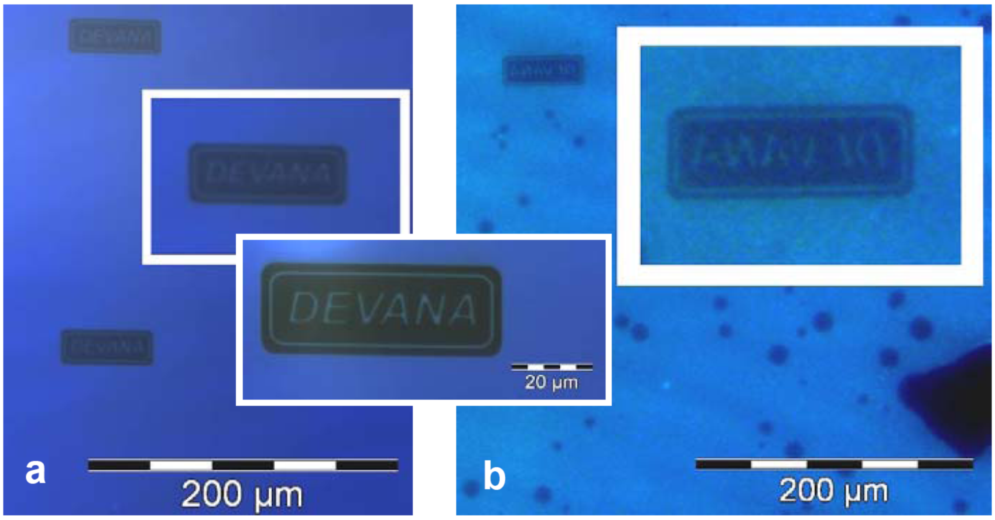

Figure 1. a) PL and b) EL images of a PF thin film with electron-beam-patterned logos on a transparent substrate

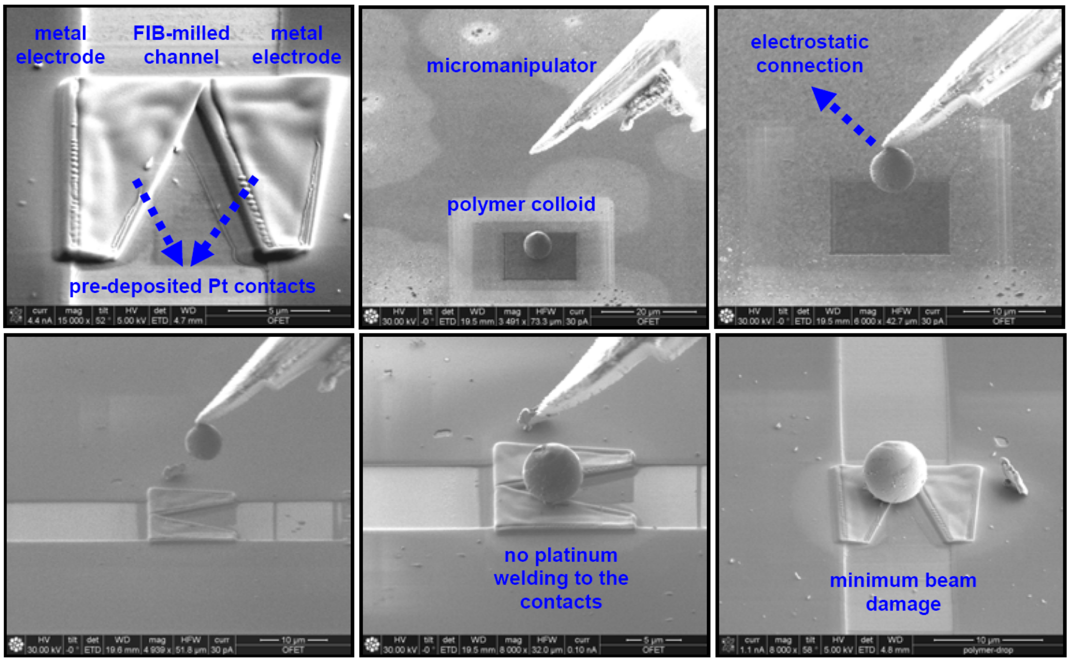

Figure 2. Prototyping of a nano-PLED structure with the FIB.