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ELECTRON DETECTOR FOR SELECTIVELY DETECTING SECONDARY
ELECTRONS AND HIGH-ENERGY REFLECTED ELECTRONS

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FIG. 1

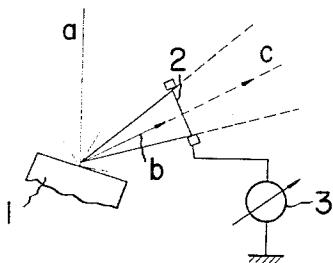


FIG. 2

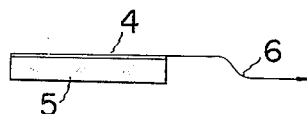


FIG. 3

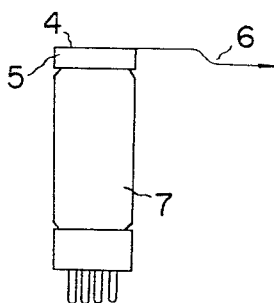
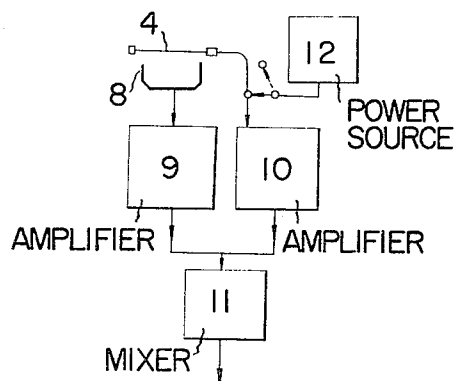


FIG. 4



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ELECTRON DETECTOR FOR SELECTIVELY DETECTING SECONDARY ELECTRONS AND HIGH-ENERGY REFLECTED ELECTRONS

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3 Claims. (Cl. 250—83.3)

ABSTRACT OF THE DISCLOSURE

An electron detector for selectively detecting secondary electrons and high-energy reflected electrons from a specimen subjected to electron bombardment, which comprises an electrically conductive film which detects the secondary electrons but causes the high energy reflected electron to pass therethrough, and an electron collector disposed behind the conductive film to collect the high energy reflected electrons passing through the conductive film.

This invention relates to electron detectors and more particularly to a new electron detector capable of selectively detecting only secondary electrons and high energy reflected electrons and of operating with amply high signal-to-noise ratio with respect to electrons of low energy.

Heretofore, reflected electron images formed by X-ray microanalyzers and a scanning electron microscope have been formed principally by reflected electrons with high energy from the specimen.

The principal reasons for this practice have been that it has not been possible for the detector for electrons beams to discriminate only the secondary electrons and that, particularly in the case when a scintillation counter is used, ample signal-to-noise ratio with respect to electrons of low energy of the order of a number of tens of electron volts could not be obtained whereby the detection performance dropped substantially.

However, there is a great need for determining differences in emissivity of secondary electrons due to differences in specimen material, surface condition, surface electric potential, and other conditions.

It is a general object of the present invention to provide means for satisfying this need.

More specifically, it is an object to provide a new electron detector of simple construction which selectively detects secondary electrons from a specimen and high-energy reflected electrons therefrom.

It is a further object to provide devices in which the electron detector of the invention is effectively utilized, and which are arranged to eliminate noise.

Briefly stated, the present invention resides in an electron detector comprising an electrically conductive film for detecting secondary electrons emitted from a specimen subjected to electron bombardment and an electron collector disposed behind said conductive film, for detecting high energy reflected electrons reflected from said specimen and passing through said conductive film.

The invention further provides a device in which the electron collector of the invention is combined with a high-energy reflected electron collector, and the outputs of the two collectors are amplified by respective amplifiers, whose outputs are combined in a mixer, a power source being provided for elimination of secondary electrons.

The nature, principle, and details of the present invention will be more clearly apparent by reference to the

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following detailed description with respect to preferred embodiments of the invention, when read in conjunction with the accompanying drawing in which like parts are designated by like reference characters, and in which:

FIG. 1 is a schematic diagram showing the essential composition and arrangement of elements for detecting secondary electrons;

FIG. 2 is a side view showing one example means for supporting the electrically conductive film used in the invention;

FIG. 3 is a schematic diagram showing one embodiment of the invention;

FIG. 4 is a block diagram showing another embodiment of the invention.

Referring to FIG. 1, the apparatus shown therein comprises essentially a specimen 1, an electrically conductive thin film 2, and an indicating instrument 3. When an electron beam *a* is projected onto the specimen 1, an output *b* consisting of a combination of high-energy reflected electrons and secondary electrons is produced.

