Specifications for Scanning Probe Microscope

The Chemistry Division requires a high-resolution imaging system consisting of a Scanning Probe Microscope (SPM) capable of Nanolithography, Nanomanipulation, and Multiple Mode Imaging Techniques. This SPM will be coupled with other sample analysis and preparation instruments for unique one-of-a-kind research analytical chemistry tool.

The following minimum instrument specifications are required including installation:

Scanning Probe Microscope (SPM) Stage

- Must be able to perform vertical engage, where the scanner moves in such a way to eliminate lateral translation of the tip during engage.
- Must include integrated software capable of automated step and repeat measurements.
- Sample size must be up to 150 mm diameter and up to 200 mm diameter with optional chuck
- Must include integrated top view optics and optical microscope with real-time color video display / image capture and cross hair. Resolution to be at least 1.5 um and be capable of a horizontal viewing area of 150 microns to 675 microns with computer controlled illumination and motorized zoom and focus.
- Must include motorized X, Y, and Z with inspectable XY area of at least 125mm x 100 mm with a resolution of 2 microns. X and Y unidirectional repeatability must be less than or equal to 3 microns typical, 10 microns maximum. Bi-directional repeatability must typically equal 4 microns for X and 6 microns for Y.
- Must include an integrated vacuum hold down system for locking samples in place. Stage locking mechanism must automatically engage upon engaging of SPM.

Closed Loop AFM Head XYZ

- Must utilize a tip scanning system which incorporates a laser tracking design to minimize added mass to scanner. Laser and deflection detection system must not be mounted on the X, Y, or Z axis. This is for speed and accuracy.
- Must include software and user interface for nano-manipulation, nanolithography, and scanning. Software must allow user to control probe velocity, vertical position, and applied voltages.
- Must support a scan range of at least 90 microns square.
- Vertical noise floor must be less than 0.05 nm RMS
- XY noise floor must be less than 2 nm RMS (6 nm Peak-to-Peak with closed loop feedback)
- X-Y linearity must be less than 1% (measured integrally)
- Z Sensor Noise force curve bandwidths 0.1 nmRMS (0.1Hz-5Khz)
- Z Sensor Noise typical imaging bandwidths 0.6 nm RMS

- Z Sensor range must be at least 8 microns in imaging mode, and at least 7 microns in force curve acquisition mode

CONTROLLER

- Controller must have the ability to perform LiftMode or equivalent, where topography is determined on the first pass over a scan line and a second pass, lifted over the sample but following the topography, measures a second parameter such as magnetic field, electric field, or the force modulation signal. Images must be able to show direct correlation between topographic and second pass data.
- The controller must provide the capability of scanning and imaging an array of data points of at least 4096 x 1024. Users must be able to select scan dimensions, e.g. 8192 x 512, or 16,384 x 256.
- Controller must be able to provide real time piezo linearity correction for piezo voltage/response to better than 2%. Linearization must operate on all scan rates and scan sizes over the entire range of the scanner without introducing noise.
- Controller must be able to provide simultaneous images from at least 3 data acquisition channels.
- Controller must be ready to accept and support signal access/break out box to directly input external signals to the instrument or monitor instrument output electronically.
- System must be capable of operating micro-actuated cantilevers and driving them with dual nested control loops. Dual nested control loops must be usable for other experiments if micro-actuated cantilevers are not used.
- The controller must support cantilever “Q Control”. Q control allows the user to adjust the Q of a resonating cantilever dependant on the application.
- The system must be ready to accept optional AFM analytical test modules (i.e. application modules) such as Scanning Capacitance Microscopy (SCM), Scanning Spreading Resistance Microscopy (SSRM), Tunneling AFM (TUNA) and Conductive AFM (CAFM) with minimal software or hardware changes.
- The system must be ready to support operation in scanning tunneling microscopy (STM) mode and fluid/liquid cell operation using manufacturer supplied hardware (tip/cantilever holders).
- The system must include a lock-in phase detector having at least four 16-bit analog-to-digital (A/D) converters with software controlled variable gain inputs to digitize the outputs of the lock-ins. Theoretical phase detection must be to 0.003° or better (practical detection limits are application dependent)
- Controller must be capable of digitally reading and controlling tip-sample separation so advanced software enhancement techniques can be utilized.

- Controller must provide three 16 bit DACs for each channel (X,Y,Z), one each for scan size, scan pattern, and offset. A single large area scanner (90 microns) must be able to provide small scans (<50nm) without artifacts caused by quantization or aliasing.
- Controller must provide complex feed-forward and feedback algorithms optimize control of tip-sample forces.
- Controller must support imaging and force curve acquisition in Tapping Mode or equivalent intermittent contact mode, where a vibrating tip intermittently contacts the surface of the sample at or near it's resonance, and where both the tip oscillation amplitude and phase shifts can be monitored
- Controller must provide dual lock-ins, each capable of 360 degree quantitative cantilever phase detection, 10 Hz to 2 MHz.
- Controller must include a cross-point switch that routes phase signals in a large number of different permutations under software control for maximum flexibility.
- Phase lock-in measurement bandwidth must be 10 Hz to 15 kHz, software-selectable so speed vs. noise can be selected by the user.

Installation and Training

- Two days on site training must be included

Must be included with system

- **Software and User Interface** enabling manipulation and lithography at the nanometer and molecular scale. Lowest noise and best positioning of any available nanomanipulation system.
- **Nanolithography Software** allowing user to build custom lithography programs to control the SPM. Use industry-standard C++ compiler to enable building (and debugging) larger programs in the form of dynamic-link libraries (DLLs) that load by SPM controller software. Must include lithography support documentation, a compiler, function libraries and sample programs.
- **Integrated Vibration Isolation Table & Acoustic Enclosure** providing acoustic isolation and increased vibration isolation
- **Electronics Console** conveniently houses SPM controller, computer, stage controller, and other hardware, while providing a work surface for system display monitors, mouse and keyboard.
- **Computer hardware & operating system** must be at least Pentium IV computer with Windows XP operating system. Monitors must be at least 18" LCD. Must include at least:
    - 2.4 Ghz, Pentium-IV Processor
    - 1024 MB RAM Memory
    - 160 GB Hard Drive
    - DVD +/- RW with DVD/CD Software
    - 10/100 Ethernet Interface

- USB support
- Video Graphics Board with Dual Monitor Support
- Video Capture Board for display of camera feedback
- The latest compatible version of SPM system software.

- **20 SiN contact Tips**
- **70 Tapping Tips**

OTHER TEXT AND SPECIFICATIONS

- The supplier must include technical and applications support through an “800” support line, at no additional charge, for the life of the instrument.
- Software upgrades must be provided free of charge for the life of the instrument
- Contractor shall provide a catalog or price list for SPM probes including: micro-actuated probes for high speed imaging, metal coated probes for EFM and MFM, DLC probes optimized for wear resistance, and custom nano-indenting probes