Electric transport and photoresponse in BP/MoS_2 heterostructure

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Abstract
Van der Waals heterojunctions between two-dimensional materials have emerged as a focal point due to their unique electronic and optoelectronic properties. In this context, the combination of molybdenum disulfide (MoS_2) as a large bandgap n-type semiconductor and black phosphorus (BP) as a narrow bandgap p-type semiconductor offers the potential for exploiting large bandgap offsets, thereby facilitating rectifying behaviours. The electrical behaviour of a BP/MoS_2 heterostructure is investigated both in darkness and under illumination by a supercontinuum white laser (see Figure 1a). The presented analysis delves into the interplay between BP, MoS_2, and the contact material, which is Cr, used for the source and drain electrodes, together with Au, elucidating an energy band model that reveals the formation of a type II heterojunction at the interface between the two semiconductive materials (see Figure 1b). This model explains the unexpectedly higher current observed when applying a negative bias to either the MoS_2 or BP side, the dominant n-type conduction and valuable photoresponse exhibited by the BP/MoS_2 heterostructure. Furthermore, time-resolved photocurrent measurements reveal a significant photoresponse, characterized by relatively fast response times, with rise times of less than 200 ms. The increased responsivity and shorter relaxation times, compared to those of MoS_2 devices of a similar kind, are attributed to the high charge carrier mobility of BP [1-3]. These findings underscore the promising electrical and photoresponse characteristics of BP/MoS_2 van der Waals heterojunctions, positioning them as good candidates for advanced optoelectronic applications.

References

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Figures

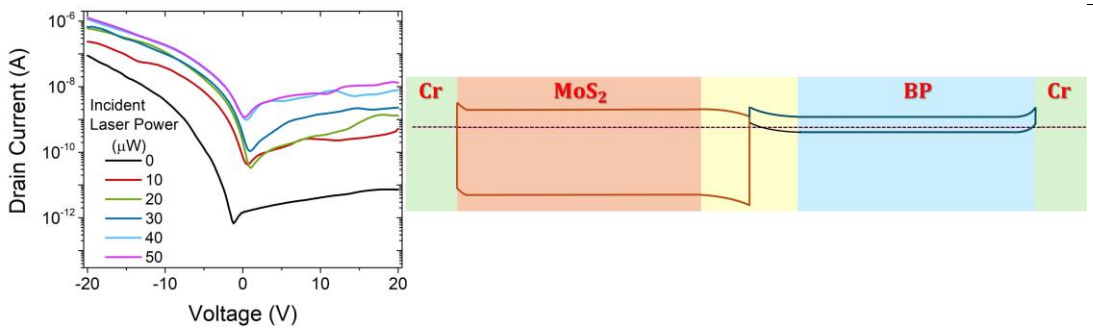

Figure 1: (a) Current-Voltage characteristics both in darkness (black) and under illumination by a white laser (coloured curves). (b) Band diagram of BP/MoS_2 heterojunction and Cr.