Smart Phase Mapping Provides the Next Level of Materials Insight

Materials Challenge

The properties of advanced ceramic materials are affected by four main compositional factors: the elements present, the ratios of those elements, the spatial distribution of the elements and how the elements are combined, i.e., the phases present in the material. A minor change in any one of the four factors can lead to a significant change in material properties. The ability to measure each of the four areas is critical to developing an understanding of the relationship between microstructure and final material properties.

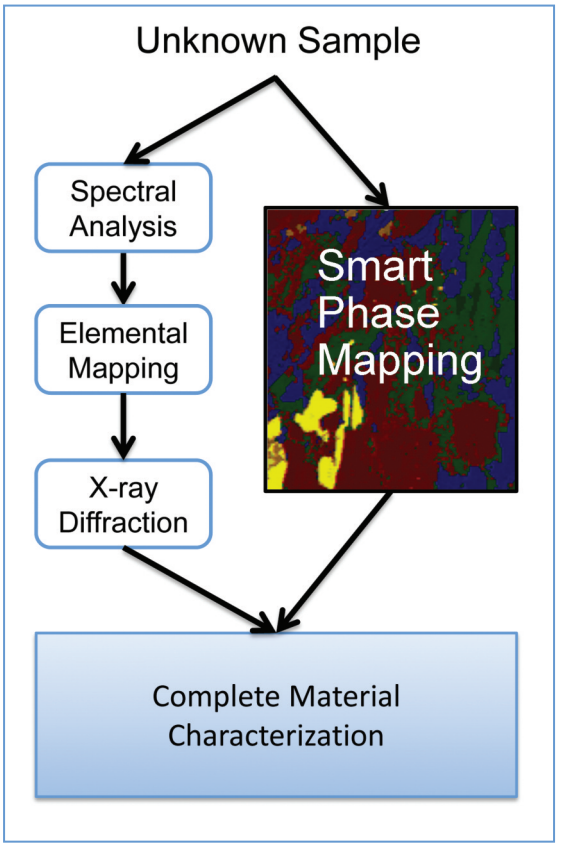
Comparison with Existing Solutions

Energy dispersive spectroscopy (EDS) and elemental mapping have traditionally been used to characterize elemental composition and spatial distribution in an effort to understand and design for materials properties. Other techniques such as X-ray powder diffraction have been used to add the phase component to the analysis.

- Traditional elemental mapping provides an accurate method for understanding the elemental ratios and spatial distribution of individual elements, but provides no insight into how the elements are combined into phases.
- Small regions containing similar elemental profiles can mistakenly be lumped together with elemental mapping, even though significant stochiometric differences may exist.
- X-ray diffraction provides reliable phase analysis, but the nature of the technique requires sample preparation that removes the ability to keep the spatial component as the sample cannot be analyzed in bulk form.

In contrast, EDAX's Phase Mapping function in TEAM™ EDS Analysis Software provides elemental weight percentages, spatial distribution and phase information with all three results collected in the same time frame as a typical EDS of the past.

- Element and phase maps are collected automatically and simultaneously. This enables the user to see how each element is distributed individually, or to review how the phases are spatially related.
- Phase mapping allows the extraction and quantification of spectra from user defined regions.
- Since the sample can be analyzed in bulk form, the spatial relationship of the phases is maintained and no further sample preparation is required.
- Sample throughput is maximized since phase information is collected at the same time as elemental data.
- As an additional benefit, counts per second maps are also automatically collected to provide an understanding of the effects of surface topography on the elemental analysis.



Microanalysis Results

The elemental maps shown in Figures 1a and 1b below show obvious differences in the distribution of the major elements, Aluminum (blue) and Oxygen (yellow). A basic image overlay (Figure 1c) shows the general relationship of these elements. When it becomes necessary to consider the additional elements present - Magnesium, Calcium, and Sulphur, in this case - or when trying to understand the small variations in the Aluminum to Oxygen ratio, elemental mapping fails to provide the complete data set required to fully understand the sample composition (Figure 1d).

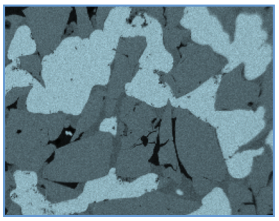


Figure 1a. Aluminum map

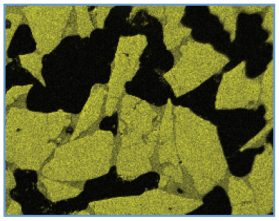


Figure 1b. Oxygen map

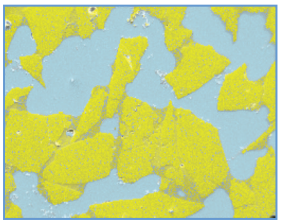


Figure 1c. Aluminum, Oxygen overlay map.

