Xelas SCAN-tfs
Xelas LAB-tfs

Measurement systems for
Thin Film Solar layers and stacks

Xelas SCAN-tfs and LAB-tfs: Measurement of Thin Film Solar samples – Thickness + n&k of Layers and Stacks

Patented RT-Method!

For Thin Film Solar (TFS) modules, many different types are currently produced: Most interesting systems are the silicon-based type (a-Si/µc-Si layers), then CIS/CIGS solar stacks , CdTe systems and finally cells based on organic layers. All types of TFS modules need at least one TCO layer as n-ZnO:Al or ITO and metallic layer as Ag, Al, Cu. Thicknesseses of thin films within the multi-layer stacks range from a few nm up to several µm.

Therefore, a large quantity of various components with very different material data n&k are currently tested, coated by several processes, like PECVD or sputtering. Which type of layer or stack will finally win a remarkable market share of PV is dependent factors as cost, efficiency and stability. From this decision in turn, it will depend which layers have to be inspected for thickness and material data n&k. Any offline tester need to be flexible and powerful but still easy-to-use and upgradable to new functions.

Solution for TFS offline measurements

NXT offers unique equipment to measure the layer thicknesses and n&k of any kind of layer or stack, taking surface structures into account. The system is equipped with standard setups for many materials and stacks and enlargable to materials unknown today.

Highlights of Xelas-tfs

Measurement of all TFS layers:

- Layer thickness 2nm-5000nm
- Spectral material properties n(λ)/k(λ)
- Surface roughness
- Refractive index profiling (N(z))

Flexible for production control and R&D

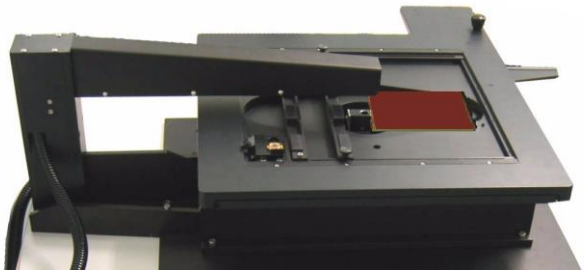
- Offline testing of standard samples and special development cases
- Contactless and non-destructive
- SCAN: x-y-mapping, one-directional scans and single-point measurements

Proven for all relevant layers and stacks

- Semi-conductive, TCO, organic, dielectric,...

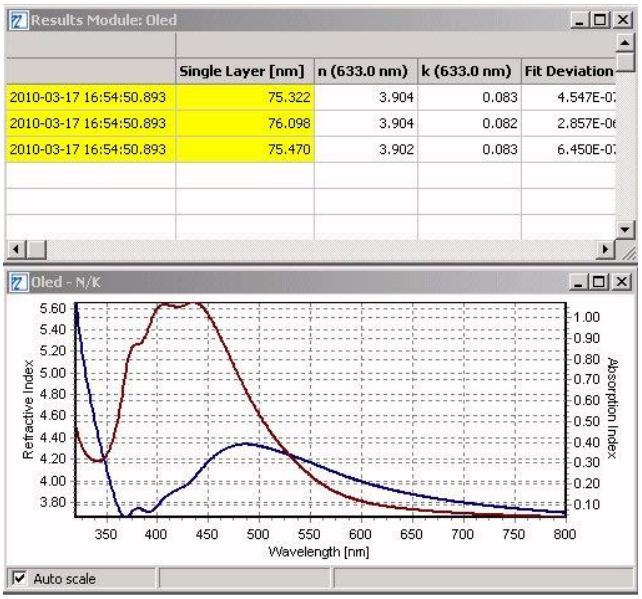
Upgradable to Optical Modelling

- Unique NXT oscillatory model : Design of own parameter sets for n&k



Offline measurement of a TFS sample

Offline testing of thicknesses and n&k

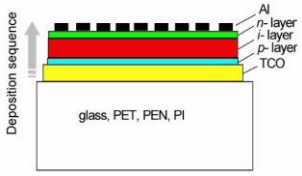


Amorphous Si layer thickness and spectral refractive + absorption index **n(λ)/k(λ)***, measured with* ***Xelas SCAN/LAB-tfs***

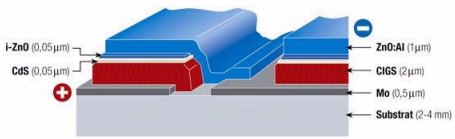
Application Examples of Xelas-tfs

- Testing substrates like glass, PEN, PET, stainless steel: Spectral reflectance, transmittance, n&k
- Single layers on substrates: Thickness and n&k
- Surface structures of substrates or layers
- Layer stacks after production steps: Thicknesses within the stack and n&k of the top layer
- Final Thin Film Solar stack: Spectral properties for efficiency check of the cell

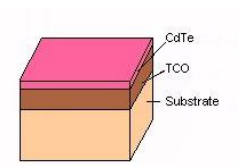
Thin Film Solar stack types for which Xelas SCAN/LAB-tfs can be used



