In-situ growth and functionalization of graphene for biosensing applications

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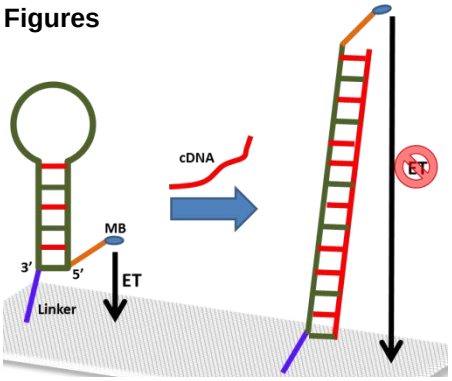
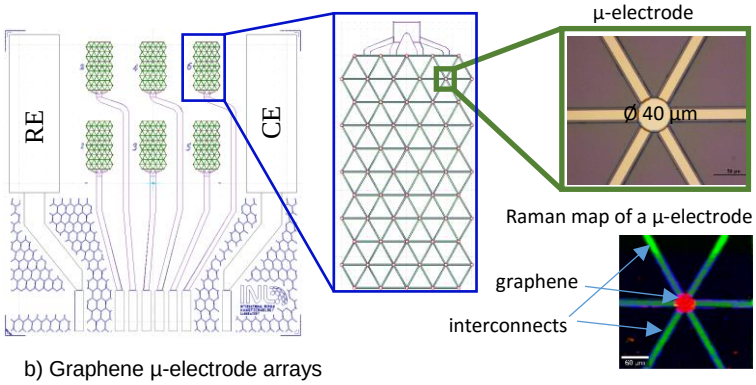
Abstract (Arial 10)

Although in recent years we have witnessed staggering achievements in both fundamental and applied research in graphene, applications still lack the pervasiveness that this material unique properties anticipated. One of the problems with the establishment of a graphene technology comes from the required transfer step, from the native metal catalyst onto the final substrate, normally using a temporary polymeric substrate. As a consequence, a non-uniform, wrinkled, contaminated with debris sheet of graphene results, which no longer exhibits the record-breaking properties of the pristine 2D material. Moreover, the transfer step takes time, requires patience and persistence, and, crucially, it is largely operator dependent, hence very prone to errors.
Graphene extreme sensitivity to electric charges and fields in its vicinity, together with its high chemical stability, provide an ideal transducing platform for biosensing applications. Biosensing requires that the active surface is highly reproducible, which can be achieved by *in-situ* growth of the graphene layer. Here we show that graphene directly grown on copper and molybdenum surfaces, provides the required type of surface, in a transfer free process that can be used for biosensor development. Moreover, the metal catalyst is patterned previously to the graphene CVD step, which implies that, by design, graphene will grow selectively only on the substrate regions where it is required. This highly simplifies the graphene patterning process, which translates into cheaper devices and higher graphene quality, since the fabrication process becomes faster and the damage inflicted to graphene by lithographic processes is minimized.
Biosensing with graphene requires surface functionalization for specific analyte detection. We used as linker a pyrene derivative (1-pyrenebutyric acid N-hydroxysuccinimide ester, PBSE), a molecule that provides π-π interactions with graphene on the pyrene end, and has a ester group at the opposite end, which reacts with the amine group of the sensing element. Nucleic acids allow the development of biosensors with high specificity and affinity and its electrochemical characterisation is commonly performed taking advantage of the well-known thiol-gold interaction. In the present work, a 29 nucleotides long methylene blue labelled DNA strand (self-complementary on its ends to form a becon) is immobilised on the electrode surface and after electrochemical characterisation of the film, hybridisation is performed with a fully complementary strand (cDNA). Surface coverage, rates of electron transfer and biosensor performance are determined from cyclic, square-wave and differential pulse voltammetry and compared with the commonly used Au based biosensors. Both macro and microelectrodes will be fabricated and the results compared. The sensor performance will be compared with that of electrolyte-gated graphene transistors whose channel is functionalized in the same manner as described above.

Figures



a) MB-labelled DNA strands immobilized on graphene surface



b) Graphene µ-electrode arrays