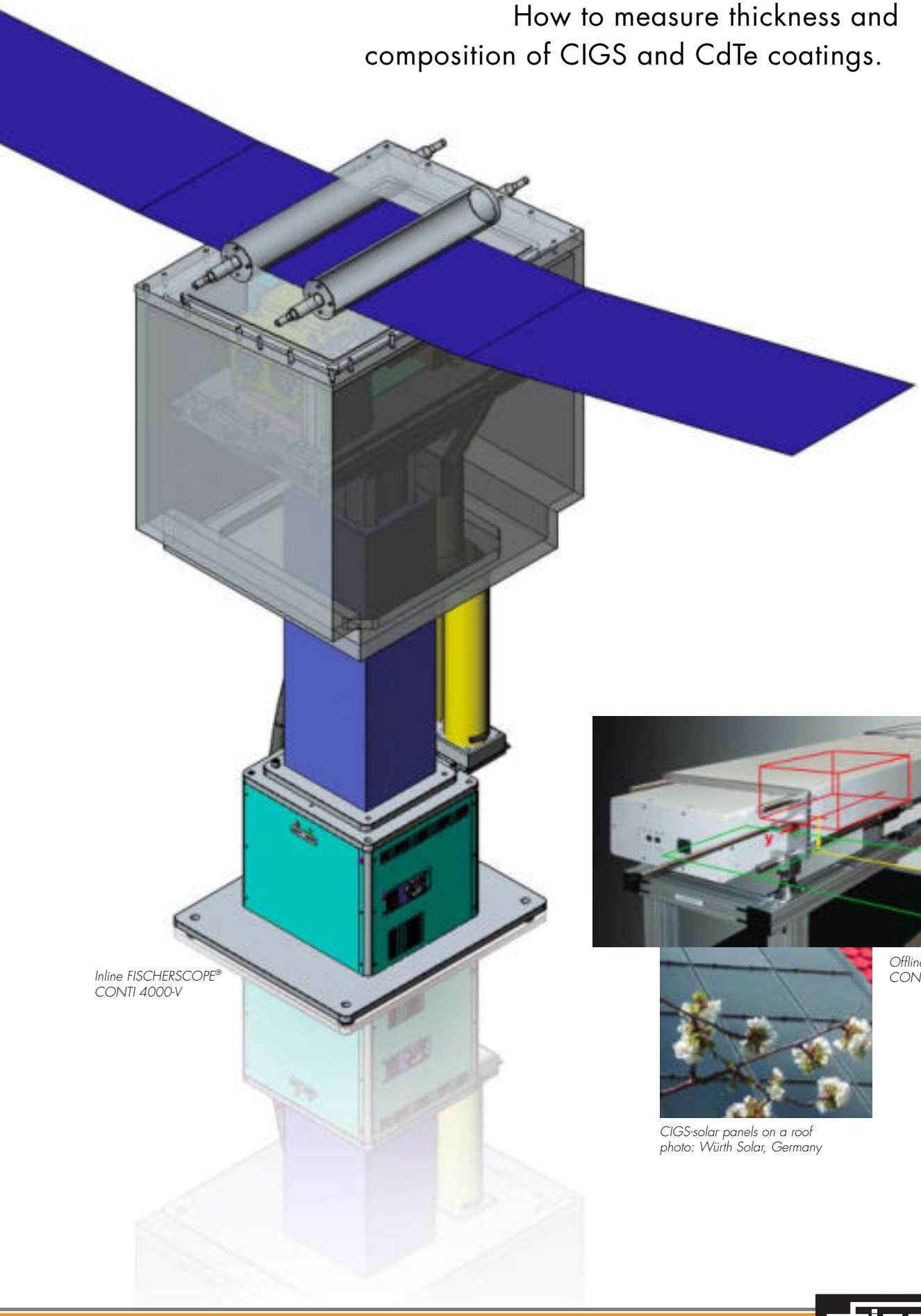
Thin Film Solar Cells.

How to measure thickness and composition of CIGS and CdTe coatings.



