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ELECTRON MICROSCOPY GROUPS

Consider "**Scanning Electron Microscopy (SEM): A Review**" (https://www.researchgate.net/publication/330168803_Scanning_Electron_Microscopy_SEM_A_Review).

Section 3 of this review describe SEM components and analysis process:

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3. Components and Working System of SEM

3.1 Main Components of SEM

The SEM machine consists of the following components:

a. A source to generate electrons of high energy, it is called electron gun.
b. Column down for travelling the electrons through two or more electromagnetic lenses.
c. Deflection system consists of scan coils.
d. Electron detector for backscattered and secondary electron.
e. A chamber for the sample.
f. Computer system consists of viewing screen to display the scanned images and keyboard to control the electron beam.

3.2 SEM Analysis Process

SEM is a tool at which invisible worlds of microspace and nanospace can be seen. Details and complexity that is inaccessible by light microscopy can be revealed by SEM. This is all can be achieved through the following process, which is well descripted by Goldstein et al. [5] :

a- The analysis will be done through applying a beam of electrons (having high-energy) in the range between (100-30,000 electron volts). Usually a thermal source is used for electron emission.
b- The spot size produced from the gun is too large to generate a sharp image therefore the SEM equipped with the lenses to compress the spot and direct the focused electron on the specimen. The spot size of most SEMs is less than (10 nm) with electrons collected from the final lens interact with the specimen and penetrate to a depth of (1μm) to generate the signals used to produce an image.

c- The image of the specimen is formed point by point depending on the movement of the scan coils, which cause the electron beam to move to discrete locations in a form of straight lines until a rectangular raster is produced on the surface of the specimen. All the process depends on magnification required. In case when the operator requests a higher magnified image, the scan coils make the beam to deflect a cross a smaller area. It is worth mentioning that the working distance, which is the distance from the last lens to the surface of the specimen, has an effect on the magnification, in which in the modern SEM this is solved by automatic adjustment.

d- Electron detector is to detect the emitted electrons (signals) from the scanned sample. In the absence of the detectors each signal generated due to the interaction between the electron beam and the surface of the sample can generate an image alone, which is ununderstandable. Both secondary electrons (SE) and backscattered electrons (BSE) are used in SEM image production. When a positive voltage is directed to the collector screen, both SE and BSE will be collected. However, only BSE will be collected in case of negative voltage applied on the collector screen. Fig 9 shows Scintillator detector, which can be used for both secondary and backscattered electrons [10].

e- The signals then are displayed on the viewing screen and the operator will control the brightness and the intensity until a reasonable clear image is obtained. In case where small details are required within the specimen, magnification beyond (10,000x) should be applied.

f- The electron voltage mode (emitted from the gun) has influence on the provided details. The scanned image will be rich in surface information if low accelerating voltages used less ISSN 1454 - 8003 Proceedings of 2018 International Conference on Hydraulics and Pneumatics - HERVEX November 7-9, Băile Govora, Romania 5 than (5 kV). In contrast, the high accelerate voltages, which range between (15-30 kV), which penetrate underneath the surface, will make the reflected signal from the surface carry details about the interior of the sample. Fig. 10 is presented to show different penetration level of electrons through the sample and the reflected signals [11].

g- The partly three-dimensional image obtained from SEM depends on visualization of the topography of the sample in terms of (shape, size and surface texture). And this depends on number of BSE and SE. Surprisingly, angle of inclination of the sample surface has a direct effect on increasing both aforementioned numbers and as a result on topographic contrast. An inclination (or it is called tilt angle as well) more than 50o up to 70 raises number of BSE and SE signal to the peak.

Group 1:

1. Define one or more resources categories to describe the SEM components.

Group 2:

1. Define one or more resources categories to describe the SEM images acquisition process and/or analysis.