Emerging Properties in Two-dimensional Strongly Disordered & Amorphous Membranes

Stephan Roche
Aleandro Antidormi and Aron W. Cummings
Institut Català de Nanociència i Nanotecnologia (ICN2)
Campus de la UAB, Edifici ICN2, 08193 Bellaterra (Barcelona) Spain
stephan.roche@icn2.cat

Abstract

After fifteen years of pursuing the fabrication or single crystal growth of monolayer materials, it turns out that for plenty of fundamental and practical reasons, more disordered forms such as reduced graphene oxides, polycrystalline or even totally amorphous forms of ultrathin atomic membranes present superior properties for coating applications and composites. It is particularly remarkable that *scalable disordered atomic membranes* can be now produced in fab environment, but simultaneously it is extremely urgent to establish the upper device performances of devices built from polycrystalline 2D materials, reduced oxide graphene, or the recently achieved *wafer-scale amorphous forms of sp^2 carbon and boron-nitride membranes* reported in Singapore [1] and Korea [2].

Here I will discuss the variety of physical properties of such disordered or completely amorphous forms of two-dimensional based materials and devices in the context of industrial applications including gas sensing, thermal, electronic and spintronic applications. In absence of usual approximations of periodicity and long range order, the supremacy of so-called order N methodologies [3,4] provide unique enabling tools to access electronic and spin transport in highly structurally complex material models. Anderson localization regimes and universal spin diffusion length will be presented [5] as well as morphology-induced thermal properties in strongly disordered reduced graphene oxides. Finally, thermal and dielectric properties of ultrathin amorphous two-dimensional membranes will be discussed in the light of recent breakthrough experiments [1,2].

REFERENCES

[1] C.T. Toh et al. Nature 577 (7789):199-203 (2020)
[2] S. Hong et al. A. Antidormi, S. Roche et al., **Nature** 582, 511–514 (2020)
[3] A. Isacsson, A.W. Cummings, et al., **2D Materials** 4 (1), 012002 (2016);
[4] Z. Fan, J. H. Garcia, A.W. Cummings, J.-E. Barrios, M. Panhans, A. Harju, F. Ortmann, S. Roche, *´Linear Scaling Quantum Transport Methodologies´,* arXiv:1811.07387 (**Physics Reports**-invited)
[5] AW Cummings, SMM Dubois, JC Charlier, S Roche, **Nano letters** 19 (10), 7418-7426 (2019)
[6] A. Antidormi, S. Roche, L. Colombo, **J. Phys. Materials** 3 (1), 015011 (2019)
[7] A. Antidormi, L. Colombo, S. Roche, **ACS Nano** (submitted)

FIGURE

Figure 1: CVD growth of amorphous ultrathin hBN membranes with ultralow dielectric constants (from [2])