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Multiscale Fluid and Solid Mechanics of UV Nanoimprint Lithography

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UltraViolet NanoImprint Lithography (UV-NIL) offers a mechanical method to print two- and three-dimensional nanometer structures on rigid and flexible surfaces. In UV-NIL droplets of photocurable monomer are placed on a substrate, pressed by a template to fill its nanopatterned features followed by UV curing to form a patterned polymeric film. Multi-billion dollar applications of the technology include bit patterned magnetic media, wire grid polarizers and even electronic logic. There are several processing challenges to realize the full potential of UV-NIL, which include distribution of thousands of photocurable drops on a substrate, complete filling of template features, removal of the template without damaging the patterned film, and maintaining uniformity across a flexible substrate. Models and simulations for the multiscale, non-linear coupling among capillary, viscous and elastic forces will be presented to optimize placement of droplets and determine process parameters and process windows to minimize residual layer thickness and printing times. Predictions will be compared with results from wafer and roll-to-roll UV-NIL tools. Fluid management is shown to be critical to the success of the process.