ABSTRACT

TRANSPARENT MULTIJUNCTION ORGANIC PHOTOVOLTAICS

By

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The widespread adoption of conventional solar cells based on inorganic semiconductors has been gaining traction in recent years but is still often hindered by high cost and lack of aesthetic appeal. Transparent organic semiconductor-based solar cells that selectively absorb in the UV and the NIR enable integration into building windows, automobiles, and consumer electronics in ways that traditional solar cells cannot. Moreover, integration onto existing infrastructure reduces the racking and installation cost. In this work, we investigate routes to improve the efficiency of transparent solar cells by utilizing multijunction architectures. A transfer-matrix optical interference model is developed as a framework to optimize the full device stack considering the angle-dependent PV performance that is critical for matching subcell photocurrents in series tandem solar cells. In addition, a new method of fine tuning energy levels of low-bandgap small molecules with infrared selective absorption was demonstrated using a series of organic heptamethine salts. By exchanging the counterion from a small, hard anion to a fluorinated weakly coordinating anion, the frontier energy of the salt is shown to shift without affecting the bandgap, thus enabling simultaneous optimization of photocurrent generation of photovoltage. We further utilize this tunability to develop heptamethine molecules with absorption as deep as 1600 nm, the deepest infrared photoresponse demonstrated to date with organic small molecules ideal for multijunction integration. Ultimately, transparent solar cells are an exciting new paradigm for solar deployment enabled by organic and excitonic semiconductors that offer a pathway to integrate solar onto virtually any surface without impacting the view.