The conductive film 2, which comprises a thin film made of an electrically conductive material such as, for example, aluminum, is disposed in the path of this output *b*. By suitably selecting beforehand the thickness of the thin film, the high-energy reflected electrons *c* are transmitted, and only the secondary electrons are detected, and the quantity of electrons so collected is indicated by the indicator 3.

If the energy of the reflected electrons is assumed to be 20 kev. its range will be of the order of approximately 3 microns. Therefore, by using a film thickness of the order of 100 angstroms, it will be possible to eliminate fully reflected electrons in this case.

One example of a method of supporting the conductive film is illustrated in FIG. 2. As shown, a conductive film 4 in the form of, for example, a thin film of aluminum, is formed by a method such as evaporation deposition on the surface of a block 5 made of a non-conductive material of relatively low electron reflection coefficient and secondary electron generation efficiency such as, for example, a synthetic resin. The conductive film 4 is provided with a lead 6.

In one example of the invention as shown in FIG. 3, the supporting member (platform) for an electron collector is formed by the scintillator of a scintillation counter 7. By this arrangement, the secondary electrons are detected by the electron collector 4, and the high-energy reflected electrons are detected by the scintillation counter (photomultiplier) 7.

It is to be understood that in the examples illustrated in FIGS. 1, 2, and 3, means may be provided to apply a suitable voltage to the electron collectors 2 and 4 and to obtain the energy spectrum of the secondary electrons.

In another embodiment of the invention as shown by block diagram in FIG. 4, means are provided to eliminate noise produced in conductive films. As shown, there are provided the secondary electron collector 4, a collector 8 for high-energy reflected electrons, amplifiers 9 and 10, a mixer 11, and an electric power source 12, for elimination of secondary electrons.

In the operation of this device, the output signals of the secondary electron collector 4 and the high-energy reflected electron collector 8 are respectively amplified by the amplifiers 10 and 9 and then combined in the mixer 11. During this operation, the intensity of noise produced because of absorption of high-energy reflected electrons by the thin film with respect to the secondary electron collector 4 is, of course, proportional to the intensity of high-energy reflected electrons detected by the high-energy reflected electron collector 8.

Therefore, the gains of the amplifiers 9 and 10 are suitably adjusted, and the output of the mixer 11 is

caused to be zero when the device is in a state where secondary electrons do not reach the conductive film 4. The power source 12 is provided to supply voltage for the purpose of preventing secondary electrons from reaching the conductive film 4 at the time of gain calibration of the amplifiers. By this composition and arrangement, only the intensity of the secondary electrons reaching the conductive film 4 always appears in the output of the mixer 11.

As described above, the present invention provides the conductive film of very simple composition and arrangement which selectively detects only secondary electrons. Furthermore, by installing the detector shown in FIG. 3 in an X-ray microanalyzer, two scanning images, namely, a high-energy reflected electron image and a secondary electron image, can be obtained at the same time.

Moreover, by the arrangement indicated in FIG. 4, even when, for example, the primary electron energy is low, and those reflected which are absorbed by the secondary electron collector increase, the effect of noise thereof is eliminated. Also, in the case where an electron beam is to scan over a specimen, variations such as the variation of reflected electron intensity due to variations of the atomic numbers of the elements constituting the specimen are constantly monitored by the reflected electron collector. Accordingly, noise can be eliminated.

It should be understood, of course, that the foregoing disclosure relates to only preferred embodiments of the invention and that it is intended to cover all changes and modifications of the examples of the invention herein chosen for the purposes of the disclosure, which do not

constitute departures from the spirit and scope of the invention as set forth in the appended claims.

What I claim is:

1. An electron detector comprising an electrically conductive film for detecting secondary electrons from a specimen subjected to electron bombardment and an electron collector disposed behind said conductive film, for detecting high-energy reflected electrons reflected from said specimen and passing through said conductive film.

2. The electron detector according to claim 1, wherein said electron collector comprises a photomultiplier including a scintillator.

3. The electron detector according to claim 1, wherein said detector further comprises a first amplifier for amplifying the output of said conductive film, a second amplifier for amplifying the output of said collector, an electric power source for preventing the secondary electrons from reaching said conductive film, a switch inserted between said conductive film and said power source, and means for producing a difference between the two outputs of said first and second amplifiers.

References Cited

UNITED STATES PATENTS

2,814,730	11/1957	Fechter	250—49.5
2,958,779	11/1960	Spear	250—71.5
3,165,629	1/1965	Oakbe	250—49.5
3,239,664	3/1966	Farrell	250—49.5

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