Application Note: 51221

The Merits of Quantitative Element Mapping at Low Acceleration Voltage and High Magnification

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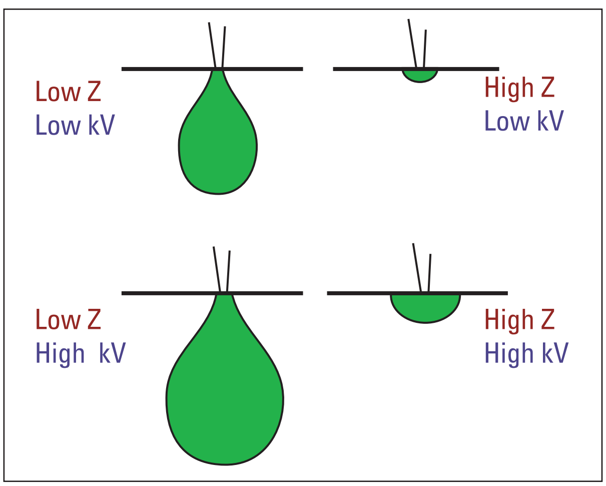
Key Words

- **Energy Dispersive Spectrometry (EDS)**
- **High Spatial Resolution**
- **Low Accelerating Voltage**
- **NORAN System 7**
- **Quantitative Mapping**

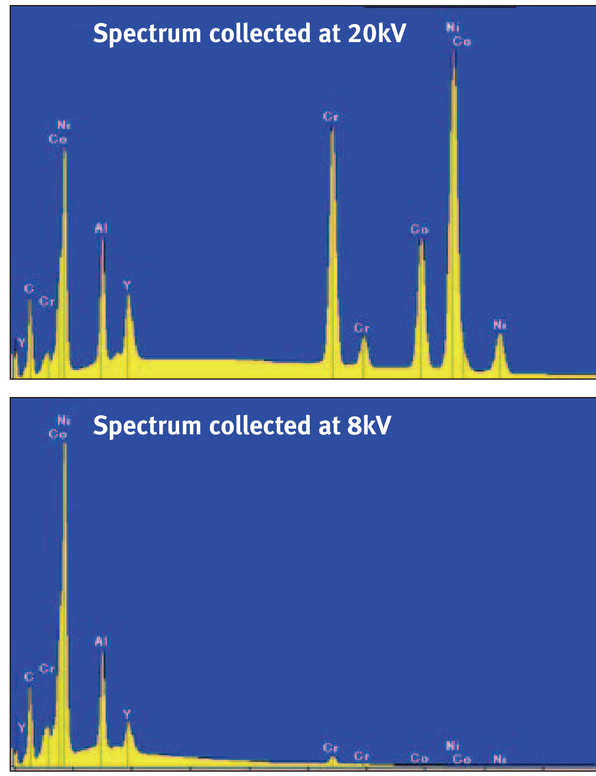
Acceleration Voltage and Spatial Resolution

The interaction volume of the generated x-rays changes with the acceleration voltage of the electron beam. If the acceleration voltage is made high, creating a large interaction volume, the spatial resolution of the X-ray analysis decreases. If acceleration voltage is reduced, conversely, the interaction volume becomes small, and the spatial resolution of the analysis is improved. But reducing the acceleration voltage too much may reduce it below the critical excitation energy of the X-ray line of the analytical element. This occurs because the incident electrons are not able to excite that appropriate X-ray and the analysis becomes impossible.

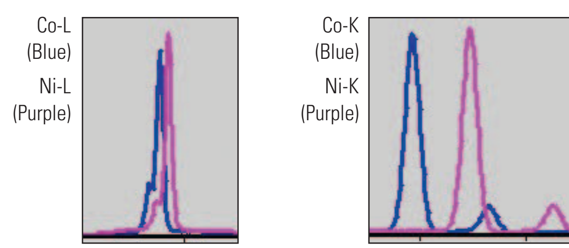


Relationship between accelerating voltage (kV) and spatial resolution (Z)

In the case of 20kV acceleration voltage, the X-ray peak of the Co-K and the Ni-K are excited sufficiently, but with an acceleration voltage of only 8kV, they are not excited sufficiently. In order to improve the spatial resolution of the analysis, an acceleration voltage of 8kV is selected but the analysis of Co and Ni require the use of the L lines.



