2-DIMENSIONAL COMPOSITES BASED ON GRAPHENE FOR FUNCTIONAL AND STRUCTURAL APPLICATIONS

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In this talk I will give an overview of different classes of composites we produce using graphene, the newest and most promising among carbon-based materials. While the application of graphene multilayers in *structural* composites (e.g. as nano-additive in bulk polymers for mechanics) is already being pursued at industrial level, an even greater impact is expected in *functional* composites, where graphene can act as a conductive, flexible and robust nanoscale scaffold to be complemented with other materials.

Graphene surface can be functionalized with organic molecules to tune its optoelectronic properties, for applications in flexible electronics and sensing. Conversely, it can be functionalized with inorganic materials (Fe_2O_3, TiO_2, SiO_2, Au, Sn or Pt nanoparticles, etc.) to act as a highly porous, conductive scaffold in electrodes for batteries and supercapacitors, in catalysts and fuel cells. Due to its 2-dimensional shape, it shall interact in peculiar ways with the cellular membrane and be used to create particular bio-composites, as example to foster cellular growth and differentiation.

Overall, the interesting potential applications of graphene are due to its truly 2D shape, its large availability in nature, its different possible sources for large scale production, and the huge amount of synthetic tools that we can have ready to use from organic synthesis, to play with graphene and transform it in the way we want.

Graphene-based composites are currently the only application of graphene already commercialized on large scale. The number of products containing these composites is increasing continuously, from tennis rackets to bicycles, to skis. However, the performance of such products is not comparable to the one of pristine graphene sheets, measured at the nanoscale, that easily outperform well-established materials such as steel, silicon or copper.

A key reason for this difference in properties is that it is not yet fully understood how 2D-based composites work at the nanoscale and, more importantly, what is the ultimate performance (mechanical, electrical etc.) that can be achieved when they are included into a bulk material. More than ten thousand papers were published on graphene composite materials in 2014. In these papers, the beneficial effect of graphene as an additive has been demonstrated for a great variety of bulk systems, but it is still not clear how extensively graphene will be used in future industrial applications, despite the importance of today’s carbon fillers. To understand if, and where, graphene and related 2D materials (GRM) can be truly competitive at the industrial level a strong combination of processing techniques, prototyping, characterization and modelling is needed.

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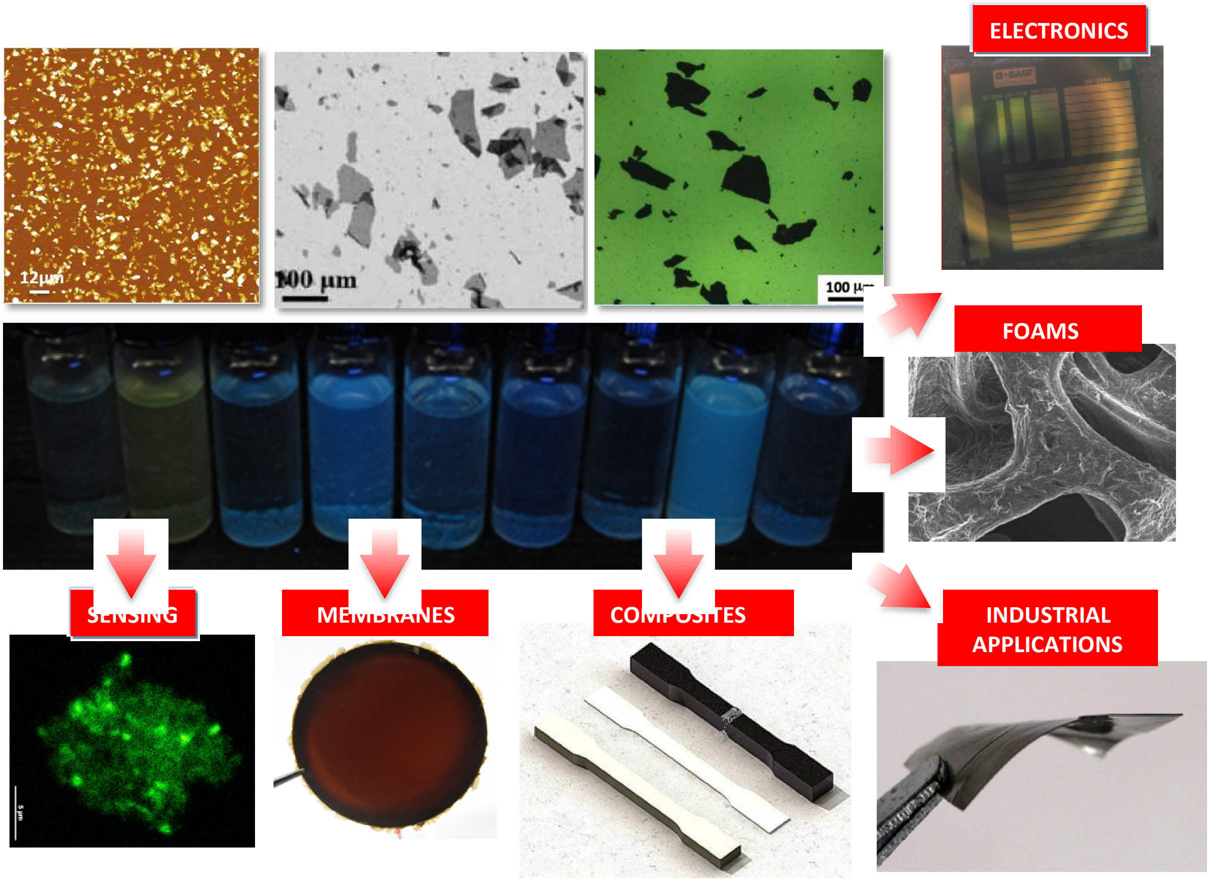

Figure 1: This is an example of a figure caption for GraphITA.