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Nanoporous graphene for optoelectronics and molecular sensing and sieving applications

Nanosize pores can turn semimetallic graphene into a semiconductor [1, 2] and from being impermeable into the most efficient molecular sieve membrane [3, 4]. However, scaling the pores down to the nanometer, while fulfilling the tight structural constraints imposed by applications, represents an enormous challenge for present top-down strategies.

Here we report a bottom-up method to synthesize nanoporous graphene comprising an ordered array of pores separated by ribbons, which can be tuned down to the one nanometer range [5]. The size, density, morphology and chemical composition of the pores are defined with atomic precision by the design of the molecular precursors. Interestingly, the hierarchical synthetic method also enables the generation of arrays of decoupled nanoribbons with tunable periodicity [6].

Our study reveals a highly anisotropic electronic structure in the nanoporous structure, where orthogonal one-dimensional electronic bands with an energy gap of ~1 eV coexist with confined pore states that might sense passing ions and molecules. The semiconducting character of the nanomaterial has been further confirmed by fabricating field-effect transistors with state of art on/off ratios. The combined structural and electrical properties makes this nanoporous 2D material a highly versatile semiconductor for simultaneous sieving and electrical sensing of molecular species.

References

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Figures

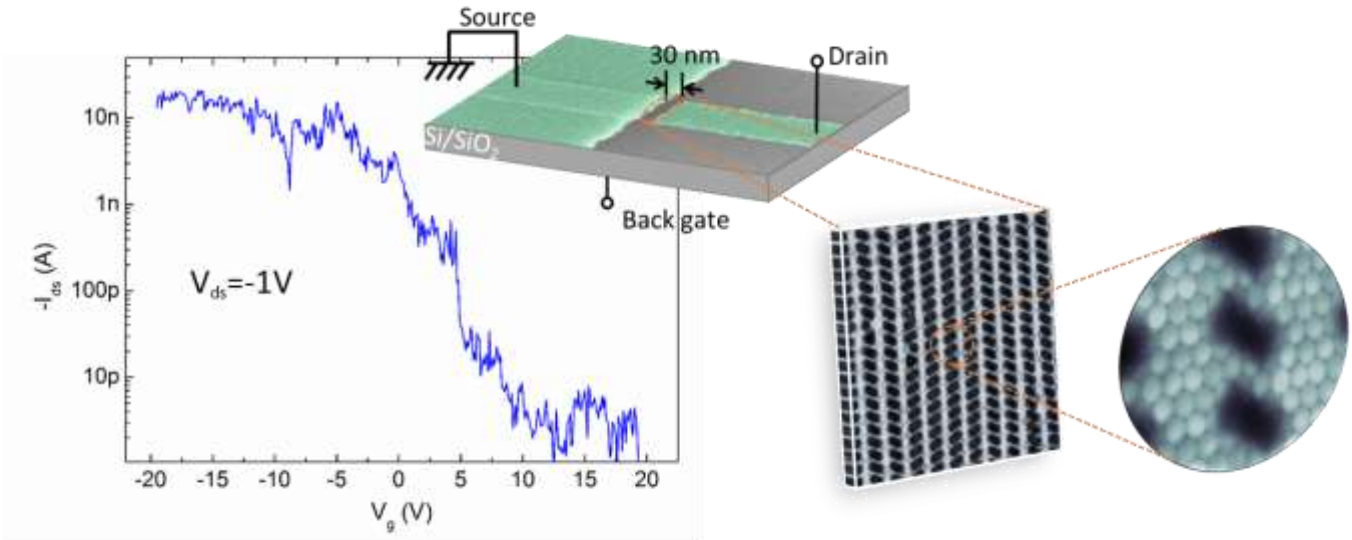

Figure 1: I_{ds}-V_G characteristics of a field-effect transistor fabricated with nanoporous graphene sheets synthesized with our bottom-up method.