ADDITIVE MANUFACTURING OF MONOMER-FREE ORMOCER®-BASED COMPOSITES FOR DENTAL AND AUDIOLOGICAL APPLICATION

Herbert Wolter, “Dental and Micromedicine”, Fraunhofer Institute for Silicate Research (ISC), Germany
herbert.wolter@isc.fraunhofer.de
Carina Kolb, “Dental and Micromedicine”, Fraunhofer Institute for Silicate Research (ISC), Germany
Somchith Nique, “Dental and Micromedicine”, Fraunhofer Institute for Silicate Research (ISC), Germany

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Additive manufacturing has a great potential, especially in the medical area where patient individual parts are required. However, there is still a lack of biocompatible materials which are printable and meet the high requirements of the targeted fields of end-use application (indirect dental restoration and earmolds). For this purpose, new types of inorganic-organic hybridpolymers (ORMOCER®s) with the indispensable biocompatibility, combined with an adapted profile of properties, have been developed.

For earmolds (audiological application, s. Fig. 1), the resulting materials show a thermoeffect, i.e. stiff/hard at room temperature (for an easy handling/cleaning) and soft/flexible at body temperature (for a comfortable wearing). The minimal storage modulus is in the range of 15 - 99 MPa, the maximal storage modulus at room temperature is up to 2550 MPa, each determined by dynamic mechanical analysis (DMA). As the softening temperature (15 - 49 °C) is also outside the normal body temperature, other applications are possible.
To achieve the aesthetic and mechanical properties for a permanent indirect dental restoration (e.g. a crown, tooth) the ORMOCER®-based resin was modified by incorporation of various filler types and sizes. Highly refractive nanoparticles like ZrO_2 were used to match the refractive index of the matrix material and the macroscopic dental glass particles to achieve the desired high, tooth-like translucency. Mechanical tests show a high flexural strength (up to140 MPa) and a Young´s modulus of 5.5 GPa, determined by three-point bending test referring to DIN EN ISO 4049:2009 (dry storage).

Figure 1: Earmolds with thermoeffect

Figure 2: Stent-like structures with memory effect

For both types of material, 3D printing was successfully implemented by using Digital Light Processing (DLP) in combination with an optimized washing and final curing step. The filigree structure of the earmolds and the high-resolution of the occlusal structure of artificial teeth/crowns was possible.

Furthermore, 3D-printed stents (model, s. Fig. 2) based on materials with thermoeffect are a promising future application in the medical field. In particular, a memory effect arising from the thermoeffect of the material is crucial regarding the ability to unfold the compressed and stiff stent when it is implanted into the body by raising the temperature to 37 °C.