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The Doping Structure of a Polymer Electrochemical Cell P-N Junction: An Optical Scanning Measurement and Numerical Study

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Polymer light-emitting electrochemical cells (PLEC) are photonic devices that function by in situ electrochemical doping for luminescent polymers. Doping in PLECs is achieved via electrically activated redox reactions in the presence of mobile counter-ions. In operation, p- and n- doping fronts form at the anode and the cathode. The fronts then propagate through the polymer film and form a p-n junction where electrons and holes recombine radiatively and emit light. The formed p-n junction is the active area of the cell and it sets the operational electrical and optical characteristics of the device. Therefore is important to understand the electronic structure and the extension of this region. The dynamic nature of electrochemical doping introduces a challenge in studying the stabilized PLECs. To overcome this problem, the doping should be fixed by reducing the mobility of the counter-ions. One way to achieve this is by cooling the device after forming the junction. Frozen PLECs p-n junctions exhibit pronounced photovoltaic response that is independent of the electrodes work functions. Moreover, the photoluminescence of the polymer is modified upon doping due to luminescence quenching. Therefore, the doping in a frozen PLEC could be mapped by optical beam induced current (OBIC) and photoluminescence (PL) scanning. We present high-resolution OBIC and PL imaging of the doping structure in a doped and frozen planar PLEC. A custom-built cryogenic and optical apparatus was employed to activate, freeze and scan the cell with a laser beam with ˜2 µm width. An extremely narrow OBIC profile of 4.5 µm in average width was resolved that accounts for less than 1% of the interelectrode spacing of the device. The OBIC and the PL measurements were used to propose the doping profile of the scanned junction. The proposed profile was tested against the experimental OBIC data via drift-diffusion numerical calculations.

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