

LECTURE 14

ZAF Factors in Microanalysis

Z factor

1) Z: Atomic Number Effect: two factors must be considered

R: Backscattering
S: Stopping Power } Determine the amount of x-ray
intensity generated in a sample

R: represents the fraction of ionization remaining in a target after the loss due to the backscattering of beam electrons.

Elastic scattering leads to backscattering which results in loss of a significant fraction of the beam electrons before all of the ionizing power of the electrons has been expended in generating x-rays of the various elemental constituents.

$$R_i = \frac{\text{Total number of photons actually generated in the sample}}{\text{Total number of photons generated if there were no scatter}}$$

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Z Factor

Values of R lie in the range 0.5-1.0 and approach 1 at low atomic numbers

S: the rate of energy loss due to inelastic scattering

S also depends strongly on the atomic number. Low-atomic-number targets actually remove energy from the beam electron more rapidly than high-atomic-number targets

$$Z_i = (R_i/R_i^*) \cdot (S_i^*/S_i)$$

R_i & R_i^* are the backscattering correction factors of element i for standard and specimen, respectively.

S_i & S_i^* are the stopping power correction factors of element i for standard and specimen, respectively.

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A Factor

- 2) A: X-Ray Absorption Effect: is usually the biggest factor that must be considered in the measurement of composition by x-ray microanalysis.

To reach the detector, x-rays have to pass through a certain amount of matter and the photoelectric absorption process lessens the intensity.

Thus, x-ray photons are either absorbed or else pass through the specimen with their original energy unchanged, so that they are still characteristic of the atoms which emitted them.

Absorption follows an exponential law, so as x-rays are generated deeper in the specimen, a progressively greater fraction is lost to absorption – a larger path is traveled before the x-ray leaves the sample

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A Factor

A shorter path length in the specimen minimizes absorption.

This can be done by using a larger take off angle and by using the minimum electron-beam energy E_0 consistent with the excitation of the x-ray lines used for analysis

$$A_i = f(\chi)/F(\chi)^*$$

$f(\chi)$ is called the standard absorption term or the absorption correction factor of a specific characteristic line of element I

$f(\chi) = f [(\mu/\rho) \text{ Cos } \psi, E_0, E_c, \bar{Z}, \bar{A}]$ where:

(μ/ρ) : is the mass absorption coefficient

$\text{Cos } \psi$: x-ray emergence angle

E_0 : initial energy of the electron beam

E_c : Critical excitation energy E_c for K,L, or M radiation from element I

Z : mean atomic number of the specimen

A : mean atomic weight of the specimen

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F Factor

3) F: X-Ray Fluorescence Effect:

For fluorescence to occur, the target must contain a species of atoms with a critical excitation energy less than the energy of the characteristic x-rays being absorbed

In such case, the measured x-ray intensity from this second element will include both, the direct electron-excited intensity and the additional intensity generated by the fluorescence effect.

Fluorescent radiation can originate at greater distances from the point of impact of the electron beam than primary radiation.

Fluorescent radiation can also be caused by continuous radiation (energy range from 0 to E_0)

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F Factor

$$F_i = (1 + \sum_j I_{ij}^f/I_i) / (1 + \sum_j I_{ij}^f/I_i)^*$$

The correction factor I_{ij}^f/I_i relates the intensity of radiation of element i produced by fluorescence by element j , I_{ij}^f , to the electron-generated intensity of radiation from element i , I_i

The total correction factor is the summation of the fluorescence of element i by all element j in the sample.

The fluorescence factor F_i is usually the least important factor in the ZAF correction.