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Charge and gas transport in complex 2-dimensional anisotropic systems

Vincenzo Palermo, Andrea Liscio, Alessandro Kovtun, Marco Affronte, Andrea Candini
National Research Council (CNR-ISOF), Bologna, Italy
Chalmers University of Technology, Gothenburg, Sweden
Università di Modena e Reggio Emilia, Modena, Italy
Palermo@isof.cnr.it

Applications of graphene and 2D materials (2DM) in electronics or composites require to study charge transport in complex systems, i.e. mesoscopic layers made of billions of stacked nanosheets. In this case, the material's electrical conductivity depends strongly on the flake-flake interaction, and on the flake size.
Besides charge transport *along* the plane, permeation of small molecules *across* the plane is also important for applications, as example, in packaging (gas barrier) or in water purification. Also, in this case, the stacking and the interaction of the different nanosheets with each other will influence strongly the transport mechanism.
Here, we give an overview of our results recently obtained to tackle this challenging problem, in particular related to:

- *Charge transport studies in composite, polydisperse 2DM systems, based on different regimes, from Arrhenius-like behavior to variable range hopping.[1]*
- *Gas transport studies in composite, polydisperse 2DM systems featuring selective permeation for different gases of industrial interest.[2]*
- *Statistical modelling of flake size distribution in 2D materials, for fundamental study or benchmarking of commercial products.[3-5]*

Overall, this approach shall help to bridge the gap between studies performed at fundamental level on single monoatomic sheets, and complex behaviour observed in realistic composite materials.

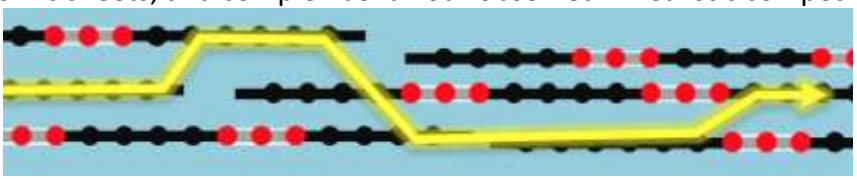

Figure 1: schematic representation of charge transport in defective graphene multilayers

References

[1] *Observation of different charge transport regimes and large magnetoresistance in graphene oxide layers*, **Carbon**, (2015) **89**, 188.
[2] *Selective Gas Permeation in Graphene Oxide–Polymer Self-Assembled Multilayers*, **ACS Applied Materials & Interfaces**, (2018) **10**, 11242.
[3] *Evolution of the size and shape of 2D nanosheets during ultrasonic fragmentation*, **2D Materials**, (2017) **4**, #025017.
[4] *Fragmentation and exfoliation of 2-dimensional materials: a statistical approach*, **Nanoscale**, (2014) **6**, 5926.
[5] *Benchmarking of graphene-based materials: real commercial products versus ideal graphene*, **2D Materials**, (2019) **6**, 025006.