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High External Quantum Efficiency in van der Waals Heterostructures for Ultrathin Photovoltaics JOESON WONG, DEEP JARIWALA, KEVIN TAT, GIULIA TAGLIABUE, ARTUR DAVOYAN, MICHELLE SHERROTT, HARRY ATWATER, Caltech — High external radiative efficiency and high external quantum efficiency are prerequisites for an efficient photovoltaic cell. In transition metal dichalcogenides (TMDCs), previous work has demonstrated that near-unity external radiative efficiency is possible through superacid passivation. Yet, near-unity external quantum efficiency has remained elusive. In this work, we experimentally demonstrate that high external quantum efficiencies (>50%) are possible in vertical van der Waals heterostructures consisting of graphene, tungsten diselenide, and molybdenum disulfide, on metallic substrates. We achieve near-unity absorption in ultrathin (<15 nm) transition metal dichalcogenides by employing non-trivial phase shifts at the TMDC/metal interface. We show that the use of both graphene and a PN junction geometry leads to an enhancement in the internal quantum efficiency, a measure of the carrier collection efficiency. Moreover, the internal quantum efficiency is shown to exhibit exciton resonances with peak efficiencies >70%. In summary, our results presented here will serve as design considerations and principles towards achieving near-unity external quantum efficiency in van der Waals materials.

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