Photo-actuated Pens for Molecular Printing

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Performing scalable scanning probe lithography is very difficult due to the serial nature of the writing process. One approach to addressing this is by employing the massive parallization afforded by cantilever-free arrays that can be manufactured to have millions of pens. However, a scalable process for physically actuating each pen independently has yet to be developed. Here, we explore the photo-actuation of pen arrays composed of polydimethylsiloxane-carbon nanotube composites, and report the first demonstration of photo-actuated pens for molecular printing.[1] Photo-actuation of these composites is characterized using atomic force microscopy and found to produce microscale motion in response to modest illumination, with an actuation efficiency as high as 200 nm/mW on the sub 1 s time-scale. Arrays of composite pens are synthesized and we found that local illumination is capable of moving selected pens by more than 3 micrometers out of the plane, bringing them into contact to perform controllable and high quality printing while completely shutting off the non-illuminated counterparts. In light of the scalability limitations of nanolithography, this work presents an important step and paves the way for arbitrary control of individual pens in massive arrays. As an example of a scalable soft actuator, this approach could also aid progress in other fields such as soft robotics and microfluidics.

[1]Z. Huang, et al., *Adv. Mater*. Early View (2017).