Analysis of identical locations of the turbine material comparing the accelerating voltage of 20 kV and the 8 kV



Superposing the peak of the L-lines and the K-lines of the Co and the Ni is indicated. In the case of the Co-K and the Ni-K lines, they are sufficiently spaced to be fully resolved. As for the Co-L line and the Ni-L lines, they are spaced close enough to cause significant overlap of the peaks.

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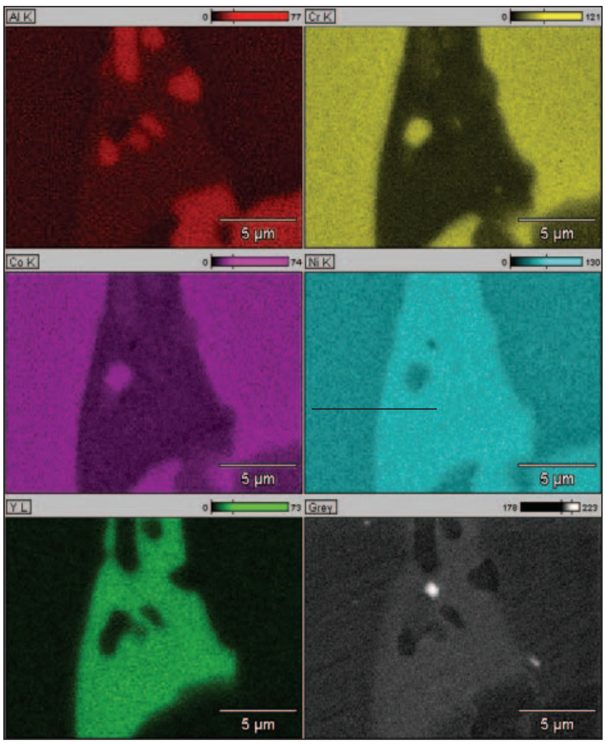
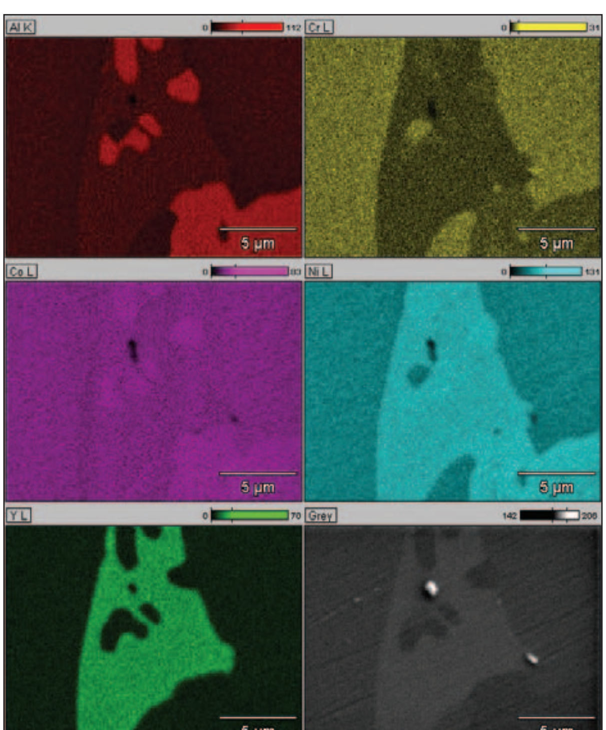
When the X-ray maps collected at 20kV and 8kV are compared, the map collected at 8kV is superior in spatial resolution. But, there is a fatal flaw in the map image of the Co-L line at 8kV because of the overlap of the Ni-L line has made a significant contribution. There are many instances in EDS analyses where peak overlaps occur between elements. Because of the peak overlap problems shown in the above count maps, low acceleration voltage acquisitions have not been generally used in the past.



