Nanostructured surfaces

Deposition of calcium silicates and hydroxyapatite nanocoating on silicon using ultrasonic cavitation technique

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Silicon-based devices often suffer from the problem of interfacing to the biological environment. At the same time, an increasing number of silicon-containing materials are being studied for application in biomedical materials and devices. For example, biomaterials containing $CaO–SiO_2$ appeared to excellent bioactivity and were found to bond have to living bone and soft tissue. Calcium inosilicate (Wollastonite, $CaSiO_3$) have been studied as materials for hard tissue repair, artificial bones and dental roots. At the same time, calcium phosphates are widely used in biomedical applications, since their chemical composition is roughly equivalent to that of the inorganic matrix of human bone. Among them, special attention has been paid to hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$ due to its exceptional high affinity to biological molecules due to the presence of positive (Ca^{2+}) and negative (PO_4^{3-}) ions on the surface.

In this study, a possibility of the fabrication of a hybrid structures $Si\backslash CaSiO_3$ and $Si\backslash Ca_{10}(PO_4)_6(OH)_2$, which integrates the nanostructured silicon with bio-active calcium phosphates and calcium silicate, using the simple and low-cost ultrasonic based technique has been demonstrated. The effects of ultrasound derive primarily from cavitation, where bubble collapse results in an enormous concentration of energy from the conversion of the surface energy, kinetic energy of liquid motion into heat and chemical energy. AFM, Micro-Raman as well as X-ray diffraction and FTIR spectroscopy was used for the obtained structures characterization.

The study shows that the cavitation impact initiated by focusing a high-frequency acoustic wave into liquid nitrogen at a frequency ranging from 3 MHz to 6 MHz resulted in Si surface structurization and deformation at the nanometer scale. This result is confirmed by the XRD and -Raman investigation. Moreover, calcium silicate is synthesized on Si substrate during sonochemical processing of the one, whereas a dense and uniform coating of hydroxyapatite could be achieved after 30 days of immersion of sonicated silicon substrate in simulated body fluid (sbf).