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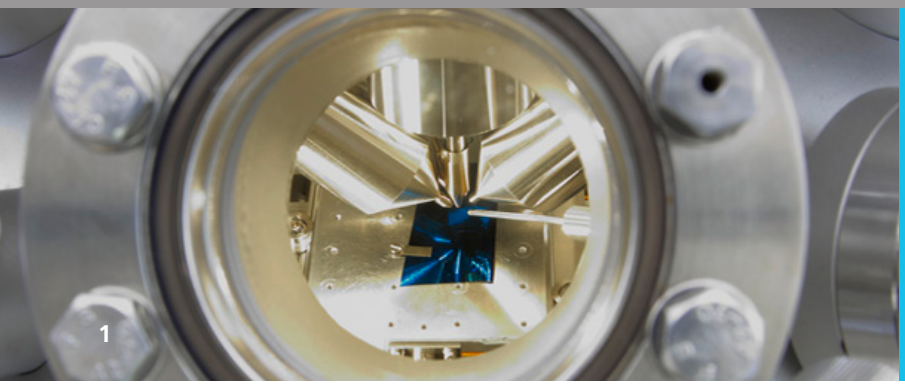

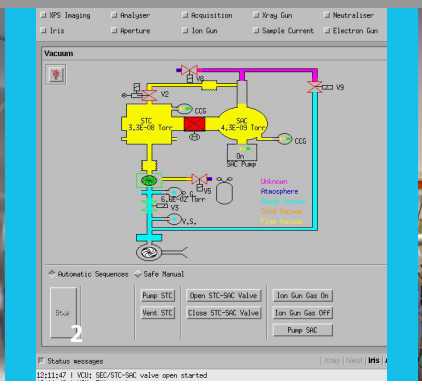

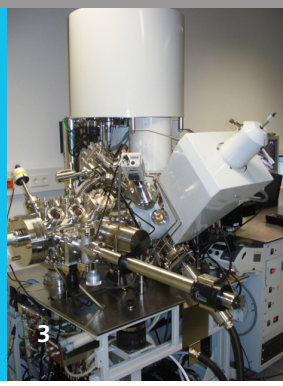

1 *ION-TOF TOF.SIMS 5.*
2 *View of the XPS vacuum system control surface.*
3 *XPS Kratos Axis Ultra DLD.*

SURFACE AND THIN FILM ANALYSIS

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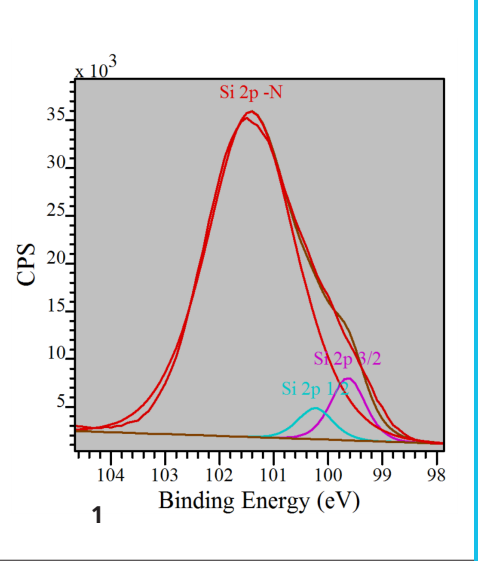
X-Ray Photoelectron Spectroscopy (XPS)

XPS provides quantitative chemical analysis of surfaces and thin layers. In XPS, X-ray stimulated electrons are emitted from the sample surface with element-characteristic energy. They are collected and detected by energy, which results in XPS spectra that contain the elemental composition. In-depth analysis is conducted by Ar-ion sputtering cycles between spectra acquisition. XPS is particularly suitable for the study of chemical bonding with the same high surface sensitivity. The peaks in XPS spectra undergo an energy shift depending on the chemical coordination (i.e. binding environment). This can be utilized to determine, for example, metal compounds and their oxidation states.

XPS Features

- Quantitative, non-destructive analysis of material composition
- Excitation with X-rays (XPS), UV light (UPS) or electron beam (AES/SAM)
- Combination with Ar ion sputter milling for successive depth profiling
- Depth resolution ~5 nm
- Lateral resolution: ~10 µm (high sensitivity) down to 0.5 µm (SAM with reduced sensitivity)
- Sensitivity down to 10^{19} atoms/cm³ (depending on atomic number)
- Straight forward quantification by tabulated sensitivity factors
- Analysis of insulators, semiconductors and metals
- Contamination free sample transfer between XPS and ToF-SIMS



