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Electro-Thermal Microcantilever Technology for Nano-CEMMS

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Goals

- The atomic force microscope (AFM) is the most widely used transducer for interrogating or inducing physical phenomena at the nanometer scale. In this research we are developing AFM-based probes to perform high-speed electrophoretic sorting and delivery of heterogeneous molecular species for use in nanometer-scale manufacturing and metrology.

Mapping to Center's Objectives

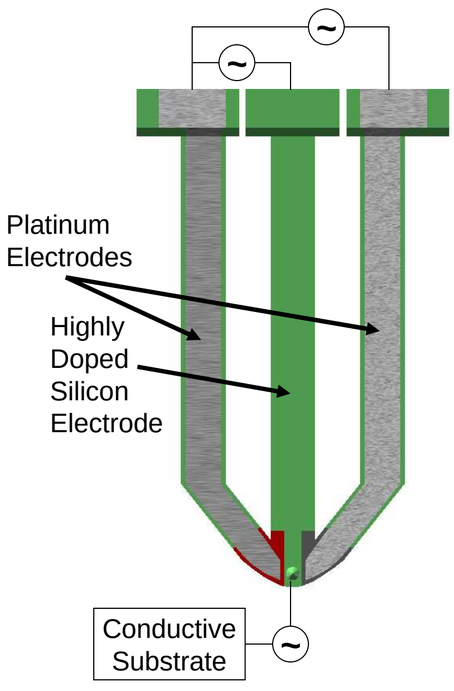
- The present approaches to nanometer-scale patterning allow highly controllable nanometer-scale deposition of biomolecules, polymers, and metals over long ranges.
- The present approaches also enable ultrafast molecular sorting of DNA and other molecular species.

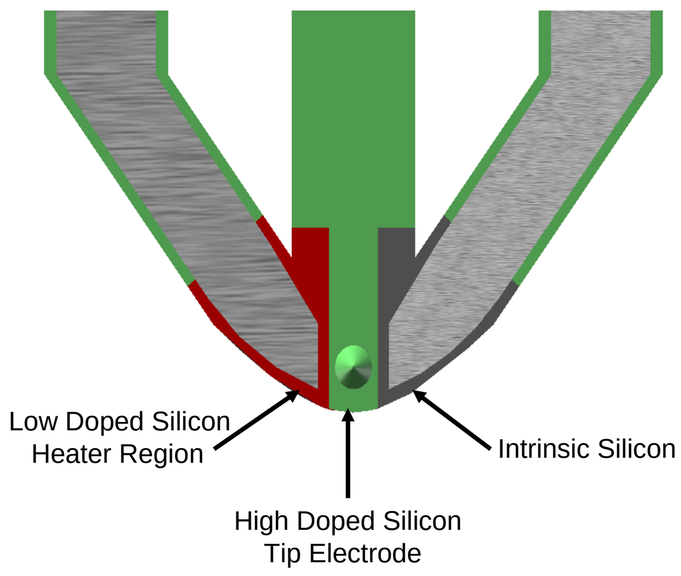
Fundamental Questions/Challenges

- How can an AFM tip be used to perform high-fidelity nanometer-scale metrology?
- How can AFM probes be fabricated and operated to produce heating and electric fields in parallel, to produce high throughput electrophoresis?

