doi: 10.1017/S1431927609097049
Microsc Microanal 15(Suppl 2), 2009

Image Quality Improvements in Thermionic Scanning Electron Microscopes

D. W. Phifer,* P. Wandrol,** and T. Vystavel**

* FEI Company, Building AAE, Achtseweg Noord 5, 5600KA Eindhoven, NL
** FEI Company, Podnikatelska 6, 602 00 Brno, CZ

Techniques to vary the landing energy have been used to achieve very low surface energy imaging over decades [1, 2], however this technique can be applied to yield other image quality improvements at a range of landing energies such as lowering the signal detection limit, improving resolution and general contrast enhancement.

Applying a bias voltage to a sample to decelerate the beam can improve resolution which is a key component of image quality. This can be achieved by slowing the electrons at the point of interaction to a speed equal to the difference in potential between the primary beam energy and the sample bias voltage. In this way a higher voltage electron beam can be used to yield a smaller interaction area. Typically this well known principle (also called cathode lens mode) has been applied to decrease interaction volumes for surface characterization at low energies [1, 2] however this same principle can be used to increase image resolution and quality.

Image quality is affected in a number of ways by beam deceleration including a lowering of signal detection limits and improvement in contrast. Particularly, imaging at lower accelerating voltages, beam deceleration can improve the ability to detect signal from conductive and semi-conductive samples. This is illustrated in figure 1 by a 500 eV image of a palladium solder/copper alloy (landing energy 500 eV/ primary beam energy 3.5 kV with stage bias of 3kV). Clearly surface details are more distinct, surface feature contrast is more visible, and the image quality is much improved. Without the beam deceleration the detection efficiency of backscattered electron (BSE) detector is very poor at 500 eV therefore the detection limit is lowered.

Improved image quality can be a direct result of the angular selection of signal that is possible with beam deceleration across a wide variety of accelerating voltages. Changing the bias voltage on the sample allows angular selection of signal and thus additional contrast mechanisms to be observed. This is illustrated in figure 2 by comparing images of microcrystalline diamond deposited on silicon substrate without using the beam deceleration to one at the same landing energy (3 keV) with the stage bias of 3 kV. Surface details are more distinct with the beam deceleration and the image quality is much improved while the contrast from atomic differences is lessened as the high angle BSE are moved in line with the primary beam axis.

References

[1] I. Mullerova and L. Frank, Advances in Imaging and Electron Physics, 2003. **128:** 309-443.
[2] E. Bauer, Rep. Prog. Phys., 1994. **57**: 895-938.

