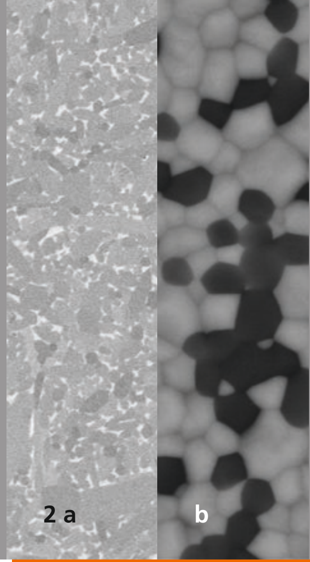

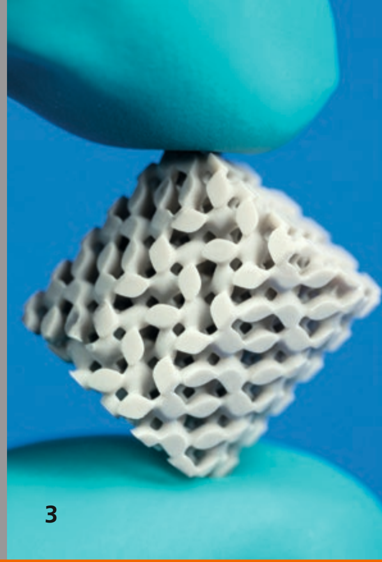

OSSEOINTEGRATIVE SURFACE DESIGN FOR CERAMIC FINGER JOINT IMPLANTS

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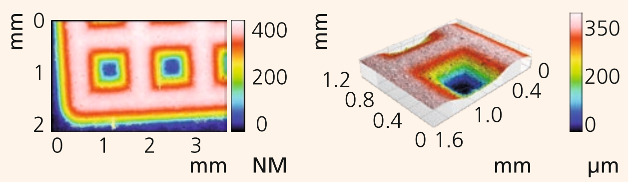
Patient-specific implants promise a high degree of fit accuracy and thus better functionality and durability. Individualization is also a great opportunity for those fields in which the possibilities of implant restoration and remobilization are still limited. For small joints, especially in the area of finger joints, therapy consists mainly of stiffening joints, which reduces mobility. In Germany alone, this affects 5 million people suffering from symptomatic arthrosis and 1.5 million people suffering from rheumatic diseases. In the Fraunhofer-internal project "Remobilization of Finger Joints by AI-based Reconstruction and Development of Patient-Specific Ceramic Implants – FingerKit", the Fraunhofer institutes IAPT, IKTS, ITEM, IWM and MEVIS are collaborating to enable, for the first time, a continuous, automatable process chain in the manufacture of patient-specific implants, from design to manufacture, to certification-compliant testing.

In this project, IKTS focuses on the material and surface design of ceramic implants. The long-term stability of custom-made finger joint implants is to be significantly increased compared with commercially available standard variants by customizing the mechanical strength, osseointegration (growth of bone cells onto the implant) and implant design. The slip casting process for the oxide ceramic materials 3Y-TZP and alumina-toughened zirconia (ATZ) enables direct shaping in a porous, structured mold. This requires the production of complex shaped casting molds with an integrated structure. The molding behavior was investigated during the casting process and material characteristics were determined. The goal is to manufacture finger joint prototypes with a macro-/microstructure of the outer surfaces in a single process step.

An exemplary macro-/microstructure is shown in Figure 1 by using white light interference microscopy.

In a parallel development track, silicon nitride (Si_3N_4) is used as bioceramic material. Implant production will be realized with the CerAM VPP process (Lithoz LCM technology), a 3D printing technology. This process can be used to create, for example, the so-called TPMS structures (triply periodic minimal surfaces, Figure 3), which have many advantages in terms of mechanical properties and osseointegration. Furthermore, the unique surface chemistry of Si_3N_4 is modified to further optimize interaction with the surrounding tissue. With this targeted topographic and chemical modification of the ceramic surface, osseointegration of implant materials is to be significantly improved.

Topography of an implant using white light interference microscopy



1 X-ray of a diseased hand (Source: istock: WILLSIE).

2 Microstructure of Si_3N_4 (a) and ATZ (b).

3 TPMS structure made of Si_3N_4.

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