Treatment of Aluminum Nitride Biosensor Surfaces for Improved Silanization

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The piezoelectric properties of aluminum nitride (AlN) films make this material a good choice for the base material in biosensor development. As the mass immobilized on the AlN surface changes, the electric signal across the sensor is modified. By correlating the change in mass to the change in the sensor signal, real time measurement of immobilized mass is realized. In order to immobilize a specific analyte, derivatization of the AlN surface by silanization is being investigated. The AlN films were pre-treated prior to silanization using two methods. In the first method AlN surfaces were treated by exposure to an oxygen plasma. The second method treated the AlN surfaces by ultrasonication in 3/1 (v/v) piranha solution, followed by rinsing in DI water. Piranha treatment was chosen because it is commonly used as a surface preparation method for silanization of other types of inorganic surfaces. The goal of a pre-treatment procedure is to improve the quality of the subsequent silane film. Pre-treatments on other types of surfaces are thought to create a clean and hydroxyl rich surface, which leads to a greater number of silane-to-surface bonds. Improved silane surfaces should create a more stable and ordered silane layer for the linkage of antibody, phage or other detecting ligands in the biosensor under development.

Four aluminum nitride films were grown using a plasma source molecular beam epitaxy method. Two films were grown on c-plane sapphire substrate and two were grown on Si (111) substrate. Previous characterization work has shown that AlN grown by this method is a c-plane oriented crystalline film. The composition is generally <10 atomic % oxygen in an other wise stoichiometric film. The untreated AlN films were characterized using air/water contact angle, x-ray photoelectron spectroscopy (XPS) depth profiling and atomic force microscopy (AFM).

Treated AlN samples were analyzed using air/water contact angle, AFM and XPS depth profiling. Preliminary results showed a significant reduction in contact angle after treatment by both methods. AFM scans showed an increase in surface roughness for both plasma and piranha treatments. Initial results from the XPS analysis indicate increased oxygen content in the film volume nearest the surface, but no effect on the deeper, bulk film material.

Both treated and untreated AlN samples were silanized with octadecyltrichlorosilane (OTS) using methods that have been described extensively in the literature for this same silane on other types of surfaces. The resulting silanized surfaces were characterized by air/water contact angle, AFM and XPS. Treated samples of Si (100) were also silanized and characterized as controls.

Results will be presented that describe the effects that piranha solution and oxygen plasma have on crystalline AlN films and their respective attributes as treatment methods for AlN surface derivatization by OTS. The results will also clarify the feasibility of using silanes to derivatize AlN surfaces on Si (111) and sapphire substrates. The ability to produce repeatable, homogeneous layers of selected chemical groups by silane derivatization of the AlN surface is considered a promising step in the development of a biosensor that uses surface immobilized phage or antibody ligands for analyte detection.