Friday, January 27, 2017 *IISc/SSCU/2017/SPM01*

Tender Notification for the Procurement of a Scanning Probe Microscope (Last Date for Submission: Feb 17th 2017)

Kindly send your best quotation for a Scanning Probe Microscope with the following technical specifications on C.I.P. Bangalore basis. Your quotation should clearly indicate the terms of delivery, delivery schedule, estimated delivery date, and payment terms. The tender should be submitted in two separate sealed envelopes - one containing the technical bid and the other containing the commercial bid, both of which should reach us, duly signed on or before 1700 hours on 17th February 2017.

The bids should be addressed to:

The Chairman,
Solid State and Structural Chemistry Unit
Indian Institute of Science (IISc)
Bengaluru, India - 560012.

The sealed bids should be sent to:

Prof. Satish Patil
Associate Professor,
Solid State and Structural Chemistry Unit
Indian Institute of Science (IISc)
Bengaluru, India - 560012.
Ph: +91-80-2293-2651
email:satish@sscu.iisc.ernet.in

Please enclose a compliance statement along with the technical bid.

Technical Specifications for the Scanning Probe Microscope

1. Broad System Requirements and Usage

We are seeking to procure a state-of-the-art scanning probe microscope (SPM) to be part of a departmental nano characterization facility. Therefore, the following technical criteria are to be met by any SPM being quoted under this tender notice:

1.1. The SPM should be capable of automating some of the very basic steps needed for high quality scanning probe measurements such as for example laser alignment, scan frequency optimization, and scan parameter optimization. These are necessary to make it relatively easy for our students to collect reliable and reproducible experimental data.

1.2. Our faculty members work in diverse areas of research at the intersection of fundamental chemistry, physics and new materials synthesis and characterization. Therefore the SPM being quoted should be an advanced SPM system that can go far beyond the basic topographic measurements routinely performed by any generic atomic force microscope. For example, the SPM should have the capability to:

1.2.1. Measure mechanical properties, of materials including biological matter, with nanometer precision.
1.2.2. Measure work functions of surfaces (functionalized and otherwise) using Kelvin probe microscopy.
1.2.3. Probe dielectric properties of thin films and nano materials using scanning probe techniques such as scanning capacitance microscopy.
1.2.4. Measure spatially-resolved (nanometer scale) conductivity of thin films and nano materials using current sensing microscopy.
1.2.5. Perform in-situ nano-electrochemical studies of nano materials in environmental cells.
1.2.6. Study nanoscale phase transformation dynamics using variable temperature SPM.

1.3. In addition, the SPM should have a modular design providing the flexibility to add any of the above capabilities or other scanning probe microscopy techniques either at the time of procurement or at a later date.

2. SPM Instrument Requirements

2.1. The SPM should be a sample-scanning system with the cantilever fixed in the laboratory frame of reference. A fixed cantilever system provides us with the flexibility to configure the SPM to perform tip-enhanced optical measurements. An alternative scanning method is to scan the SPM probe tip relative to the sample stage – commonly called the tip-scanning geometry. However, in a tip-scanning geometry, the tip motion can cause scanning-dependent variations to the local electric field near the SPM tip, which potentially leads to non-reproducible results. If a sample scanning system is

Prof. Satish Patil (satish@sscu.iisc.ernet.in)

unavailable, the tenderer can quote a system with a tip-scanning geometry. In this latter case, the tenderer should clearly mention how the local electric-field variations near the SPM probe tip in a tip-scanning geometry are corrected for.

2.2. It is required that the optics assembly that comprises the laser, beam directing optics and the detector must have no relative motion during scanning.

2.3. The tip-sample mechanical loop must not include the optics assembly so that the mechanical motion of the sample/tip is decoupled from the optics assembly thereby enabling low noise scans.

2.4. The SPM scanner, optical light source and optical camera assemblies must all be modular and field-upgradeable or user selectable.

