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A Chemist's Approach to Nanofabrication: Towards a 'Desktop Fab'

by

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Microfabrication and printing techniques have revolutionized the world; however, most are not simple, cheap, and rapid enough to allow for the creation of prototype devices on the benchtop. Recently, massively parallel scanning-probe based methods have been used to address such challenges and mark a step towards the realization of a "desktop fab." Such a tool should enable simple, flexible, high-throughput, and low-cost nano- and microscale patterning and allow chemists, biologists, and engineers to rapidly synthesize and study systems pertaining to nanoparticle catalysis, single particle electronic devices, and biochemical processes at the cell surface. Specifically, we have been pursuing cantilever-free scanning probe lithographic methods to achieve these goals. These methods are promising in that they are intrinsically low cost, high resolution, and massively parallelizable. We developed polymer pen lithography (PPL), which uses arrays of elastomeric tips on a rigid backing layer to transfer chemically reactive materials (e.g. alkanethiols, proteins, polymers, nanoparticles) in a direct-write manner onto a variety of surfaces. The science and development of PPL has enabled researchers to systematically investigate phenomena in chemistry, biology, and materials science. For example, we utilized PPL to create arrays of polymer nanoreactor whereby each nanoreactor was used to generate metal, metal oxide, alloy, and heterogeneous nanoparticles and investigate catalytic activity. In addition to PPL, we have also developed hard-tip, soft-spring lithography which utilizes Si tips to produce sub-50 nm features in a force-independent manner. This architecture is also useful for directing light for both near- and far-field photolithography, a procedure termed beam pen lithography (BPL). Importantly, we have shown that BPL can be massively multiplexed through the use of a digital micromirror device in order to allow one to rapidly produce arrays of arbitrary nanoscale features across centimeter-scale surfaces.