GRENADA Publishable summary

The discovery of new structures in carbon materials is giving way to vast opportunities for new scientific knowledge and emerging industrial applications. As we celebrate the ten year anniversary of the discovery of graphene, the number of scientific publications and related press articles exposing the potential of graphene continues to grow exponentially. In the history of our collective knowledge on materials science, no other material has received such intense scientific attention in so little time.

The GRENADA project set out to explore the inputs and conditions that influence the final properties of graphene with the objective to make it fit for purpose. The two-dimensional structure of graphene is responsible for many of its unique properties, in particular the excellent thermal and electrical properties. Paradoxically, it is also this same two-dimensional structure which makes graphene highly sensitive to minor changes in its surroundings. By gaining a thorough understanding of the synthesis conditions that produce exceptional graphene, as well as the external factors that can subsequently alter or degrade such properties, the path to industrial implementation will be traced.

Results obtained during the GRENADA project demonstrate the potential of graphene to compete with and exceed the performance of many existing materials in industrially relevant applications. For example, for graphene to replace indium tin oxide (ITO) in display applications, both excellent electrical conductivity and high optical transparency are required. Progress has been made in this direction with films of graphene exhibiting sheet resistivity as low as 135 ohms per square and optical transparency exceeding 95%, in line with application requirements. More importantly, display test vehicles have validated the functionality of graphene as an electrode in operating OLED devices with light emission at voltages as low as 4 volts.

In parallel, significant results have been achieved for the future use of graphene in energy storage devices such as supercapacitors and lithium batteries. Functional battery test cells were fabricated with reduced graphene oxide proving the feasibility of battery fabrication based on chemically synthesized graphene. High capacity supercapacitor test vehicles were also validated with graphene exhibiting energy density performance equivalent to commercial supercapacitors in side-by-side evaluations.

Nevertheless, integrating today’s graphene into industrial applications is not as easy as a “drop-in” replacement. There are still significant challenges to overcome before the materials properties of graphene obtained in a laboratory setting can be regularly repeated in a large scale industrial setting. The loss of fidelity of the material can be explained on the one hand by the difficulties to synthesize on a large scale, as well as by the susceptibility of the material to modification upon interaction with its surrounding environment. We have made significant progress on these issues and now see that graphene is slowly but surely making its way into the marketplace.