# "Enabling Layout and Process Optimization with Fast, Full-Field Simulation of Droplet-Dispensed UV Nanoimprint Lithography"


## Prof. Hayden Taylor, Mechanical Engineering, UC Berkeley


***Time:*** *3:30 pm, Friday, November 6, 2015;* ***Location:*** *CEER Conference Room in the EME Building of the Pickle Research Campus: 10100 Burnet Road, Building 133, Austin TX 78758*


Full-field, physically-based simulation of nanoimprint lithography (NIL) is needed to address the throughput-*versus*-yield challenges that are currently faced by NIL. We demonstrate a simulation framework that can track the spreading and coalescence of tens of thousands of picoliter-volume resin droplets beneath a nanoimprint template, predicting evolution of feature filling and residual layer thickness (RLT) uniformity during the imprinting of geometrically complex designs such as found in solid-state memory.

Our new simulation approach builds upon our existing simulation techniques for chip-scale, *spun-on* thermal [1] and UV-curing [2] resists and for roll-to-roll imprint [3]. These techniques discretize the imprinted area on a square grid, and employ a mechanical impulse response that describes how the surface of the resist deforms when loaded by the template in each grid location. Template–resist contact pressures are computed for multiple timesteps.

To simulate droplet-dispensed imprinting, it is essential to account for the merging of multiple droplets within each grid location before template filling occurs. Previous work simulating droplet spreading has captured subtle capillary effects exquisitely, but has been constrained by computational requirements to only a few features or droplets, *e.g.* [4],[5]. In contrast, our approach does not need to solve for the behavior of each individual droplet and can simulate the spreading of $>10^4$ droplets. To avoid entrapment of chamber gases between merging droplets, most processes initially bow the template and spread the resist radially outwards [6]. We find that for typical droplet properties, the template must have a radius of curvature of $\lesssim$500 mm where it meets the propagating fluid front to prevent gas entrapment.

We have integrated our new droplet deformation model with models for elastic template deflections and cavity filling, and have explored the imprinting of a 30 mm-by-40 mm field that is reminiscent of Flash memory. We have used simulation to investigate the behavior of partial imprinted fields at the wafer edge, as well as the influence of layout density modifications at the edge of the printed field.

Simulations on a 1 mm grid take ~5 s to run on a standard personal computer; those using a 0.1 mm grid require $\lesssim$5 minutes. This simulation approach thus offers NIL users a rapid method for evaluating ways of achieving production throughput targets of $\lesssim$1 s/field spreading time.

I will also describe our work to commercialize nanoimprint simulation models for both spun-on and droplet-dispensed resist, and will describe my experiences working in Singapore as a postdoc and faculty member.



[1] Taylor and Boning, SPIE **7641** 764121 (2010).
[2] Taylor and Wong, *Proc NNT* 2011.
[3] Taylor, *Proc MRS*, Nov 2012.
[4] Reddy *et al.*, *Phys Fluids* **17** 122104 (2005)
[5] Liang *et al.*, *Nanotechnology* **18** 025303 (2007)
[6] Lu and Schumaker, US Patent Application 12/327,618


**<u>Bio</u>**: Hayden Taylor is an Assistant Professor in the Department of Mechanical Engineering at the University of California, Berkeley. He was previously an Assistant Professor at Nanyang Technological University in Singapore, a Postdoctoral Research Fellow in the Biosystems and Micromechanics group at the Singapore-MIT Alliance for Research and Technology, and a Research Associate in the Microsystems Technology Laboratories at MIT. Hayden received the B.A. and M.Eng. degrees in Electrical and Electronic Engineering from Cambridge University in 2004, and the Ph.D. in Electrical Engineering and Computer Science from MIT in 2009. He is the founder of Simprint Nanotechnologies, which develops nanoimprint process modeling software.

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