

The Naval Research Laboratory (NRL) has a requirement for a high resolution scanning electron microscope (SEM) system designed for automatic operation. This system must have a field emission electron source, and must include a high speed ElectronBackscattered Diffraction (EBSD) system also designed for automatic operation. Additionally the SEM must be compatible with and configured for future EDS analysis hardware. Specific requirements are as follows:

The Field Emission Scanning Electron Microscope must meet or exceed these requirements:

Electron gun and column assembly:

The microscope must be equipped with a Schottky-type field emission gun.

A resolution of $\leq 1.2\text{nm}$ at 30kV and $\leq 2.5\text{ nm}$ at 3 kV.

The probe current range must be from 1 picoAmp to at least 100 nanoAmps.

The accelerating voltage must include the range 0.2 – 30 kV.

Electromagnetically controlled final aperture adjustment.

Fully automated electron optics adjustment.

Detectors:

The system shall include a secondary electron SE detector.

The system shall include a single-crystal YAG Backscattered Electron (BSE) Detector.

-The BSE detector shall be retractable and motorized.

- The position of the BSE detector shall be controllable by an external Application Programming Interface (API).

Integrated Picoammeter with continuous readout.

Infrared (IR) chamber camera.

Vacuum System:

Turbomolecular pump with Lubricant Free Dry Scroll backing pump

Stage/Chamber:

Stage should be at least a 5-axis stage (X,Y,Z Translations, Rotation, Tilt).

Capable of tilting to at least -30° to 90° for EBSD analysis.

Capable of 360° sample rotation.

X,Y,Z translations \geq 100mm

Allow for a maximum sample height of at least 145mm.

Chamber:

The chamber should be compatible with a future addition of a plasma cleaner.

The chamber should be equipped so as to receive an EBSD detector and also allow for future upgrades of an simultaneous EDS detector.

Specimen exchange:

The system shall be equipped with an automatic load lock.

The sample exchange should be fully automatic including:

- The sample can be placed on the exchange mechanism without additional screws or clamping
- The sample will then be automatically brought into the vacuum chamber, placed on the SEM stage and bring the chamber to the proper vacuum automatically
- All of these functions must be able to be executed through an API calls to external software.

The accuracy of the loading of the system must be equal to or less than +/- 0.25mm and a angular accuracy of +/- 0.25 degrees.

Scanning/imaging:

The system must be able to collect and save images from built in detectors at least 8k x 8k pixels at 16bit/pixel.

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

Dynamic Focus correction must be included.

Tilt Correction must be included.

SEM Automated Control:

Besides the API functions already discussed, the system shall be able to be controlled through a user designed external program through OEM supplied API that includes control of:

Beam voltage, current, working distance

Scanning parameters including magnification, scan speed, image pixel size, and external scan control.

Stage control including getting/setting stage position for all five axis.

Additionally this remote capability must be addressable through TCP/IP protocols.

Future compatibility:

The SEM system should be designed so that in the future, a EDS system can be added the SEM that allows for simultaneous EBSD/EDS data collection.

The SEM should be designed so that in the future an in-situ plasma cleaner could be added to the system.

EBSB System:

EBSB Camera:

The EBSB camera should be capable of collecting EBSB patterns at least 640 x 480 pixels with no applied pixel binning.

The collection rate should be at least 630 patterns per second at 4 x 4 pixel binning.

The insertion of the EBSB camera must be motorized and vacuum integrity must be maintained during detector insertion and retraction.

The face of the camera must have tilt adjustment to maximize EBSD pattern quality at small to large working distances. This adjustment must be accessible while in the camera is inserted in the chamber without breaking vacuum.

EBSD control computer/software:

All computers, monitors, and other hardware accessories necessary for the operation of the EBSD software and hardware must be included. Any 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:

-A workstation computer and applicable software will be supplied with the system to control the EBSD system and data collection and analysis.

-The software shall perform automated indexing of the EBSD patterns collected. The indexing should be able to be performed as the patterns are collected, or off-line as a post collection process.

-The EBSD analysis software must be able to create IPF, Euler, Grain boundary and Phase Maps, Pole figures, and Orientation densities. Also analyze Schmid factor, and misorientation kernel.

EBSD automation:

The system shall include a OEM provided Application Program Interface (API) that allows an external user-written program to control the EBSD collection system including:

- The insertion and retraction of the EBSD camera.
- Reading and exporting individual EBSD patterns from the camera
- Setting up scan areas and parameters, starting these scans and saving the data to disk.
- Exporting the data from the file to common text/image formats.

Future compatibility:

The EBSD system should be designed so that in the future, a EDS system can be added the SEM that allows for simultaneous EBSD/EDS data collection.

Delivery Date:

Delivery shall be no later than 150 days from the date of award.

Warranty:

- A minimum, a warranty of twelve months from receipt of (SEM and EBSD Camera) equipment including mechanical, optical and electrical parts and labor on defects in the system and on the specifications of the system is required.
- 1 year warranty for

Documentation (manuals):

- NRL requires (1) electronic copy in either PDF or Microsoft Word format of the following documents: the Operation and Maintenance Manuals, the Interface Control Document (ICD), the Installation Manuals, and the Documentation for the API functions.

Optional features that should be priced separately:

SEM Control knob board.

Integrated Plasma Cleaner for SEM chamber.

Forward/Backscatter solid state detectors integrated with EBSD system.