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Ion-mediated growth of ultra thin molybdenum disulfide layers on highly oriented pyrolytic graphite

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Abstract

Van der Waals (vdW) heterostructures composed of different two-dimensional (2D) materials are at the center of many novel devices. To prepare vdW heterostructures which are of the highest quality and suitable for applications, chemical vapour deposition (CVD) can be used to grow the 2D materials directly on top of each other and thus build the vdW heterostructure in a bottom-up fashion. However, obtaining layers of uniform quality by precisely controlling their growth poses a severe challenge. The aim of our work is to understand the growth mechanisms and we have chosen MoS_2 layers on highly oriented pyrolytic graphite (HOPG) as a model system for the MoS_2-graphene interface. In our model system we observe, that MoS_2 layers do not grow on the HOPG terraces but are more likely to grow at HOPG edges, one-dimensional defects, which obviously acts as growth seeds. In graphene however, step edges are absent and the ever-improving quality of commercially available CVD graphene yields less and less defects per unit area. While this is clearly an advantage for most devices, in the light of our findings it constitutes a major disadvantage for the bottom-up preparation of vdW heterostructures. To overcome this obstacle we artificially introduce defects into the HOPG surface by highly charged ion irradiation. In this way we induce an easily controllable number of quasi zero-dimensional defects before the chemical vapour deposition of MoS_2 takes place. We show that this treatment results in MoS_2 island growth on top HOPG terraces.