Inline FISCHERSCOPE®
CONTI 4000-V

Offline FISCHERSCOPE®
CONTI 4000-DPP

CIGS-solar panels on a roof
photo: Würth Solar, Germany

FISCHERSCOPE® X-Ray equipment for in-line-process applications.

For a production engineer, it is desirable to get high quality data of process related parameters such as thickness, concentration and homogeneity of the CIGS-coating shortly after the coating process. This guarantees the opportunity to adjust process parameters as soon as the data indicates deviation from product specifications. The only way to obtain this data quickly is to install X-ray measuring equipment in-line with the process.

Figures 1 and 3 show schematically the layout of a CIGS solar cell plant for horizontal glass panels and roll-to-roll substrate processes. For both plant designs the X-ray measurements are made at the end of the process cycle. Fig. 1 and Fig. 3 show how the in-line X-ray equipment has been integrated into various production lines, it is evident that in-line X-ray equipment always has to be adapted to special process conditions such as: high temperature, vacuum, limited space, and the chance of chemical contamination.

Multi-stage flat glass CIGS panel technology

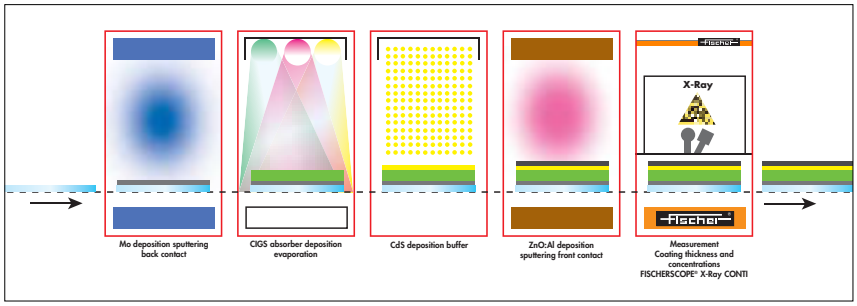


Fig.1: *Basic concept for continuous deposition of Mo, CIGS, CdS, ZnO layers and in-line XRF measuring chamber with a FISCHERSCOPE® CONTI 4000-V instrument. Horizontal step-by-step transport of glass panels through the different deposition processes*

A possible solution for an EDXRF instrument which is designed to measure in-line within an evaporation type process chamber is shown in Fig. 2. Water cooling, heat shielding, X-ray vacuum interface flanges are all part of the measuring device integration and are provided as customized solutions. If required the design provides easy access to the equipment.

Fig. 2:
FISCHERSCOPE® CONTI 4000-V for downward installation into a CIGS-coating plant (horizontal moving CIGS-panels below custom cylindrical EDXRF instrument, see Fig.1)

Roll-to-roll technology CIGS solar foils

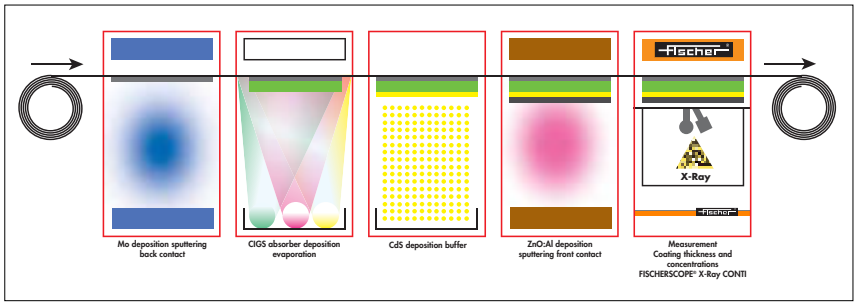


Fig.3: *Basic concept for flexible CIGS solar foils. Continuous deposition of Mo, CIGS, CdS, ZnO layers and in-line XRF measuring chamber with a FISCHERSCOPE® CONTI 4000-V instrument. Concept allows depositions on plastic, stainless steel, or aluminum foils at high speed*

Fig. 4 shows a schematic example of the installation of a FISCHERSCOPE® CONTI 4000-V instrument into a plant using roll-to-roll technology for flexible CIGS solar cells. With this technology polyimide, stainless steel or aluminum foils can be continuously coated in the described sequence of Mo/CIGS/CdS/ZnO coatings. The EDXRF equipment is operated in an upward measuring configuration.

