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TRANSPARENT CONDUCTORS AND GAS SENSORS FROM 2D MATERIAL THIN FILMS

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Chemical sensors are an enabling tool across many industries, including the largest ones such as energy, transport, and construction. Low-cost, high performance sensors, especially ones compatible with flexible substrates, are becoming increasingly important with the development of mobile gadgets and wearable devices. Here we show chemical sensors produced in a facile way from inexpensive materials. The sensors, made of liquid-phase exfoliated (LPE) 2Dmaterials deposited on a substrate with Langmuir-Blodgett assembly, are only several nanometers thick, with high optical transparency, high sensitivity to various chemicals, made with an inexpensive process that can be applied to any substrate, including flexible ones. The method that we demonstrate is scalable and consistently yields films of high quality. The sensors that we make from graphene are more sensitive to humidity than ones demonstrated with CVD graphene, with up to 30% change in sheet resistance upon exposure to water vapor. The LPE graphene sensors are also ultrafast, enabling applications suchas real-time respiration monitoring and touchless finger proximity detection. We also demonstrate chemiresistive sensing of nitric acid vapour, ozone gas, and CO_2 with the same films. Using thin sheets of LPE $PtSe_2$ we show NH_3 and NO_2 gas detection with unprecedented 200 ppb and 15 ppb detection limits, respectively. The physical mechanism for the high sensitivity is an abundancy of reactive edges that trap analyte molecules. Our large-area low-cost films are also excellent candidates for use in transparent conductor applications, with a transparency higher than 80% at sheet resistances on the order of 10 kOhm, which result in a better figure of merit than films made with any other deposition method from liquid solutions of 2D materials. Finally, we present the use of ultrathin LPE hexagonal boron nitride films as a layer that protects CVD graphene from photochemical oxidative degradation.

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