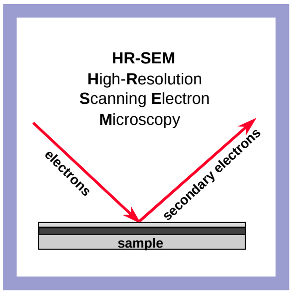
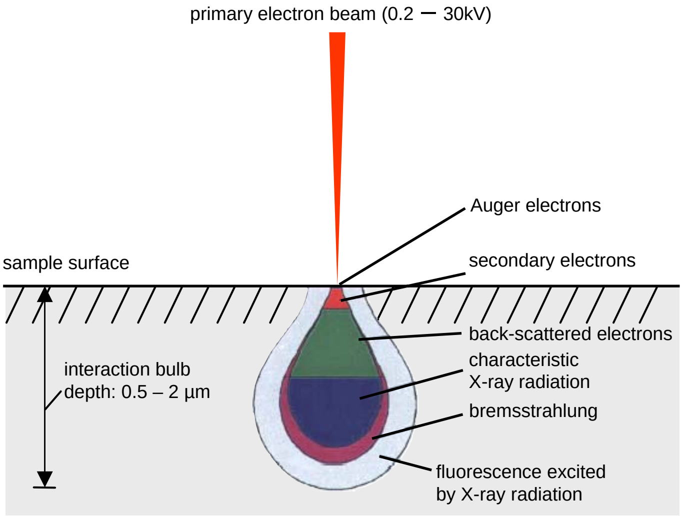
# HR-SEM

## High-Resolution Scanning Electron Microscopy



Scanning electron microscopy is a classical technique for imaging the topography of surfaces. The sample is scanned line by line with a focussed electron beam. Electrons emitted from the sample are detected and the signal forms an image on a monitor. Compared to conventional optical microscopy, considerably higher magnifications and focal ranges can be realised with this method.

### Principle



An electron beam (primary electron beam) is produced with a Schottky field emission gun and an acceleration voltage $V_A$ of several kV. Electric and magnetic lenses focus the beam on the sample surface. The acceleration voltage of the beam and the material composition of the sample defines a volume of interaction, in which secondary electrons (SE), back-scattered electrons (BSE), x-ray radiation, and other radiation is produced. The interaction occurs within a depth ranging from < 1 µm up to a few µm. A secondary electron detector detects the electrons scattered by the sample surface, multiplies this signal and displays it on a monitor. This method images topography, material and element contrasts.

### Specifications

| | |
|---|---|
| Equipment: | high-resolution scanning electron microscope with a Schottky field emission gun |
| Sample manipulator: | rotation: 360°<br>tilt: 15-75°<br>x/y/z translation: up to 50 mm |
| Cathode: | Schottky field emission cathode (SFEG) |
| Lateral resolution: | 1.5 nm ($V_A > 10$ kV), 2.5 nm ($V_A = 1$ kV), |
| Acceleration voltage $V_A$: | 0.2 – 30 kV |
| Sample current: | < 1 pA up to ca. 20 nA |
| Magnification: | ca. 20 – 100.000 in HR mode<br>ca. 2500 – 800.000 in ultra-HR mode |

### Options

Surface and cross-section images of thin films
Film thickness determination
Analysis of the shape and size of particles and inclusions
Electron Beam Induced Current (EBIC) measurements in solar cells

### Requirements

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

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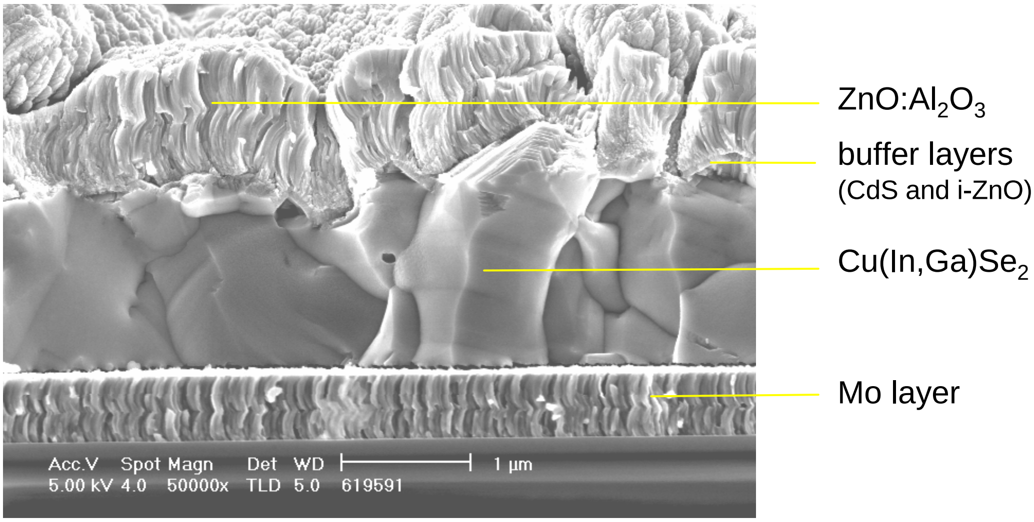
# HR-SEM Application Examples

