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TITLECathodoluminescence Detector ✓

This invention relates generally to a cathodoluminescence device and more particularly to a cathodoluminescence detector exhibiting relatively high efficiency and high discrimination against signals due to backscattered electrons.

While cathodoluminescence (CL) detectors are generally known, in conventional CL detectors using a solid-state detector as the detection element, the photodiodes are positioned inside the electron microscope vacuum chamber either on the side of the specimen or above it. A glass cover, normally coated with a very thin sputtered layer of indium-tin oxide, is therefore placed in front of the solid-state detector to reject backscattered electrons that can also contribute to the detector signal. The sputtered conductive and optically transparent thin layer on the glass is used to prevent a charging phenomenon from taking place. However, the glass cover in front of the solid-state detector can itself actually be a powerful CL emitter. This means that the glass can act as an extremely efficient converter of backscattered electrons to light which would

be detected by the solid-state photodiode; however, the backscatter in prior art apparatus bears little or no relationship to the specimen under observation. Such detectors, moreover, lack portability and have generally been designed so as to be dedicated exclusively to suit the particular type of electron microscope vacuum chamber with which it is used. This invention seeks to overcome the above mentioned drawbacks.

In accordance with this invention there is provided a cathodoluminescence detector apparatus for the vacuum chamber specimen stage of an electron microscope to be used for cathodoluminescence microscopy and analysis, said apparatus being characterised by:-

- (a) a base member for mounting the apparatus in said vacuum chamber on the specimen stage;
- (b) at least one photosensitive member responsive to radiation emitted from a specimen being scanned by an electron beam of the electron microscope;
- (c) means secured to said base member for supporting said at least one photosensitive member;
- (d) means for coupling a detection signal from said at least one photosensitive member;
- (e) means secured to said base member for supporting the specimen; and
- (f) parabolic reflector means located adjacent said

specimen and said at least one photosensitive member and having a concave reflective surface for reflecting radiation emitted from said specimen to said photosensitive member and absorbing backscattered electrons from said specimen.

Thus it is the primary objective of this invention to combine a parabolic light reflection device with the photo-sensitive solid state detection device in a cathodoluminescence detector which can easily be mounted and removed from the vacuum chamber specimen stage of an electron microscope. The detector, moreover, includes a generally flat photosensitive element and will be effectively absorbed by the parabolic light reflector.

This invention will be further described and illustrated with reference to an embodiment shown as an example and described in conjunction with the accompanying drawings wherein:

Figure 1 shows schematically an electron microscope including a cathodoluminescence detector in accordance with this invention; and
Figure 2 shows a central transverse cross section illustrating in more detail the detector shown in Figure 1.

Referring now to the drawings, an electron microscope EM is shown in Figure 1 comprising an electron

emitter or cathode 1, a Wehnelt Cylinder electrode 2, an anode 3, a beam adjustment system 4, a beam scanning system 5, a final lens 6, a lower pole piece 7 of the final lens, a specimen stage 8 with an adjustment device 9, an electron detector 10 and a cathodoluminescence detector 11 in accordance with this invention. All elements are located in an electron microscope housing 12.

In normal operation of the electron microscope, the electron beam 13 emitted by the cathode 1 will irradiate a specimen 14, shown in Figure 2, arranged on a specimen stub 15 so that radiation due to interaction with the specimen can be detected. The specimen 14 is scanned by the electron beam 13. Transmitted, reflected and/or secondary electrons or other radiations generated by the interaction between the electron beam 13 and the specimen 14 are typically detected by the detection system shown generally by reference 10, to which a video monitor system, not shown in the drawing, is connected. The detection system 10, however, plays no part in the subject matter of this invention, the details of which will now be described.

