Single molecule graphene biosensors: chemistry matters

Gregory F. Schneider

Universiteit Leiden, The Netherlands

Exploiting the full potential offered by graphene in sensing applications requires extensive fundamental studies of the behaviour of the surface and of the edges of graphene upon their interaction with biological systems (lipids, proteins, enzymes, DNA, RNA and ultimately biological cells), as well as a quantification of the measurable electronic response of the graphene surface (and edge respectively) caused by a biological stimuli such as the presence and the passage of a biomolecule. The surface and the edges of graphene operate as sensors in two fundamentally different ways: in a typical solution-gated graphene field-effect transistor, the surface is sensitive to charge transfer conferred by a molecule in the vicinity of graphene and therefore could potentially detect a single molecule as a whole, while edges can be used as atomically flat electrodes that could transversally sense the precise structure and chemical composition of a biomolecule passing close to the edges. In both cases, biomolecules are being sensed, but the level of output information is different: surfaces can trap, detect and sense while edges can provide sequence information. This holds the potential that one can combine both and use the surface to selectively trap and identify, guide electrophoretically the trapped molecule towards the edge, and obtain molecular information; for example, using a transverse electrochemical current generated between two edges separated by a physical gap on the order of the lateral dimension of the biomolecule.

In my research group, we conduct interdisciplinary research on graphene in the field of bionanotechnology. We particularly investigate the chemical properties of graphene from the perspective of using this material, for example, as a sensor by exploiting its unique surface and edge reactivity. To these ends, graphene has three fantastic properties: it conducts electricity outstandingly well, its edge is only a single carbon atom thin, and the fact that all the atoms are located on the surface makes graphene very sensitive to nearby environmental changes.