

Holographic identification of titanium implants

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INTRODUCTION: An innovative design attribute was developed as Unique Device Identification (UDI) for medical devices [1]. Holographic security features and highly complex Diffractive Optical Elements (DOE, revealing images like QR codes, logos, article or lot numbers when illuminated by a laser, see Fig. 2) are integrated directly into the titanium implant material to ensure traceability or brand protection to prevent product counterfeiting. This nanostructured surface-labelling is fully tissue-compatible because the embossing process is based on a physical structuring of the implant surface without additives or coating. The underlying holographic nanostructures are resistant to all conventional sterilization methods.

METHODS: A structured, ultra-hard steel stamp was used to emboss the surface of titanium parts for holographic labelling. The visibility of the created holograms was investigated for different process parameters and the precise and detailed sub-micrometer structure of the embossed surface was qualified by SEM and AFM. Wear tests have been performed for up to 5'000 stamping cycles on a moving titanium plate to prevent the same spot from being repeatedly stamped.

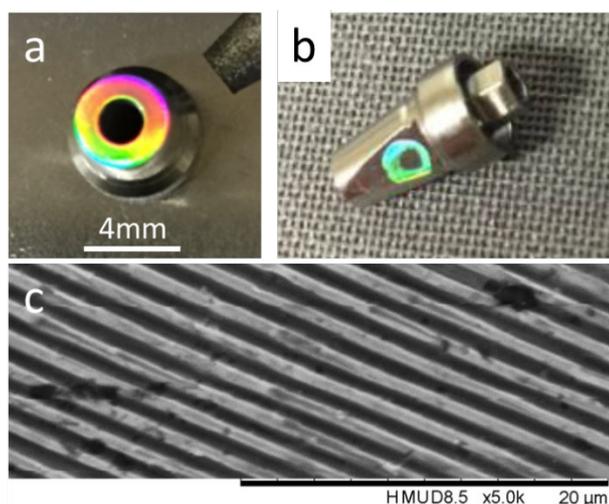


Fig. 1: a, b) Clearly visible embossed holograms on Ti abutments. c) Scanning Electron Microscopy image shows the periodicity of the diffractive structure on the tooled titanium surface.

RESULTS: The holographic structures can be transferred from the stamp to the surface of the titanium components. Diffractive characteristics

like iridescent light effect can be detected visually under white light (see Figures 1a and b) and the corresponding periodic pattern can be observed by SEM (Figure 1c). The most important process parameters identified were the temperature, the contact force per unit area and the surface roughness of the area to be stamped. With constant forming force, the embossing process becomes more efficient at higher process temperature and decreasing surface roughness of the stamping area.

The durability test of the stamp revealed a serviceability up to 5'000 tooling cycles. Although the average grating height of the master structure on the stamp was reduced by 32 %, the holographic effect is still nicely visible on the stamp and on the imprinted Ti devices. Even incompletely embossed patterns work as long as there is periodicity.



Fig. 2: A DOE-diffracted laser produces a visible, precalculated image on a screen.

DISCUSSION & CONCLUSIONS: It has been demonstrated that it is possible to transfer diffractive sub-micrometer structures such as visible holograms and Diffractive Optical Elements into titanium implant material. This unique holographic identification feature allows verification of the authenticity of implants, prosthetic parts or instrument and could serve as a UDI for medical devices.

REFERENCES: ¹ Unique Device Identification (UDI) for medical devices, Task Order No. 24, food and drug administration (2012).

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