doi:10.1017/S1431927613007940
Microsc. Microanal. 19 (Suppl 2), 2013

Evaluation of a Multi-pixel CMOS Photon Detector

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A multi-pixel complementary metal-oxide-semiconductor (CMOS) photon detector for secondary electron (SE) detection in the scanning electron microscope (SEM) has been developed [1]. This solid-state detector was designed to replace the photomultiplier tube (PMT) and other components constituting the widely-used Everhart-Thornley (ET) detector and thus improve certain key aspects of the SE detector. It offers potential advantages such as lower power and voltage requirements, greater cost effectiveness, thinner profile, pixel-selection configurability, and opportunities for future integration of useful features. Fabricated in an optically-enhanced Austriamicrosystems (AMS) 0.35µm CMOS process technology, a prototype version of the photon detector was tested in laboratory conditions and has produced encouraging chip-level experimental results [2-3]. The photon detector has been externally coupled to a SEM for experimental evaluation. Although the optical and electron-optical configuration was far from optimal, resulting in poor collection efficiency, micrographs were successfully generated and comparisons with existing detectors were conducted.

A micrograph captured with the pixellated CMOS photon detector, showing a bonding wire on a bond pad, is presented in Figure 1(b). The image has been digitally enhanced to increase contrast. The original micrograph exhibited low contrast, as the photon detector may not have detected sufficient signal, chiefly due to its small detection area and poor collection efficiency. When compared to the micrograph captured with the back-scattered electron (BSE) detector (Figure 1(a)), the micrograph generated with the pixellated CMOS photon detector is fully recognisable, but seems to lack sharpness. It is suggested that this is because a large beam spot size was configured to increase the beam current for generation of a larger signal, and the consequent increase in spot size has resulted in poorer resolution. Some loss of topographical detail is also apparent, and it is probable that this is due to charge accumulation arising from the use of a large beam current. A further comparison of micrographs captured with the BSE detector and the pixellated CMOS photon detector is presented in Figure 2. When compared to Figure 1(b), the micrograph in Figure 2(b) shows improved resolution, and this may be attributed to the use of a smaller beam spot size.

Figure 3 compares the micrographs of copper flakes on carbon substrate taken with the existing SE detector and the pixellated CMOS photon detector. The setting used was magnification = 168×, EHT = 15kV and a scan speed of 5.1 sec/frame. It shows that with suitable instrumental settings, the pixellated CMOS photon detector is able to produce satisfactory SE images.

The results obtained thus far have demonstrated the potential of this photon detector in generating SE images. To further improve the imaging quality, aspects such as scintillator used, size of photosensitive area and collection efficiency will be investigated [4].

References:

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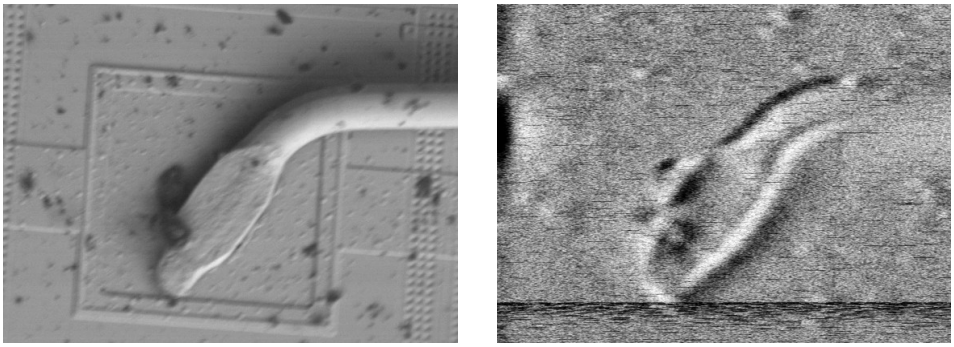
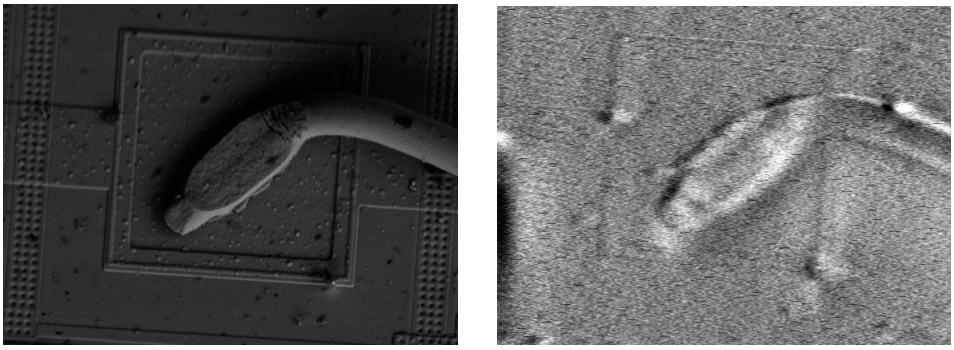
[3] J.H. Chuah and D.M. Holburn, 15th Eur. Microsc. Congr. 2 (2012) 119.
[4] This research is generously supported by Carl Zeiss Microscopy. The authors are indebted to Mr. Daniel Aldridge, Dr. Debbie Waller and Dr. Paul Robertson for their technical assistance and discussions.



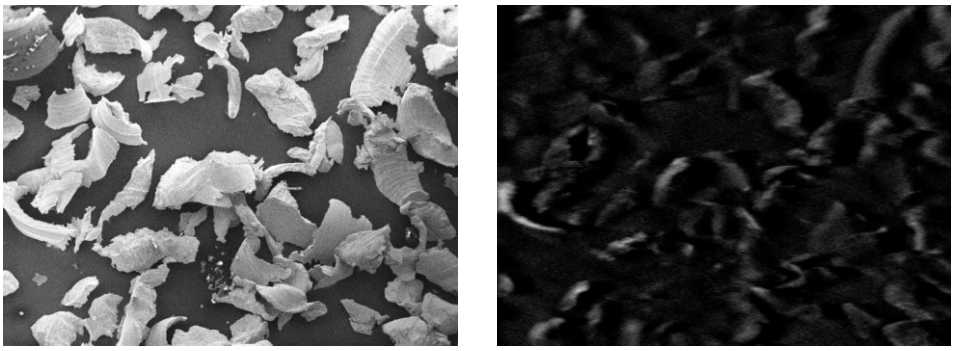
(a) (b)

Figure 1. Comparison of micrographs showing a specimen of wire bonding taken with a) BSE detector and b) multi-pixel CMOS photon detector (with contrast enhancement)



(a) (b)

Figure 2. Comparison of micrographs showing a specimen of wire bonding taken with a) BSE detector and b) multi-pixel CMOS photon detector (with contrast enhancement)



(a) (b)

Figure 3. Comparison of micrographs of copper flakes on carbon substrate taken with a) SE detector and b) multi-pixel CMOS photon detector

https://doi.org/10.1017/S1431927613007940 Published online by Cambridge University Press