556g Plasma-Induced Graft Polymerization of Polyvinyl Acetate Nanofilms Onto Inorganic Oxide Surfaces

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Polymer films have been used for surface engineering of inorganic and organic substrate surfaces to enhance substrate chemical selectivity and modify surface topology in such areas as biotechnology, tribology, chromatography, chemical sensing and separation technology. Thin polymer films which are applied via traditional spin-coating or surface adsorption have low thermal and chemical stability which can lead to film dewetting and surface degradation. In contrast, grafted polymer films are composed of polymer chains that are covalently tethered to the substrate surface. Thus, by graft polymerization, a robust, grafted polymer phase on a substrate surface with unique nanoscale-sized topological properties can be engineered.

Polymer films can be graft polymerized onto substrate surfaces via free-radical initiators, cationic/anionic initiators, or by using a combination of a catalyst and an initiator for controlled graft polymerization. Yet, each of these techniques relies on the presence of initiator sites covalently bound to the surface by silylation, Self Assembled Monolayers (SAM), or functionalized molecules that act as anchoring sites for monomer grafting on inorganic oxide surfaces. The surface density of initiation sites is limited by the intrinsic availability of native surface hydroxyl groups for attaching the initiators to the substrate (e.g., silicon oxide averages 5 hydroxyl groups/nm2). An alternate approach that overcomes the limitations of surface hydroxyl chemistry is plasma-induced graft polymerization. In this approach, high energy plasma particles can be employed to chemically alter the substrate so as to create surface peroxide groups that can be used as grafting initiators. The density of initiation sites on the substrate surface is controlled by the properties of the plasma (RF power and the substrate treatment time). However, grafted polymer density is also demonstrated to be a strong function of surface pretreatment, substrate surface water coverage and appropriate gas exposure of the substrate following plasma surface treatment. By controlling these parameters, a higher density of grafted polymer chains can be achieved in comparison to traditional approaches.

In the present study, we report on surface modification of Silicon <100> wafers via plasma-induced graft polymerization by utilizing hydrogen plasma for surface treatment with subsequent grafting of Vinyl Acetate. The presence of the grafted polymer chains on the substrate was confirmed by contact angle and infrared spectroscopy. Surface topology and surface feature uniformity was evaluated by Atomic Force Microscopy (AFM). A statistical representation of polymer chains on the surface will be presented through surface feature radial distribution, polymer height and volume distribution, and polymer feature mapping to estimate the mean polymer interchain distance. The topological feature properties of the unique plasma modified surface will be compared to conventional approaches such as free-radical graft polymerization and controlled/living graft polymerization to demonstrate the advantages of plasma initiation.