

[54] ELECTRON MICROSCOPY

[72] Inventor: William Charles Nixon, 2 Causewayside
Fen Causeway, Cambridge, England

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[56] References Cited

UNITED STATES PATENTS

2,901,627 8/1959 Wiskott et al.....250/49.5

3,084,061 4/1963 Hall 250/49.5 X
3,401,261 9/1968 Fuchs 250/49.5

OTHER PUBLICATIONS

"Scanning Electron Microscopy" by C. W. Oatley et al. from
Advances in Electronics and Electron Physics, Academic
Press, New York, Vol. 21, 1965, pages 181 & 241-246.

Primary Examiner—William F. Lindquist

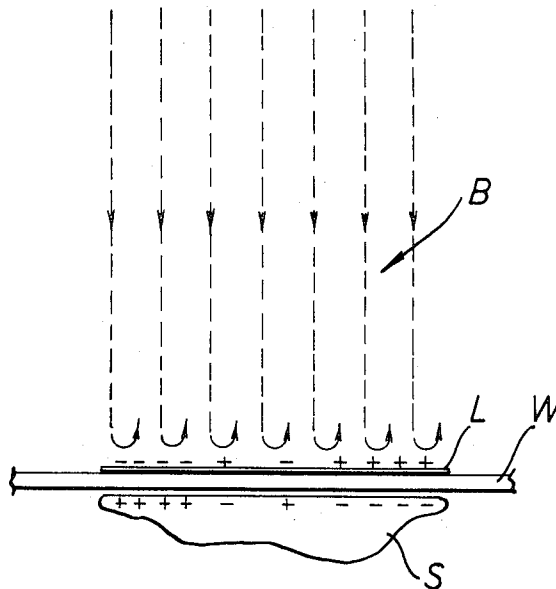
Attorney—Scrivener, Parker, Scrivener & Clarke

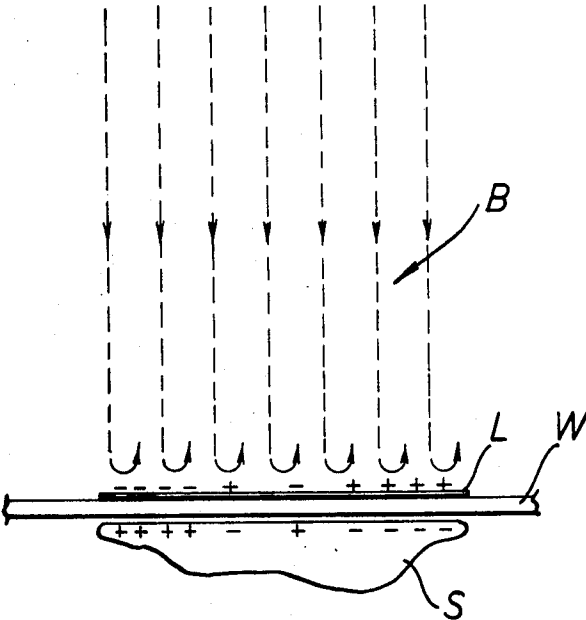
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ABSTRACT

Mirror electron microscope techniques are used indirectly to
examine the electric or magnetic field in a specimen, such as a
biological cell, situated outside the evacuated microscope
chamber by examining the field on a layer or surface im-
mediately inside a wall of the chamber adjacent the outside of
which the specimen is placed.

1 Claim, 1 Drawing Figure





ELECTRON MICROSCOPY

This invention relates to electron microscopy. In the so-called mirror electron microscope a diffuse beam of electrons is projected towards the specimen to be examined and the specimen is maintained at a potential almost equal to or slightly negative with respect to that of the gun from which the electrons originate, so that the electrons are subjected to a strong retarding field as they approach close to the specimen and in fact never reach it but are turned back and, in the absence of any disturbing influence, they return along the path by which they approached the specimen. However any irregularities of contour or of electrical or magnetic field at the surface of the specimen will influence the paths of the electrons as they are moving slowly in the immediate neighborhood of the specimen surface and so if an image is formed with the returned electrons this image will show contrast characteristic of the contour and/or field at the specimen surface.

Such an arrangement has been used for examining the pattern of the electric or magnetic field at, for example, the surface of an integrated circuit element. However, the method has hitherto depended on the specimen being inside the vacuum chamber in which the electron beam and the image are formed. This precludes straight away the examination of those specimens which require to be in an environment at atmospheric pressure.

An attempt has been made with an ordinary transmission microscope, working with electrons of exceptionally high energy, to observe living tissues enclosed in a tiny chamber, only a few microns thick, which is at atmospheric pressure and has entry and exit windows for the electrons, but the high energy of the electrons necessitates apparatus of high cost and large dimensions and the unwanted X-rays that are produced necessitate heavy shielding to protect the users. Moreover, the high energy electrons and the X-rays soon destroy the tissues which are being observed.