2.5. The microscope stage must provide motorized coarse-positioning of the sample over several millimeters under software control.

2.6. The instrument must have demonstrated true atomic resolution (true atomic resolution is defined as the ability to image atomic point-defects repetitively when scanning under ambient conditions) scanning in water or in a liquid with similar relevant physical properties as water in a non-contact or tapping measurement mode over several frames of imaging. The tenderer must include actual technical data and the conditions under which the data was acquired so that the committee may evaluate the qualifications of the proposed instrument. An unsubstantiated claim of being technically compliant will not be considered.

2.7. DC and AC height noise of <25 pm is required. The DC height noise should have been measured with the SPM probe tip in static contact with a hard surface (nearly non-deformable surface such as a ceramic or a silicon substrate of approximately 0.5 mm thickness). The AC height noise should have been measured while the SPM probe tip is in resonant contact with a hard surface similarly to the one described above for the case of DC height noise. Both DC and AC noise measurements should have been performed with integral and proportional gains set to values normally used in topographic contact or tapping/non-contact scanning mode. Noise over the frequency range of 1 Hz to 1 kHz should be reported. The tenderer must include actual technical data and clearly mention the conditions under which the data was acquired so that the committee may evaluate the qualifications of the proposed instrument. An unsubstantiated claim of being technically compliant will not be considered.

3. SPM Scanner Requirements

At least one SPM scanner must be included with the instrument. The requirements for the scanner are as follows:

3.1. SPM scanner should be a closed loop scanner, which is also capable of measuring in the open loop configuration.

3.2. The scanner should independently actuate X, Y and Z directions. (The mutually perpendicular directions in the sample plane are referred to as X and Y and the direction perpendicular to the sample plane is referred to as the Z-direction).

3.3. The scanner must provide an X, Y range of at least 25 microns and a Z-range of at least 5 microns.

3.4. The scanner's X, Y, Z sensor noise should be less than 75 pm. Noise over the frequency range of 1 Hz to 1 kHz should be reported. The tenderer must include actual technical data and clearly mention the conditions under which the data was acquired so that the committee may evaluate the qualifications of the proposed instrument. An unsubstantiated claim of being technically compliant will not be considered.
3.5. The out-of-plane (Z-direction) motion during an X-Y scan should be 5 nm or lower over the closed-loop scan-range.
3.6. The scanner must enable acquisition of images with atomic-scale resolution in the closed-loop scanning mode. The specifications of the scanner should also be compliant with requirement *2.6*
3.7. The scanner should allow for imaging samples of at least ½ inch (12.5 mm) in diameter.
3.8. The scanner should support scanning in a variety of environments such as in ambient, inert gas or in liquid media (over a wide range of pH values). Please provide technical data to exemplify the various environments in which the proposed system can function.

4. SPM Optics Requirements

4.1. All necessary SPM optics components such as lenses, light source, etc., should be provided with the SPM.
4.2. The instrument should have optics positioned above the SPM probe tip (The probe tip is directly above the sample)
4.3. The resolution of the optics should only be restricted by diffraction limits (should only be limited by the wavelength of light).
4.4. The optics should have aberration corrections incorporated. An apochromatic correction to minimize aberration is required.
4.5. The illumination light source should be software controlled and optics that utilize principles of *Kohler illumination* should be incorporated for uniform sample illumination.
4.6. The optics should provide a minimum field of view of 750 microns x 650 microns.
4.7. The optics must include a fully software integrated CMOS camera (3 megapixels or higher). The software must include digital zoom, pan and capture, as well as balance, shutter speed and binning.

5. SPM Controller and Electronics

5.1. The SPM control electronics must enable 100% digital operation.
5.2. The system must provide thermal cantilever resonant frequency tuning to at least 5 MHz.
5.3. The instrument must be capable of frequency-independent fully-digital quality factor control (Q-control) of a SPM cantilever. The Q-control should at the least be possible in the range of 5 kHz – 10 MHz. Such a Q-factor control is essential for performing high quality, low noise imaging.
5.4. The instrument must include software-controlled relays for the X, Y and Z piezoelectric transducers' high voltage supplies and the laser power. Such software

controlled-relays should provide for a fully software-controlled operation for changing the laser power and for piezoelectric transducer control.

