Enhanced Light Harvesting in Polymer Solar Cells Featuring Biomimetic Light Trapping Scheme

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Significant progress on the device performance of polymer solar cells (PSCs) with nearly 100% internal quantum efficiency has been made in recent years via the incorporation of new materials, morphology control, interface engineering, and device fabrication processes. However, further improvement in efficiency remains a daunting challenge due to limited light absorption in conventional device architectures. Advanced light manipulation is extremely attractive for applications in organic optoelectronics to enhance light harvesting efficiency. A novel method of fabricating high-efficiency single-junction PSCs of various material systems is herein proposed by nanoimprinting biomimetic moth eye nanostructures into quasi-periodic gradient shape active layer and antireflective coating for broadband self-enhanced light absorption with optimum charge extraction. The light harvesting efficiency of PSCs is increased 20%, yielding an enhanced power conversion efficiency exceeding 10% without sacrificing the charge transport properties. The optical simulations provide an understanding of optical manipulation of light in-coupling process in PSCs. The light harvesting enhancement in PSCs is clarified as the self-enhanced absorption due to collective effects of the pattern-induced anti-reflection, light scattering as well as surface plasmonic resonance due to the combined result of both the two-dimensional sub-wavelength structures and the continuously tapered morphology on the patterned surface with a superior gradient refractive index profile at the interface. Note also that the method developed here brings about an invaluable advantage, which enables the processing compatibility with the high-throughput large-area roll-to-flat and roll-to-roll manufacturing techniques in future mass production of low-cost organic optoelectronic devices.

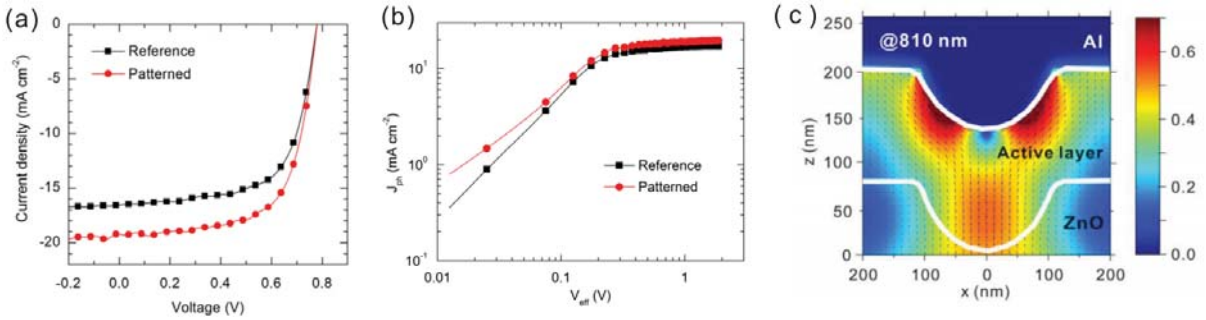

Figure. Device performance of polymer solar cells with and without light trapping Scheme.

References

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