Simulation-Based Design for 3D Printing of Shape Changing Components

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The objective of this work was to develop an experimentally validated simulation model for Digital Light Processing (DLP) 3D printing to investigate residual stresses and shape distortion. A UV-curable acrylate resin was used to prepare samples using a custom made DLP equipment at GaTech. Hole-drilling method was used in combination with two-dimensional subset-based digital image correlation software to quantify residual stresses in the 3D printed samples. An experimentally validated Finite Element Analysis (FEA) simulation model was developed to predict residual stresses formed during the layer-by-layer deposition. A nonlinear constitutive model involving the frontal photopolymerization was established. A parametric study was carried out using the FEA based simulation model and the results indicated that decreasing the curing time and increasing the layer thickness decreased residual stress. The model-based approach provides a low cost and effective method to predict and manage the residual stress in 3D printed parts. The knowledge gained in this work can potentially form the bases for future modeling work of 3D printing.

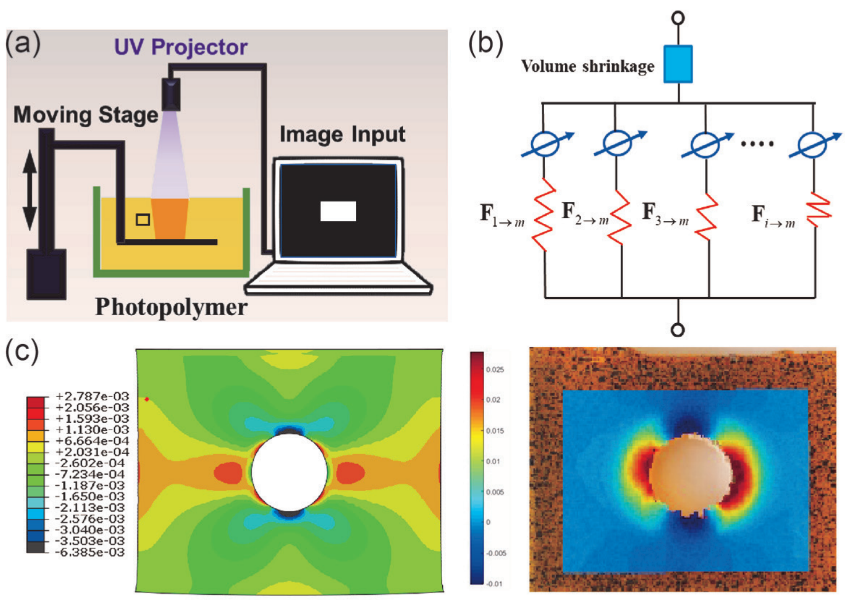

Figure 1: (a) Schematics of DLP printing setup. A CAD design of object was sliced into black and while images and passed to UV projector for photocuring. The object was reconstructed in a lay-by-layer manner. (b) One-dimensional rheological analogy for the photocuring phase evolution model. The switch will be turned on when new crosslinks form. (c) Comparison between the simulation and DIC experimental results of reidual strain after punching a circular circle in a retangular sample.