A General Strategy for Directly Writing Nanoscale Patterns of Nanoparticles and Polymer–Nanoparticle Composites.

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In thermal Dip Pen Nanolithography (tDPN), a heatable AFM cantilever regulates the deposition of an ink through controlled melting, much like a nanoscale soldering iron. Control over writing is exceptional—deposition may be turned on or off and the deposition rate easily changed without breaking surface contact. Moreover, the technique may be performed in UHV and is compatible with standard CMOS processing. tDPN has been successful at depositing materials ranging from semiconductors to insulators to metals at speeds up to 200 µm/s.

Recently, we have become interested in directly depositing nanoparticles-polymer composites. Nanoparticles and nanoparticles–polymer composites offer many new capabilities that could greatly advance nanoelectronics, data storage, biosensors, and optical imaging applications. However, these applications often require that the nanoparticles or composites be formed into nanostructures that are precisely deposited on a surface or in a device. This requirement has spurred the development of many new nanolithographies but, to date, they have exhibited relatively low resolution (>~100 nm), a lack of generality to a range of materials, or the requirement of many serial processing steps. With tDPN, we can deposit with nanoscale precision a wide range of polymers (PMMA, P(VDF-TrFE), polyethylene) that contain metallic nanoparticles, semiconducting nanoparticles, or small molecules. An oxygen plasma can remove the polymer to reveal evenly dispersed nanoparticles or, for some combinations, precisely-placed 10 nm wide rows of nanoparticles. The flexibility and precision of this approach should greatly speed the advent of AFM tip based nanomanufacturing.