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CISSY: A station for preparation and surface/ interface analysis of thin film materials and devices

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Abstract: The CISSY end station combines thin film deposition (sputtering, molecular beam epitaxy ambient-pressure methods) with surface and bulk-sensitive analysis (photo emission, x-ray emission, x-ray absorption) in the same UHV system, allowing fast and contamination–free transfer between deposition and analysis. It is mainly used for the fabrication and characterization of thin film devices and their components like thin film photovoltaic cells, water-splitting devices and other functional thin film materials.

1 Introduction

The experimental CISSY setup was constructed for the surface and interface analysis of chalcopyrite $Cu(In_{1-x}Ga_x)(S_ySe)_2$ "CIGSSe", or "CIS" thin-film solar cells, operable as laboratory surface analysis system using commercial x-ray and UV sources or as beamline end station at the BESSY II synchrotron facility. The station name was derived from CIS and SYnchrotron. It houses an XES-300 (Scienta Gammadata) x-ray spectrometer for x-ray emission (XES) and a CLAM 4 (VG) electron analyzer for photoemission (PES) spectroscopy. These techniques deliver information about the chemical and electronic sample structure on a complementary depth scale. With probing depths up to half a micrometer, XES provides information of the near-surface sample bulk. PES in contrast only probes the first monolayers of a sample and hence is very surface sensitive. Using the integrated output signals of either of the two spectrometers, x-ray absorption spectroscopy (XAS) in electron or photon yield modes, respectively,

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can be performed.
The special feature of the CISSY setup is the unique combination of these spectroscopies with in-system sputter and ambient pressure preparation capabilities for thin films. In the CISSY end station, some of the crucial steps of the preparation of thin film solar cells and other thin film devices can be performed in-system, allowing the direct transfer from preparation to the analysis chamber, avoiding contamination. Industrial thin film preparation methods like magnetron sputtering (for transparent conductive oxydes) or the Ion Layer gas reaction (ILGAR) process, as well as various wet chemical deposition methods (for extremely thin buffer layers, e.g between solar absorbers and selective contacts) are available. A physical vapor deposition (PVD) chamber equipped with molecular beam epitaxy (MBE) sources and metal dispensers allows the deposition of thin films of various materials. Surface photovoltage (SPV) of device components can be measured under UHV in an additional chamber either spectrally resolved or, using a laser diode, in the time resolved mode.
Furthermore, a programmable sample manipulator enables laterally resolved measurements (with the resolution limited by the excitation spot) or measurements on the constantly moved sample, thus reducing damage of radiation sensitive material, e.g. organics. This arrangement allows for the characterization of real-world sample surfaces and interfaces prepared under controlled conditions such as vacuum or inert gas.

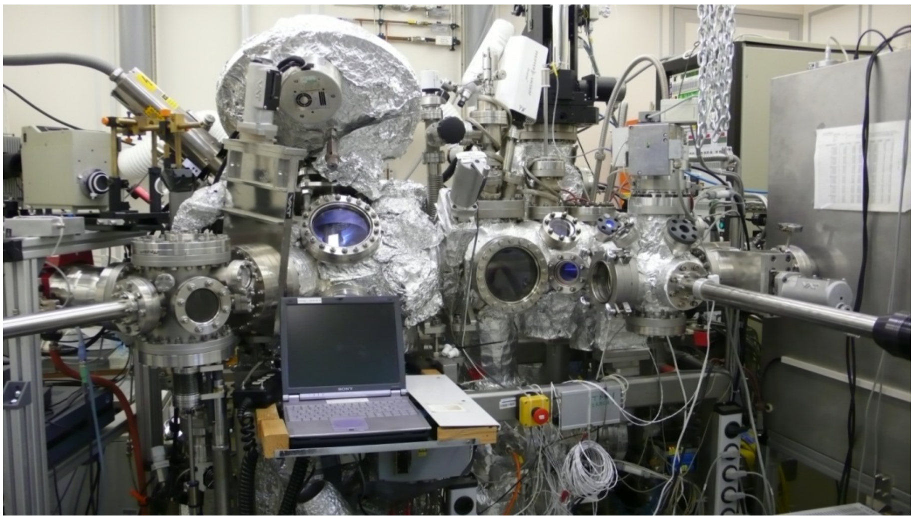

Figure 1: View of the CISSY station in the laboratory (glove box partly visible on the right side).

2 Instrument application

- Analysis of surface and near surface elemental composition by soft x-ray PES (conductive solid inorganic or organic materials)
- Determination of surface chemistry (oxidation states)
- Analysis of band line-up in semiconductor multilayers
- Bulk analysis by XAS and XES
- Determination of surface photo voltage
- In-system preparation of thin layers (currently oxides, sulfides, alkali metals and alkali fluorides)

3 Technical Data

Monochromator	Flexible
Experiment in vacuum	Yes
Temperature range	100-600 K
Detector	CLAM 4 hemispherical electron analyzer, XES-300 x-ray spectrometer
Manipulators	PINK x,y,z, rotation, tilt, heating with resistive heater and cooling with liquid N_2, sample current measurement, application of sample bias, thermocouple
Preparation	Wet chemistry in glove box, sputter-deposition of oxides, sulfides and other compounds, MBE for metals and compounds, sputter cleaning

Table 1: Technical parameters for the CISSY chamber.

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