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Robust plasma activated coatings for orthopaedic implant applications

Behnam Akhavan, Steve Wise, Marcela Bilek

The University of Sydney, Sydney, Australia

behnam.akhavan@sydney.edu.au

The use of bone implantable devices has become a viable alternative treatment for patients suffering from bone diseases. In 2010, there were more than 400,000 knee and hip replacement surgeries undertaken in Germany alone. Zirconium-based alloys are promising materials for orthopaedic prostheses due to their low toxicity, superb corrosion resistivity, and favourable mechanical properties. The bare surfaces of metals, however, lack the specific surface chemistry and may trigger foreign body response, inflammation, or infection. The integration of such bio-implantable devices with local host tissues can be strongly improved by the development of plasma polymerized acetylene and nitrogen (PPAN) that covalently immobilizes bio-active molecules. The stability of the plasma polymerized layer in body fluids is critically important and must resist failure even when scratched. In this study, we present a novel approach for the fabrication of chemically and mechanically robust films through deposition of PPAN on biased zirconium substrates. A custom-made plasma polymerization system consisting of a RF electrode and a pulsed voltage source was utilized for plasma polymerization. As evidenced by both XPS data and SEM observations, the PPAN film resisted failure, while no delamination, cracking, or buckling was observed after scratching and subsequent incubation for 1 week to 2 months in Tyrode's solution at 37°C. XPS results revealed that excellent zirconium-PPAN adherence is linked to the formation of metallic carbide and carbonate bonds at early stages of film growth induced by ion implantation. Such atomic interfacial mixing resulted in the formation of a continuous smooth film near the substrate as suggested by AFM and ToF-SIMS results. Deposition of PANN via this technique holds great promise for the fabrication of robust bioactive surfaces on other carbide-forming early transition metals such as titanium and niobium.

Keywords
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