Pedro Alpuim et al., J Material Sci Eng 2017, 6:6(Suppl)
DOI: 10.4172/2169-0022-C1-076

Graphene functionalized field-effect transistors for biomedical applications

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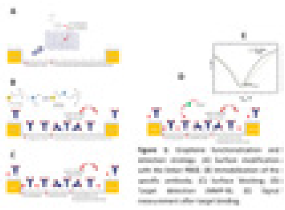
The importance of bio sensing systems in biomedical research is steadily increasing, as they became pervasive in a large range of health applications, from prognosis and diagnosis to personalized medicine. Graphene is a material of choice for sensing applications, with its highly conjugated, high mobility, zero bandgap 2D electronic system providing extreme sensitivity to charges and electric fields in its vicinity, combined with a high chemical stability and ease of processing. However, specific target biorecognition on graphene requires surface functionalization. We developed a general process for immobilization of probe molecules on graphene surfaces, based on π-π interactions with a pyrenic linker (PBSE). Electrolyte-gated field-effect transistors (FETs), with receded integrated gate architecture were fabricated at the 200 mm wafer scale followed by functionalization of the graphene channel for detection of antigens and DNA. A graphene immuno-FET is designed to detect the biomarkers of the hemorrhagic transformation of ischemic stroke. The probe is immobilized by reaction of the PBSE succinimidyl ester groups with a primary amine from the antibody protein. The device is able to detect the biomarker (MMP-9) in concentrations down to 0.01 ng/mL, in a range up to 10 ng/mL. Compared with existing MMP-9 immunoassays, ours has a much shorter time to diagnostic since it is based on a simpler label-free protocol. The nucleic acid sensor is made by immobilization of single-stranded DNA (25 nucleotides long) on the PBSE-functionalized graphene transistor channel. Hybridization with complementary DNA was detected down to 1 aM, with a saturation attained at 100 fM and sensitivity to single nucleotide polymorphism. These results show that the fabrication of graphene sensors using standard clean-room technology, with high sensitivity and low cost, is possible.



Biography

Pedro Alpuim is the Group Leader in 2D materials and devices at INL. He works in 2D materials CVD and device fabrication, with emphasis in biosensors. Optoelectronic devices for light detection and solar energy conversion are within his research interests. He is a Professor in the Physics Department of the University of Minho (UM), where he teaches graduate and undergraduate courses on the physics of electronic devices, nanotechnology, and clean-room fabrication. He received a PhD degree in Materials Engineering from IST Lisbon in 2003, working *in silico*n thin film devices for flexible electronics, and a Master's degree in Physics from the UM in 1995. He installed a thin-film laboratory at UM where he focused on fabrication of thin-film silicon solar cells, piezo resistive sensor arrays for health care and thermoelectric junctions of telluride compounds for micro-cooling and energy scavenging.

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