Analysis and Optimization of the Binder Burnout of 3D-Printed Ceramic Components

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The production of sophisticated ceramic components by means of 3-D printing is becoming increasingly important in modern industry. Thanks to this method, prototype production or the manufacture of small series can be realized much faster and more efficiently compared to alternative or traditional ceramic manufacturing processes. One of the leading manufacturers in the field of lithographic 3D-printers for ceramic components is Lithoz GmbH, Vienna, Austria. Through interdisciplinary collaboration between specialists from the fields of mechanical engineering, process engineering and chemistry, Lithoz has succeeded in developing a manufacturing system which enables for additive manufacturing of ceramics for industrial and medical applications.

In lithography-based ceramic 3D manufacturing (LCM), an emulsion consisting of a ceramic powder and a UV-curing liquid binder is exposed to light, layer by layer, so that a three-dimensional ceramic green body is obtained over time. The green body is then heat-treated in a furnace, where the organic binder is burned out. Subsequently, the green body is sintered at higher temperatures and the final ceramic component is obtained. The heat treatment has decisive influence on the structure and properties of the final product. Too fast debinding can lead to cracks in the structure, which will not anneal during sintering.

Presented in this work is the thermal characterization of an alumina green body with ~21% organic binder (UV-cured organic). Measurement techniques such as Thermogravimetry (TGA) and Simultaneous Thermal Analysis (STA) were employed to gain a deeper insight into the binder burnout. The influence of heating rates (different time-temperature regimes) and different sample shapes (solid, crushed) was analyzed. Furthermore, kinetic analysis was carried out to allow for modelling of the binder burnout temperature profile. Dilatometry (DIL) and Laser Flash Analysis (LFA) were used to analyze the change in density and thermal diffusivity/conductivity during sintering. The results obtained can be used to optimize temperature control, thereby, avoiding structural damage during heat treatment, and, thus, designing efficient manufacturing processes.