In Figure 2, a parabolic light reflector 16 is shown having a shiny interior concave surface 17 for light reflection. This can be achieved by either a coating of

a thin film of aluminium on a parabolic cup, a fine surface finish on an aluminium parabolic cup, or an industrial grade piece of aluminium foil formed in the shape of a parabolic mirror with the shiny side as its internal surface. A central opening 18 is provided on top of the reflector 16 for the passage of the scanning electron beam 13. A photosensitive solid state device 19 comprises either a photodiode having an annular form with an opening 20 at the centre or two or more small devices, now shown, positioned around the opening 20. The photosensitive device 19 sits on an electrically conductive cell holder 21 comprising a flat plate having a central opening 29 by means of an electrically insulating intermediate piece 22 fabricated, for example, from a ceramic material. The photosensitive solid state device 19 is positioned at the same level or slightly below the top surface of the specimen 14. Thus backscattered electrons from the specimen 14 will not strike the photosensitive area of the device 19 directly and therefore most of them will be effectively absorbed by the parabolic light reflector 16.

A pair of small aligned openings 23 are formed in both the cell holder 21 and the insulating material 22 through which pass two well shielded electrical signal leads 24 carrying the detected signals from the

photosensitive element 19 and coupled to an amplifying circuit (not shown). The cell 19 is secured in position by means of a pair of clamp/screw connection devices 25 securing also the signal leads 24 beneath the holder 21.

The parabolic light reflector 16 and the cell holder 21 are rigidly held together by means of a peripheral clamp 26 so as to form a mechanically integrated unit. The top opening 18 in the parabolic reflector 16, consisting of a circle of about 5mm in diameter, and the photosensitive detector element 19 are concentric with respect to the central optical axis which is also coincident with the electron beam 13. This mounting configuration results in a high collection efficiency of the reflected light by the photosensitive element 19.

Also included is a specimen stage adaptor unit 27 which is a specially machined base member. The boss part of the member 27a is provided with a centralised threaded bore 28 into which the specimen stub 15 for holding the specimen 14 can be inserted and tightened. The specimen stage adaptor unit 27 and the integrated parabolic light reflector/photosensitive cell unit 11 can be interconnected by means of threaded boss 27a and central opening 29 which comprises a screw threaded hole formed in the cell holder 21, thus providing a unitary device. Such a construction results in a device having

a suitably electrically conductive path for electron discharge. Should backscattered electrons be collected by the electrically conductive parabolic reflector 16, they can be discharged to the electron microscope ground through the same discharge path so that charging problems are eliminated. The entire unit thus formed can be retrofitted to any standard electron microscope vacuum chamber housing 12 by means of a single threaded stud 30 on part 27b without any modification.

The mounting and removal of the cathodoluminescence apparatus in accordance with the embodiment shown and described herein is similar to that for a normal specimen loading or exchange operation. The loading and unloading of the specimen 14 is realised simply by removing the base member 27 from the cell holder 21.

The parabolic light reflector 16 and the photosensitive device 19 together with its supporting plate 21 being mechanically and rigidly connected, can be easily and accurately positioned with respect to one another. The specific design of the parabolic light reflector 16 will enable the efficient reflection of CL signals from the specimen 14 perpendicularly towards the photodevice 19. Furthermore, the small hole 18 on the top of the parabolic light reflector 16, which provides an unobstructed and clear passage for the incoming

electron beam 13 from the electron emitter 1, will result in a light collection angle in the order of 2π steradians.

The preferred embodiment of the present invention can thus be repeatedly mounted and removed from an electron microscope without any modifications to the electron microscope being required. It should be noted that the entire unit including the specimen moves together during adjustment. The optical alignment will not present a problem once it is adjusted during the assembly stage.

The simplicity of the construction makes the time taken to set up the detector effectively similar to that needed for a normal specimen loading or exchanging operation. In this way the electron microscope can be returned to other tasks speedily without compromising normal functions.

Having thus shown and described what is considered to be the preferred method and embodiment for implementing the present invention, it is to be noted that the same has been made by way of illustration and not limitation.



