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Low kV Imaging using Charge Balancing

Kenneth Png

Carl Zeiss Microscopy Ltd, Applications Department, Cambridge, UK

Scanning electron microscopy (SEM) is a widely used technique to image materials. Traditionally, the choice of materials has been restricted to conductive samples because non-conductive material is unable to dissipate the negative charge from the electron beam. The negative charge builds up on the surface, causing artefacts and distorting the acquired image. To overcome this problem, an effective method of dissipating the charge is necessary.

One method to dissipate charge is to reduce the acceleration voltage of the electron beam. The interaction of the electron beam with a material produces electrons which leave the surface. The number of electrons leaving can be balanced with the number of electrons arriving from the primary beam [1]. However, if the acceleration voltage is too low, more electrons will leave and a positive charge builds up on the sample. With fine control of the beam energy, charge equilibrium can be achieved and an image free of charging artefacts obtained. Typically, an acceleration voltage of less than 1 kV is required to charge balance, but this is sample dependent. At low acceleration voltages the interaction depth is small which enhances surface detail [2,3] and beam damage is minimized. An electron column containing an in-lens detector is preferred since it allows for short working distances which reduce chromatic and spherical beam aberrations, particularly at low kV.

The Carl Zeiss ∑IGMA HD, a field emission SEM, was chosen to examine butterfly wings which are both non-conductive and beam sensitive. The ∑igma HD permits very fine control of acceleration voltage and has a highly efficient in-lens secondary electron detector which uses a unique final lens design to attract secondary electrons up the column to the detector.

Butterfly wings have a complex structure. Each scale contains pillars that link a number of elongated parallel ridges. In figure 1, the intricate structure of the butterfly wings can clearly be seen. At 490 V, charge is balanced and the image is stable. Very fine surface detail is revealed on the pillars which cannot be resolved at higher kV. At higher magnifications, the charge per unit area is higher so the image can charge up. This can be compensated by finely tuning the acceleration voltage.

Charge balancing using low kV is an effective technique for obtaining high resolution images of non-conductive samples in their natural state. Fine control of the acceleration voltage is required to balance the charge. The high surface detail it provides is advantageous in many biological and surface analysis applications.

References:

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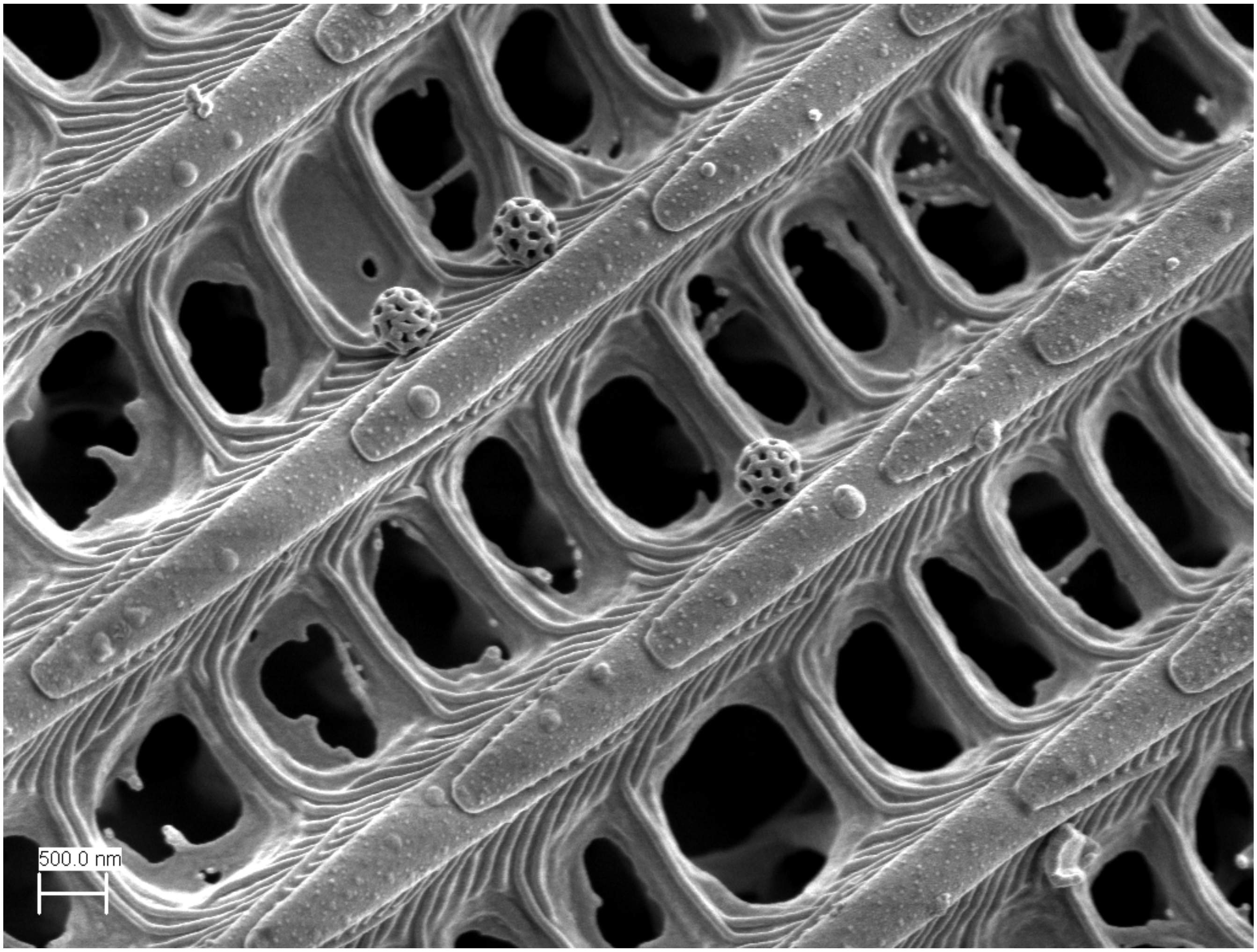

Figure 1. Butterfly wing at 490 V acceleration voltage using a secondary electron in-lens detector. No charging observed.

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