The importance of morphology in printed nanosheet networks for device applications.

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Abstract

Printed networks of graphene and other 2D materials will be important in a range of applications from electrodes to sensors to energy storage devices. For many of these applications, maximizing (or minimizing) the conductivity of such networks is important. 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. It is however expected that the morphology of printed networks will very strongly impact the resistance of inter sheet junctions. However. in general, the morphology of printed networks is also poorly understood, because of the lack of appropriate tools to interrogate it. Here, I will demonstrate a nano-tomography technique, based on a combination of SEM &FIB, that can be used to obtain 3D images of nanosheet networks with 5 nm resolution. From such images, one can obtain a range of different parameters including pore network porosity and tortuosity, nanosheet alignment and stacking arrangement as well as nanosheet network connectivity and tortuosity. We will also use new techniques to estimate the junction resistance in nanosheet networks and link them to morphology. We have extended the 3D imaging technique to interrogate printed devices, separating different nano-layers from electrodes and measuring parameters such as interfacial roughness and identifying pin holes. Having demonstrated the morphology of nanosheet networks I will describe a number of electronic devices based on these networks. Such devices include piezo resistive sensors which require poorly connected low conductivity networks as well as printed transistors which require highly connected networks to achieve high mobility. Finally, I will show preliminary results on printed heterostacks acting as printed diodes with rectification ratios up to 10,000 that can act as sensitive photodetectors.

Figures

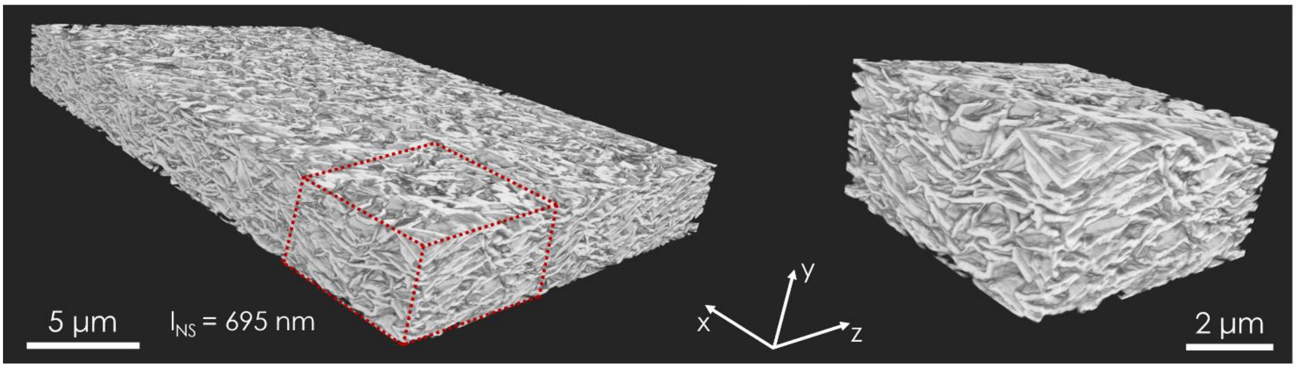

Figure 1: 3D image of a nanosheet network spray cast from LPE graphene nanosheets.