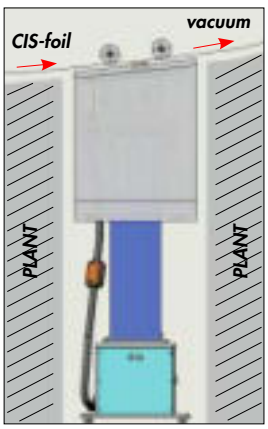
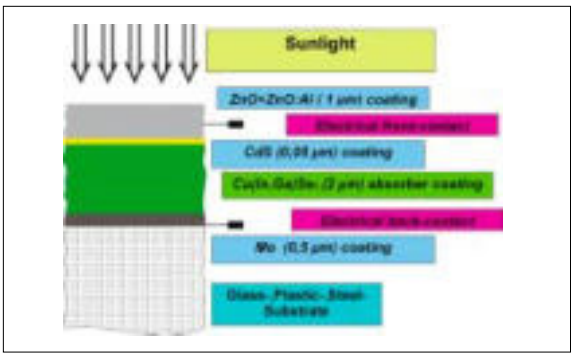


Fig. 4:
FISCHERSCOPE® CONTI 4000-V for upward installation into a CIGS-coating plant (horizontal moving CIGS-foils within a vacuum chamber, above the EDXRF head, as Fig.3)



CIGS- Solar Cell (multi-layer thin film composites)
CIGS for Copper, Indium, Gallium, Selenium ***(Fig. 5)***

Offline continuous measurements with CONTI 4000-DPP

Offline equipment – independent of the usual in-line difficulties of vacuum, heat, limited access space etc.– is well suited to measure X-Y scans across the CIGS-coated substrate. It provides valuable 2-D information concerning the homogeneity of the coating over the whole CIGS-product.

If one is interested in measuring the coating parameters on large CIGS-panels or long sheets the CONTI 4000-DPP can be adapted in various modifications. Products with a maximum width of 1000 mm, and infinite length can be measured.

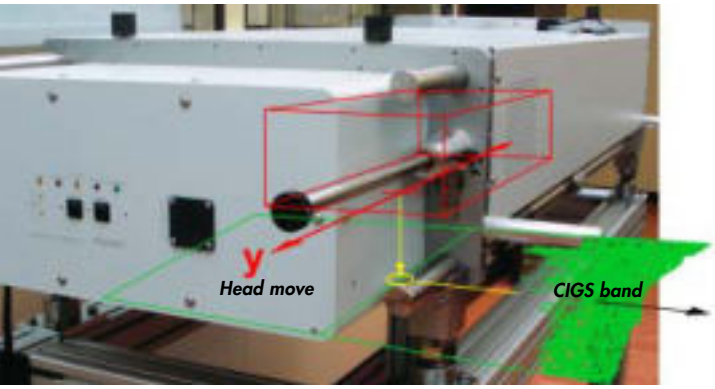


Fig. 6:
FISCHERSCOPE® X-Ray CONTI 4000-DPP measuring instrument (here in preparation for web testing). The web (sample) is indicated by the green region The yellow arrow describes the primary X-ray beam where the yellow trace on the web suggests the analyzed line. The red double-arrow marks the traversing motion of the measuring head.

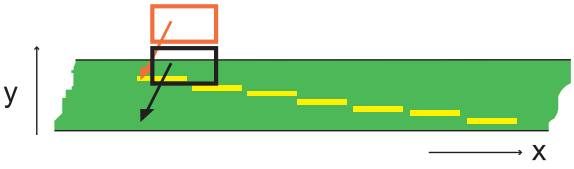


Fig. 7: Principal sketch for measuring CIGS thicknesses and concentrations of large panels. The CONTI measuring head can be freely programmed to Y-coordinates along the panel-width. As a result there will be measuring positions along the transport direction X (in yellow).

