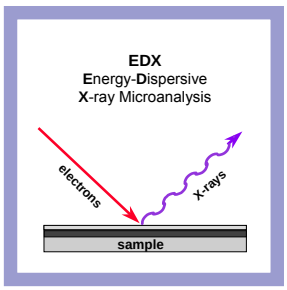
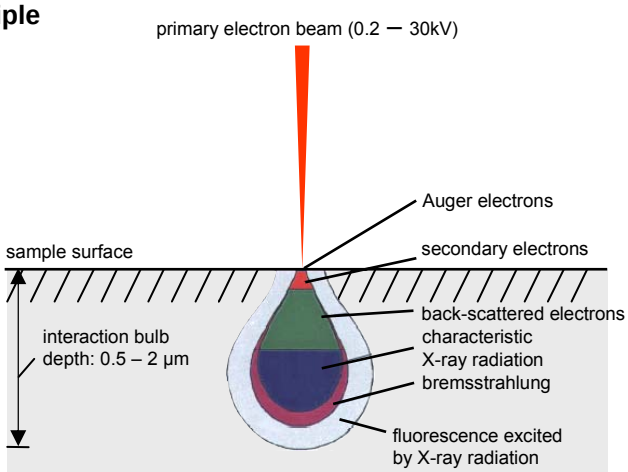
EDX

Energy Dispersive X-ray Microanalysis



The primary electron beam generated in the electron microscope is not only a valuable tool for imaging the surface but also for analysing the chemical composition of samples. The electron beam interacts with the sample within a volume which depends on the acceleration voltage of the electron beam and on the elemental composition of the sample. As a result, x-ray radiation is produced, along with secondary electrons (SE) and other radiation. The energy of the x-ray radiation depends on the atomic number of the respective emitting atom and is therefore characteristic for that element. The EDX detector registers the emitted x-ray radiation and sorts it into an energetic spectrum.

Principle



The x-ray radiation is excited within a spherical or bulb-shaped volume (see figure). The penetration depth of the electrons and the emission depth of the x-rays depends on the acceleration voltage for the electrons, the mass density of the sample, and the energy of the x-ray radiation. The depth of the excitation volume ranges from < 1 µm to a few µm.

Specifications

Detector:	Si(Li) detector (liquid-nitrogen-cooled)
Energy resolution:	≤ 129 eV for Mn Kα
Elemental detection:	atomic numbers ≥ 4 (Be)

Options

Measurement and qualitative/quantitative evaluation of EDX spectra at surface points or areas.
Determination of the elemental distribution along a line (line-scan) or over an area (mapping).

Requirements

Sample size:	up to 50 mm x 50 mm
Sample thickness:	up to 30 mm
Sample properties:	dry, no out-gassing, vacuum-compatible

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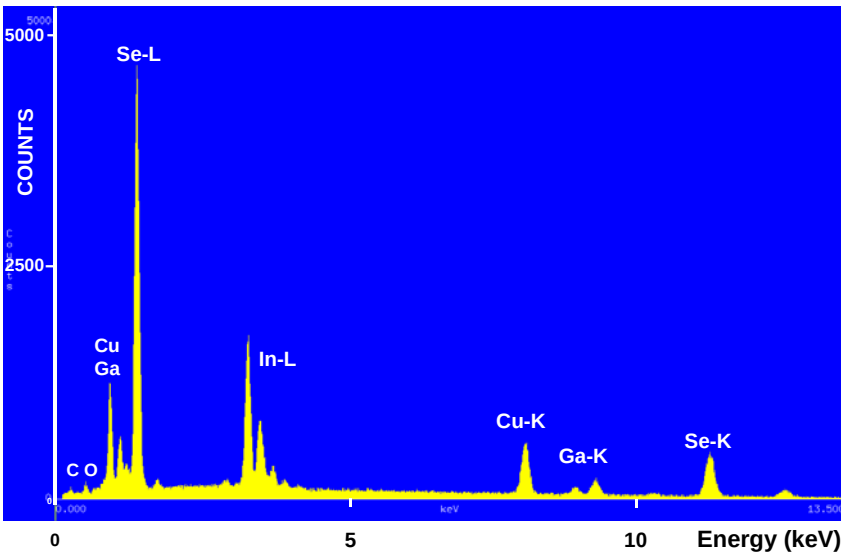
EDX Application Examples

Using the energy dispersive x-ray microanalysis system integrated with our HR-SEM, we can examine the evaporated, sputtered, or chemically deposited films or layer systems for thin-film solar modules regarding their chemical composition or analyse defects which occurred during the coating process.

