Surface modification by ion implantation, microfabrication and plasma treatment

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Surface modification using three different methods are presented. The first method consists on very low energy (49 eV) gold ion implantation in the polymer PMMA (polymethylmethacrylate). The result is a thin subsurface metal-polymer layer with gold nanoparticles of size less than 10 nm. In situ resistivity measurements were performed as the implantation proceeded. Theoretical models suggest that the metal/polymer composite conductivity is due only to percolation and that the contribution from tunneling conduction is negligible. TEM, STM and AFM were used for imaging the buried gold layer and individual nanoclusters. The gold implantation process was modeled by computer simulation using TRIDYN and accurately predicted the layer width. The composite gold/polymer was also characterized by SAXS (Small Angle X-ray Scattering) giving information about monomer size, gyration radius, correlation distance, mass fractal dimension and surface fractal dimension. The second method consists on microfabricating periodic microstructures. We have modeled, fabricated, and characterized superhydrophobic surfaces with a morphology formed of periodic microstructures which are cavities. This surface morphology is the inverse of that generally reported in the literature when the surface is formed of pillars or protrusions, and has the advantage that when immersed in water the confined air inside the cavities tends to expel the invading water. This differs from the case of a surface morphology formed of pillars or protrusions, for which water can penetrate irreversibly among the microstructures, necessitating complete drying of the surface in order to again recover its superhydrophobic character. We have developed a theoretical model that allows calculation of the microcavity dimensions needed to obtain superhydrophobic surfaces composed of patterns of such microcavities, and that provides estimates of the advancing and receding contact angle as a function of microcavity parameters. The model predicts that the cavity aspect ratio (depth-to-diameter ratio) can be much less than unity, indicating that the microcavities do not need to be deep in order to obtain a surface with enhanced superhydrophobic character. Specific microcavity patterns have been fabricated in polydimethylsiloxane and characterized by scanning electron microscopy, atomic force microscopy, and contact angle measurements. The measured advancing and receding contact angles are in good agreement with the predictions of the model. The third method consists on plasma treatment of diamond surface. We have formed and characterized polycrystalline diamond films with surfaces having hydrogen terminations, oxygen terminations and fluorine terminations, using a small plasma gun to bombard the diamond surface, formed by plasma assisted CVD in a prior step, with ions of the wanted terminating species. The potential differences between surface regions with different terminations were measured by Kelvin Force Microscopy (KFM). The highest potential occurred for oxygen termination regions and the lowest for fluorine. The potential difference between regions with oxygen terminations and hydrogen terminations was about 80 mV, and between regions with hydrogen terminations and fluorine terminations about 150 mV. Regions with different terminations were identified and imaged using the secondary electron signal provided by scanning electron microscopy (SEM), since this signal presents contrast for surfaces with different electrical properties. The wettability of the surfaces with different terminations was evaluated, measuring contact angles. The sample with oxygen termination was the most hydrophilic, with a contact angle of 75°; hydrogen-terminated regions with 83°, and fluorine regions 93°, the most hydrophobic sample. In this diamond modified surface, human dental stem cells (hDSC) were growing, presenting different behavior for regions treated with different plasmas.