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Development of chopped scan control for beam blanking

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Beam blanking is a technique in electron microscopy whereby the electron beam is interrupted from reaching the sample at high speeds or frequencies. This is required for a range of experiments, including lock-in amplification of minute signals, close control of electron dose/fluence, or capture of fast events with high temporal resolution or in synchronization with external clocks. Beam blanking is typically achieved by deflecting the beam from the optical axis with added blanking plates into a purposely designed blanking aperture. However, this approach requires installation of additional hardware into the microscope column. Development of an alternative approach is presented here, where the beam is deflected using the normal scan control coils into a vacuum or sacrificial point in the sample plane. This removes the need of additional components in the microscope column and places the added complexity of beam blanking into the scan controller only.

Whilst blanking with the scan coils can be thought of as adding a second blanking pattern on top of the regular scan pattern, such a hardware configuration does not provide means to choose the position of the vacuum or sacrificial beam position, or to synchronize the two patterns, therefore the normal scan controller must take on the task of beam blanking in addition to beam scanning. This enables the user to freely define a position for blanking, which may be from a pre-scanned image, or from preplanned coordinates. Generation of both patterns from the same controller also enables the freedom to choose if blanking and scanning are synchronised to the same clock or are free running. Use of the scan controller in this fashion requires complex scan algorithms, as established scan patterns in electron microscopy already include advanced flyback strategies at end of line and end of frame.

Attached Figure presents such a scan pattern with blanking – a very small 3x3 pixel scan is shown here to simplify presentation, but resolution in this scan mode is only limited by the scan resolution of 16-bit corresponding to 65,536 x 65,536 pixels. A 1 µs acquisition time was used, with a line start wait of 10 ns, a beam return time of 320 ns, without any pre-scan, pixel settling or additional holding time. Digital frame, line and pixel trigger outputs typically used for detector or camera synchronization are shown here to guide the presentation and were set to a duration of 200 ns. A blanking reference frequency of 10MHz was selected for this example in order to give a visible blanking duration comparable to the pixel acquisition time. The blanking position was set to 0,0 (top left) and the image scan was set to begin at 32768,32768 (middle) of the scan space. Note in the analog scan outputs for

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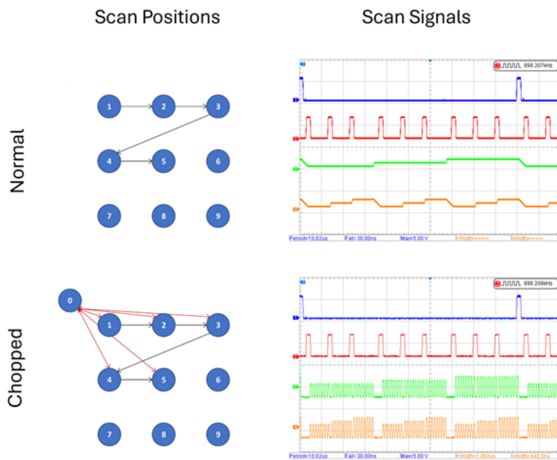
column and row signals how the beam is encoded to jump between the blanking pixel and the image pixels, which gives a chopped appearance to the analog traces.

Practical application of this chopped scan mode for beam blanking will be shown in TEM and SEM, including the limitations to be expected from using the scan coils for such fast beam motion. It will be shown that hysteresis and amplifier bandwidth limitations restrict the maximum blanking speed possible to a range of approximatively 100kHz, which could be overcome with further development of distortion removal algorithms, however all this is achieved without modifications to the microscope column.

Graphic:



Keywords:

Scan control, Beam blanking