

Nanometer Scale Thermal Processing for Scalable Nano-Manufacturing

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Atomic force microscope (AFM) cantilevers with integrated heaters have been developed for application to data storage, where many thousand parallel cantilever probes can perform parallel reading or writing of data [1]. Similar heated cantilever probes have since been developed for nanometer-scale measurements of materials properties [2,3] and nano-manufacturing [4,5].

Figure 1 shows a schematic of a silicon AFM cantilever with a heater element integrated at the free end. Figure 1 also shows a scanning electron microscope image of a fabricated cantilever [6].

The temperature of a silicon AFM cantilever can be controlled over the range 25- 1000 °C [6]. The cantilever has a thermal time constant of about 10 μ sec [6].

The contact between a heated AFM tip and a substrate forms a hotspot in the substrate with diameter as small as a few nm [7]. Within this hotspot, it is possible to perform nanometer-scale thermal manufacturing. In one approach, the heated tip operates like a miniature soldering iron [4]. The tip is coated with a polymer or a metal that is solid at room temperature but melts and flows from the tip onto a surface when the tip is hot. In another approach, the tip can scan over a substrate that has a temperature-dependant chemical reactivity. This thermo-chemical nanolithography (TCNL) can pattern temperature-activated chemical reactions with spatial resolution 12 nm [5].

The heated AFM can be used to perform data reading or metrology of a surface [8]. As the heated cantilever scans over a surface, changes in surface topography can be thermally sensed in the cantilever, providing sub-nm imaging resolution [8].

Because both writing and reading are performed using thermal control of the cantilever, no optical access is required. Thus it is possible to scale these writing and reading techniques to large cantilever arrays [1, 8].

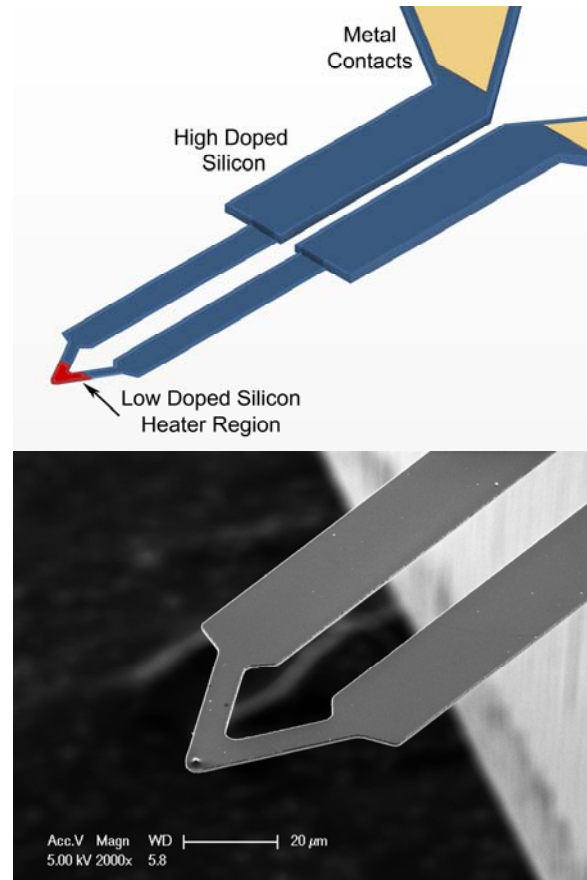


Fig. 1 Top: schematic of AFM cantilever having integrated heater. Bottom: Scanning electron microscope image of a silicon atomic force microscope cantilever having an integrated heater. The tip has radius of curvature < 20 nm.

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