TU/e MSc THESIS AWARD 2020
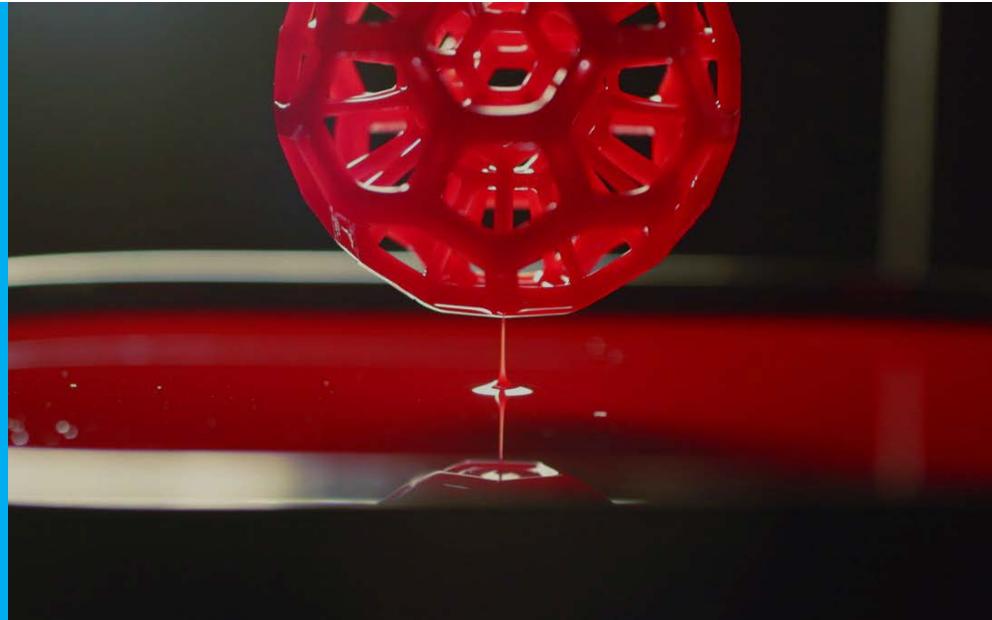
Graduate Program:
MECHANICAL ENGINEERING

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Photopolymerization-based Additive Manufacturing (AM), a technique in which a product is built in a layerwise fashion by local curing of a liquid monomer, is increasingly being adopted by the high-tech sector. Nevertheless, industry still faces several challenges to improve the repeatability of product quality. It is commonly recognized that there is a need for an in-depth understanding, in-situ monitoring and real-time control of the curing process to work towards end-products of higher quality. This need motivates the investigation on closed-loop control of the curing process and the build-up of material properties.

This pioneering research illustrates the potential of this new process control paradigm where material properties are controlled in closed-loop and in real-time. A control-oriented model is developed that describes the multiphysical photopolymerization process and connects curing kinetics, heat flow, strain and stress evolution. Moreover, an extension to existing control systems theory is proposed to anticipatively control the process through the quadratic tracking framework.

The potential of this model-based control strategy is demonstrated by means of a theoretical-numerical framework that illustrates the material property build-up during photopolymerization processes such as stereolithography. The proposed framework is supported by experiments that validate the controlled monomer conversion at zero-dimensional scale. This work has been submitted for both journal and conference publication.
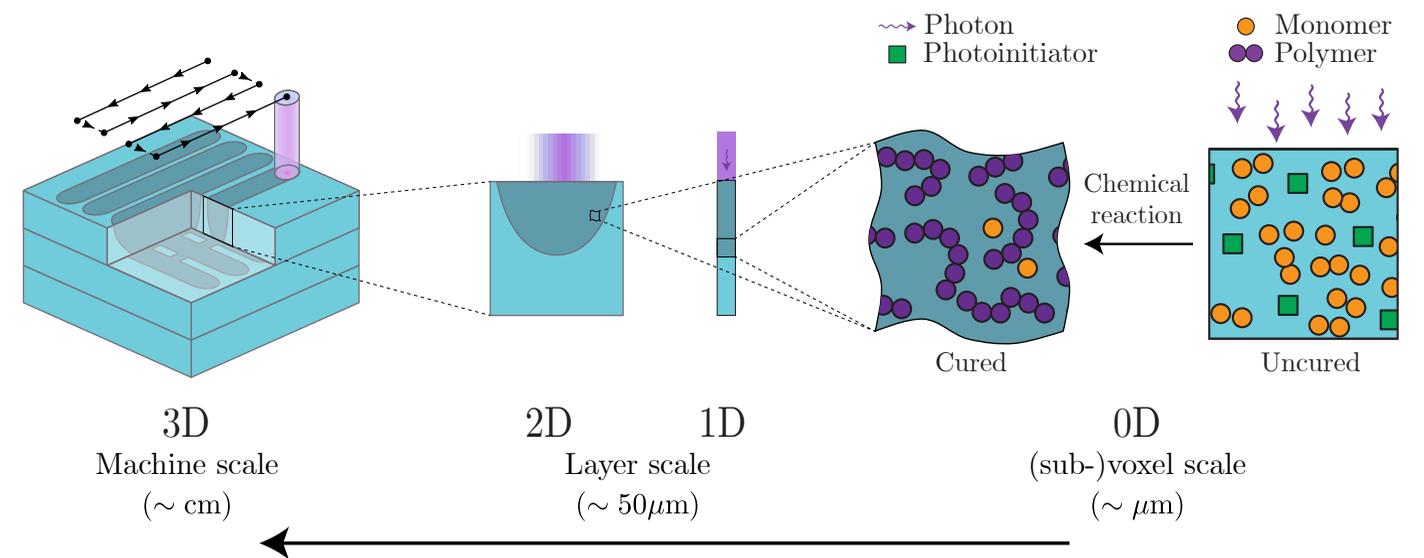

Figure 1: Bottom-up roadmap, ranging from a 0D (sub-)voxel to a full 3D product, illustrating the different scales to control the photopolymerization process.