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Sub-cell photocurrent balance in multi-junction organic photovoltaics

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Multijunction (MJ) architectures are a key approach to enhancing photovoltaic power conversion efficiency, surpassing the Shockley-Queisser limit, and potentially advancing organic photovoltaics (OPVs) into the range of commercial viability. There has been much work in the field regarding this architecture, primarily focusing on materials selection and architecture optimization to maximize photocurrent generation. However, there has been little discussion on utilizing the imbalance of sub-cell photocurrents for efficiency optimization. The present study will present an MJ-OPV architecture comprising sub-cells with dissimilar FFs, for which the fully optimized (i.e., maximum power conversion efficiency) cell is comprised of photocurrent imbalanced sub-cells. Firstly we demonstrated the importance of fill factor (FF) in optimizing MJ-OPVs. Notably, the largest measured FF of the MJ-OPV is 25% higher than that of the small-FF sub-cell, indicating that the FF of multi-junction devices need not be limited by both comprising sub-cells. Then discuss an accessible technique to determine sub-cell photocurrent balance simply from the reconstruction of current-voltage curves of the MJ device from representative single-junction devices. Finally, we simulate a broad array of sub-cell thicknesses and show that FF of the MJ device can be predictably varied via sub-cell photocurrent imbalance. We conclude that the gain in FF can dominate any losses in short-circuit current when optimizing MJ devices comprising sub-cells with dissimilar FFs. These methods are broadly applicable to multi-junction photovoltaics and should be utilized to fully optimize power conversion efficiency.

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