P110

Antibacterial copper deposited onto and into the oxide layer of titanium implants

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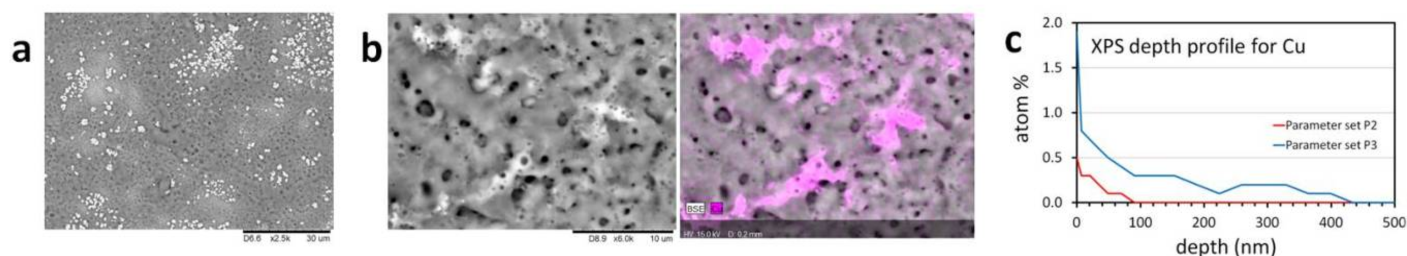
Introduction:

Bacterial infections taking place immediately or years after orthopaedic, trauma or dental surgeries cause serious problems for the patients. Functionalizing implant surfaces by antibacterial copper may represent a promising strategy to reduce the risk of infections immediately after implant placement but also to prevent late infections. We present data on surface treated titanium demonstrating the successful functionalization of implants with antibacterial copper.



Materials and Methods:

Discs (Ø12 mm, 2 mm thick) of commercially pure titanium of grade 4 were anodized according to the spark-assisted anodizing method (SAA method) [1]. The SAA method was modified in such a way that copper was electrochemically deposited in a combined deposition-anodizing process using a proprietary electrolyte and proprietary process parameters (KKS TioCel^{TM}). Three sets of process parameters (P1, P2, and P3) were applied which differ essentially in the process time and the consumed cathodic charges. The process times of the parameter sets follow the sequence P1 < P2 < P3 and the transferred cathodic charges are 20 As, 123 As and 202 As. The surface was characterized by SEM/EDX (Hitachi TM3000) and XPS depth profile analysis using argon ion sputtering (PHI Quantum 2000).

Results and Discussion / References:

Depending on the process parameters either copper onto or into the oxide layer of the implant surface is observed (Fig. 1a and 1b).

Figure 1 SEM images of the titanium discs after the electrochemical process using (a) parameter set P1, revealing copper particles (white spots) on the surface and (b) parameter set P3 showing smeared copper regions within the oxide layer (bright areas in the left backscattered electron image and magenta regions identifying Cu in the EDX mapping on the right). c) The XPS depth profile of copper for samples treated with parameter sets P2 and P3 is shown.

Process parameter set P1 leads to superficial Cu cluster whereas no copper particles are detected for parameter sets P2 and P3. Smeared copper regions within the oxide layer are instead detected by EDX mapping and XPS depth profile analysis (Fig. 1c). Interestingly, the prolonged process time and larger amount of transferred charges for P3 is reflected in a deeper occurrence of copper in the oxide layer down to 400 nm compared to only 70 nm for P2. These data show that copper can be successfully incorporated into the oxide layer. Release kinetics for copper deposited into the surface is expected to be slower than for copper adsorbed onto the surface [2]. A slower release might be beneficial to prevent late infections.

REFERENCES

[1] C. Jung (2010) *European Cells and Materials*, **19** (Suppl 2):4.

[2] A. Kessler, L. Straumann, U. Pieles, M. de Wild, C. Jung (2014) *European Cells and Materials*, **27** (Suppl 2):24.

Bereitgestellt von | Fachhochschule Nordwestschweiz FHNW
Angemeldet
Heruntergeladen am | 21.11.14 16:21