Two-Dimensional Mapping of Energy Transfer in Graphene/MoS2 Photodetectors

Earle, Michael

Single-atom thick crystals have the potential to be used in smaller, faster electronics, replacing the silicon-based semiconductors found in current computers. In particular, graphene, a single-atom-thick crystal of carbon, has been used with photosensitive Transition Metal Dichalcogenides (TMDCs) to create multifunctional devices, including ultrahigh-gain photodetectors, which utilize graphene to quench excitons at the junction between the two materials. This research mapped the quenching effects at play in heterostructures of graphene and MoS2, a common TMDC, which were fabricated via mechanical exfoliation and viscoelastic stamping. Two-crystal samples of graphene and MoS2 were fabricated, one with MoS2 on top, the other with MoS2 on the bottom, revealing 27 to 35 times less photoluminescence (PL), respectively, due to exciton quenching by graphene. In areas where graphene contacts MoS2, the decrease in PL indicates the transfer of energy from MoS2 to graphene, where it can be harnessed in the form of an electric current, causing the heterostructure to act as a photovoltaic device. However, a three-crystal heterostructure with graphene on both sides of MoS2 showed nearly six times more PL in areas where graphene existed on both sides of MoS2. This secondary “graphene encapsulation” effect, in which graphene serves as a barrier between the MoS2 and trapped charges in the amorphous oxide layer on the SiO2 substrate, shows potential for preserving the electronic properties in LEDs and devices that would be exposed to environmental contamination. Understanding graphene’s interactions with TMDCs is the first step in creating flexible, high efficiency graphene-based photodetectors.

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