Characterising charge transport in printed nanosheet networks

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Abstract

In recent years, it has become clear that networks of electrochemically exfoliated semiconducting nanosheets (e.g. MoS2) can be used to fabricate state-of-the-art printed transistors with mobility exceeding 10 cm2/Vs. It is likely that this field will develop to see the use of these materials in a whole range of high-performance printed electronic devices. However, the mesoscale physics of electrical transport in these networks is still poorly understood. In particular, the role of inter-sheet junctions has not been quantified. For example, achieving the ultimate performance of such printed devices requires the junction resistance to be suppressed below the resistance of the individual nanosheets themselves. However, values of these quantities remain unknown. In this talk I will discuss the conditions for achieving high mobility printed networks and describe some of their basic properties. The talk will describe the fundamental properties of nanosheets required to minimize junction resistance as well as the deposition methods that are most suitable to achieving such junctions. I will demonstrate layer-by-layer deposition of well-ordered networks of various nanosheets including graphene, MoS2 and silver nano platelets. I will describe new analytic techniques which utilize novel electrical models which can be combined with impedance spectroscopy to measure both the mean nanosheets and junction resistance within the network. As I will demonstrate, this allows one to simultaneously measure both nanosheet and junction resistance as a function of temperature allowing us to differentiate inter- from intra-nanosheet charge transport mechanisms. Measurements of junction resistance for a range of different semiconducting nanosheets shows a well-defined empirical relationship between electronic structure and junction resistance. In addition, the junction resistance depends sensitively on the aspect ratio of the nanosheets within the network due to a combination of the effects of morphology and junction area. Taken together this data allows us to demonstrate a road map for the production of high mobility printed nanosheet networks for flexible and wearable electronic devices.

Figures

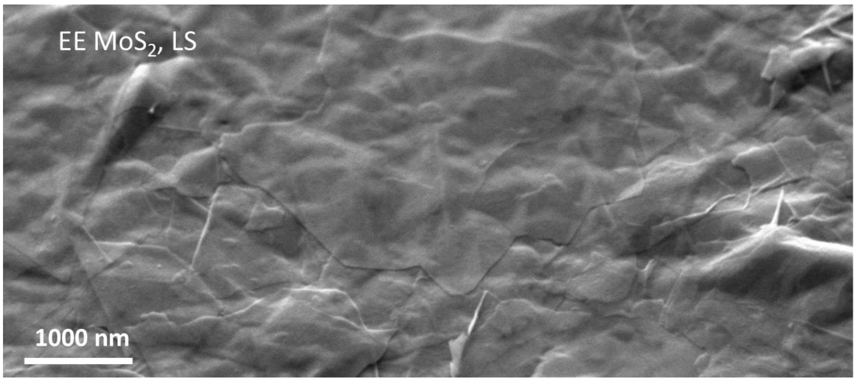

Figure 1: SEM image of the surface of a high-mobility network of electrochemically exfoliated MoS_2 deposited by a Langmuir-Schaeffer type deposition process.