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Environmental XPS characterization of a bioengineered gold nanoparticle/porous silicon interface with calibrated surface conductivity

Porous Silicon (PSi) platforms are attractive supports for biomedical devices in a wide range of therapeutic and diagnostic applications. PSi structures are in fact biodegradable and can be easily bioconjugated. It is the association of a tailorable pore structure and a precise conjugation that provide the final properties of a PSi based biomedical assembly. In the present work, we have merged the conjugation strategies of PSi surfaces with those of gold nanoparticles (GNPs). From the side of PSi, an immunosensitve interface was formed by modification of the PSi surface with (3-Glycidyloxypropyl)-trimethoxysilane (GPTMS) and anchorage of an antibody (against prostate specific antigen (PSA), a cancer biomarker). The same antibody was tethered to GNPs so that calibrated interaction between platform and particles could be achieved by performing a sandwich assay with different concentrations of PSA. The process of surface modification of PSi was monitored step by step by using environmental X-ray photoelectron spectroscopy (env-XPS). This analysis showed that the freshly formed PSi presented no C-H contamination, the C-O contribution was the determinant contribution after GPTMS activation and that the O-C=O peak presented an intensity much more in agreement with what expected for a typical aminoacid chain than what typically reported with conventional XPS. The env-XPS analysis further confirmed the presence of GNPs on the surface. By performing identical protocols on PSi supports with interdigitated NiCr electrodes we could probe the surface conductivity. The NiCr contact formation implied an ion beam creation of 200 nm deep slots and their filling with NiCr, deposited by magnetron sputtering. The changes in the impedance upon PSA binding at different concentrations were detected. Relevantly, a device equivalent circuit could be proposed containing a series resistance element related to the surface conductivity. The series resistance decreased (the surface conductivity increased) for increasing concentrations of PSA. A combined dark-field and scanning electron microscopy study of the PSi surface after the bioassay demonstrated the increasing density of GNPs at higher PSA concentrations. The results suggest that specific immune reactions can be exploited to biofabricate interfaces with controlled physical parameters such as surface conductivity, which can be reversely used to fabricate highly sensitive biosensor devices.

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