Application of Bremsstrahlung Background Calculation and Automated Element Identification to TEM EDS Spectra

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Qualitative analysis is a major benefit of Energy Dispersive Spectrometers (EDS) based on collection of whole spectral X-ray distribution in one step. An automated element identification approach, EXpertID, was developed for evaluation of SEM spectra with utilization of decision loops based on internal quantitative calculation assessments and repeated fit of spectra reconstructions and simulations [1].

The required calculation of bremsstrahlung distribution for background approximation follows [2] and was modified with the absorption terms ε_{E_ν} and A_{E_ν} [3]:

$$N_{E_\nu}^{br} \quad = \quad \varepsilon_{E_\nu} A_{E_\nu} \left[a + b \frac{E_0 - E_\nu}{E_\nu} + c \frac{(E_0 - E_\nu)^2}{E_\nu} \right]$$

$E_\nu\ E_0$ Photon energy E_ν and primary electron energy E_0
$N_{E_\nu}^{br}$ Number of bremsstrahlung counts in channel with photon energy E_ν
ε_{E_ν} Detector efficiency with photon energy E_ν
A_{E_ν} Self absorption in specimen with photon energy E_ν
a, b, c Coefficients for spectra fit

If let a always zero, for each spectrum segment the coefficients b and c are possible to determine at the respective flanking two preselected fit points (regions) containing no X-ray peaks. There is no limit to the number of fit regions that are possible to use. The coefficients change with each section. The c is additionally zero between spectrum begin and first fit point and also until the end.

A different X-ray excitation and absorption physics must be considered with application for TEM specimen spectra. The primary electron energy with typically 200 kV is much higher than with SEM. Because the TEM specimens are very thin, the self absorption A_{E_ν} is much reduced and depends on specimen thickness. The model was extended by introduction of a TEM specimen layer thickness and density. The absorption calculation for thin TEM specimen follows the simple X-ray absorption law and is even possible to neglect in many cases.

Therefore the detector efficiency ε_{E_ν} becomes the crucial part of the background approximation. Modern SDD detectors for TEM have no vacuum window (windowless) [4]. The knowledge of the detector absorption layers is then the most important part of absorption effects. The windowless SDD spectra have usually many more counts in the low energy region and the measured background is very close to the primarily emitted Bremsstrahlung quanta distribution.

Some investigations are presented to show an improved TEM-spectra background approximation for windowless SDD. The detector chip front contact structure has the major influence to the detector efficiency and its knowledge is a basic requirement. Actually it seems that using a windowless SDD in the TEM is a setup to investigate the SDD front contact structure.

Finally the background calculation is a core part of automated element identification, which is based mainly on repeated spectra reconstructions. A good approximation also in low energy parts of the

spectrum is required to get proper element decisions with corresponding line assessments (K->L and L->M coupling of lines from same element).

Some examples are presented with application of the modified and improved background calculation and automated element identification EXpertID for TEM EDS spectra evaluation.

References:

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