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All-printed electrochemical thin-film transistors from networks of liquid-exfoliated nanosheets

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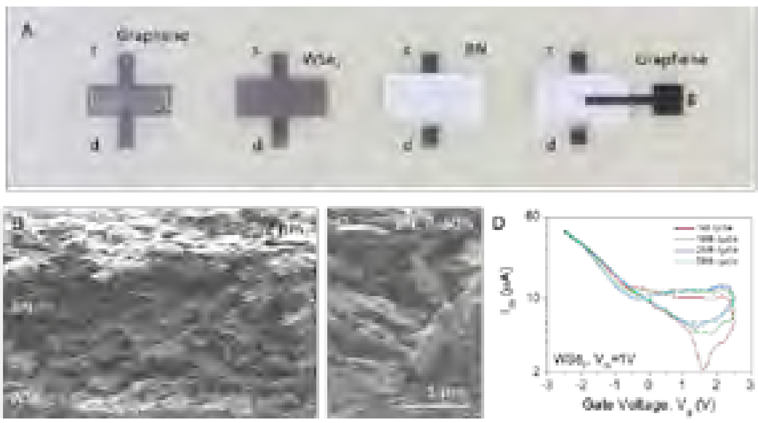
With the advent of the Internet of Things, the development of printed electronics (PE) is becoming increasingly important, with much research focusing on developing new materials. A number of material sets have been studied, including organics, inorganic nanoparticles and nanotube/nanowire networks. High operating voltages (up to 50 V), low mobility (<10 cm /Vs) and poor current injection are still challenges for organic thin film transistors (OTFTs). Networks of inorganic nanoparticles or nanotubes have demonstrated mobilities and on:off ratios of >10 cm^2/Vs and >106 respectively, but may face problems with scalability and integration. These problems have led a number of researchers in the field of 2D materials to attempt to produce printed transistors where the channel material is a network of semiconducting nanosheets. Because of the relatively high mobility of 2D materials, such a network might display mobilities which are competitive or even superior to those achievable with printed organics. In addition, one could envisage all-printed transistors consisting of interconnected networks of semiconducting, conducting and insulating 2D nanosheets. However, switchable nanosheet networks have not been demonstrated. Here, using electrolytic-gating, we demonstrate all-printed, vertically-stacked electrochemical transistors with graphene source, drain and gate electrodes, a transition metal dichalcogenide channel and a BN separator, all formed from nanosheet networks. The BN network contains an ionic liquid within its porous interior that allows electrolytic gating in a solid-like structure. Nanosheet network channels display on-off ratios of up to 600, transconductances exceeding 5 mS and mobilities of >0.1 centimeters squared per volt per second. The on-currents scaled with network thickness and volumetric capacitance as well as the network mobility. In contrast to other devices with comparable mobility, large capacitances, while hindering switching speeds, allow these devices to carry higher currents at relatively low drive voltages to become trauma, informed that would help this recognition.



Biography

Jonathan Coleman is the Professor of Chemical Physics in the School of Physics and the CRANN and AMBER Research Centers, Trinity College, Dublin. His research involves liquid exfoliation of layered compounds such as graphene, boron nitride and molybdenum disulphide. Exfoliation of these materials gives 2D nanosheets which can easily be processed into thin films or composites from applications from energy storage to sensing to electronics. He has published approximately 250 papers in international journals including Nature and Science, has an h-index of 72 and has been cited ~30000 times. He was recently listed by Thomson Reuters among the world's top 100 materials scientists of the last decade and was named as the Science Foundation Ireland Researcher of the Year in 2011. He has been involved in a number of industry-academic collaborative projects with companies including Hewlett-Packard, Intel, SAB Miller, Nokia-Bell Labs and Thomas Swan.

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