



ADDITIVE MANUFACTURING OF HIGH STRENGTH OXIDE CERAMICS VIA SELECTIVE LASER MELTING (SLM)

Rapid Manufacturing (RM) techniques, more specifically Selective Laser Melting (SLM) allow for fast generation of complex, net-shaped objects, based on 3D-CAD data. At the Fraunhofer Institute for Laser Technology (ILT) the possibility of creating $\text{Al}_2\text{O}_3 / \text{ZrO}_2$ parts via SLM was firstly introduced. The specimens reach densities of > 99 % and crack formation is fully suppressed by means of a high temperature preheating.

Task

Besides creating dense, crack-free and thus, high strength oxide ceramics limitations to the surface finish still persist. Accordingly, a surface roughness of $R_z 150 \mu\text{m} - 200 \mu\text{m}$ is achieved. Therefore, a reduction of the surface roughness is subject to present research.

Approach

In order to suppress crack formation, a homogenized CO_2 -laser beam is applied for high-temperature preheating of the powder bed, reaching preheating temperatures of just below the melting point of the applied powder mixture (~ 1830 °C). Due to this high preheating temperature a large low-viscous melt pool evolves during selective melting. This melt pool exceeds the specimen's boundaries, causing poor

surface qualities. Online process control by means of high speed videography allows for analyzing the dynamic of the melt pool. Based on this analysis appropriate process parameters and scanning strategies may be identified. Accordingly, the surface finish is improved by using a multi contour scan at elevated scanning velocities where the contour scans serve as a barrier against spilling of the melt pool.

Results

The above mentioned strategy allows for generating structural oxide ceramics consisting of 58.5 wt.-% Al_2O_3 and 41.5 wt.-% ZrO_2 at a surface roughness of $R_z < 70 \mu\text{m}$ at densities of > 99% without any formation of cracks.

Applications

Main application for additive manufacturing of structural ceramics is the individual fabrication of dental restorations. This new approach aims at reducing manufacturing costs due to high material efficiency and absence of any tool wear, thus, securing competitiveness of German manufacturers of dental restorations.

Further applications can be found as high temperature and high wear appliance in the aerospace and automotive sector.

Contact

Dipl.-Ing., Dipl.-Wirt.-Ing. Yves Hagedorn M.Sc.
Phone +49 241 8906-674
yves-christian.hagedorn@ilt.fraunhofer.de

1 Process control: Selective Laser Melting of ceramics.

2 Ceramic framework for dental restorations.