5.5. The controller of the SPM should have BNC outputs that provide access to all major signals routed to the SPM. Such major signals should at least include (but need not be limited to):

- 5.5.1. Cantilever deflection
- 5.5.2. Reflected optical signal on the photodiode
- 5.5.3. Amplitude and phase of cantilever oscillation
- 5.5.4. Lateral force
- 5.5.5. Output signals from X, Y and Z sensors
- 5.5.6. X, Y and Z piezo drive voltages
- 5.5.7. At least two BNC for auxiliary user inputs
- 5.5.8. At least two BNCs for auxiliary user outputs

5.6. The electronics must include digitally controlled switches for user-defined signal routing via the auxiliary user output and inputs mentioned above.

5.7. The device parameters should be stored on an on-board non-volatile memory, so as to avoid storing parameter files on an external computer.

5.8. Details of controller electronics:

- 5.8.1. Suitable analog-to-digital controllers (ADCs) and digital-to-analog controllers (DACs) capable of handling several input signals to, or output signals from the SPM are necessary – please provide all details of ADCs and DACs in the controller.
- 5.8.2. Minimum image capture buffer size of 512 MB is desired.
- 5.8.3. Please provide details of all electronics that are part of the controller including the number, speed and frequency range of operation. A list of electronics components should include the details of lock-in amplifiers, frequency synthesizers, field-programmable gate arrays (FPGAs), any noise filters and processors such as the digital signal processor.

6. SPM Operating Modes

6.1. The SPM must be capable of performing measurements in the below listed measurement modes. Acquisition of data during scanning should be possible in both the trace and retrace portions of the scan.

- 6.1.1. Contact SPM Mode (Tip is in contact with the sample)
- 6.1.2. Intermittent/Tapping/Non-Contact Mode (Tip is either in physical contact intermittently or never physically contacts the sample surface during a scan)
- 6.1.3. It should be possible to perform force versus displacement curves/maps
- 6.1.4. Magnetic Force Microscopy Mode
- 6.1.5. Kelvin/Surface Potential Microscopy Mode
- 6.1.6. Nanolithography and Nanomanipulation Mode
- 6.1.7. Current Sensing Scanning Probe Microscopy Mode

6.1.8. Piezoresponse Force Microscopy Mode
6.1.9. High Voltage (+/- 150 V) Piezo Force Microscopy Mode
6.1.10. Scanning Tunneling Microscopy Mode

6.2. The SPM as quoted should, at the least, enable us to perform measurements using modes listed in 6.1.1 to 6.1.8.
6.3. The SPM as quoted should include a variable temperature sample stage which would allow the sample temperature to be varied over a temperature range of at least 5 °C to 100 °C while performing SPM measurements.

7. Light Source and Photo Detector Requirements

7.1. The microscope must have an optical sensing bandwidth of at least DC to 5 MHz.
7.2. SPM's DC photo detector noise must be <10 pm. Noise over the frequency range of 1 Hz to 1 kHz should be reported. The tenderer must include actual technical data and clearly mention the conditions under which the data was acquired so that the committee may evaluate the qualifications of the proposed instrument. An unsubstantiated claim of being technically compliant will not be considered.
7.3. SPM's AC photo detector noise must be less than 50 fm/√ Hz above 200 kHz. The tenderer must include actual technical data and clearly mention the conditions under which the data was acquired so that the committee may evaluate the qualifications of the proposed instrument. An unsubstantiated claim of being technically compliant will not be considered.
7.4. Laser spot positioning and photo detector centering must be motorized and be automated via software control.
7.5. In addition to the mechanical excitation of the cantilever, an option to excite the cantilever via a photo thermal means is preferred. Such photothermal excitation must be possible with laser spot sizes of <10 microns.

