Surface modification of 3C-SiC (001) via organic functionalization

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Statement of Purpose: The adhesion of cells to materials and biomolecular recognition processes are of high importance when considering the development of a biosensing and/or an implantable device. For instance, the process of cell attachment is mediated by the interactions between cell-surface receptors and extra cellular matrix (ECM) proteins adsorbed on the substrate, in which the wettability, roughness, and charge of the surface play important roles [1-3]. On the other hand, most biomolecule recognition-based systems require a covalent attachment of specific molecules with controlled structural order and composition [4].

Surface functionalization provides many advantages in the development of semiconductor based biosensor fabrication. It may be used for imparting molecular functionality to the substrate, thus enabling sensitivity towards chemical stimuli [4]. But the biocompatibility of the substrate must somehow be assured for systems that will be used *in vivo*.

Silicon carbide (SiC) is a very promising candidate for biotechnological applications. It is mechanically extremely hard, chemically inert, and biocompatible [5-8]. Despite the exceptional properties of this material, very little work, as compared to glass or Au surfaces, has been reported regarding the preparation of functional SiC surfaces.

The functionalization of SiC substrates for bio-inspired detection/recognition mechanisms has a very high potential for diverse applications [7]. Being that SiC is a biocompatible semiconductor, we have studied the adsorption of two organosilane molecules, namely octadecyltrimethoxysilane (ODTMS) and amino-propyldiethoxymethylsilane (APDEMS) on 3C-SiC (100).

Methods: n-type 3C-SiC was grown on Si (0001) in a CVD reactor at USF. The samples were then ultrasonically cleaned in acetone and isopropanol, followed by immersion in piranha solution (H_2SO_4:H_2O_2 2:1). Next a diluted HCl (1:2 HCl:H_2O) dip was performed followed by a 5% diluted HF dip. Self-assembled ODTMS layers were achieved by immersing the samples in a solution of 5% ODTMS in anhydrous toluene for 150 min at 14 °C. To support the reaction, 0.5% butylamine was added as a catalyst [9]. Finally, the samples were sonicated twice in toluene and methanol for 20 min each to remove any physisorbed molecules. For APDEMS, the samples were immersed in 1% APDEMS in anhydrous toluene for 90 min at room temperature in an Ar environment, followed by ultrasonic cleaning in toluene and isopropanol, for 20 min each [9]. After SAM formation, the samples were placed in ethanol to prevent bacterial growth and surface oxidation before cell seeding.

The characterization of the substrates was done by static water contact angle (SWCA) measurements. In addition, atomic force microscopy (AFM) measurement of the surface topography was performed using an XE-100 Advanced Scanning Microscope from Park Systems, along with X-ray photoelectron spectroscopy (XPS) and contact potential difference (CPD) measurements to assess the quality of the films.

Results: SWCA measurements give an idea of the degree of hydrophobicity and hydrophilicity of the functionalized substrates. The ODTMS functionalized substrates resulted in a hydrophobic surface (92±3°) whereas the APDEMS surface was moderately hydrophilic (51±4°) as in [9]. Surface topography analysis with AFM showed a similar roughness prior and after functionalization with no aggregates observed on the surface (~ 7.3 -8.8 nm).

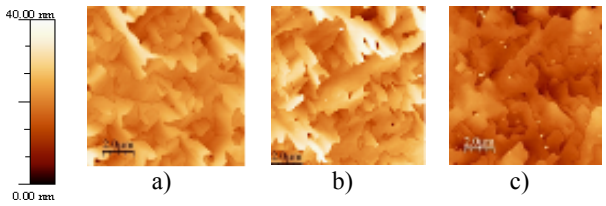

Fig 1. AFM of a) 3C-SiC b) ODTMS modified 3C-SiC and c) APDEMS modified 3C-SiC. Scan area 10x10 µm

XPS (data not shown) corroborates the presence of nitrogen (N1s) after silanization with APDEMS which is a sign of successful functionalization of the substrate. The C1s spectrum showed evidence of the hydrocarbon constituent of both molecules.

Conclusions: We have demonstrated the successful surface functionalization of 3C-SiC leaving free functional end groups. While the hydrophobic methyl group of ODTMS can serve as a starting point for the deposition of polymer supported lipid membranes, the reactive amino group of APTES could serve as the starting point for biomolecule immobilization or increased cell proliferation [10].

References:

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