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Photonic Structuring of Bulk Heterojunction Organic Solar Cells

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The major challenge in solar cell technology dwells in achieving an efficient absorption of photons with an effective carrier extraction. In all cases, light absorption considerations call for thicker modules while carrier transport would benefit from thinner ones. This dichotomy is the fundamental problem limiting the efficiencies of photovoltaics, especially promising low-cost polymer solar cells. We present experimental and theoretical solutions to this problem applying photonic crystal nanostructuring in bulk heterojunction solar cells made of poly-3-hexylthiophene:[6,6]-phenyl-C61-butyric acid methyl ester (P3HT:PCBM). We discuss theoretical models of optical absorption that occur for the photonic design that result in a 22% enhancement over a conventional planar cell. We also calculate the local exciton creation profile within the photonic crystal structure to show nanopatterning also reduces carrier transport length. Finally, experimental results are presented that follow the theoretical predictions along with our nano fabrication method to show this approach can be used to produce improved large-area nanostructured P3HT:PCBM solar cells. In collaboration with John Tumbleston, Physics and Astronomy Department, University of North Carolina at Chapel Hill; and Doo-Hyun Ko and Edward Samulski, Chemistry Department, University of North Carolina at Chapel Hill.