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New Real Time Visualisations for X-ray Mapping Data

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X-ray maps are typically obtained by integrating counts in energy bands ("windows" or ROI “regions of interest”) straddling the characteristic energy for each element of interest, and using the integrals as image pixel intensities. These “element maps” are popular because they can be displayed immediately and are perceived to demonstrate the spatial distributions of elements. Fig.1(a) shows an example of three maps obtained by this method that appear to show similar distributions for Si and W and a complimentary distribution for Na. The pitfalls of this approach have long been recognised: the bremsstahlung background changes with material content and different element peaks can fall in the same energy window. Thus, the Na map shows detail generated by changing content of other elements and the Si and W maps both look the same because the energy windows for Si Kα and W Mα are virtually identical. One solution is to use full spectrum processing at each pixel to achieve background subtraction and overlap correction [1] and this technique has become known as “quantitative mapping” [2]. Quantitative mapping has been regarded as an “off-line” tool because of the time required to do the computations and it has been suggested that quantitative maps are not as “smooth” as intensity maps when spectra only contain a few counts [3]. Now that large area SDD detectors are available, data rates of 100 kcps or more are easy to achieve even at low beam kV [4] and there are enough counts in a pixel to make it worthwhile to deliver more accurate real time displays. With advances in computing power, comprehensive “FLS” correction procedures [5] can now be implemented “on-line” as the data are acquired to give both an unbiased measure of net peak intensity and an estimate of the expected statistical error. The combination of higher count rates and accurate spectrum processing gives the “FLS” results in fig 1(b) where the Si K-series FLS map is no noisier than the original window map and the Na and W maps now reveal the true distributions of these elements. In the Na maps, the background artefact is effectively removed and all that remains are statistical residuals where the positive excursions leave a “ghost” of the original artefact distribution. In fig. 1(c) these residuals are removed by applying a 3-sigma threshold test using the statistical estimate calculated by FLS.

Most EDX systems can allocate colours to individual element maps, mix these maps to form a colour composite and optionally present this as an overlay combined with an electron image. The user has to be expert enough to pick which maps are likely to give an effective mix that exposes phases but in an example like 1(b) conventional window mapping does not expose any difference between the Si and W maps. FLS processing removes irrelevant background detail and the duplication of maps caused by peak overlap so that colour layering can be used more effectively to display regions of different composition. Furthermore, the relationships between maps can be assessed automatically to make an optimal choice of colours and generate a layered colour image that immediately reveals regions of different material content or “phases” during acquisition. The use of FLS improves the separation of element distributions so that the connection between the original element distributions and the regions of different composition in the layered image is established by the common colour as shown in fig.2. The use of real time FLS correction and automatic colour layering provides more accurate and intuitive presentations for the user, particularly at the high data rates achieved with modern EDX detectors and electronics.

References

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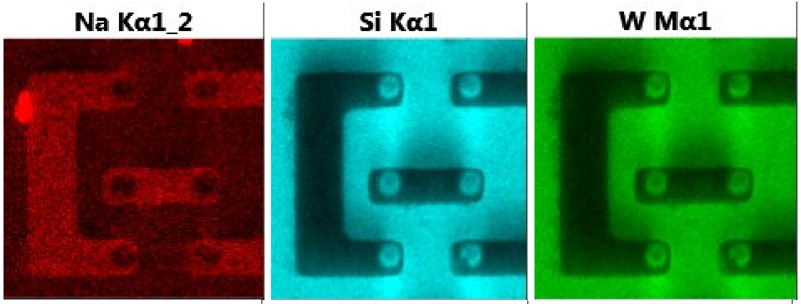
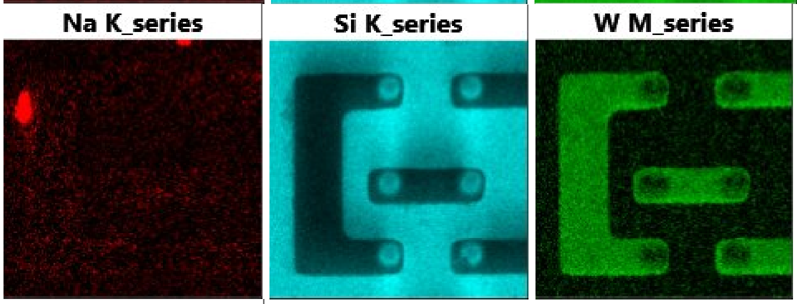


FIG. 1.
(a) Conventional energy window maps, field width 20um



(b) FLS processed maps with background removed and peak overlaps corrected

(c) Effect of statistical significance thresholding. The Na K-series map from (b) has pixels set to zero wherever they fall below the calculated 3 sigma statistical threshold.

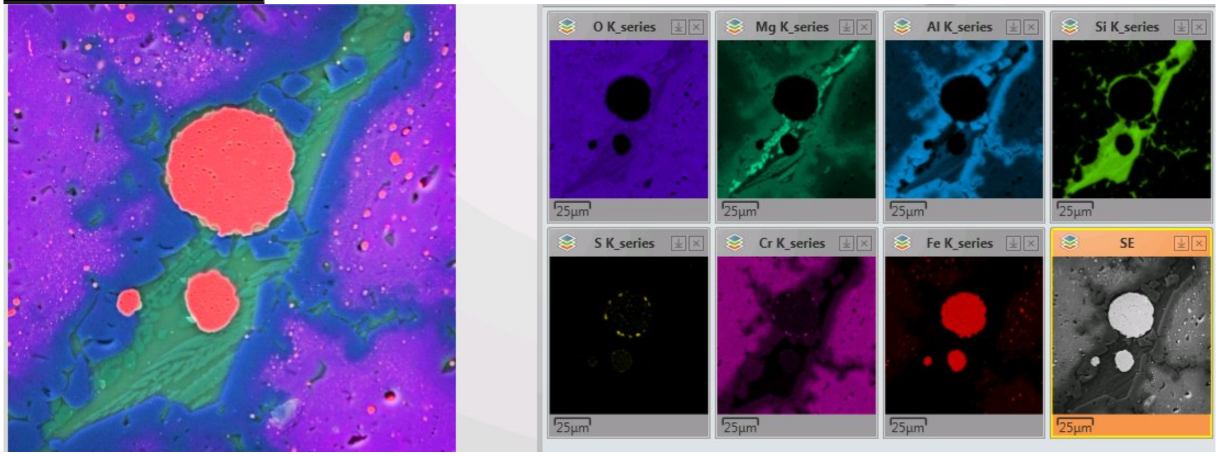


FIG. 2. X-ray and SE data composite image, 100µm field width, exposes regions of different composition. Colour shows relationship to element distributions in the FLS maps on the right.