Nanoporous graphene field-effect transistors

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An energy bap between valence and conduction bands is essential for electronics applications because it allows a material to turn the flow of electrons on and off. One way of introducing a bandgap into graphene is to make extremely narrow ribbons of the material. However, traditional methods to fabricate graphene ribbons, such as lithographically defining ribbons from bulk graphene and bottom-up synthesized ribbons have issues with yield, rough edges, or suitable bandgaps. In addition short lengths have prevented the fabrication of high-performance field-effect transistors. We have recently reported a bottom-up method to synthesize nanoporous graphene (NPG) comprising an ordered array of pores separated by ribbons, which can be tuned down to the one nanometer range (1). The size, density, morphology and chemical composition of the pores are defined with atomic precision by the design of the molecular precursors.

Here we report the fabrication of NPG-based field effect transistors (Fig. 1) with large on-off ratio of up to 10^4 (Fig. 2) and a high device yield of ~75% for 30-nm long channels, which is a reflection of the fairly large areas of our NPG. This contrasts with recent studies based on ribbons where a yield of ~10% was reported for channel lengths of 20 nm (2). The combined structural and electrical properties makes the NPG a highly versatile semiconductor with potential for simultaneous sieving and electrical sensing of molecular species.

References

[1] C. Moreno, M. Vilas-Varela, B. Kretz, A. Garcia-Lekue, M. V. Costache, M. Paradinas, M. Panighel, G. Ceballos, S. O. Valenzuela, D. Peña, A. Mugarza, Science 360, (2018) 199

[2] J. P. Llinas et al, Nat. Commun. 8, (2017) 633

Figures

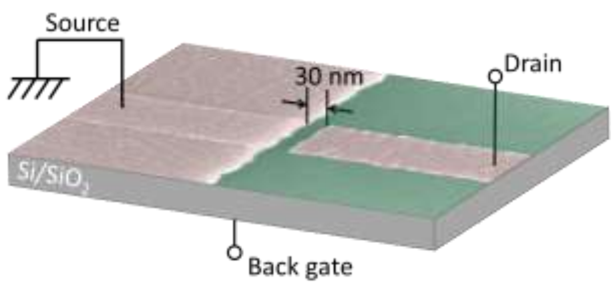

Figure 1: Coloured scanning electron microscope image of the nanoporous graphene transistor device.

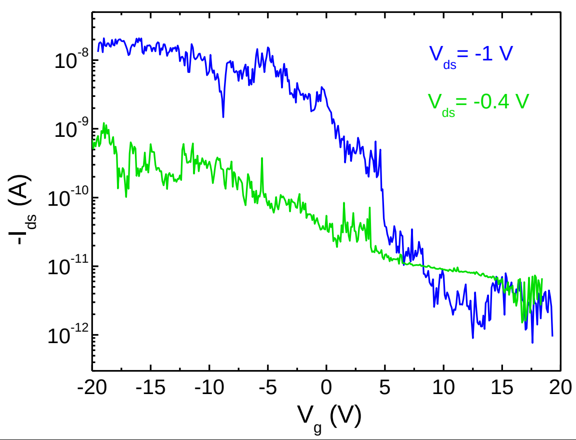

Figure 2: Source-drain current (I_{ds}) function of back gate voltage (V_g) characteristics of a nanoporous graphene transistor with 30-nm-channel length using a back-gate across a 90-nm-thick SiO_2 oxide at the indicated source-drain voltages.