Offline standard equipment (table-top) FISCHERSCOPE® X-Ray

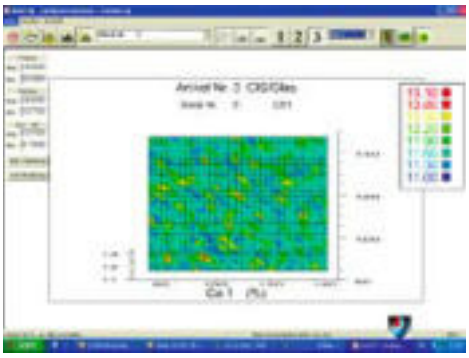
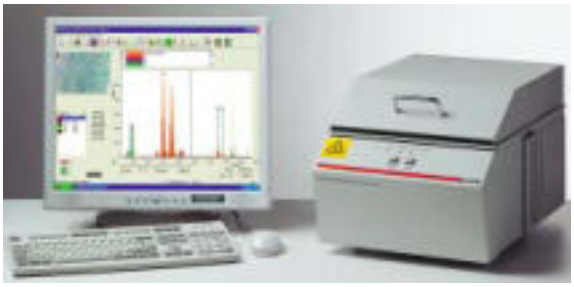


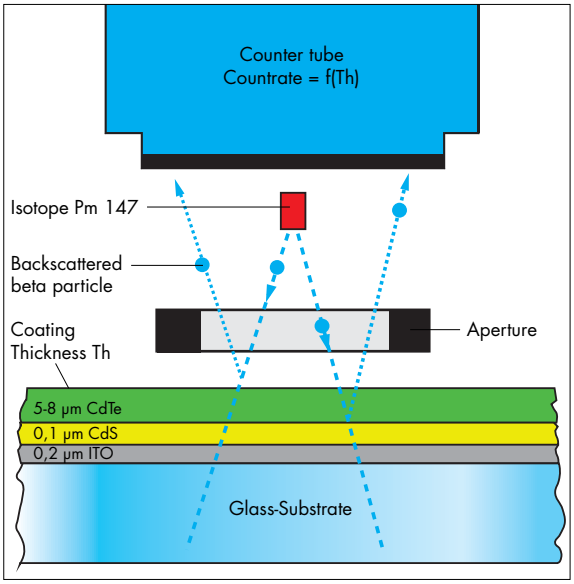
Fig. 8a: Table-top FISCHERSCOPE® X-Ray XDV® for the quality lab (measuring and scanning of CIGS coatings with programmable X-Y table).
Fig. 8b: Example of a two-dimensional X-Y scan measuring Ga-concentrations (11 – 13,1 atomic %).

Usually each CIGS solar cell production plant has one or more quality laboratories. In order to run a stable process a lot of chemical and physical parameters have to be monitored. For quick offline analysis of smaller sized CIGS sample parts the table-top X-Ray XDV® offers X-Y scanning capabilities. A similar but more cost effective unit is the X-Ray XAN-DPP, that allows for single position measurement without X-Y table.



FISCHERSCOPE® X-Ray XAN-DPP Spectrometer for quick analysis of small CIGS objects in the quality lab (manual table)

Offline standard equipment (table-top) BETA-backscatter measurements on CdTe panels with Z9NG hand probe, Pm-147 Isotope, FISCHERSCOPE® MMS® or MMS® PC, BETASCOPE®



Beta-backscattering is used to measure CdTe or CdS thin films. Beta particles – emitted by a Pm-147 source – are interacting with the atoms of the coatings and the glass-substrate. Special algorithms in the FISCHERSCOPE® MMS® or MMS®-PC units convert count rates into coating thickness values.

Fig. 9:
Betaprobe Z9NG, Pm-147 isotope, 1,6 mm aperture on CdTe-panel

The Beta-backscattering method is applied to measure 1) CdTe coatings (5-8 µm) on Base (CdS/ITO/Glass) or 2) CdS coatings (50 – 200 nm) on Base (ITO/Glass).

The information in this brochure contains only general descriptions and performance features that do not always apply as written, or that may be changed due to continuous development of the products. The desired performance features are binding only if they are expressly agreed upon in the contract.

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