doi:10.1017/S1431927611005447
Microsc. Microanal. 17 (Suppl 2), 2011
© Microscopy Society of America 2011

Digital BSE Imaging on SEMs

Toshihide Agemura*, Tsunenori Nomaguchi* and David C. Joy**,***

* Advanced Microscope Systems Design 2nd Department, Naka Division, Nanotechnology Products Business Group, Hitachi High-Technologies Corporation, Hitachinaka, Ibaraki 312-8504, Japan
** Electron Microscopy Facility, University of Tennessee, Knoxville, TN 37996 -0840
*** Center for NanoPhase Materials Science, Oak Ridge National Laboratory, Oak Ridge, TN 37831-6496

A decade ago, the YAG backscatter electron (BSE) detector (SEMs) was in common use on scanning electron microscopes at high accelerating voltages of more than 15kV. Since then, many SEM manufacturers have devised various methods to attain compositional contrast on SEM images at lower accelerating voltages, for example, configurations of a gold conversion plate with an ExB filter, an energy filter with an Everhart-Thornley detector, a divided-area semiconductor detector, and so on.

A method has been introduced during this past year to obtain low-loss electrons (LLE) at higher accelerating voltages [1]. Similarly, a SEM manufacture has developed a LLE detector set within the optical axis inside a SEM column for use at lower accelerating voltages. The LLE detectors introduced above include a high-pass energy filter in order to separate higher energy BSEs near the potential of the primary electron (PE) beam, from lower energy BSEs ranged from 50eV to the PE energy. Currently, there are only two types of BSE detection methods commercially available, one is the high-pass energy filter detector, the other is a detector collecting all BSEs without any energy discrimination. The former choice means displaying BSE images by obtaining the compositional and surface information of a specimen while the latter detection method requires displaying images by obtaining the compositional and inner information averaged from the entire BSE energy range. If it were possible to display a BSE image by extracting the energy region of interest (ROI) from the complete BSE energy distribution spectrum, then this would make it possible to extract some valuable information which is presently buried in the averaged BSE information. By definition, LLE images could be obtained as well.

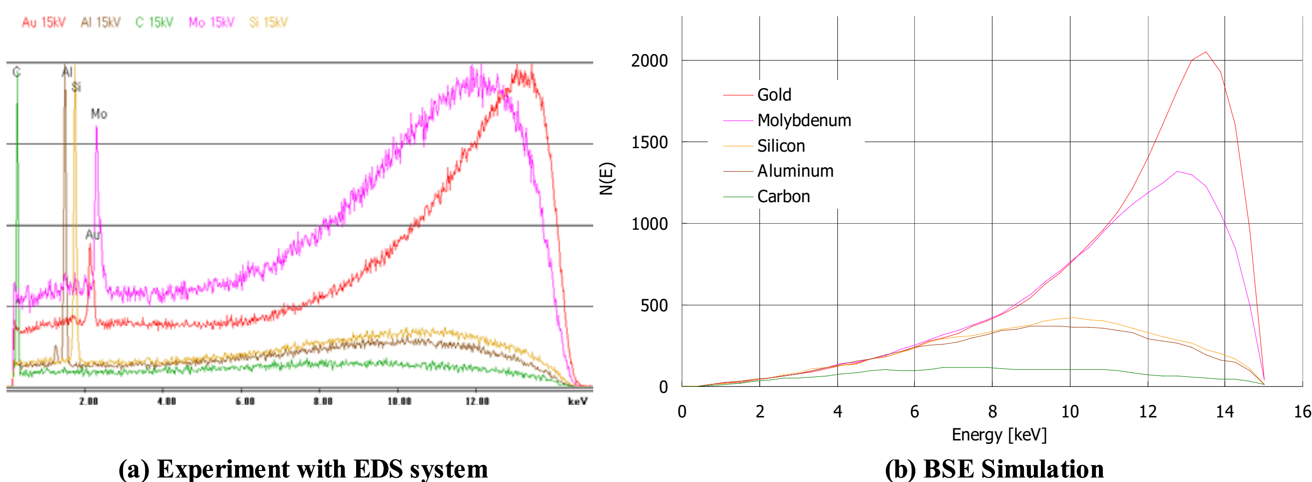
This paper will focus on a simple method to obtain the BSE energy distribution by using a commercially available EDS system. The electron-trap located in front of the silicon drift detector (SDD) in order to prevent the BSEs from hitting the detector was intentionally removed and a spectrum was then obtained to check whether any BSE energy distribution information was visible or not. FIG. 1(a) shows the BSE energy distribution of pure Au, Mo, Si, Al and C samples at an accelerating voltage of 15kV with the EDS system and FIG. 1(b) shows the corresponding Monte-Carlo simulated results. Although characteristic X-ray peaks are visible in the lower energy region of the spectrum, it is readily possible to see a BSE energy dependence on the spectrum by comparing between the experimental and simulated results. Using existing EDS mapping software, which is simple to display images from selected energy ROIs, making it possible to display element specific BSE images. FIG. 2 shows an SE image (a) and mapping images (b) and (c) of a Zr/TiC/Al_2O_3 material at 15kVfor an image field of view of 25μm. The frame time was about 10s and images were integrated for 64 frames with drift correction provided by the EDS mapping software. The ROIs were set at the energy range from 4.0kV(30%) to 15kV(100%) for FIG. 2(b) and from

