
Specification for Atomic Force Microscope/Scanning Probe Microscope

The Naval Research Laboratory (NRL) has a requirement for an atomic force microscope/scanning probe microscope (AFM/SPM). The AFM will be used for analysis of the surface patterning, structure electron transfer properties in contact and non-contact modes at ambient and low temperatures, and for nano positioning of individual protein molecules. This instrument must be suitable for soft biological materials. The AFM must be able to take topographical, mechanical, and electrical images of the samples. The instrument must allow for regulation of the sample temperature (from +40 to -130C), include the possibility for working with liquid samples, and include the accessories for elasticity and electrochemical analysis of the individual molecules in the specimen. The instrument must have the ability for specimen illumination with external light. The AFM must be insensitive to vibration, dust, humidity and fluctuation in the ambient temperature.

The AFM must consist of the following components and meet or exceed the following minimum specifications:

1. Basic Unit

The basic unit must include an XYZ stage enclosed in an environmental control chamber that is vacuum ready and include a bell jar. The XY stage must employ a drift free stage design with at least +/-3 mm of travel.

2. SPM Head

The head must be capable of either SPM or AFM operation, including simultaneous AFM feedback and current measurements. The AFM optical level arm must provide operation in topography image, phase image, lateral force, elasticity, current, I-V (current-voltage dependence), S-V (conductivity-voltage dependence), and CITS (current imaging tunneling spectroscopy) curves in contact and non-contact modes. Scan range shall be not less than 0-10 microns (in XY) and 0-2 microns (in Z). The level of vertical noise must not be more than 0.03 nm, and horizontal noise must not be more than 0.6 nm. System drift must be 0.05 nm/s or less. Current sensing sensitivity must be 1 pA or less.

3. SPM Control

The SPM must have electronics for feedback control, bias, final approach motor control scan generation and power supply. It must include inputs for external X, Y, Z signals and external sample bias and have at least 16 bit digital resolution in XYZ. Real time controls must include feedback loop controls for all modes of operation. AFM feedback modes must include contact mode, AC slope mode, AC FM mode, AC phase mode, magnetic force microscope (MFM) and Kelvin probe lifting. AC mode frequency input must be variable over at least three orders of magnitude. STM feedback mode must include

constant current and constant height. Data must be simultaneously displayed in forward and reverse scans, as both a line scan and an image. Up to four data channels must be displayed simultaneously from all available channels of data. The system must have a dual-phase lock-in amplifier for frequencies 0.5-100 kHz, a pulsed force mode extension, and a two-channel oscilloscope with a break out box. It must include a Q-Control system for standard tapping, liquid tapping and MFM/EFM (magnetic force microscope/electric force microscope) applications.

4. High Resolution Video optical microscope

The AFM must have a high resolution video optical microscope with 8.0-0.5 mm field view and a 16:1 color TV camera.

5. Illumination

The microscope must include a light source with a positionable optical light guide and focusing lenses for one or several ports for additional sample illumination not interfering with the system operation. It also should have an additional SNOM (scanning near field optical microscope) fiber holder for the SPM.

6. Sample Compartment

The AFM must be able to operate in controlled gaseous and liquid environments. It should include a four-terminal specimen holder, a sample exchange function, an extension ring, and a flat top bell jar.

Video access with a CCD camera must allow for monitoring the scanner position with resolution of at least 2 microns.

7. Vacuum system

The microscope must include a 50 liter per second Turbo-molecular pump backed to a rotary roughing pump and generate a vacuum level of at least 7×10^{-5} torr.

8. Cooling system

The AFM must guarantee to maintain the samples temperature up to +40C and down to at least -130C with accuracy +/-0.1C or better.

9. Electrochemistry

The AFM must include an open-type fluid cell for the AC and contact mode with a set of counter and reference electrodes.

10. Vibration isolation

The high level of vibration and electrical isolations giving vibration frequency 1 Hz or less must be provided by a microscope platform or vibration isolation chamber.

11. Software

The software shall provide all necessary components for performing experiments and data analysis including user defined programmable scanning and data analysis and should allow for continuous updating. The data analysis function should include roughness, bearing ratio, histogram, grain analysis, high and low path filters, fast Fourier transformation and math functions. The data output shall be in ASCII code and/or any major graphic formats (TIFF, JPEG, etc.).

12. Accessories kit

Accessories should include at least 25 SPM tips, 25 contact AFM tips, 25 AC AFM tips, and magnetic tips holders.

13. Installation and Training

The price of the instrument must include installation at NRL, Washington, D.C. Installation shall include a demonstration that the instrument is in compliance with the specification. The installation shall include minimum two days of on site training for 2 people to familiarize them with the proper operation and care of the instrument.

14. Documentation and Warranty

A full set of all written documentation customarily provided to the public with a commercial item shall be provided. This shall include user manual(s) or equivalent as well as copies of any software, and any manuals on the software included with the system, if customary provided. This documentation must be received at NRL with the system hardware, unless other arrangements are agreed to by the NRL representative.

The contractor shall offer the Government at least the same warranty terms, including offers of extended warranties, offered to the general public in customary commercial practice. The warranty terms must be included in the system price. The period of the warranty shall begin upon acceptance.