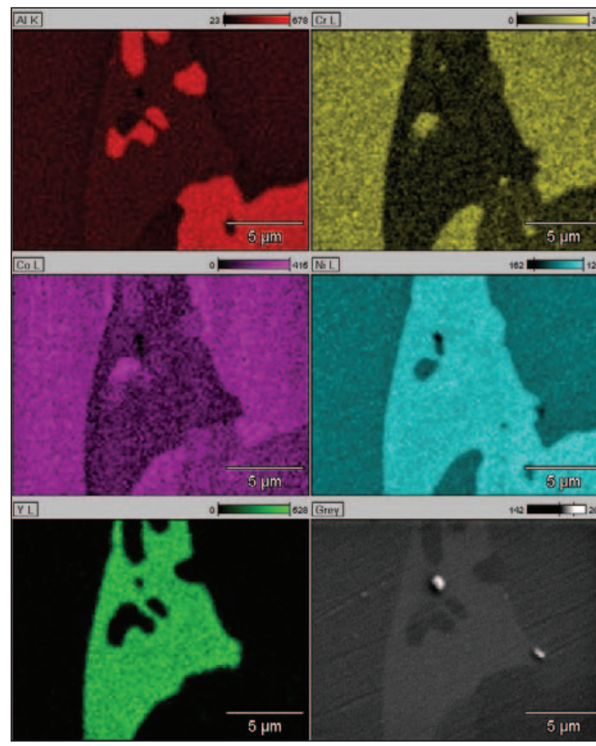
X-ray count maps collected with an accelerating voltage of 20 kV



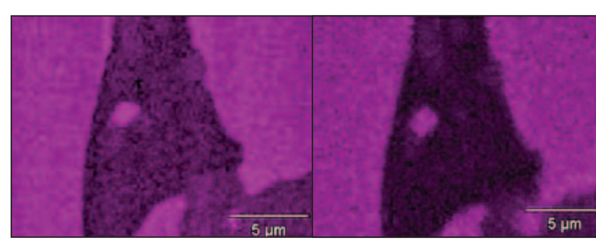
X-ray count maps collected with the accelerating voltage of 8 kV

Application of Quantitative Mapping

To correct for the peak overlap problems described previously, the quantitative composition routines typically used for analyzing simple spectra have been adapted to process spectral imaging maps. The processing routines in the Thermo Scientific NORAN System 7 software (1) remove the background in the EDS spectrum, and (2) separate the contributions of each element from overlapped peaks and provide net count maps. If requested by the analyst, a third routine can apply a matrix correction to obtain quantified compositions. The net count maps from the turbine material at 8kV clearly show the peak separation ability of the routines



Net count maps collected with the accelerating voltage 8 kV

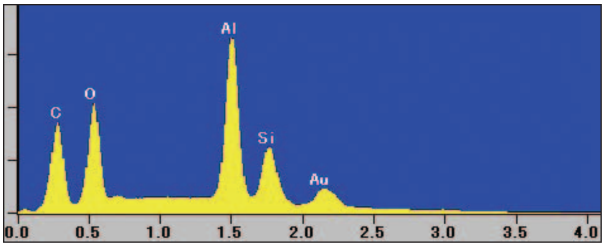


Co-L quantitative map at 8 kV (left), Co-K quantitative map at 20 kV (right)