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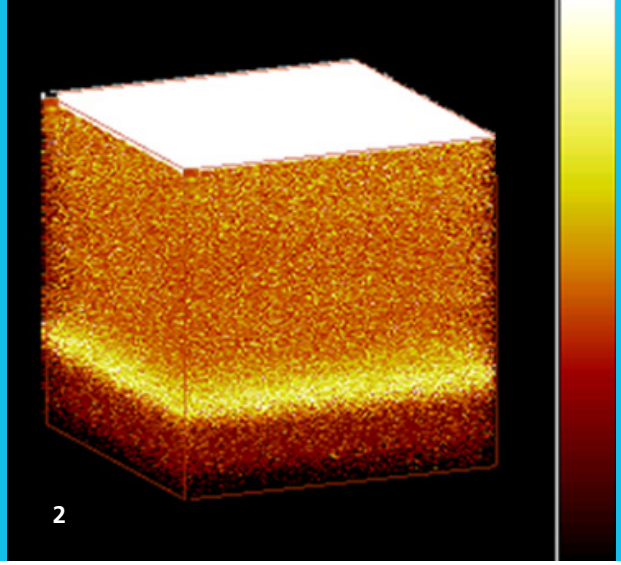
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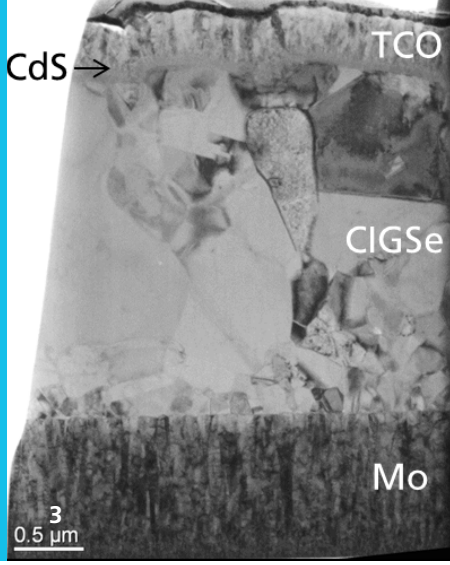

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Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS)

ToF-SIMS is a powerful tool for depth profiling of dopants and contaminations in high-purity materials and thin film systems. The distribution of impurities is of high interest in thin film systems, funcional layers and bulk materials. In ToF-SIMS, secondary ions that are sputtered from the surface, are »weighed« by their time of flight. For 3-dimensional ToF-SIMS depth profiling technique two ion beams are applied: a pulsed primary beam for quasi-static analysis of the uppermost atom layers, and a high-current sputter beam for milling into depth. The method allows various data processing and evaluation of raw data that is independent of the measurement procedure. ToF-SIMS elemental intensities can be quantified by means of a reference sample with similar material composition.

ToF-SIMS Features

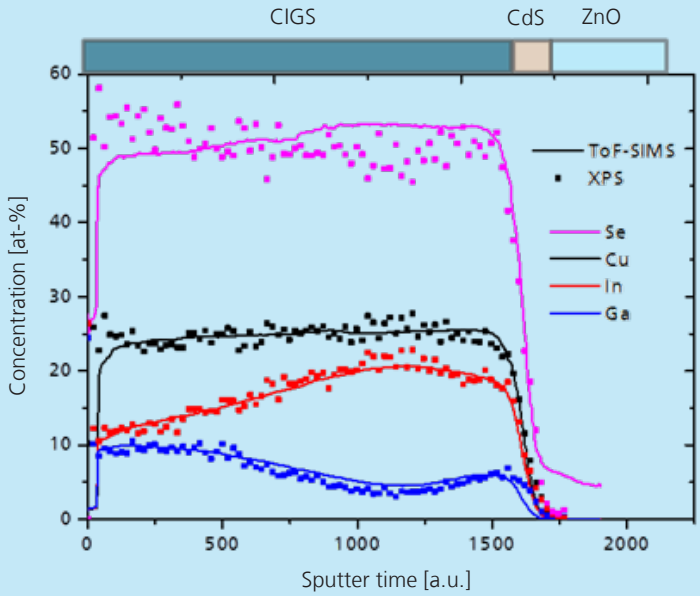
- Quasi non-destructive surface analysis (elements, compounds, clusters) by mass spectra
- Measurement of secondary electrons with positive or negative charge
- Combination with ion sputter milling for successive depth profiling
- Depth resolution better than 10 nm
- Lateral resolution: from 5 µm (high sensitivity) down to 0.2 µm (reduced sensitivity)
- 3D reconstruction
- Sensitivity down to 10^{15} atoms/cm³ (ppb range)
- Analysis of insulators, semiconductors and metals
- Contamination free sample transfer between ToF-SIMS and XPS

Artifact-Free Cross Section Preparation

The preparation of CIGS samples by standard Ga-FIB results in the formation of Cu-rich agglomerates in the CIGS layer. These occur both in the cross-sectional and TEM lamella preparation and thus are visible in both the SEM and the TEM. Using a specially tailored preparation procedure, developed in-house, it is possible to obtain images without visible artifacts.

Transmission Electron Microscopy

TEM is used to acquire information about morphology and crystallinity of layer compounds. High-resolution TEM is used for imaging of (ultra-thin) layers with resolution in the nm range as well as chemical analysis by nano-spot EDX with high sensitivity.



4 *Composition of Cu(In,Ga)Se2 measured by ToF-SIMS and XPS.*

1 *XPS high-resolution spectrum of Si-rich SiN_x.*

2 *3D map of sodium distribution in a thin film solar cell.*

3 *TEM at a cross-sectional lamella of a CIGS solar cell after special artifact-free preparation.*