

SECONDARY-ELECTRON IMAGING BY SCINTILLATING GASEOUS DETECTION DEVICE

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The environmental scanning electron microscope (ESEM) incorporates the functions of the conventional SEM while it has the added capability of allowing the examination of virtually any specimen in a gaseous environment.¹ The main modes of imaging are all represented in the ESEM, and some developments with regard to the secondary electron (SE) mode are reported herewith.

The conventional E-T detector fails to operate in the gaseous conditions of ESEM, but this obstacle has been overcome with the advent of a gaseous detection device (GDD).^{2,3,4,5} The principle of operation of this device is based on the monitoring of the products of interaction between signals and gas. Initially, the ionization from the signal/gas interaction was used to produce images of varying contrast and, later, the gaseous scintillation, from the same interaction, was also used to produce images. First, a low bias was applied to various electrodes but later a much higher bias was used for the purpose of achieving additional signal gain.⁶ By careful shaping and positioning the respective electrode, it was shown that SE imaging is possible in the ESEM. This has been also independently demonstrated by use of a special specimen preparation.⁷

Presently, it is shown that SE images can be obtained by an equivalent method, namely, by applying a high bias to an electrode and by collecting the photons generated in the electron avalanche initiated by the SE from the specimen surface. Already, it has been proposed^{3,4} that devices used in particle physics can, in principle, be also used for image formation in the ESEM. In this regard, the "gas proportional scintillation counter"⁸ properly modified and transferred to the ESEM conditions could give rise to a "scintillation GDD".³ Thus, a pin-electrode biased with 400 volts was positioned 3 mm above the specimen and immediately below the tip of one of the light pipes used previously.³ The pressure was maintained at 1.5 mbar with ambient air. It was found that, in relative terms, a very weak signal was collected when the electrode bias was turned down close to zero volts. However, the signal was greatly amplified as the electrode bias was increased. Just before the on-set of breakdown, the signal intensity was stabilized and normal imaging could be practiced. No other external electronics devices (amplifiers) were necessary, except for the standard photomultiplier. Under these conditions, a typical image is shown in Fig. 1. The specimen is the same as that used in a previous report⁶, namely, a printed-circuit-board surface showing copper (upper left) and glass fiber matrix (lower left). For comparison, Fig. 2 shows the same area imaged with a plastic scintillating BSE detector symmetrically positioned with respect to the previous light pipe.³ Clearly, the second image bears the characteristics of a BSE image (i.e. Z-contrast) for the given materials, while the first shows SE characteristics.⁶ Further proof of this is given by Fig. 3 showing a thin (2 nm) film of Pt on bulk silicon, both superimposed with 2 nm thick C films.⁷ In the BSE image (Fig. 4) the carbon film is invisible.

SE imaging was also performed at real TV scanning rates by use of the scintillation GDD. The possibility of high frequency response has already been predicted⁴ and its proof here is of extreme importance for further developments of the generalized GDD and its applications. Its advantages have been discussed elsewhere.⁴

References

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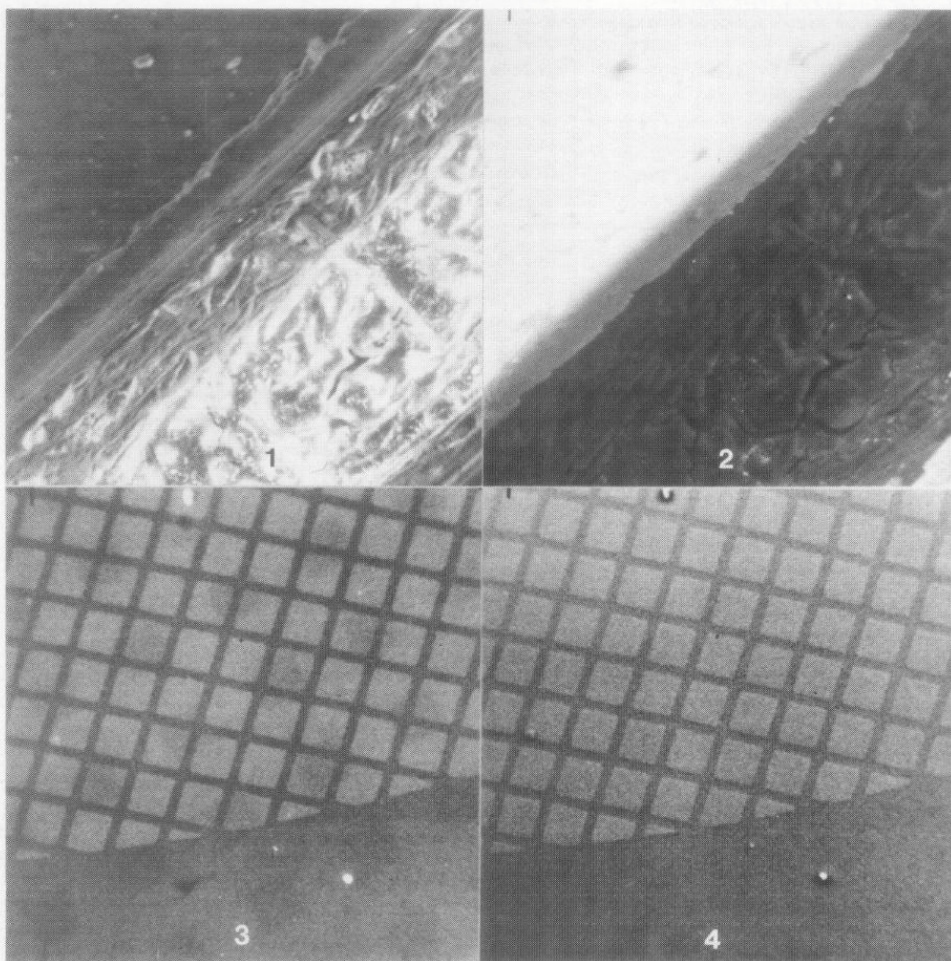


FIG. 1.--SE image of printed-circuit-board surface showing Cu (upper left) and glass fiber insulating matrix (lower right). Horizontal field width=340 μm .

FIG. 2.--Same field of view as in Fig. 1 imaged with BSE detector.

FIG. 3.--Platinum (bright squares) and carbon (dark squares) films (2 nm thick) deposited on Si; SE image. Horizontal field width=340 μm .

FIG. 4.--BSE image of same area as in Fig. 3. 15 keV used in all cases.