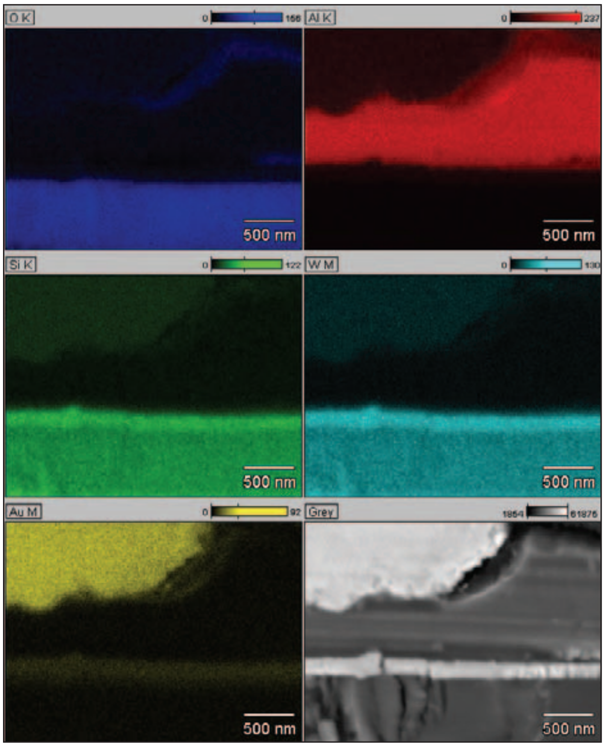
The quantitative map using the Co-L at the acceleration voltage of 8kV has almost the same appearance as the quantitative map using the Co-K line which was collected with at the acceleration voltage of 20kV. This shows that the separation of the Co-L line and the Ni-L line was done accurately by the peak deconvolution function of the quantitative map routine. Without this corrective routine, low acceleration voltage analyses would not provide accurate information, so they were avoided. This routine now permits routine low voltage analyses, which provides higher resolution element maps and permits the use of higher magnifications.

Quantitative Map of Semiconductor Device Wire

Spectral imaging data was collected on a semiconductor wire-bond using an acceleration voltage of 4kV at a magnification of 40k times for 30 minutes. The cumulative spectrum from the whole analysis area indicates the elements that are present in the sample.

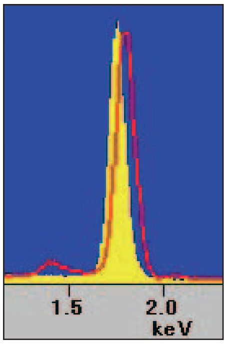


Cumulative spectrum of analysis area

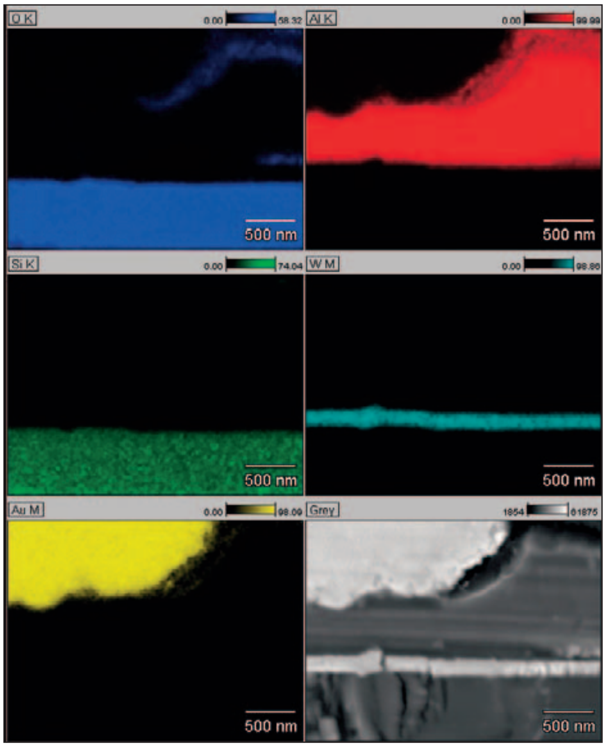


Peak count map of wire

The count maps for the expected elements are displayed. It was noted that the Si and W maps appear very similar. The figure at the right shows the collected spectrum with a Si-K peak (yellow) and a W-M peak (the red-light district) with a severe peak overlap. By creating maps using these peaks, the display of Si and W maps appear to be the same.



When the quantification routines are performed, it becomes obvious that the Si is contained in a Si-O layer which is completely separated from the W, which is restricted to a barrier metal section. Once again, the correct spatial distribution of the elements is obtained when the correction routines are used to separate highly overlapped peaks. This analysis is especially useful when the magnification of the SEM is high.



Quantitative element maps of wire

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