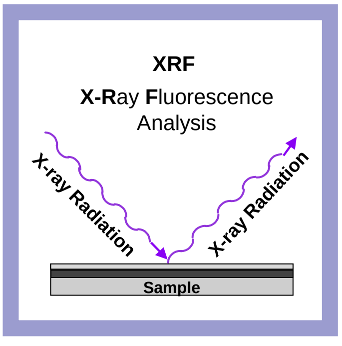
XRF

X-Ray Fluorescence Analysis

X-ray fluorescence analysis (XRF) is a standard method for the fast and non-destructive determination of film thicknesses and the elemental composition of solids and liquids. The XRF system in operation at ZSW was specially developed and optimised for the elemental analysis and determination of film thicknesses of multi-layer systems. Therefore, this XRF system is able to non-destructively determine the composition of individual layers within a multi-layer system. Another special feature of the XRF analysis at ZSW is that the measurements do not need to be performed in vacuum, i.e. liquids can also be analysed.

Principle



The sample is excited by x-ray beams with energies up to 50 keV. X-ray fluorescence radiation which is characteristic for each element is produced by the ionisation of inner atomic shells and subsequent transitions of electrons from higher energetic states into these ionised states.

The energy of the emitted x-ray photons is detected by a Si(Li) detector. The entire energy spectrum of the emitted x-ray photons is simultaneously recorded with a multi-channel analyser.

The information depth is determined by the penetration depth of the incident x-rays, the energy of the resulting characteristic x-rays, and the x-ray absorption of the sample. The information depth is therefore element- and material-specific and can extend up to several 10 µm.

Specifications

X-ray tube:	Rhodium, 50 kV
Detection limit:	$\geq$ 0.001 at.% (10^{-5})
Lateral resolution:	1 mm, 300 µm or 100 µm
Information depth:	10 µm
Elemental detection:	Atomic number $\geq$ 9 (fluorine)

Options

Detection and quantification of elements in solids and liquids
Composition and film thickness of thin films
Measurement of individual layers in multi-layer systems (up to 3 layers)
Spatially resolved analyses
Automatic recording of many-point analyses, linescans, and mappings

Requirements

Sample size up to 30 cm x 30 cm
Samples up to 70 cm x 70 cm: analysis only possible in centre region
Sample thickness maximum 90 mm

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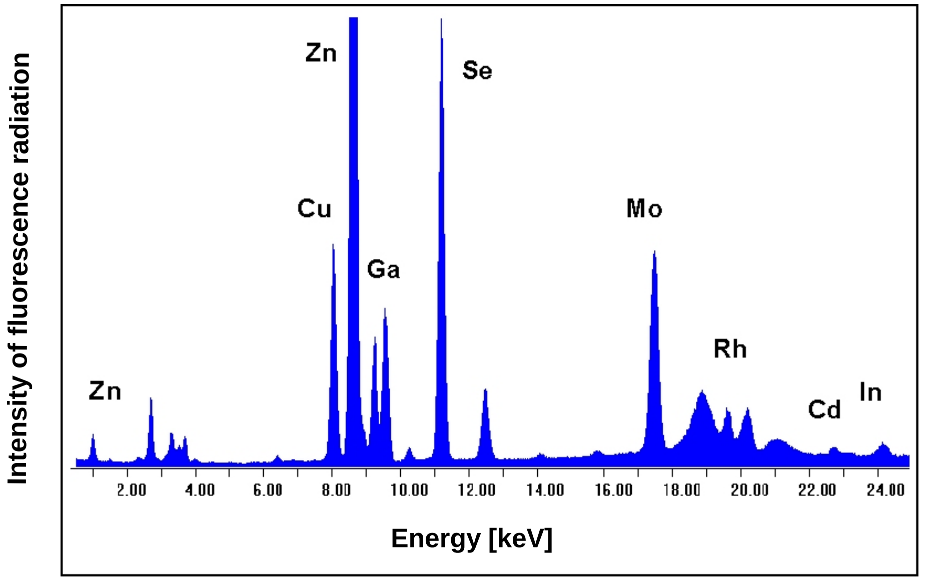
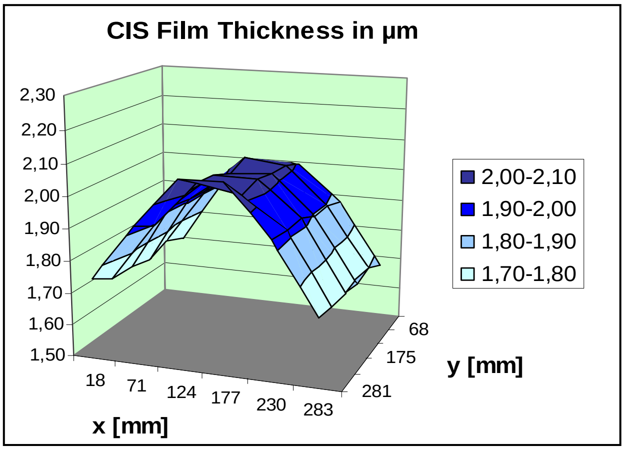
XRF Application Examples

