On Antimicrobial Surface Modifications of Titanium Substrates by Metal Plasma Immersion Ion Implantation and Deposition for Medical Applications

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Abstract

Medical implants are widely used in surgery and dentistry, i.e. for total joint replacement or dental implants. However, an implant remains a foreign material in the human body and therefore its surface has to be biocompatible. In particular no adverse reaction should be provoked and a fast integration into the functionality of the respective tissue has to be guaranteed. Additionally, implants should exhibit an antimicrobial effect to minimize the implant-associated risk of infection. Such infections are a huge problem in clinical practice since microorganisms can cause severe adverse effects in combination with tissue necrosis in the worst case. These infections can even persistent against antibiotics and the body's immune system. Hence, revision surgery is required in most cases.
Titanium is a widespread material for implants due to its favourable material and mechanical properties. Surfaces of Titanium implants should ideally be designed to promote the attachment of target tissue cells. At the same time, they should prevent bacterial adhesion, achievable through specific modification strategies. Copper could be well-suited as an antimicrobial finish, since it combines good antimicrobial properties with a certain bio-tolerance with regard to eukaryotic cells.
In this contribution, we present results of the implantation and deposition of Copper into the subsurface and on the titanium substrate surface by means of plasma ion immersion implantation and deposition (Cu-PIII&D). Depending on the sample mount and on the process parameters, the absolute amount of copper on and in the surface and the copper release from the surface can be adjusted respectively. It was found, that the kinetic of the copper release in Dulbeccos modified eagle medium (DMEM) can be adjusted between some μmol/l up to 3 mmol/l Cu. Furthermore, the longtime release varieed between a full release after 2 days and a remaining release of more than 1 mmol/l even after 7 days. This also affects the antimicrobial properties of the modified surface and reveals promising strategies to avoid biofilms on Titanium implants.

Keywords: medical implants, antimicrobial, copper

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