Electronic properties of the graphene and TaS_2 hybrid systems

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Transition metal dichalcogenides (TMDCs) belong to the class of materials with the general formula MX2, where M is a transition metal atom from group IV (Ti, Zr, Hf), V (V, Nb, Ta) or VI (Cr, Mo, W), while X is a halogen atom (S, Se, Te). Nowadays, TMDCs are widely used as components of heterostructures with other types of two-dimensional layered systems. Recent research shows that the interactions between components of the heterostructure are highly complex, and those systems should not be treated as a simple sum of their components. In this case, the occurrence of new phenomena and properties must be considered.

The hybrid system of 1T-TaS_2 and graphene will be presented. The interactions between components were studied for two different configurations: graphene on top of TaS_2 and single and few layers of TaS_2 deposited on to graphene substrate. The obtained results proved that it is possible to assemble the graphene/TMDCs hybrids in a controlled manner while keeping the material interface uncontaminated. This allows for providing the experimental results for model (perfect) heterostructure and addressing its fundamental properties. These are the first steps in studying the interactions between 1T-TaS_2 and graphene and utilizing them for further applications. The main conclusion is that, despite the interactions occurred and the two-dimensional character of the materials, both components of heterostructure preserve their fundamental and unique properties. This means that the proximity effect can be considered as a factor that tunes the properties of the system rather than destroys them, which was not previously clear for graphene/1T-TaS_2. However, because of the proximity effect, a p-doping of the graphene is observed in a heterostructure which is proved by ARPES, STS and additionally by theoretical calculations. Additional conclusion from presented study is that graphene can be utilized as a protective layer of TaS_2.This finding is important because it opens the path for further construction of devices that combine the advantages of both materials joined in the heterostructure. Moreover, the preservation of the material properties and the possibility of reaching the uncontaminated interface allow for further modification of the electronic properties of the hybrid by changing the angle between layers. Those findings are highly promising and will be future studied in the scope of twistronics.

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