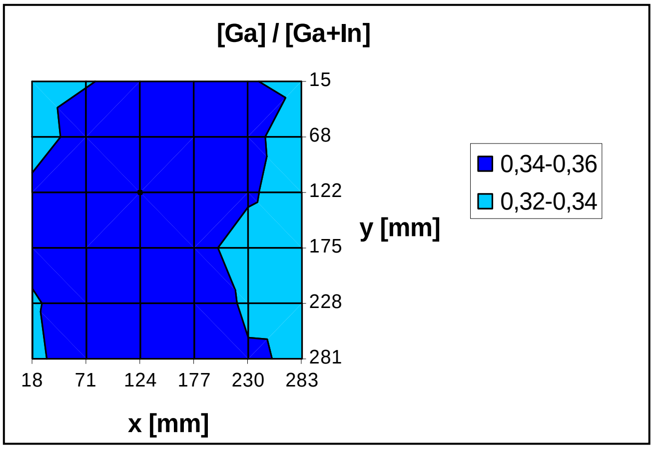
CIS solar module: survey spectrum



XRF survey spectrum from a CIS solar module. The Zn from the ZnO front contact, the Mo from the molybdenum back contact, and the Cu, In, Ga, and Se from the absorber are easily recognisable. The Cd peak is noticeably smaller since the CdS film is very thin. The peak integrals of the K-lines are used for quantification.

CIS absorber (30 cm x 30 cm): Spatially resolved [Ga] / [Ga+In] ratio and film thickness





For quality control of our CIS modules we regularly perform linescans and mappings with XRF.
The large information depth of XRF enables us to calculate from a single measurement the film thickness of the ZnO front contact, the CdS buffer layer, the CIS absorber, and the Mo back contact, as well as the CIS film composition. The thickness of the absorber and the Ga / [Ga+In] ratio of a 30 cm x 30 cm CIS modul are shown as examples in the figures.

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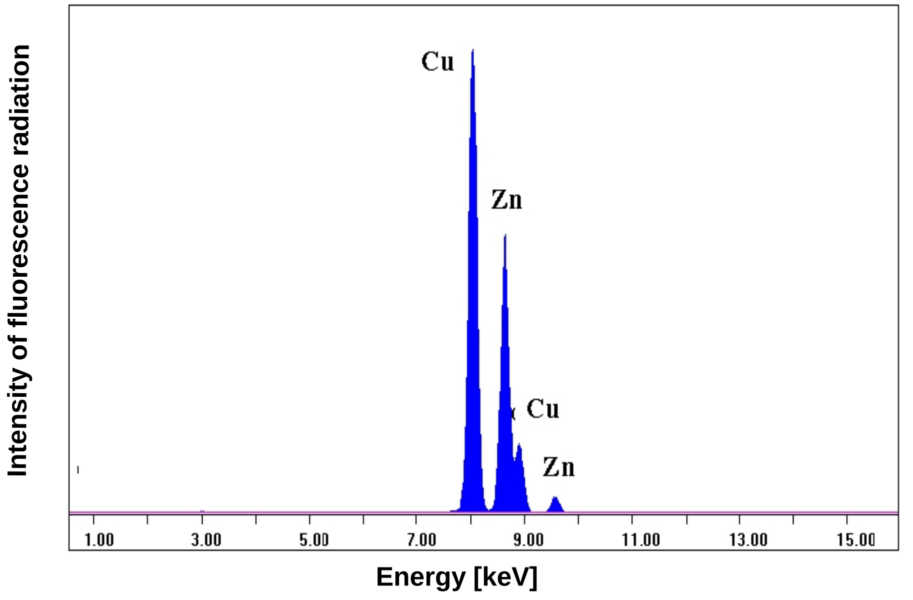
Detection of brass



XRF spectrum of an unknown contact material. The analysis reveals that the material consists of 65 % Cu and 35 % Zn, thereby identifying it as a brass alloy.

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