Advanced Engineering P. Ltd.

*Experts in Metallography,Failure Investigation and RLA*

# Metallurgy for Industries

**Power | Petrochemical |Fertilizer| Chemical | Refinery| Engineering| Automobile**

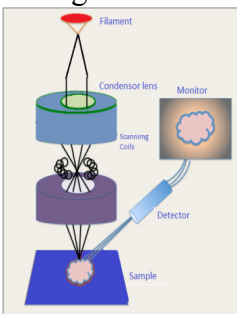
A Monthly News Letter February, 2013 Volume 03

## Fundamentals of Scanning Electron Microscopy and EDS analysis

An advance material characterization tool

### Scanning Electron Microscope

A Scanning electron Microscope which is commonly known as SEM uses electron beam instead of visible light for imaging surface topography of the sample. A typical SEM consist of an electron Gun, Magnetic lenses a XY raster Scanning mechanism and an electron detector. The following schematic shows function of a SEM.




Using magnetic lens a focused Beam of electron is used to scan the small area of sample gives many benefits for imagining.

### Function of SEM

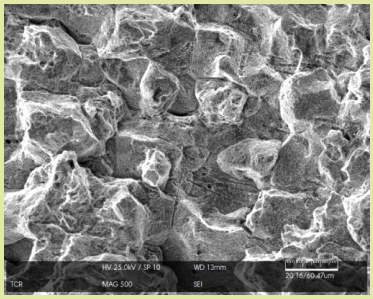
The interaction between the incident electrons and the surface of the sample is used to get image of surface morphology of the sample. When the incident electrons come in contact with the sample, energetic electrons are released from the surface of the sample. The patterns made by the interaction yields information on size, shape, texture and composition of the sample.

A variety of detectors are used to attract different types of scattered electrons, including secondary and backscattered electrons as well as x-rays.

The secondary electron Detector (SED) is the most common imaging technique for SEM. The SED image can achieve very high resolution of the order of few nanometers having magnification of the order of 100,000x to 150,000x. the following shows crystalline particles at 160,910x Magnification.

## Microstructure of the Month

***



**Magnification:** 250x

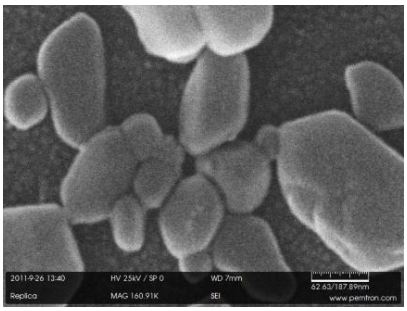
**MOC:** ASTM A182 Gr.F-22, Cl-1

**Component:** Weldolet

**Observation:** The photographs show brittle nature of crack fracture surface with inter-granular cracking. The cracking has occurred on the prior austenite grain boundaries.

**Cause:** This is a typical inter-granular cracking due to heat treatment. The origin of the crack is from sharp corner of the component. Rapid quenching was the root cause.

**Useful hints:** Scanning Electron Microscopy is an useful tool in fractography to identify the subtle features that reveal the nature of the fracture. Fracture surface provides the necessary evidences that can trace back to the reason of failure

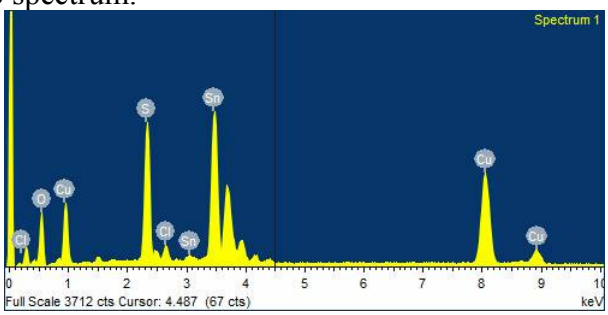



Backscatter electrons are incidental electrons reflected backwards; images provide composition data related to element and compound detection. Although topographic information can be obtained using a backscatter detector, it is not as accurate as an SED.

