Novel approach for Additive Manufacturing of silicon nitride-based finger joints via vat photopolymerization (CerAM VPP) technology.

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Patients who receive joint stiffening due to wide variety of causes are restricted in their freedom of movement, which increasingly becomes a challenge for their quality of life with increasing age. The Fraunhofer Society therefore pursued a novel approach to solve this problem by a cross-institutional project "Fingerkit". In this project, AI methods are used to design individual finger joint implants based on patient-specific data automatically. The implant designs require a dense wear couple section combined with a parametrized meso-macro porous TPMS (Triple Periodic Minimal Surface) as the implant stem for optimized bone ingrowth.

One part of Fraunhofer IKTS was to realize the designed implants in ceramic using near-net-shaping methods such as additive manufacturing, because ceramics have the advantage of being metal-free with comparable strength and are even biologically better tolerated. In addition to its generally excellent properties, such as hardness, high mechanical strength, wear, and corrosion resistance or even stability at high temperatures, silicon nitride (Si_3N_4) is a very interesting material for medical applications, as the material surface can be tuned by chemical treatment or micro structuring, for instance.

In previous projects, Fraunhofer IKTS has already developed a high performance Si_3N_4 material (≥ 1000 MPa bending strength) optimized for dry pressing. However, complex implant designs and high demands on accuracy require the use of high-resolution printing technologies such as lithography-based processes. Fraunhofer IKTS uses a DLP-based CerAM VPP process (Lithoz LCM technology). For this purpose, the high performance Si_3N_4 material was adapted to develop a new photoreactive suspension for the LCM printing technology.

The authors would like to give an insight into the research project, with focus on Si_3N_4 suspension development (40 vol.% solid content) and characterization, manufacturing of test components (density > 99 % related to th. D.) and on novel finger implants made of Si_3N_4.