CLAIMS

1. Cathodoluminescence detector apparatus (11) for the vacuum chamber specimen stage (8) of an electron microscope (EM) to be used for cathodoluminescence microscopy and analysis, said apparatus being characterised by:-

- (a) a base member (27) for mounting the apparatus (11) in said vacuum chamber on the specimen stage (8);
- (b) at least one photosensitive member (19) responsive to radiation emitted from a specimen (14) being scanned by an electron beam (13) of the electron microscope;
- (c) means (21) secured to said base member (27) for supporting said at least one photosensitive member (19);
- (d) means (24) for coupling a detection signal from said at least one photosensitive member (19);
- (e) means (15) secured (28) to said base member (27) for supporting the specimen (14); and
- (f) parabolic reflector means (16) located adjacent said specimen (15) and said at least one photosensitive member (19) and having a concave reflective surface (17) for reflecting radiation emitted from said specimen (14) to said photosensitive member (19) and absorbing backscattered electrons from said specimen (14).



2. An apparatus in accordance with Claim 1, wherein said at least one photosensitive member (19) comprises a planar member and wherein said specimen (14) is generally coplanar with said photosensitive member (19).
3. An apparatus in accordance with Claim 1 or 2, wherein said parabolic reflector means (16) includes an aperture (18) for permitting the electron beam (13) to impinge on said specimen (14).
4. An apparatus in accordance with Claim 3, wherein said aperture (18) comprises a central aperture.
5. An apparatus in accordance with any preceding claim, wherein an electrical insulator means (22) is located between said at least one photosensitive member (19) and said means (21) for supporting said photosensitive member.
6. An apparatus in accordance with any preceding claim, wherein said at least one photosensitive member (19) comprises an annular member including a central opening (20) and wherein said specimen (14) is located in said central opening (20).



7. An apparatus in accordance with any preceding claim, wherein said at least one photosensitive member (19) comprises a plurality of coplanar photosensitive members.

8. An apparatus in accordance with any preceding claim, wherein said base member (27) comprises a specimen stage adaptor unit including a first body member (27a) for supporting said specimen, a second body member (27b) for supporting said means (21) for supporting said at least one photosensitive member (19) and a third body member (30) projecting from said second body member for attachment to said vacuum chamber specimen stage (8).

9. An apparatus in accordance with Claim 8, wherein said first body member (27a) includes means (28) for receiving a specimen stub which operates to support said specimen (14).

10. An apparatus in accordance with Claim 8 or 9, wherein said means (28) for receiving the specimen stub comprises a threaded bore.

11. An apparatus in accordance with Claim 8, 9 or 10, wherein said third body member (30) comprises a threaded stud.



12. An apparatus in accordance with any one of Claims 8 to 11, wherein said means (21) for supporting said at least one photosensitive member (19) comprises a flat annular plate (21) including a central aperture (29) through which said third body (27a) projects.

13. An apparatus in accordance with any preceding claim, wherein said means (21) for supporting said at least one photosensitive member (19) and said electrical insulator means (22) includes at least one mutually aligned hole (23) therein for connecting said means (24) for coupling a detection signal to the underside surface of said at least one photosensitive member (19).

14. An apparatus in accordance with any preceding claim, wherein means (26) are provided for attaching said parabolic reflector means (16) to said means (21) for supporting said at least one photosensitive member (19).

15. An apparatus in accordance with Claim 14, wherein said means (26) for attaching comprises means for securing a peripheral edge of said parabolic reflector means (16) to said means (21) for supporting said at least one photosensitive means (19).



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16. An electron microscope incorporating a cathodoluminescence detector apparatus as claimed in any one of the preceding claims.

