

Goals and Potential Impact if Successful

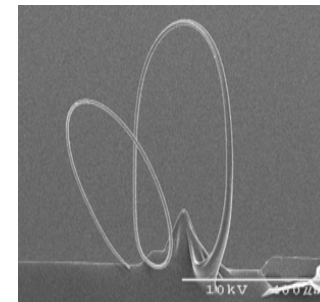
Development of a formulation for the design, construction and control of micro- and nano-scale robots.

Miniature micro/nano-robots have unique advantages:

- direct accessing to small areas and the micro/nano-scale
- increased flexibility, functionality and robustness
- being low cost, many (swarms), adaptive, and distributed

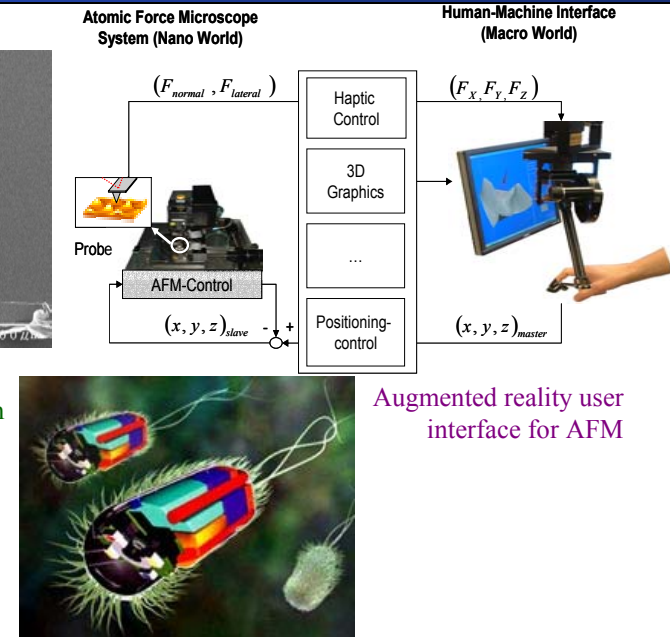
Applications in:

- Health care, biomedical devices, and biotechnology
- Environmental monitoring
- Scientific tools
- Search and rescue
- Inspection, maintenance and repair in extreme environments
- Manufacturing, assembly, information technology, etc.



3D polymer micro/nano-fiber manufactured by an AFM probe

Biomimetic surgical micro-robots



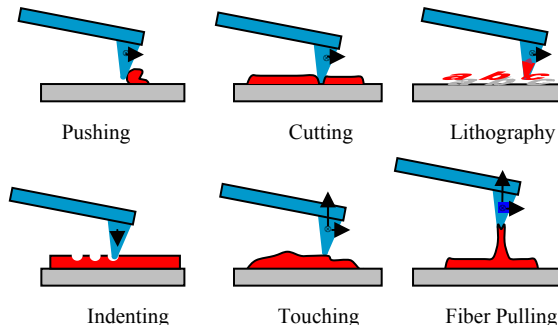
Augmented reality user interface for AFM

Approach and Accomplishments

Overall design methodology specific to the application:

- Micro/nano-scale continuum physics modeling
- Teleoperated and autonomous control
- Atomic Force Microscope probe as a nanoscale robot and sensor
- Rapid prototyping of micro/nano-systems
- Advanced man-machine interfaces
- Biomimetics

Possible mechanical nano-manipulation tasks by an AFM probe



Bottlenecks and Open Research Questions

- Three-dimensional, parallel, and autonomous nano-manipulation systems are required for nano-material characterization, prototyping novel nano-scale devices, sensors and mechanisms, and mass-produced nano-manufacturing applications.
- New hybrid systems integrating and controlling biological entities and micro/nano-electromechanical systems and using the chemical energy as the power source would be a promising direction.
- Novel realistic continuum model based real-time micro/nano-physics simulators would enable micro/nano-mechanics training and rapid prototyping of micro/nano-systems.
- Miniature nano-scale robots, sensors, and systems would open novel applications in health care, environmental monitoring, search and rescue, biotechnology, wearable devices, self-organizing displays and robots, and desktop size nano-manufacturing system applications.
- Biomimetics could enable multi-functional, robust and smart novel nano-scale sensors, robots, and materials adapting the nature's solutions to the challenging nano-scale engineering problems.
- Advanced human-machine interfaces for nano-scale microscopes, robots, and manufacturing systems are indispensable for direct human control on complex and time-varying applications.