Scanning electron microscopy methods in study of micro objects

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Introduction:

The investigations of different materials and objects in the material science and in other fields and technologies require the use of scanning electron microscope (SEM). In the last time electron microscopy is claiming more and more in process of observation of small objects. SEM is indispensable when observation of objects with the size less then visible light wave ($\lambda_0 < 5*10^{-7}$ *m)* is requiring.

As example it can be shown the use of SEMs in chemistry, material physics, biology and nanotechnology. Also this equipment is using in applied physics, in particular during the process of track membrane production and in the creation of the membrane of new generation.

The aim of this work is the acquaintance of the students with scanning electron microscope and the study of the methods of sample investigations with the use of SEM.

Description of the work

1. Equipment and methods

The scanning electron microscope JSM-840 enables morphological observation of microstructures. It can be upgraded with additional equipment for full elemental analysis.

One can see on the scheme of Fig. 1 construction of column and detectors of electrons of scanning electron microscope.

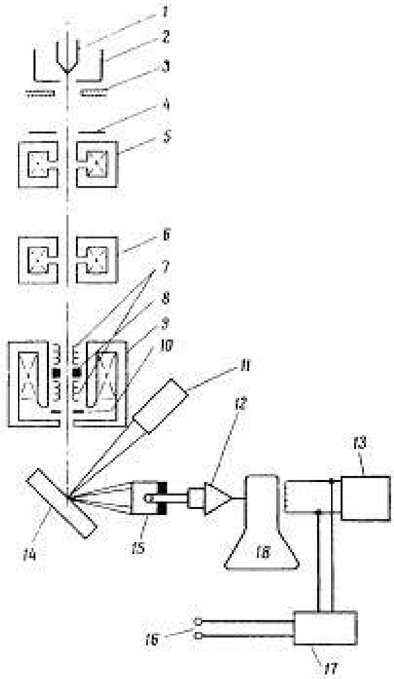


Fig.1. Electron optical scheme for scanning electron microscope

1 - cathode; 2 – Wehnelt electrode; 3 - anode; 4 - aperture; 5 - 1^{st} condenser lens; 6 - 2^{nd} condenser lens; 7 - scanning coils; 8 - stigmator; 9 - objective lens; 10 - aperture; 11 – X-ray detector; 12 – pre-amplifier; 13 – scanning circuits; 14 - specimen; 15 – secondary electron detector; 16 – to the double scanning coil; 17 – magnification control; 18 - CRT.

Tungsten cathode (1) is a source of electron emission. Wehnelt electrode (2) makes possible preliminary focusing of electron beam and the tension between cathode and anode (3) is an accelerating voltage for electrons coming from cathode.

The electron optical system consists of a three-stage magnetic lens and a double deflection scan system. A two-stage zoom condenser lens (5, 6) is employed. The objective lens (9) focus the electron beam to small spot (size is about 5-9 nm). This lens is designed that the aberration coefficients are minimized irrespective of the work distance. The electron beam spot is setting going into raster by scanning system (13, 16).

The secondary electron detector (15) and X-Ray detector (11) built into the model of SEM presented on the scheme.

Fig. 2 shows general view of scanning electron microscope JSM-840 (JEOL, Japan)

