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A MULTI-PHYSICS, MICRO-MECHANICAL MODEL OF THE ADDITIVE MANUFACTURING PROCESS OF CERAMICS

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Fabrication of ceramics through an additive manufacturing (AM) process opens up new possibilities in comparison to conventional ceramic manufacturing techniques. The high geometrical flexibility allows for the production of complex components even in small series. The process chain is highly similar to the injection molding of ceramics using a polymer binder [1], whereas in this case the part geometry is constructed through stereolithography. The ceramic particles are resolved in a photo-active monomer resin that is deposited and selectively illuminated in a layer-wise fashion. This intermediate, 'green' phase ceramic part is then finished into the final product by a subsequent debinding and sintering step.

Although the current state-of-the-art facilitates printing of small structures with fine features accurately, several challenges prevent the manufacturing of larger technical ceramics. The main challenge is to avoid the formation of cracks for increasing structural dimensions [2]. In order to improve the mechanical properties of the green product, further understanding of the stereolithography process is necessary. To this end, a multi-physics, micro-mechanical finite element model has been developed [3]. This model relates process parameters, e.g. light source characteristics, and material properties, e.g. ceramic filling fraction, to the development of residual stresses and deformations in the green product.

In this contribution, the model is used to perform several parameter studies to investigate the effect of particle distributions and geometries, refractive properties and illumination strategies on the quality of the green product. Furthermore, the model is employed to derive relations between process parameters and resulting mechanical properties on a macroscopic level of observation. These homogenized relations can be used to perform numerical simulations of the building process on a structural scale.

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