Dehydration assisted nanoimprint of PEDOT:PSS nanogratings to improve organic photovoltaics

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In recent years, nanoimprint lithography (NIL) has emerged as an effective method to improve power conversion efficiency (PCE) for organic photovoltaics (OPV) devices by providing an ordered and continuously interdigitized morphology in active layers for both efficient charge separation and collection.[1] NIL can also be used to pattern the hole transport/electron blocking layer layers (HTL/EBL) in bulk heterojunction OPV and a more efficient charge carrier collection has been observed using imprinted poly(3,4-ethylenedioxythiophene)poly(styrenesulfonate) (PEDOT:PSS).[2] However, due to its nonthermoplastic property and poor mechanical strength, PEDOT:PSS is difficult to pattern and the grating feature sizes are still typically limited to micrometers or submicrometers.[2,3] Because of these limitations, the application of imprinting PEDOT:PSS for organic electronic devices is limited up to now.

We demonstrate the fabrication of PEDOT:PSS nanogratings by a dehydration assisted nanoimprint technique. Dehydration of PEDOT:PSS increases its mechanical strength for nanoimprint and for the first time results in formation of high quality fine nanogratings of 60 nm in height, 70 nm in width, and 70 nm in spacing when imprinted at 100 ^{o}C and 2 MPa for 600 sec, as shown in Figure 1. PEDOT:PSS nanogratings are used as HTL/EBL in bulk heterojunction poly(3-hexylthiophene-2,5-diyl)(P3HT):[6,6]-penyl-C61-butyric-acid-methyl-este r (PCBM) OPV, showing enhancement of PCE in comparison to devices with non-patterned PEDOT:PSS films. The effects of imprint temperature, pressure and nanostructure morphology on PEDOT:PSS properties and device performance are also studied by P3HT:PCBM solar cells using PEDOT:PSS films imprinted with a flat non-patterned Si mold under the same temperature of 100 ^{o}C, and pressure of 2 MPa and their combination for 600 sec. As shown in Figure 2, we find that device performance are highly dependent on the PEDOT:PSS treatment conditions.

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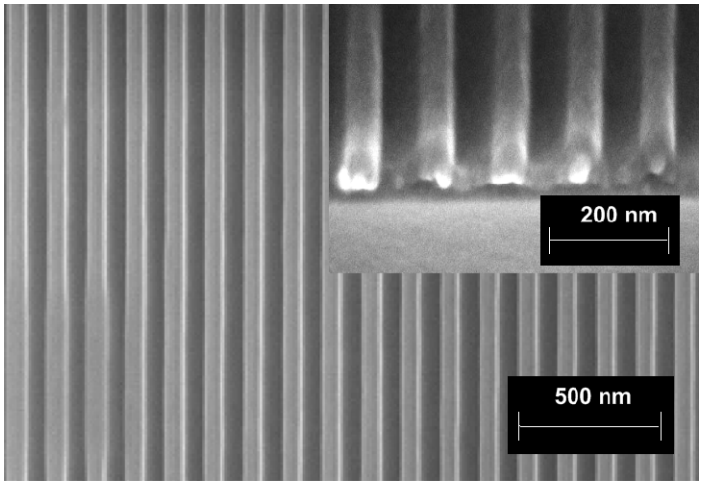

Figure 1: SEM images of PEDOT:PSS nanogratings with height h= 60 nm, width w= 70 nm, and spacing p= 70 nm.

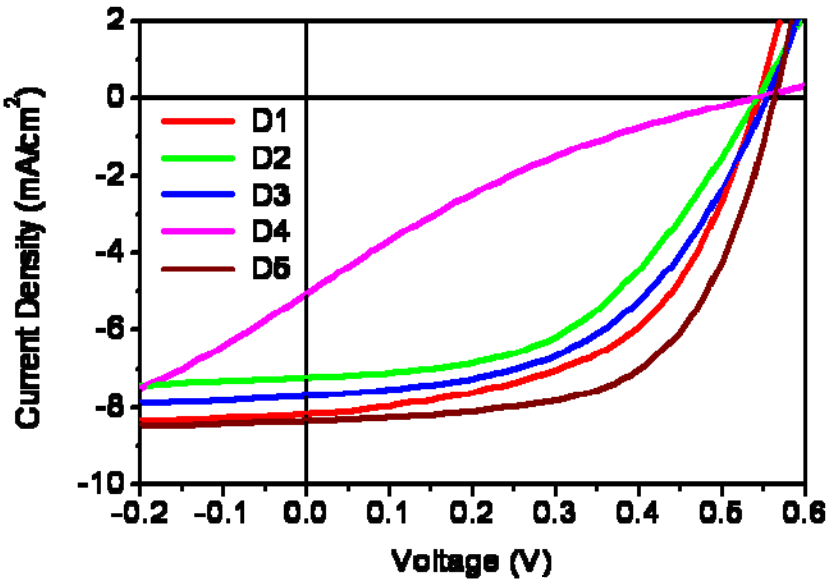

Figure 2: *J-V* characteristics of P3HT:PCBM solar cells with PEDOT:PSS nonimprinted (D1), imprinted by plain Si mold at 100 ^{o}C (D2), imprinted by plain Si mold at 2 MPa (D3), imprinted by plain Si mold at 100 ^{o}C and 2 MPa (D4) and imprinted by nanolined Si mold at 100 ^{o}C and 2 MPa (D5).