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Plasma Immersion Ion Implantation-induced polymer densification for the production of silver-containing antimicrobial coatings on medical implants

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Infections, especially by multi-resistant bacteria, are one of the main problems in modern-day implant surgery. Coatings containing silver nanoparticles are a very promising approach to this matter.
Ag-nanoparticles can be introduced into hydrogenated, diamond like carbon (a-C:H), which is a very suitable material for implant coatings due to its high biocompatibility and wear resistance.
In contrast to standard PVD/CVD methods, we follow an alternative hybrid synthesis route based on the ion induced transformation of silver–polymer nanocomposites into Ag-nanoparticles-containing a-C:H. Starting with the deposition of a nanocomposite of colloidal metal and a polymer by wet chemistry this polymer layer is subsequently transferred into DLC by ion irradiation. For the irradiation both conventional ion implantation and plasma immersion ion implantation have been used, while the latter is preferred due to its possibility to irradiate the three-dimensional replacement parts. With this approach, we were able to coat both smooth and rough medical titanium substrates, as used in joint replacing implants, with a wide range of different silver concentrations in the coatings.
Presence of high concentrations of Ag-nanoparticles within the DLC matrix have prevented the growth of the human pathogenic bacteria Staphylococcus aureus and Staphylococcus epidermidis, proving the antimicrobial activity of the generated implants. Cultivation of various mammalian cells revealed a high biocompatibility of the DLC matrix without Ag-nanoparticles. However, DLC layers containing Ag-nanoparticles exhibit a dose dependent cytotoxicity that increases with increasing silver concentrations while antimicrobial Ag-concentrations were also toxic for all tested mammalian cell types.
Further on, we developed a new method based on surface acoustic waves that enables the investigation of cell adhesion strengths on implant surfaces under shear flow.

Keywords
Antibacterial Coating