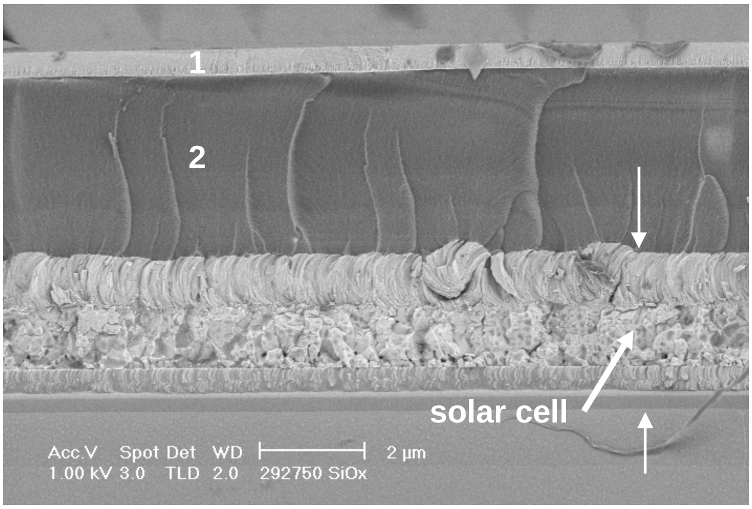
We examine the morphology of various solar cell layers, especially metallic contact films, semiconductor films, and barrier films, with the high-resolution scanning electron microscope.

Studying the cross-section of a solar cell reveals information about the grain structure and the thicknesses of the different layers. We can thereby gain insight into the film growth, the effectiveness of protective films, and the formation of defects during the individual processing steps.

## The layer structure of a CIS thin-film solar cell displayed by scanning electron microscopy



CIS cell: Cross-section image of a thin-film solar cell with Mo, $Cu(In,Ga)Se_2$, buffer (CdS, i-ZnO), and $ZnO:Al_2O_3$ layers.



Cross-section image of a $Cu(In,Ga)Se_2$ thin-film solar cell with two additional functional films 1 (diffusion barrier) and 2 (smoothing layer).

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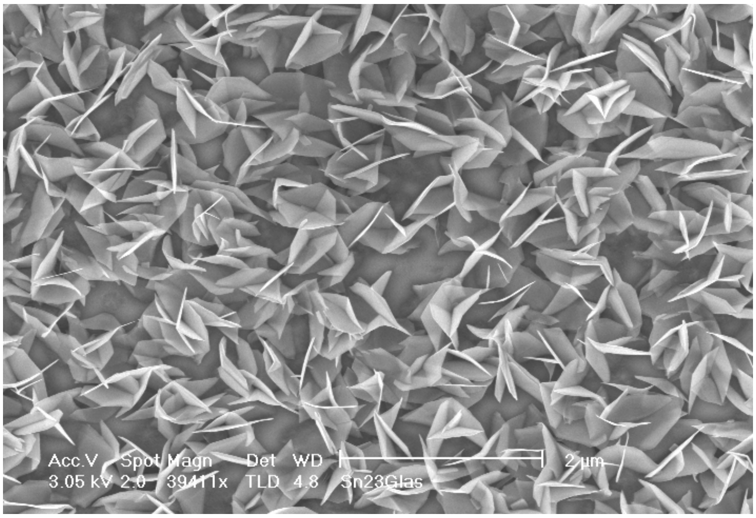
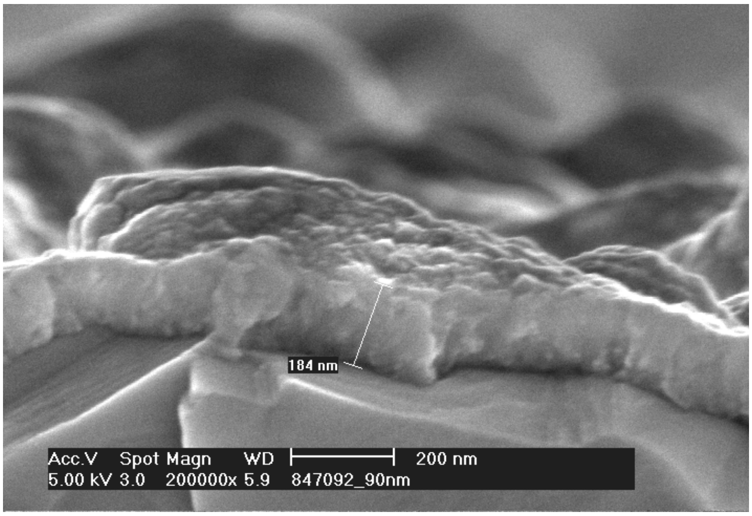
# HR-SEM Application Examples

## Surface image of a functional film under the electron microscope



Platelet-shaped $SnS_2$ crystals on $Cu(In,Ga)Se_2$ (Top view)

## Determining the film thickness with the scanning electron microscope



Cross-section image of a $In_2S_3$ film on $Cu(In,Ga)Se_2$

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