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Multiphysical modeling of the photopolymerization process for additive manufacturing of ceramics

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Abstract

Additive manufacturing (AM) of ceramics through vat photopolymerization is a promising technique in which a ceramic filled photopolymer is selectively solidified in a layer-wise manner towards the final part geometry. Large scale adoption and optimization of AM for ceramics requires an in depth understanding of the process, which is pursued through a theoretical-numerical approach in this work. A modeling framework is proposed that integrates the coupled effect of four relevant physical mechanisms: *(i)* light propagation through the heterogeneous matter; *(ii)* conversion of the photopolymer; *(iii)* thermal effects and *(iv)* evolution of mechanical properties upon solidification. Interestingly, the inclusion of ceramic particles (compared to the regular vat photopolymerization process) has a marked influence for each individual physical mechanism. Even though the individual key ingredients are established, the coupled and integrated framework provides innovative insights, demonstrating how difficult it is to achieve homogeneous polymerization for ceramic-filled resins.

Keywords: additive manufacturing, ceramics, vat photopolymerization, process modeling, coupled multiphysics, micro-scale modeling

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