Zero excess energy for carrier multiplication in van der Waals layered materials

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Carrier multiplication (CM), a photo-physical process to generate multiple electron-hole pairs by exploiting excess energy of free carriers, is explored for efficient photovoltaic conversion of photons from the blue solar band, predominantly wasted as heat in standard solar cells [1,2]. Current state-of-the-art approaches with nanomaterials have demonstrated the improved CM but are not satisfactory due to high energy loss and inherent difficulties with carrier extraction.

Here, we report efficient CM phenomena in van der Waals (vdW) multilayer that commences at the energy conservation limit and proceeds with high conversion efficiency [3]. A small threshold energy, as low as twice the bandgap, was achieved, marking an onset of quantum yield with enhanced carrier generation. Strong Coulomb interactions between electrons confined within vdW layers allow for rapid electron-electron scattering to prevail over electron-phonon scattering. In addition, the presence of electron pockets spread over momentum space could also contribute to the observed high CM efficiency. Combined with high conductivity and optimal bandgap, these superior CM characteristics identify vdW materials as an attractive candidate for third-generation solar cells.

References

[1] Aerts M. *et al*. Nature communications 5, 3789 (2014).
[2] Trinh M. T. *et al*. Nature photonics **6**, 316 (2012).
[3] Kim *et al*. http://arxiv.org/abs/1801.01675.