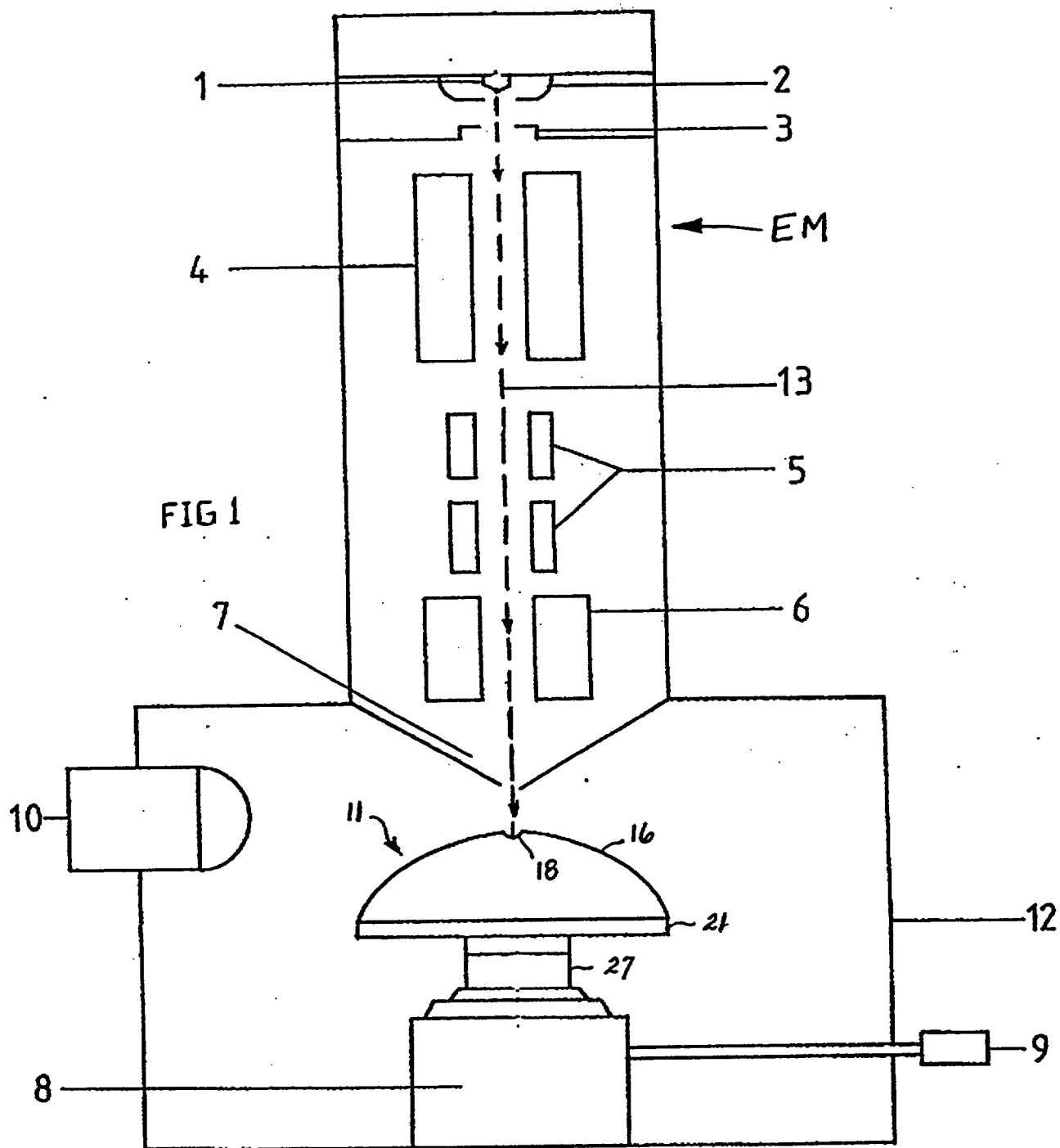
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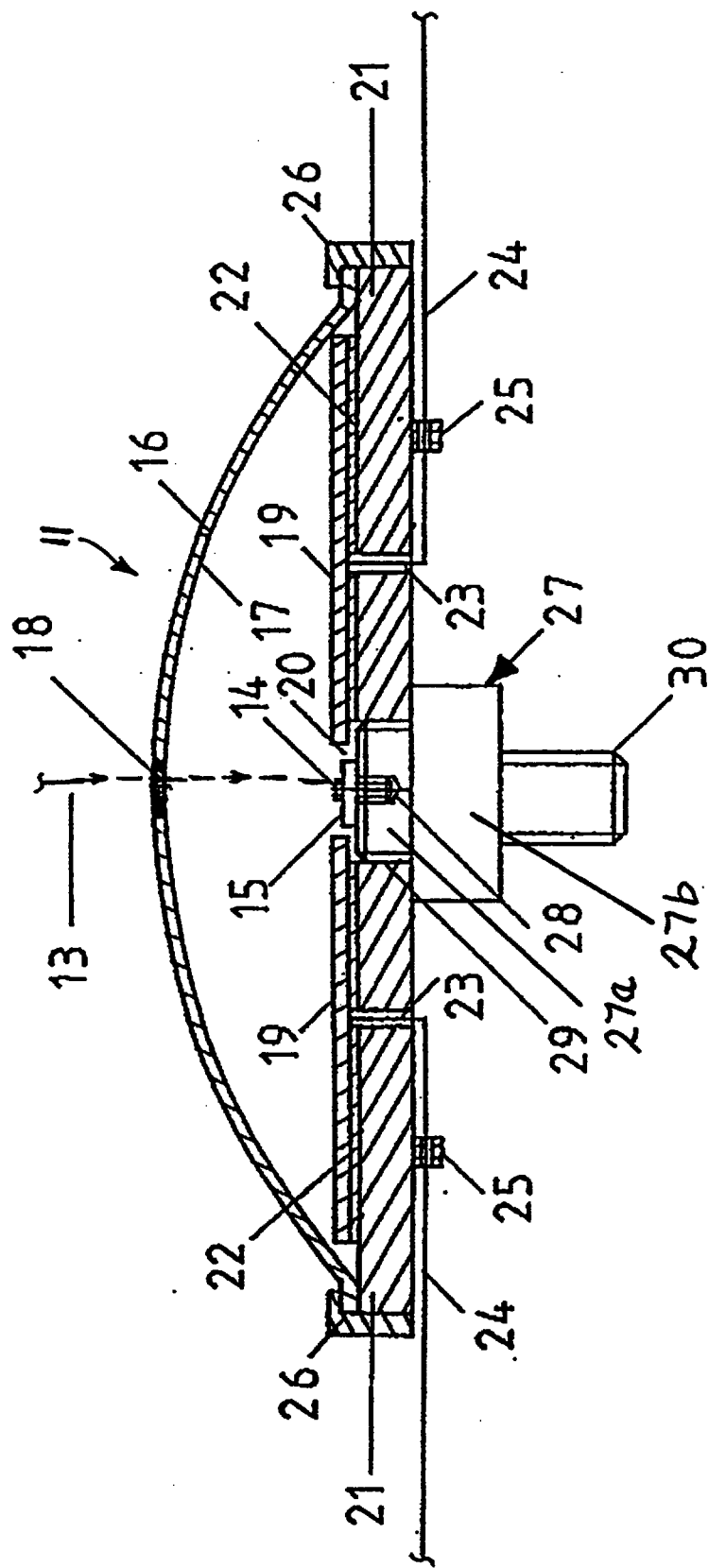
ABSTRACT (Figure 2)