The aim of the present invention is to provide a new technique for examining the distribution of electrical or magnetic contrast, or even other forms of contrast, in a specimen without the specimen having to be within the high vacuum that prevails inside the microscope. According to the invention this is achieved by placing the specimen against the outside of a thin substantially gas-impermeable wall, on the inside of which is an at least partially conducting layer that is examined by the use of mirror microscopy techniques. Where the contrast to be examined is electrical field or electrical charge distribution the wall would be of electrically insulating material and would effectively form the dielectric in a capacitor with the specimen on the outside forming one plate and the layer on the inside forming the other. The electrical charge pattern on this layer is an image of that on the specimen itself. Thus in forming a contrast image, in the mirror microscope, of the distribution of charge in the conducting layer I obtain indirectly an image of the distribution of charges, and hence of electrical potentials, in the specimen that is outside the microscope chamber.

Where the field to be examined is a magnetic one the wall must be non-magnetic but could be electrically conducting.

The invention will now be further described with reference to the accompanying diagrammatic drawing.

In this drawing a portion of the wall of a mirror electron microscope is illustrated at W. The microscope can be of the general kind described by M. E. Barnett and W. C. Nixon in the Journal of Scientific Instruments, 1967, Vol. 44 page 893 to 898. A relatively diffuse beam of electrons, not a finely focused probe, approaches the target but, as the target is at substantially the same potential as the gun at which the electrons are generated, the electrons are subjected to a strong retarding action in the final part of their approach to the target and in fact never reach it but return in the general direction from which they came. Thus while they are close to the target they are moving only very slowly and are strongly affected by any electrical or magnetic fields present in the region close to

the target. The returning electrons are collected and formed into an image which reveals the field distribution at the target without ever actually coming into contact with it.

In normal mirror microscopy the target is the specimen under examination. In the arrangement according to the present invention the target is a layer L of electrically conducting material on the inside face of the wall W, the wall being of electrically non-conducting material and being gas-impermeable. The wall W is as thin as possible consistent with being strong enough to withstand the pressure difference between the high vacuum on the inside and the pressure, which will normally be atmospheric, outside.

The specimen, indicated as S, is placed against the outside of the wall W opposite the layer L. As indicated, any electrical charge distribution in that surface of the specimen in which is against or close to the wall W is reproduced in the layer L. Preferably the layer L is of material which has a very high resistance and it could be a semi-conductor, so that the charge on it does not leak away too rapidly.

The diffuse electron beam is indicated at B. In an alternative arrangement it could be in the form of a finely focused beam or probe that scans the layer L in a time-sequential manner like the beam of an ordinary scanning electron microscope, but the same technique of subjecting the electrons to a retarding field and turning them back would still be employed.

Where the specimen S contains magnetic rather than electric contrast then the wall W could be of electrically conducting material, but it must be non-magnetic. Where the wall is of insulating material the layer L is retained, but this layer could be omitted where the wall is electrically conducting, and then the wall itself could be at the appropriate potential to provide the necessary retarding field. The action is analogous to the electrical charge version in that the electrons are strongly influenced by the magnetic field of the specimen itself during the period in which they are moving slowly in the region close to the wall.

It will be appreciated that the invention opens the way to the examination, by electron microscope techniques, of electrical fields and potential patterns, and magnetic fields, in specimens that cannot be put into a vacuum, and in particular living biological tissues, such as nerve cells, and allows these to be studied over long periods, as the specimen is not subjected to any radiation.

In a modification the electron beam could be allowed actually to strike the wall W at low impact energy and the contrast image would be formed by the resulting secondary electrons rather than by returning primaries but, like the returning primaries of the example described above, these secondary electrons would be strongly influenced by the local electric or magnetic field at the wall.

I claim:

1. An electron microscope for examining the electrical field pattern at the surface of a specimen comprising an enclosure defining an evacuated chamber, a wall of said enclosure having inner and outer faces, said wall being of thin, gas impermeable electrically insulating dielectric material, means for generating a beam of electrons within said chamber and directing it towards said wall, a coating of electrically conducting material on the inner face of said wall at a negative potential selected to subject the electrons of said beam to a strong retarding action in the final part of their approach to the coating and to return them before they reach said coating in the general direction from which they came, means for locating a specimen against the outer face of said wall and within the area defined by the coating on the inner face of said wall, said specimen, wall and coating defining a capacitor wherein any non-uniform static electrical charge distribution present on said specimen surface is imaged by capacitor effect as an electrical charge distribution on said coating, and collecting and image-forming means for revealing the field distribution on said coating by the effect of said field distribution on the paths of the returning electrons.

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