Nanomanufacturing using Heated Probe Tips

*William P. King**
Department of Mechanical Science and Engineering, University of Illinois Urbana-Champaign
**contact author: wpk@illinois.edu*

Presentation

Short Description: **The ultasmall hotspot at the end of a heated atomic force microscope cantilever tip is the smallest controlled heat source ever produced, and can be used for nanometer-scale thermal nanomanufacturing.**

Keywords: atomic force microscope, nanoscale thermal processing, thermal dip pen nanolithography

Abstract: When the tip of a heated atomic force microscope (AFM) cantilever is in contact with a solid surface, the tip-surface contact is as small as a few nm. Resistive heating in the cantilever can heat this small contact area up to 1200 °C. This paper describes how this ultrasmall hotspot can be used for thermal nanomanufacturing.

Heated AFM cantilevers were developed for data storage [1], but have since been used for measurements of materials properties [2], studies of nanometer-scale heat transfer [3], and nano-manufacturing [4,5]. A key requirement for these applications of heated AFM cantilevers is their thermal, mechanical, and electrical design and calibration [6].

In thermal dip pen nanolithography (tDPN) [4], a heated cantilever tip is coated with an ink that is solid at room temperature but can be melted from the tip when the cantilever is hot. When the tip scans over a surface, deposition from the tip can be controlled through the cantilever temperature. It is possible to deposit both organic materials and low melting temperature metal solders with nm-scale features. In thermochemical nanolithography (TCNL), a heated tip is in contact with and scans over an organic film having a thermally-reactive chemistry [5]. TCNL offers the ability control chemical reactions with nm-scale features.

References

[1] Vettiger, P., G. Cross, et al. (2002). "The "Millipede"-Nanotechnology Entering Data Storage." IEEE Transactions on Nanotechnology **1**(1): 39-55.
[2] King, W. P., S. Saxena, et al. (2006). "Nanoscale Thermal Analysis of an Energetic Material." Nano Letters **6**(9): 2145-2149.
[3] Park, K., G. L. W. Cross, et al. (2008). "Experimental Investigation on the Heat Transfer Between a Heated Microcantilever and a Substrate." Journal of Heat Transfer-Transactions of the Asme **130**: 1002401-1-1002401-9.
[4] Nelson, B. A., W. P. King, et al. (2006). "Direct deposition of continuous metal nanostructures by thermal dip-pen nanolithography." Applied Physics Letters **88**(3).
[5] Szoszkiewicz, R., T. Okada, et al. (2007). "High-speed, sub-15 nm feature size thermochemical nanolithography." Nano Letters **7**(4): 1064-1069.
[6] Lee, J., T. Beechem, et al. (2006). "Electrical, thermal, and mechanical characterization of silicon microcantilever heaters." Journal of Microelectromechanical Systems **15**(6): 1644-1655.