https://doi.org/10.1017/S1431927611005447 Published online by Cambridge University Press

13.5kV(90%) to 15kV(100%) for FIG. 2(c). It is very clearly seen that FIG. 2(b) has the same form as a conventional BSE image while FIG. 2(c) is the same as a LLE image. A significant impediment to this simple experiment was the very small solid angle subtended so that the image acquisition time needed to be long in order to obtain the images with an adequate signal-to noise ratio; however a possibility does exist for designs which incorporate a much larger solid angle semiconductor detector with a multi-channel pulse analyzer as used in all EDS systems. In conclusion, we believe that this digital detector system is very simple, versatile and will be very beneficial for many SEM users.

References

[1] T. Agemura, T. Nomaguchi and T. Onishi, Microscopy and Microanalysis 16(2010), 632-633.



(a) Experiment with EDS system **(b) BSE Simulation**

FIG. 1. The BSE energy distribution of Au, Mo, Si, Al and C at 15kV for (a) experimental results using an EDS detector without an electron-trap and (b) Monte-Carlo simulated results.

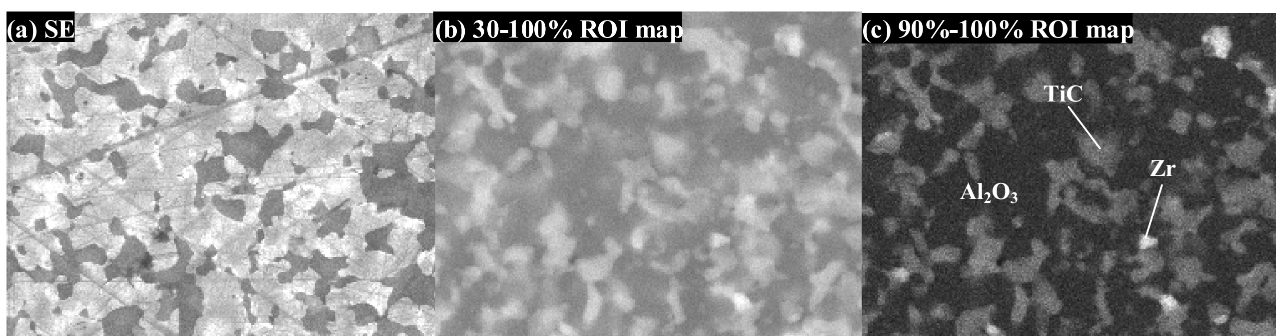


FIG. 2. An SE image (a) and mapping images (b) and (c) of a Zr/TiC/Al_2O_3 material. The field of width of the images is 25μm. All images were taken at 15kV with the mapping function on an EDS system. Frame time was about 10s and 64-frames were integrated with the function of drift correction on the EDS system software. ROIs were set at the energy range from 4.0kV(30%) to 15kV(100%) for the image (b) and from 13.5kV(90%) to 15kV(100%) for the image (c).

https://doi.org/10.1017/S1431927611005447 Published online by Cambridge University Press