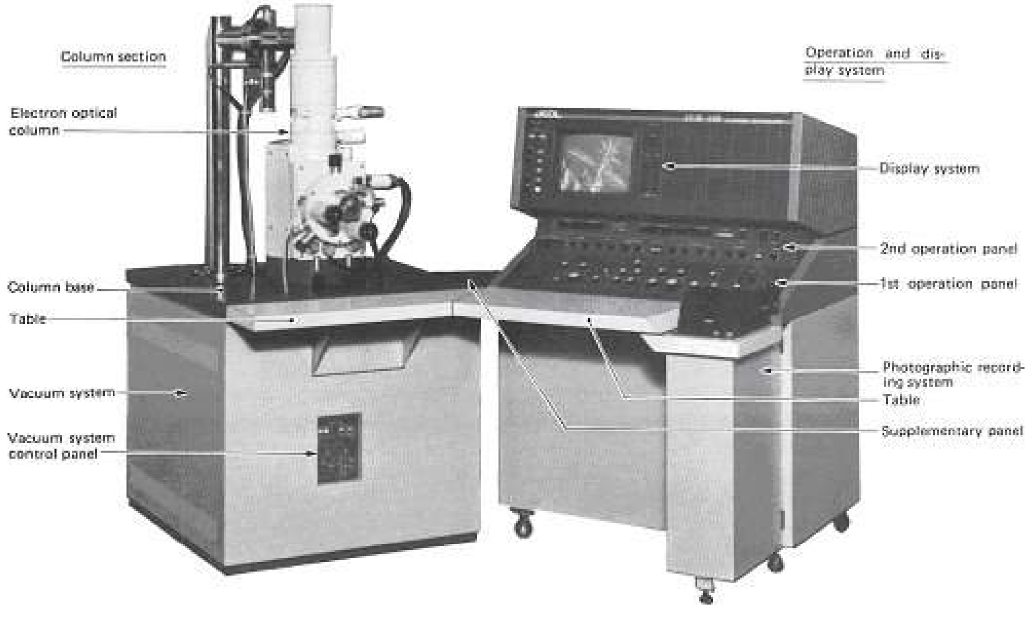


Fig. 2. General view of scanning electron microscope JSM-840

The electrons pass the distance between electron gun and specimen stage through the column and interact with sample substance. As result different types of radiation are generating.

On Figure 3 one can see the scheme illustrating this effect.

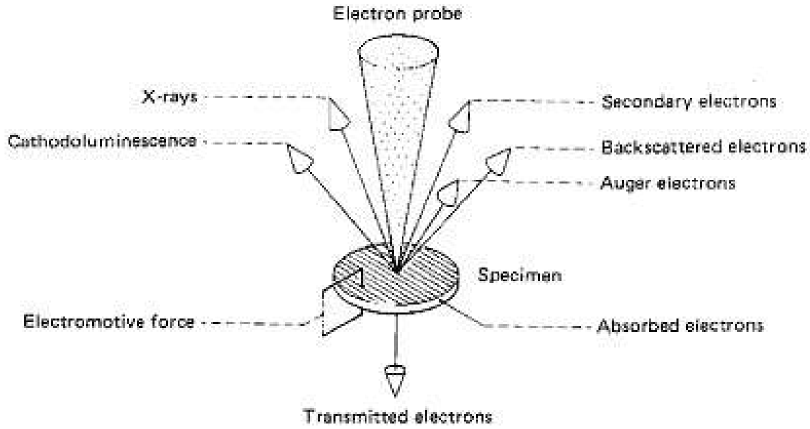


Fig. 3. Signals generated from specimen by initial electron beam

The kind of information received during observation depends on the system that is used for investigation. Secondary electrons are mostly using for the images of sample surfaces. Backscattered electrons give us information about atomic number dependence and make the contrast in channeling mode. X-Rays make possible elemental analysis.

JSM-840 is the model of analog SEM. In the last time the use of digital images is more comfortable for different kinds of operations (printing, publishing, comparison, processing etc.). The system GALLERY-512 makes possible to digitize images created on SEM screen. The scheme of connection of different parts of this system is presented on Fig. 4.

