Assembling graphene with diamond as novel platforms for biointerfacing and photovoltaics

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Recent advances in the fabrication of diamond and graphene have established these carbon materials as the most promising candidates on the roadmap for the next generation building blocks for the electronics industry. Here we consider processes and advantages in the integration of both these materials into a common platform for biointerfacing with neural tissues as well as for photovoltaics.

The first structures considered here address neurointerfacing devices combining diamond and graphene microelectrode array networks. These assemblies can be used in applications aiming to repair the nervous system following an accident or disease, notably to correct the loss or impairment of eyesight (through retinal degeneration) or hearing (through damaged cochlea). Traumatic spinal injuries, drug-resistant epilepsies, psychiatric disorders and chronic neurodegenerative pathologies can also be treated (in the cortex) with such reconstructive approaches. There is a need to create better implantable devices through the use of improved interfacing between the electronic implants and living cells. For such, the involvement of high-quality, low-cost, carbon-based materials constitutes a real breakthrough. Diamond and graphene are well-adapted for use in medical implants, because they (i) offer a wide range of electronic properties (metal, semiconductor and insulator), (ii) are bio-inert and (iii) are physically robust. In the case of diamond, notable advances included the fabrication of micro-electrode arrays (MEAs) for cell and tissue interfacing with 'soft' diamond implants (diamond on polymeric materials). Devices were evaluated in laboratory animals for retinal stimulation demonstrating their robustness. These diamond implants considerably reduced the formation of glial scar tissues, enabled stimulation currents to be raised by more than one order of magnitude before causing visible chemical alteration, and enabled long lasting operation with reduced biofouling. The introduction of atomic layers of graphene onto diamond surfaces is expected to improve the device performance, while providing highly sensitive recording capabilities and maintaining the advantages of diamond implants, including operational stability.

In parallel, for photovoltaic applications, there are fundamental reasons why integrating diamond and graphene, along with organic or inorganic photoactive materials, can be advantageous in many applications. The diamond – graphene – organic interfaces present unique properties such as energy offsets that favour fast charge transfer for photovoltaics, and it combines high carrier mobility, ultrahigh thermal conductivity with thermal and chemical robustness. One of the point to improve to take advantage of structures targeting photochemical properties of graphene/quantum dots is to be able to couple them efficiently on a transparent substrate that provides electrical conductivity without altering the all-carbon nature of the graphene interface. Here we aim at designing, fabricating and assembling solar devices on a unique all carbon electronics platform, based on graphene sheets hybridised on conducting and transparent diamond electrodes.