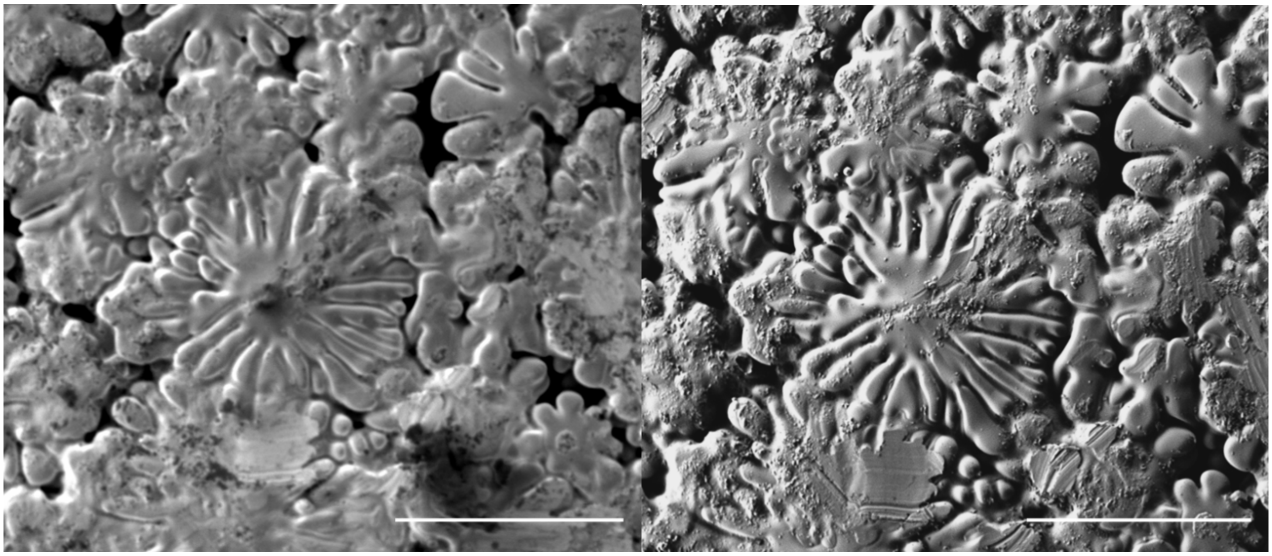

FIG. 1. Improved detection limit and improved surface details is illustrated by the comparison of the left - traditional secondary electron image of a palladium solder/copper alloy at 500 eV and right – beam deceleration BSE image (landing energy of 500 eV/accelerating voltage of 3.5 kV with stage bias of 3 kV). Scale bar represents 30 µm.

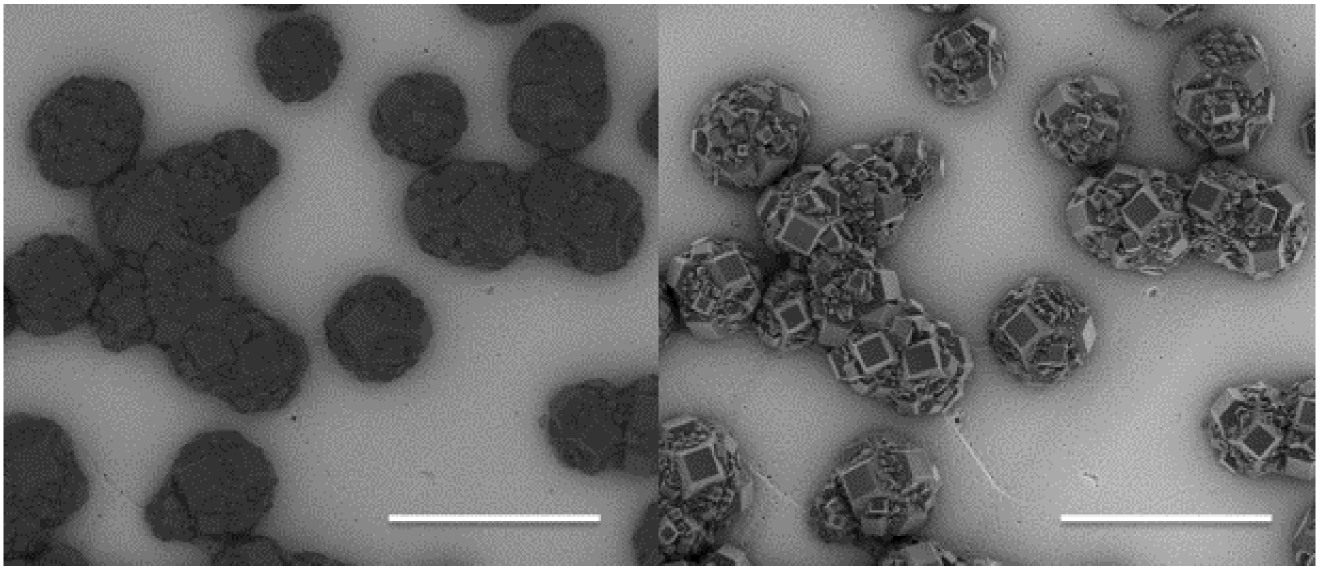

FIG. 2. Microcrystalline diamond deposited on silicon substrate. Left – conventional BSE image taken at 3 keV, right – beam deceleration BSE image (landing energy of 3 keV /accelerating voltage of 6 kV with stage bias of 3 kV). Scale bar represents 20 µm.