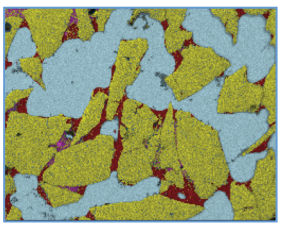


Figure 1d. Aluminum, Oxygen, Sulphur, Magnesium, Calcium overlay map.

Figure 2 is an enlargement of Figure 1d, and, at first glance, appears to accurately explain the compositional nature of the sample. To completely characterize the microstructure and to be able to understand a material well enough to propose modifications that impact its material properties, further insight is required. The Smart Phase Mapping feature in TEAM™ EDS Enhanced Analysis System provides the approach to reach this new level of understanding.

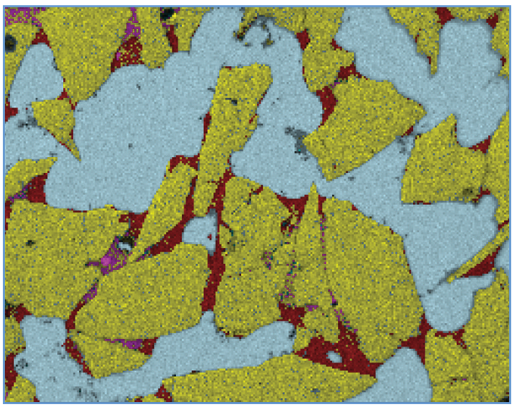


Figure 2. Image overlay of five elemental maps. When multiple elements are present, each element can be difficult to distinguish visually.

The presence and distribution of minor elements, as well as small fluctuations in ratios of major constituents, can affect materials properties such as toughness, corrosion resistance and thermal conductivity. By collecting an EDS phase map, the total EDS spectrum and variations in component peak intensity are used to identify the various phases present in the sample. In this case, with elemental mapping it is impossible to determine the number of phases present, while Smart Phase Mapping clearly quantifies five phases (Figure 3).

The result is a single phase map, collected at the same speed as an elemental map, which clearly describes the overall chemical makeup of the material, as shown in Figure 3 below.

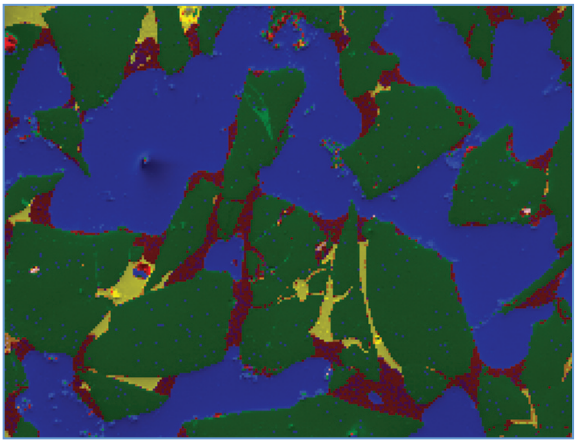
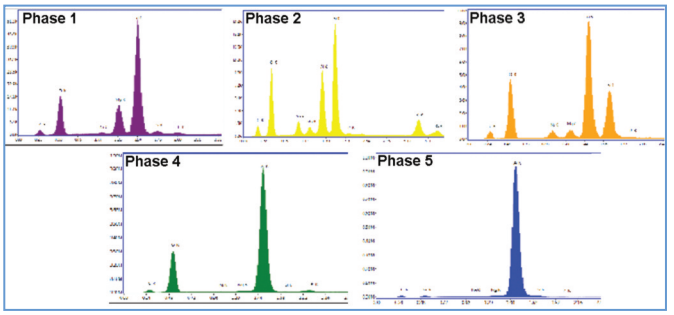


Figure 3. One minute Smart Phase Map collected at 200 kcps throughput and 131 eV resolution, clearly showing the five different phases in the sample.



Recommended EDAX Solution

Smart Phase Mapping, a key component in TEAM™ EDS Enhanced Software, is recommended to help engineers and scientists fully understand the true microstructure of their materials. Paired with Octane Silicon Drift Detectors, this powerful data is collected at blazing speeds and high quality, providing the ultimate in materials insight.