Titanium surface engineering using detonation nanodiamonds towards biomedical applications

Sascha Balakin [a, b], Lotta Römhildt [b], Joerg Opitz [b], Gianaurelio Cuniberti [a, c, d]

[a]Institute for Materials Science and Max Bergmann Center of Biomaterials, Dresden University of Technology, Budapesterstrasse 27,D-01069 Dresden, Germany
[b]Fraunhofer IKTS, Fraunhofer Institute for Ceramic Technologies and Systems, Materials Diagnosis IKTS-MD, Maria-Reiche-Straße 2, D-01109 Dresden, Germany
[c]Dresden Center for Computational Materials Science, Dresden University of Technology, D-01062 Dresden, Germany
[d]Center for Advancing Electronics Dresden, Dresden University of Technology, D-01062 Dresden, Germany

Titanium and titanium-based alloys have been used as implant material for a long time, due to their high ratio of tensile strength and young modulus (σ_U/E), excellent corrosion properties and high biocompatibility, respectively[1]. The rate and quality of osseointegration in titanium implants are strongly related to their surface properties. In order to improve the biological, chemical, and mechanical properties, surface modification is often performed[2] using various coating materials.

We propose denotation nanodiamonds (DNDs) as a coating material for biomedical applications, due to their nontoxicity, structural and surface properties. According to the high variety of functionalization possibilities DNDs can be integrated in composites, biological systems, electronics, and surface technology[3]. The Fig. 1 shows two innovative approaches: (A) enhanced biocompatibility of metallic implant materials using hierarchical structures of DNDs. These micro- and nanostructures, created by photolithography based processes, will improve the cell attachment. A possible solution to reduce the healing time of implants is shown in approach (B). The first stage contains the establishment of an anodic oxide layer with intrinsic homogenously distributed DNDs. Afterwards, bioconjugated DNDs will be attached to this oxide layer. Promising candidates for a biofunctionalization of DNDs are growth factors, antibiotics and antimicrobial peptides (AMPs). AMPs offer an alternative strategy to conventional antibiotics with a broad-spectrum activity (antibacterial, antiviral and antifungal) and a rapid onset of killing[4].

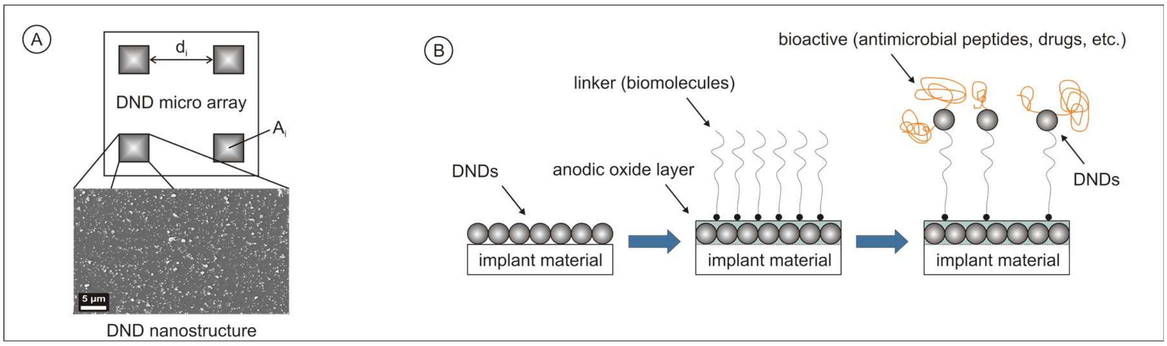

Fig 1: *(A) Nano- and microstructuring of Ti using DNDs with various structure sizes Δd_i or array areas ΔA_i, respectively (B) Bioconjugated DNDs covalent attached to an anodic oxide layer with incooperated DNDs[5] to enhance the implant material surface properties.*

These hypotheses will be verified experimentally using osteoblast migration, proliferation and differentiation tests. In the first stage structural investigations were conducted. We are going to present the first outcomes regarding properties of the DND coating suspensions as well as DND surface chemistry and DND coating topography. The used methods are zeta potential and dynamic light scattering measurements, infrared spectroscopy as well as SEM top view of DND coatings.

[1] M. Niinomi, Science and Technology of Advanced Materials 4, **2003**, 445
[2] X. Liu et al., Materials Science and Engineering: R: Reports Vol.47, **2004**, 49
[3] A. Krueger, Adv. Mater. 20, **2008**, 2445
[4] Y. J. Gordon et al. Curr Eye Res. 30(7), **2005**, 505
[5] A. Shaikh, PhD thesis, TU Dresden, submitted **2016**