A field-emission cathode in the electron gun of a scanning electron microscope provides narrower probing beams at low as well as high electron energy, resulting in both improved spatial resolution and minimized sample charging and damage. The JSM-7001F, Thermal Field Emission SEM, is the ideal platform for demanding analytical applications as well as those requiring high resolution and ease-of-use. The specimen stage is large, motorized, automated, and fully eucentric with 5-axis motion option (X, Y, Z, Tilt, and rotation). The specimen chamber handles specimens up to 200mm in diameter. Moreover, JSM-7001F model is equipped with unique features such as one-action specimen exchange airlock, small probe diameter at large probe current and low voltage. Also, the current model has two imaging modes (SEI and RBEI). Up to four live images can be simultaneously viewed, including signal mixing, and a single scan can record and store all four images at once. In addition, the current SEM is powered with two analytical detectors: Energy Dispersive X-ray Spectroscopy (EDS) and Electron Back Scattered Diffraction (EBSD).

**Observation in the GB (Gentle Beam)**

This mode can help lower the charging effect on the specimen by applying the bias voltage to the specimen stage. The ability to image non-conductive samples at moderate to high kV and higher beam current can be performed without the need to coat the sample with metal or carbon for conductivity.

**Capabilities**

FESEM produces clearer, less electrostatically distorted images with spatial resolution down to 1.5 nm. That's 3 to 6 times better than conventional SEM.

**Resolution (secondary electron image)**
- 1.2 nm guaranteed (at accelerating voltage 30kv).
- 3.0nm guaranteed (at accelerating voltage 1kv).
- 3.0nm guaranteed (at accelerating voltage 15kv, probe current 5nA, WD 10nm).

**Magnification**

- SEM mode: x10 (at WD 40 mm) to x 1,000,000.
- Automatic magnification correction function is available.
- Switching from any magnification to preset magnification is possible.
- Image rotation correction: Provided for WD in each EOS mode.

**Image modes**

- Secondary electron image (SEI).
- Backscattered electron image (BEI).

**Accelerating voltage (Acc. V.)**

- **SEM mode**
  - 0.5 to 30 KV.
  - (10V steps from 0.5 to 2.9 KV).
  - (100V steps from 2.9 to 30 KV).

- **Gentle Beam (GB-Lmode):**
  - 0.2 to 30 KV.

- Probe current: is order of $10^{-12}$ to $2 \times 10^{-7}$ A.
- Smaller-area contamination spots can be examined at electron accelerating voltages compatible with Energy Dispersive X-ray Spectroscopy.
- Reduced penetration of low kinetic energy electrons probes closer to the immediate material surface.
- Need for placing conducting coatings on insulating materials is virtually eliminated.
The In-Lens Thermal FEG, which is a combination of FEG and the first condenser lens, can produce ten times larger probe current than a conventional FEG and is sufficient for EDS and EBSD with the smallest objective lens aperture for high resolution imaging.

**Detectors**

1- **Energy Dispersive X-Ray Spectroscopy (EDS)**

**Principle of Operation**

As the electron beam of the SEM is scanned across the sample surface, it generates X-ray fluorescence from the atoms in its path. The energy of each X-ray photon is characteristic of the element that produced it. The EDS microanalysis system collects the X-rays, sorts and plots them by energy, and automatically identifies and labels the elements responsible for the peaks in this energy distribution.

The EDS data are typically compared with either known or computer-generated standards to produce a full quantitative analysis showing the sample composition.

Data output plots the original spectrum showing the number of X-rays collected at each energy level. Maps of element distributions over areas of interest and quantitative composition tables can also be provided as necessary.
EDS identifies the elemental composition of materials imaged in a Scanning Electron Microscope (SEM) for all elements with an atomic number greater than boron. Most elements are detected at concentrations on the order of 0.1%.

Applications include

- **Failure analysis**
  - Manufacturer: Oxford Instruments (UK)
  - Model: INCA X-act.

- **Materials evaluation and identification**
  - Contaminants.
  - Elemental diffusion profiles.
  - Multiple spot analysis of areas from 1 µ to 10 cm in diameter.

- **Failure analysis**
  - Contamination identification.
  - Unknowns identification.

- **Quality control screening**
  - Material verification. Plating specification and certification.

2- Electron Backscatter Diffraction (EBSD)

**Principle of Operation**
Field Emission Scanning Electron Microscope

Electron Backscatter Diffraction (EBSD) is a technique which allows crystallographic information to be obtained from samples in the scanning electron microscope (SEM). In EBSD, a stationary electron beam strikes a tilted crystalline sample and the diffracted electrons form a pattern on a fluorescent screen. This pattern is characteristic of the crystal structure and orientation of the sample region from which it was generated. The diffraction pattern can be used to measure the crystal orientation, measure grain boundary misorientations, discriminate between different materials, and provide information about local crystalline perfection. When the beam is scanned in a grid across a polycrystalline sample and the crystal orientation measured at each point, the resulting map will reveal the constituent grain morphology, orientations, and boundaries. This data can also be used to show the preferred crystal orientations (texture) present in the material. A complete and quantitative representation of the sample microstructure can be established with EBSD.

EBSD System:
- Manufacturer: Oxford Instruments (UK)
- Model: HKL-Nordlys
- Main Features:
  - Mapping Speed: maximum indexed mapping speed of 100Hz
  - High Resolution CCD: 1344 x 1024 pixel CCD camera offering high resolution EBSP measurements required for Phase Identification and Discrimination of materials with very complex crystal structure
  - Forescatter Detector (FSD): Forescatter detectors reveal the grain and subgrain structure of a sample.

Measurement Capabilities

- Orientation and Phase Mapping

Example: EBSD Map showing both Ferrite (red) & Austenite (blue) phases in duplex steel
- Grain Size:
Field Emission Scanning Electron Microscope

EBSD Applications

- Study of texture and recrystallization in sheet metals for improved formability and surface finish.
- Study of texture in relation to electrical and magnetic properties.
- Influence of grain boundary properties on corrosion, fracture and fatigue in metal manufacturing.
- Distribution of grain boundary misorientations, twin boundaries and other special boundaries related to material properties.
- Through thickness variations in texture, for example in sputtering targets.
- Measurement of grain sizes, texture development, and electromigration in microelectronic interconnects.
- Study of fabric in geological materials.
- Thin films, in particular growth of epitaxial layers with applications in solar cells, thin film transistors, non volatile memories, ferroelectric films, and light emitting and laser diodes.
- Phase identification, discrimination and fraction determination including analysis of intermetallic materials, carbides and hydrides.