A cathodoluminescence detector (11) for the vacuum chamber specimen stage of an electron microscope comprises a base member adaptor element (27) with threaded stub (30) to connect with the microscope specimen stage (not shown here), and supporting specimen (14) on support (15) mounted on threaded boss part (27a) of element (27). Boss (27a) is secured with a planar support (21) which carries an annular photosensitive member (19) with interposed insulant layer (22) and connections (24). A parabolic reflector (16) is located over member (19) and includes aperture (18) for passage of electron beam (13). The polished concave reflective surface (17) of reflector (16) reflects radiation emitted from specimen (14) to member (19) and absorbs backscattered electrons from the specimen (14).

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ABSTRACT**CATHODOLUMINESCENCE DETECTOR**

A cathodoluminescence detector (11) for the vacuum chamber specimen stage of an electron microscope comprises a base member adaptor element (27) with threaded stub (30) to connect with the microscope specimen stage (not shown here), and supporting specimen (14) on support (15) mounted on threaded boss part (27a) of element (27). Boss (27a) is secured with a planar support (21) which carries an annular photosensitive member (19) with interposed insulant layer (22) and connections (24). A parabolic reflector (16) is located over member (19) and includes aperture (18) for passage of electron beam (13). The polished concave reflective surface (17) of reflector (16) reflects radiation emitted from specimen (14) to member (19) and absorbs backscattered electrons from the specimen (14). (Fig. 2 is to be published.)