Graphene field effect transistors for biosensing and bioelectronics

Jose A. Garrido,
Lucas Hess, Benno Blaschke, Max Seifert and Martin Lottner

Walter Schottky Institut & Physik-department,
Technische Universität München, Germany

garrido@wsi.tum.de

The development of the future generation of neuroprosthetic devices will require the advancement of novel solid-state sensors and actuators with a further improvement in the signal detection capability, a superior stability in biological environments, and a more suitable compatibility with living tissue. To date, interfacing of living cells and tissue with solid-state electronic devices has mainly been based on conventional silicon technology, in particular using Si metal-oxide-semiconductor field-effect transistor (MOSFET) structures. However, some of the drawbacks associated with this technology, such as its limited stability in aqueous environments and a relatively high electrical noise, have triggered the study of alternative materials and technologies. In this respect, SGFETs based on Si-nanowires, AlGaN/GaN heterostructures, H-terminated diamond, carbon nanotubes and, more recently, graphene have been investigated as sensing devices.

Among these materials, graphene is a particularly attractive candidate for bioelectronic applications, due to its remarkable physical and chemical properties. The extremely high charge carrier mobility in graphene leads to a field-effect transistor (FET) performance that is superior to most known semiconductors. Since the first isolation of graphene in 2004, it has been recognized that the outstanding properties of this material could provide game-changing benefits in the development of highly sensitive sensors for advanced applications like biosensing or the detection of single molecules. Currently, graphene devices have been successfully used in several demanding biosensing applications, such as the detection of cell action potentials, protein adsorption, as well as the amperometric detection of different substances

This contribution will provide an overview on graphene based solution-gated field-effect transistors (G-SGFETs) and their application in biosensing and bioelectronics. We will first discuss the science and technology of SGFETs based on CVD graphene, comparing the performance of these devices with other competing technologies. Further, we will demonstrate a versatile route for the functionalization of graphene SGFETs aiming at the introduction of specific sensing mechanisms. Finally, we will report on the detection of action potentials of cells using graphene SGFETs. The high sensitivities of G-SGEFTs, combined with their biocompatibility and the possibility to use flexible substrates could pave the way for a new generation of neuroprosthetic devices, such as retinal implants.