

## **Specifications for Variable Pressure Scanning Electron Microscope (VP-SEM)**

The Naval Research Laboratory (NRL) has a requirement for a variable pressure scanning electron microscope (VP-SEM) system. This system must have a field emission electron source, and must include Electron Backscatter Diffraction (EBSD) and Energy Dispersive Spectroscopy (EDS) capabilities. An additional option is the trade-in of NRL's current LEO 1550 SEM. Specific requirements are as follows:

### **1. Variable Pressure Field Emission Scanning Electron Microscope**

The VP-SEM must meet or exceed the following specifications

#### ***1a. Electron Gun and Column Assembly***

The microscope must be equipped with a Schottky-type field emission gun. The probe current range must be from 1 picoAmp to at least 100 nanoAmps. The accelerating voltage must include the range 0.5 – 30 kV, adjustable in steps no greater than 0.1 kV at the low end (0.5 to 3 kV) and no greater than 1kV at the high end (3 to 30 kV). The system must include an aperture control mechanism for maintaining a constant small spot size when changing conditions.

#### ***1b. Resolution***

A resolution of  $\leq 1.2$  nm must be achievable at 30kV. A resolution of  $\leq 3$  nm must be achievable at 1 kV. Resolution must be demonstrated to meet or exceed these specifications after installation at the NRL site. This resolution must be achievable with all accessories installed.

#### ***1c. Vacuum System***

The microscope must operate in both high-vacuum mode (less than  $10^{-5}$  Torr) and low-vacuum mode (including the range of 0.02 to 1 Torr) for imaging and analysis of uncoated samples with low conductivity. The system must provide for an automatic switching between high- and low-vacuum modes with no manual valve switching required by the user. The system must contain a gun isolation valve that is interlocked with the accelerating voltage control and the specimen exchange chamber to protect the gun in case of vacuum loss in the rest of the system. The pump down time (i.e. the time between the introduction of the specimen to the chamber and the time at which the accelerating voltage can be turned on) must be less than 3 minutes.

#### ***1d. Detectors***

The system must include a secondary electron detector as well as a backscattered electron detector, both capable of operating in both high- and low-vacuum modes. The backscattered electron detector must be capable of both topographic imaging and z-contrast imaging. An IR camera must be included for viewing the chamber during operation.

***1e. Chamber and Specimen Exchange***

The microscope chamber must be large enough to accommodate specimens 6 inches in diameter and up to 2 inches tall, with all attachments and detectors (including EBSD camera and EDS detector) installed. The chamber must include enough ports so that all attachments and detectors can be installed simultaneously with no manual switching. The microscope design must include an airlock or load lock for the introduction of specimens to the chamber. The dimensions of the introduction port must be large enough to accommodate specimens at least 2 inches in diameter and 1 inch tall. Introduction of the specimens to the chamber should be guided (i.e. by a rod or fixture) to ensure proper positioning. There must be an option to bypass the airlock or load lock for the introduction of larger specimens into the chamber.

***1f. Stage***

The microscope must include a 5-axis specimen stage, which must have a minimum travel distance of 80 mm in the x- and y-directions and 40 mm in the z-direction. The range of tilt must include -5 to +70 degrees. The stage must be capable of continuous 360-degree rotation about the z-axis. The stage position must be controllable by the software as well as hardware such as a joystick.

***1g. Controls***

The image magnification, stigmatism, and focus must be controllable both by the software and by a set of knobs, which must be included. The stage position must be controllable both by the software and by hardware such as knobs, a joystick or track ball.

***1h. Computer Hardware and Software***

The system must include software for operation of the microscope, which must control all of the necessary options for normal operation of the microscope. The software must allow for multiple users to maintain individual accounts, and for each user's settings to be saved in their individual account. All necessary computer hardware must be included, including the computer and all monitors, keyboards, mouse, joystick, and any other controls. The monitor(s) must measure at least 19" diagonally and must have a minimum resolution of 1280x1024 pixels, which must be supported by the computer hardware and the microscope software. At least one USB port must be available exclusively for attachment of portable storage media.

The computer software must allow for control of all microscope features, including selection of vacuum mode (high- or low-vacuum), accelerating voltage, and detector. It must also allow for navigation of the specimen and stage, for correction of rotation and tilt of the specimen, and image focus and stigmatism.

***1i. Scanning, Imaging and Image Processing***

The microscope hardware and software must be capable of scanning and recording images at resolutions of at least 2560x1920 pixels. The option of saving images as both .tif and .jpg formats is required, with the option of 8-bit or 16-bit format.

Multiple scanning speeds must be selectable by the user through the software, and the option of a reduced-screen scanning mode as well as a point mode are required. Frame averaging must be a user-selectable option.

## **2. Electron Backscattered Diffraction (EBSD) System**

The system must be equipped with an electron backscattered diffraction system for the measurement of local orientations, textures, and phase identification

### ***2a. EBSD Camera***

The EBSD camera must be capable of recording up to 320 frames per second at 8x8 binning. The camera phosphor screen must be circular for best translation of the signal solid angle. The camera must be suitable for both orientation imaging and phase identification applications.

The EBSD camera must be mounted to the SEM chamber and must have one insertion point for pattern collection. The camera's EBSD detector must be equipped for motorized insertion into the chamber and retraction out of the working area of the chamber. Vacuum integrity must be maintained during detector insertion and retraction. The camera must be equipped with a sensor to avoid collision. The EBSD system must be capable of operation in both high- and low-vacuum modes.

### ***2b. Additional Hardware and Software***

All computers, monitors, and other hardware accessories necessary for the operation of the EBSD software and hardware must be included. All additional hardware, such as beam control or camera position control hardware, must be included. Software for both the collection and the analysis of EBSD data must be provided

### ***2c. Installation and Training***

Installation and training on the EBSD system must be provided as described in item (4).

## **3. Energy Dispersive Spectroscopy (EDS) System**

The microscope must be equipped with an Energy Dispersive Spectroscopy (EDS) system for the analysis of chemical composition. The system must include a silicon drift detector (SDD) with a resolution of 136 eV or better. Data collection and analysis software must be included. All additional necessary hardware, including computers and accessories, must be included. Installation and training on the EDS system must be provided as described in item (4).

## **4. Installation and Training**

The contractor shall provide the installation of all parts of the VP-SEM system. The entire system, including EBSD and EDS systems, must meet all specifications prior to acceptance. Specifications must be demonstrated prior to acceptance. The vendor must ensure complete compatibility of the VP-SEM with the installed EDS and EBSD systems.

Training of at least three NRL employees is required on the VP-SEM system as well as on the EBSD and EDS accessories and must be included in the system cost.

**5. Maintenance and Warranty**

The VP-SEM and all associated accessories must be offered with the same warranty terms, including offers of extended warranties, as is offered to the general public as customary commercial practice

**6. Trade-In of Existing Microscope (OPTIONAL)**

It is desirable for the vendor to offer to accept the trade-in of the LEO 1550 SEM currently in use at NRL at a proposed trade-in value, and to offer a discount on the overall price equal to the proposed trade-in value of that microscope. If the vendor proposes and the Government exercises this option, the vendor will be responsible for removing the current SEM and associated parts from NRL before installing the newly purchased system.