Solar energy conversion in van der Waals heterostructures

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Abstract

Photovoltaic cells for solar energy harvesting are today mainly made out of crystalline semiconductors or organic compounds. Beside the high production costs, crystalline semiconductor cells have the drawback of being heavy and bulky. Organic cells, on the other hand, suffer from low carrier mobility and short lifetime of the organic material. To overcome these drawbacks, we engineered a new type of solar cell based on atomically thin transition metal dichalcogenide (TMDC) layers. Due to the thickness of the used materials the advantages of low raw material costs, high flexibility and semi-transparency are intrinsic parameters. This, combined with the wide range of available band gaps and the good carrier mobility make atomically thin TMDC crystals a promising candidate for next generation solar cells[1]. Recent work demonstrated that atomically thin WSe_2 can be electrostatically doped such that hole and electron conduction is achieved and that it can be used to realize a lateral hetero-junction which can be operated as a solar cell[2].
The main drawback of the mentioned structure is the small interaction area. To overcome this limitation, we fabricated planar van der Waals heterojunctions by stacking two[3], and also multiple, atomically thin TMDC layers. Figure 1a shows that such a planar p-n can indeed be used for efficient solar energy harvesting. Besides measurements of electrical transport and the photovoltaic properties, we will present photoluminescence measurements that clarify the working principle of these devices. In addition we will present improved cells, formed by a triple TMDC heterojunction as schematically depicted in Figure 1b.

References

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Figures

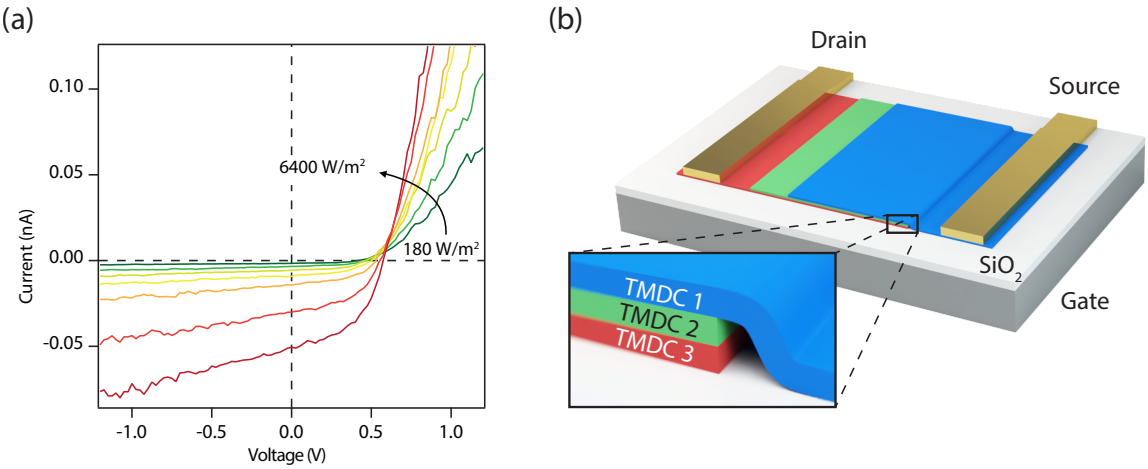

Fig. 1(a) I-V characteristic of the MoS_2 – WSe_2 heterostructure device under optical illumination with P_{opt} =180…6400 W/m^2. (b) Schematic illustration of a triple junction heterostructure device.