Thickness-dependent transport properties of black phosphorus multilayers

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2D-layered materials are gaining considerable attention for next generation electronic and optoelectronic technologies. Monoatomic black phosphorus (BP) is regarded as one of the most promising systems due to its unique electronic properties such as relatively small bandap and ultrahigh mobilities expected in the monolayer limit. However, in order to verify the applicability and performance limits of this material, the thickness-dependent transport properties must be evaluated.
DC electrical transport characteristics of high quality BP field-effect transistors were studied within a wide range of thicknesses at room temperature. A non-trivial increase in conductivity and hole density with reduced layer number was observed. This phenomenon is shown to be associated with the non-negligible interlayer coupling which causes a spatial redistribution of free charge carriers towards the central layers. As a result, naturally protected 2D hole gas can be encapsulated within the innermost layers of flakes consisting of tens of layers, opening the potential for harnessing its properties for future applications.