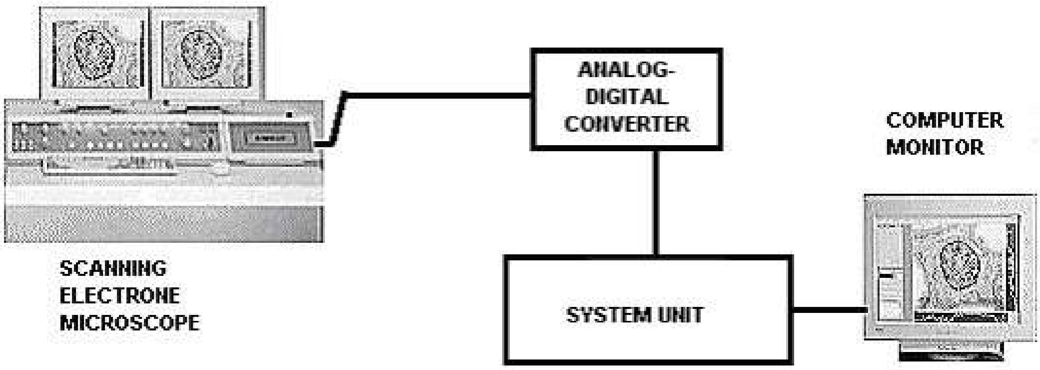


Fig. 4. The system of digitizing of analog images received from SEM

TV signal from SEM is transferring to analog-digital converter (ADC) and then it is processing by special system and showing on the computer monitor as digital picture in PCX format. It can be stored, processed or converted to other picture formats.

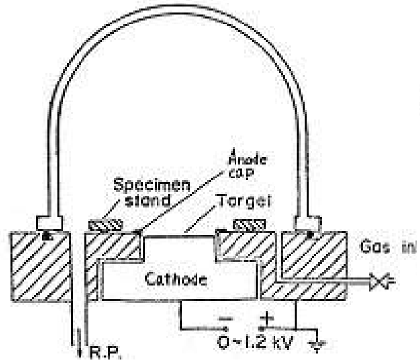
During the process of use of SEM it is possible to observe the samples consist of different materials. In case the non-conductive specimen is investigating it is necessary to cover it with conductive layer. There are three general reasons for this operation:

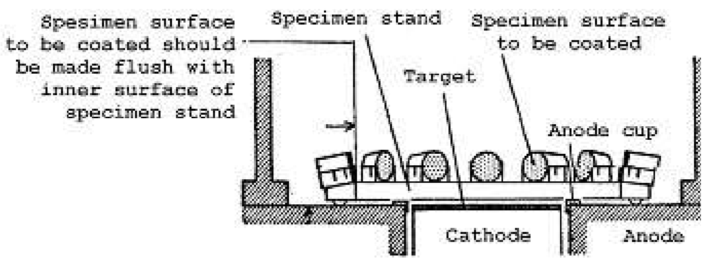
- the surface of sample must be electro conductive to minimize charging from initial beam;
- the surface of sample must be thermo conductive to minimize local heating (as result of high density current in the influence area);
- the material of sample must have high atomic number to increase the coefficient of secondary electron emission.

First and second items can be assured by carbon layer on the sample surface. But a lot of secondary electrons can be provided from element with high number of electrons on the outer atomic levels (for example Cu, Ag, Au, Pt, etc.). In accordance of all these reasons the gold or platinum layers is most preferable. In comparison with other materials these two have low levels of evaporating temperature and are inactive in respect of sample materials.

The special devices must be use for the creation of thin conductive layers on the sample surfaces. As example ion sputter is shown on the Figure 5. The schemes of sample dispositions are presented on Figure 6. The samples are supporting on the specimen stages with electro conductive glue and placing into the stand as shown on the scheme of Fig. 6b. The bell jar mount on its place and the air under it is pumping. When the pressure under it will achieve the level 0.2 torr the ionize voltage between anode and cathode will switch and samples will be covered by thin layer of target particles.

Fig. 5. The general view of ion sputter





a **b**

Fig. 6. The scheme of inner construction under the bell jar of ion sputter:
a) construction of device; b) disposition of specimens on the stand.

2. Practical works

1. Preparation of samples for SEM observation: mounting on specimen stage and coating with gold.
2. Insertion prepared samples into object chamber of microscope and observation the surfaces.
3. Photographing of interesting objects and areas.
4. Discussion of results of investigations.
5. Preparing of the reports.

3. Report content

The students must prepare the report on the works carried out and present it to RSC. In this paper must be shown all stages of operation with illustrations, description of the devices and the methods used during the work and conclusions.

4. Level requirements

All students must to have basic knowledge of physics, electrical engineering and practical skills in electronic equipments and computer operating.

5. References

1. D. Pease, Histological Techniques for Electron Microscopy, Academic Press, New York and London, 1960
2. J. Goldstein, H. Yakowetz, PRACTICAL SCANNING ELECTRON MICROSCOPY, Plenum Press, New York and London, 1975

2-3 students can work at the Laboratory of electron microscopy at the same time.

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