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Event Streamed Spectrum Imaging (ESSI)

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X-ray mapping is a powerful method for the visualization of elemental information using images. The current trend of x-ray mapping is toward full spectrum collection or spectrum imaging [1-3]. Spectrum imaging is the collection and spatial registration of all x-ray events yielding a spectral data cube. Various analytical methods can be applied to the data cube, ranging from simple elemental region-of-interest images, to spectral summation of the pixel elemental weight percent, to true chemical phase images [4].

Spectrum imaging is an important tool in x-ray microanalysis; however, current implementations lack true integration with scan generation and the collection of other signals of interest such as secondary and backscattered electron images. As a result, scan generation is auxiliary to the collection of x-ray events leading to overhead delays in sequential acquisition and data transfer. To overcome overhead delays and other limitations a new method has been developed–Event Streamed Spectrum Imaging (ESSI). ESSI treats x-ray events as simply another signal source. The x-ray events are assembled with other signal sources into a pixel event that contains all data acquired at a specific pixel position. The pixel events are packetized and streamed to a host computer where they are buffered and stored to disk. The entire assembly and packetizing process is performed at a hardware level providing an extremely efficient process with zero overhead for the collection of all electron, x-ray and other information registered to every x-y beam position over single or multiple frames. Since host extraction for processing is not coupled to acquisition, a high degree of interactive analysis is possible including real-time alteration of analysis conditions by eliminating the need to restart the acquisition. The analysis routine replays the saved events from the beginning until it synchronizes with the live events.

ESSI provides unique capabilities including a new form of passive drift correction (Spatial Frame Lock) shown in Fig 1 and Fig 2 and an improved form of programmed beam acquisition (Dynamic Dwell Modulation) shown in Fig 3.

Drift correction during spectrum image collection is typically provided using an active correction to collect electron image data at defined intervals. The electron image is compared to a reference image, drift correction vectors are computed, and the correction applied to re-center the area of interest. Using ESSI, electron information is collected at the same time as x-ray information thus removing the electron image collection step. Because frame information is retained in the event stream, Spatial Frame Lock can look ahead and compute drift correction vectors before assigning x-ray events to pixel locations. Even bad frames resulting from beam fluctuations or vibration can be detected and skipped thus preventing them from corrupting the resultant x-ray map.

Programmed beam acquisition is the collection of a spectrum image using a mask to define areas of different x-ray dwell times [5]. This method is highly useful in samples with localized regions of interest; e.g. cells or particles on a support substrate. By reducing data collection times over areas with minimal information, the time spent collecting a spectrum image can decrease significantly.

Dynamic Dwell Modulation improves current programmed beam acquisition methods by allowing the dwell mask to be altered on a frame-to-frame basis. The mask shape definition can be modified in addition to changes in the x-ray dwell times. Dynamic Dwell Modulation uses ESSI as a collection method: dwell changes are treated as auxiliary events and the event stream contains all information associated with the spectrum image collection.

References

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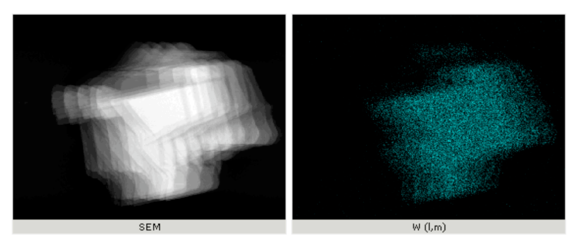

FIG. 1. Spectrum image of a tungsten carbide particle with stage induced drift.

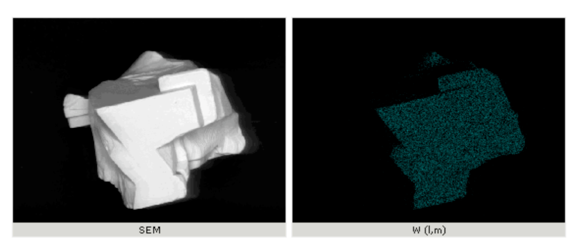

FIG. 2. Identical spectrum image data set with Spatial Frame Lock drift correction enabled.

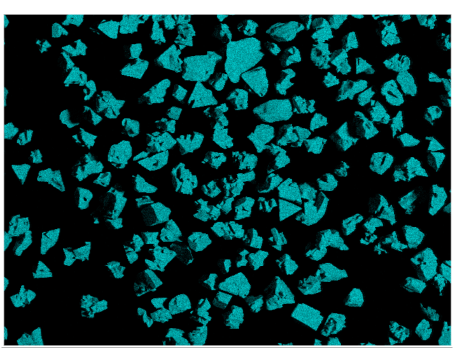

FIG. 3. Tungsten carbide particles acquired with Dynamic Dwell Modulation. The x-ray dwell time is 10 times longer over the particles than the surrounding background area.