Research Plan

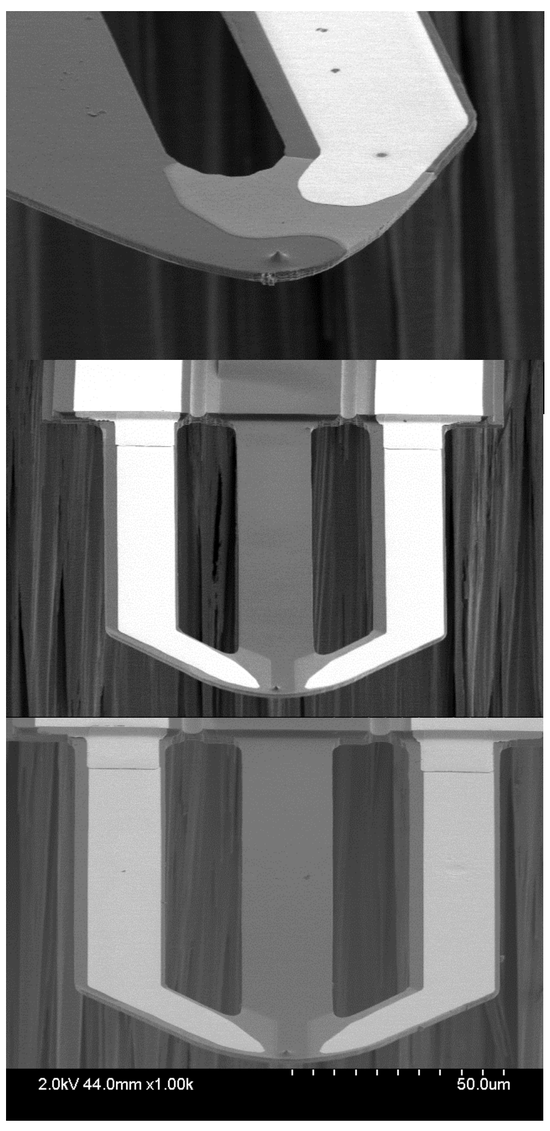
- Our research builds upon our experience in the design, fabrication, and use of silicon AFM cantilevers having integrated resistive heaters, and the expertise of our collaborators at UC-Irvine in electrophoresis on AFM.
- The heated tip may be used to locally deposit, decompose, or induce thermal reactions on a surface.
- The platinum electrodes may be used to induce electric fields to separate molecular species electrophoretically on the surface of the AFM probe.
- The highly doped silicon tip electrode may be used to induce electric fields to sort and locally deposit molecules on a conductive substrate.

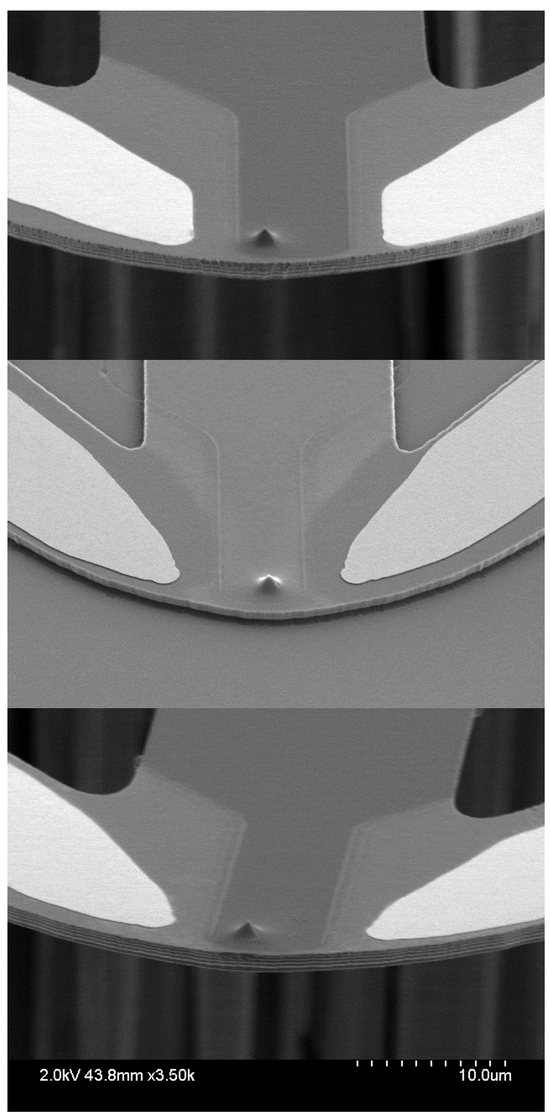




Research Results

- We have recently developed microcantilevers with heaters and integrated electrodes. These probes allow unprecedented resolution in electrophoretic sorting, electrophoretic patterning, thermal patterning, and thermal measurements.





- For this research we have developed six designs of AFM cantilevers. Each cantilever has platinum sorting electrodes and a highly doped conductive tip. Designs vary by number of legs, electrode geometry, and heating capability.

Broader Impact

- Significant advancements to the state of the art in sorting molecules at ultrafast rates. Broad impact in nanometer-scale patterning and metrology are envisioned. These approaches are highly scalable.

Interaction with Other Projects

- This research performs nanometer-scale patterning at fast rates and high temperature, allowing the nano-patterning of materials both thermally and electrically.
- This research enables the sorting and patterning of biomolecules, an active research program at UC-Irvine.
- In this research, we are working on nanometrology, which is critically important for all of the research thrusts in the center.

Future Efforts

- We are working on parallelization and writing/metrology over very long ranges.
- We are working to develop our techniques to include electophoretic deposition of biomolecules and thermal deposition of nanoparticles.