**Advantages of SEM**
SEM has many advantages over conventional optical microscope.

**Higher depth of Focus:** Due to higher depth of focus SEM can be effectively used in imaging fracture surfaces.
**Higher resolution:** Resolution of SEM is about 100 times higher than optical microscope.
**The flexibility of magnification**: SEM employs magnetic coils for raster scanning, by controlling current through coil precise control of scan area is possible, hence it is very easy to adjust magnification of image. The SEM image magnification can be varied continuously from as low as 20x to as high as 150,000x which is not possible for optical microscopes.

**EDS ( Energy Dispersive Spectroscopy) analysis**
X-rays, emitted from beneath the sample surface, can provide chemical composition of the sample. X-Rays are captured by detector commonly known as EDS Detector. EDS is an established technique used to characterise the elemental composition of a sample under the beam of an electron microscope. The technique exploits the fact that an X-ray is generated when an orbiting electron is displaced by an electron of the microscope beam. Analysis of the X-ray energy, a fundamental characteristic of an element, then leads to the identification of the element. A material is characterised at a single point by a value showing the ratios of elements or with an array of points over the sample by a so-called elemental map that shows the individual elemental concentrations as a series of colour-coded images. EDS is a very useful tool in analysis of small quantity of sample. EDS detectors can detect elements from Boron to Uranium from periodic table. The EDS detector can detect the concentrations as low as 0.1 %. Typical EDS spectrum is plotted as X-Ray Energy in KeV (Kilo Electron Volt) V/s cps (counts per second). The following figure shows typical EDS spectrum.

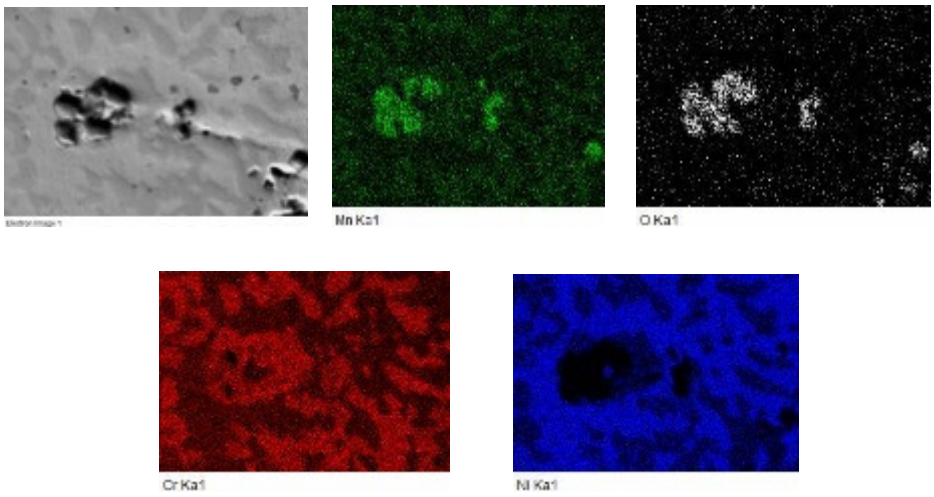



There are several modes of operation of EDS. Which are listed below.

- Point analysis
- Selected area analysis
- Elemental Mapping.

Point analysis is preferred to identify microscopical features such as inclusions, phases in the

microstructure,
Selected area analysis is preferred to analyse the inhomogeneous samples to average out localised irregularities in the chemical composition. It is preferred in analysing minerals samples, powder samples, general corrosion etc. applications.
EDS mapping gives elemental image which is useful in visualising location and concentration of various elements on a SEM image. It is preferred for identifying multilayer coating, multi phases in microstructure, corrosion mapping. The following figure shows SEM image against distribution of Mn (Green), O (White), Cr (Red) and Ni(Blue) elements in a metallic sample.




EDS can be very useful in identifying localise defects, corrosion products, unknown material, qualitative analysis of inorganic matter, Mineral analysis, coating or plating analysis, analysis of glass, Catalysts etc.

* * *