A graphene-edge ferroelectric molecular switch

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As the quality of bulk graphene has improved in recent years [1], edges have become key to understand the properties of nanodevices made from this two-dimensional material. Phenomena occurring at graphene edges are not only relevant from a fundamental point of view [2,3]; these effects could also be exploited to design electronic devices with novel functionalities. Here, I present recent experiments [4] showing that the electrical properties of graphene devices strongly depend on its edge functionalization, and how this can be used to engineer innovative memory devices.

Specifically, polar molecules adsorbed solely at the oxidized edges of encapsulated graphene devices (Fig.1) exhibit ferroelectricity, displaying a switchable and remanent dipole alignment in response to an external electric field [4]. The presence of such aligned molecules at graphene edges leads to a measurable macroscopic charge bistability in gated graphene devices even at room temperature. As demonstrated by both electrical measurements and theoretical calculations, this effect is highly sensitive to the chemical termination of the graphene edge: it quenches by undertaking a fluorine functionalization.

This molecular system comprises an experimental realization of envisioned memory capacitive ("memcapacitive") devices, whose capacitance is a function of their charging history (Fig. 2), and can be exploited to investigate correlated molecular systems and to design energy efficient neuromorphic architectures.

References

[1] Wang et al. **Science** (2013), 342, 614.
[2] J.M. Caridad et al. ***Nature Comm***. 9, (2018) 659.
[3] J.M. Caridad et al. ***submitted***, (2019).
[4] J.M. Caridad et al. ***NanoLetters***, 18, (2018), 4675

Figures

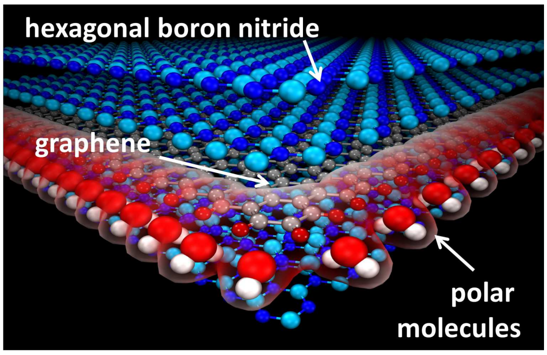

Figure 1: Illustrative image of confined and aligned water molecules at graphene edges.

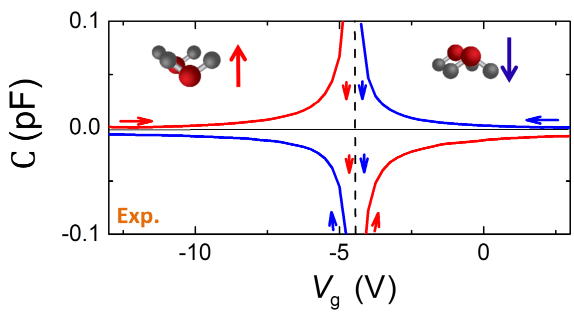

Figure 2: Measured hysteretic device capacitance C(V_g) in water vapour due to the two-state molecular alignment occurring at graphene edges