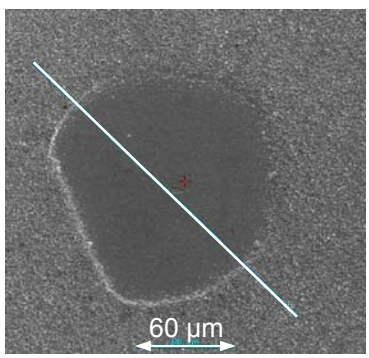
X-ray spectrum of the solar-active $Cu(In,Ga)Se_2$ layer in a thin-film solar module

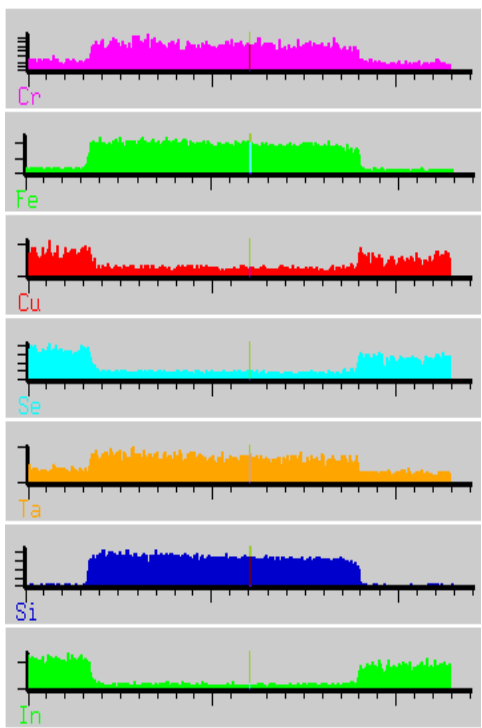


EDX spectrum of a $Cu(In,Ga)Se_2$ film (20 kV, 520 pA, 100 s, 50 µm x 30 µm). The elements O and C are also detected along with Cu, In, Ga and Se.

Distribution of elements from a line-scan over a coating defect in a $Cu(In,Ga)Se_2$ film on a Cr steel substrate

Left: Scanning electron microscopic image of a circular defect.
Right: Line-scan diagonal over the circular defect (line in the left image). The concentrations of the elements Cu, In and Se are much lower within the defect, whereas the elements Fe and Cr from the steel substrate and Ta and Si from an intermediate layer are more strongly represented.





Interpretation: The $Cu(In,Ga)Se_2$ film is almost completely absent within the defect. The excitation volume of the electron beam therefore penetrates the underlying layers down to the steel substrate and the elements from these layers are more strongly represented in the measurement. The absence of the absorber film likely resulted from a foreign particle which was on the substrate during $Cu(In,Ga)Se_2$ growth.

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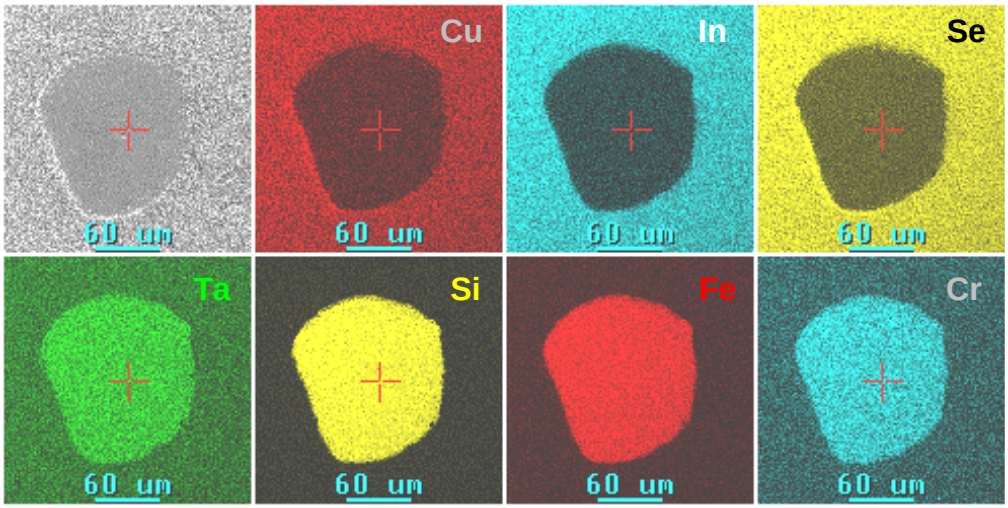
EDX Application Examples

Elemental distribution images (mappings) of a coating defect from a $Cu(In,Ga)Se_2$ film on a Cr steel substrate



SEM image of a circular defect (upper left) and elemental distribution images for the elements Cu, In, Se, Ta, Si, Fe, and Cr at the defect. The concentrations of the elements Cu, In and Se are much lower within the defect (darker), whereas the signals from the elements Fe and Cr from the steel substrate and Ta and Si from an intermediate layer are stronger.

Interpretation: The $Cu(In,Ga)Se_2$ film is almost completely absent within the defect. The excitation volume of the electron beam therefore penetrates the underlying layers down to the steel substrate and the elements from these layers are more strongly represented in the measurement. The absence of the absorber film likely resulted from a foreign particle which was on the substrate during $Cu(In,Ga)Se_2$ growth.

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