8. SPM System Software

8.1. The cost of the SPM should also include all necessary software for operating the SPM in all the modes mentioned in 6.1.1 to 6.1.10.
8.2. The system's software must be integrated with the hardware and must provide a single-point interface for all the standard SPM modes listed in 6.1.1. to 6.1.10 and for other user-specific modes such as for imaging in different environments and for variable temperature imaging.
8.3. The system's software should store all imaging parameters, even while performing measurements under user-defined scanning conditions.
8.4. The data acquisition system must be capable of recording individual image sizes of at least 6000 pixels x 6000 pixels with a resolution of 300 ppi.
8.5. The software must enable 3D rendering of scanning probe measurements data and preferably allow the user to generate, display and visualize 3D real-time scan images.

8.6. The software must allow the acquisition and the simultaneous display of data from multiple channels such as amplitude, phase, topography, current and any user defined auxiliary channel inputs in both the trace and retrace scan directions.
8.7. The software should enable overlaying of real time data for assessing correlation amongst various data inputs and must include the ability to overlay 3D images with any image data channel in real-time.
8.8. The graphical user interface should be user-customizable.
8.9. Image analysis using compatible post-processing software should be possible while real time data acquisition.
8.10. Built-in techniques for cantilever spring constant calibration (i.e. techniques to identify cantilever resonant frequency) such as thermal noise measurement are required.
8.11. The software must include nano lithography and nano manipulation.
8.12. The software must include drift compensation (defined as the ability to track a given spot on the sample surface with nanometer precision). It should be possible to apply drift compensation to any imaging mode. Drift compensation should also be possible during variable temperature imaging.
8.13. Since this will be a generic user tool, user-programmable control and analysis should be possible with the provided software platform.
8.14. The software should be compatible on different operating systems so that offline image processing is possible. Please give a list of operating systems with which the software is compatible.
8.15. Free software upgrades must be available for the lifetime of the instrument.
8.16. A computer that communicates with the SPM hardware and provides a user interface between the SPM hardware and the user should be provided with the SPM.

9. Other Requirements and Options

9.1. The quotation must include a thermally- and acoustically-isolating enclosure. Enclosure must provide at least 20 dB of acoustic isolation.
9.2. The damping of the vibration isolation must be sufficient to allow open- and closed-loop imaging with atomic-scale resolution in labs with floor accelerations <0.5 mm/s^2. Relevant technical details should be provided.
9.3. It should be possible to actively control the temperature of the enclosure to within 0.5 °C. Such low thermal drift is desired so as to perform long duration phase transformation measurements.
9.4. There should be an option to field-upgrade or change the light source to a small spot (< 10 micron X 10 micron) illumination for measurements requiring high scan rates with small cantilevers. The cost of small light sources should be quoted as an optional upgrade.

10. Terms and Conditions

10.1. The vendor is responsible for the installation of the system at the institute.
10.2. The price quotation should include the cost of installation and training of potential users.

10.3. The system should be provided with at least one year of warranty, on all parts and labor, from the date of installation.
10.4. The vendor should have a track record of having previously supplied at least five advanced SPMs in India. Details of SPMs that were previously supplied must be provided.
10.5. The vendor should have qualified technical service personnel for the equipment based in India.
10.6. The lead-time for the delivery of the equipment should not be more than 3 months from the date of receipt of our purchase order.
10.7. The indenter reserves the right to withhold placement of final order. The right to reject all or any of the quotations and to split up the requirements or relax any or all of the above conditions without assigning any reason is reserved.

Yours Sincerely,

Satish A Patil
Associate Professor,
Solid State and Structural Chemistry
Indian Institute of Science (IISc)
Bengaluru, India.
Ph: +91-80-2293-2651
email: satish@sscu.iisc.ernet.in