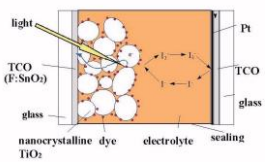
a-Si PIN/NIP type



CIS/CIGS solar cell



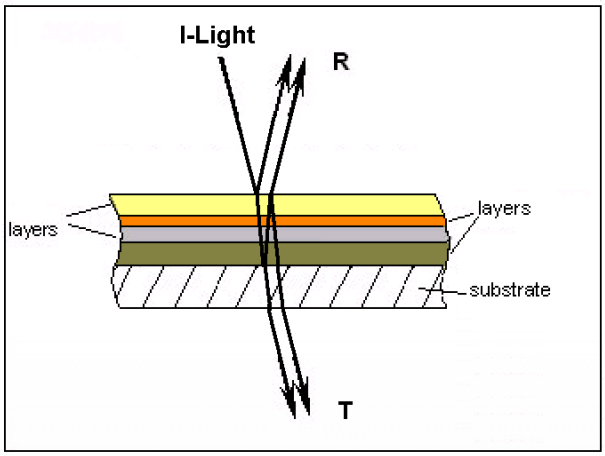
CdTe pre-final solar stack



Organic film solar cell

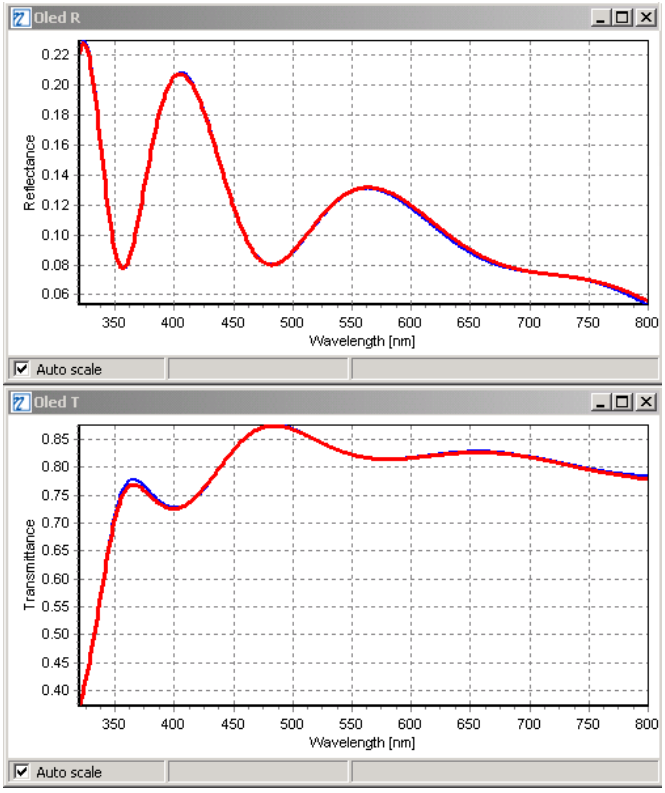
Principle of Measurement

Phase differences between the front and rear side reflection of thin layers cause interference. Absorption inside each layer changes light wave amplitude. Both of these phenomenona can be used together to measure the layer thickness and refractive and absorption index n&k of thin layers.



Reflectance R and transmittance T at a layer stack

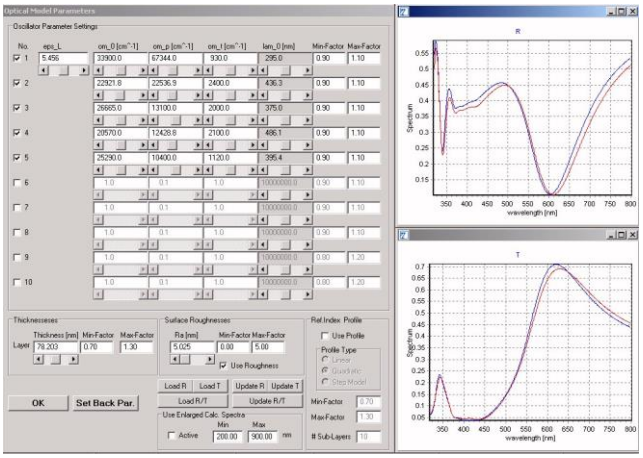
After recording the specta of the sample, a mathematical calculation is performed in which the layer thicknesses and the parameters for the optical properties n&k are varied until model and measurement match perfectly.



Spectral fit of R and T of a TCO layer (ITO) for a-Si solar cell (measurement = blue / model simulation = red)

Our proprietary algorithms use a special type of oscillatory model which is applicable to all kind of materials. Further, they take surface roughness of the substrate or layers into account.
Precise modelling of all component from the substrate to each layer is the key to measure extremely thin layers down to 2nm on substrate, as well as very small variations of layers within a stack.

By the additional software option Optical Modelling, all parameters can be set and a database of pre-configured material setups is delivered. Refractive index profiling, a change of refractive index in vertical direction along build-up the layer, can be simulated for three different profile types.



Layer of a-Si: Setup for Optical Modelling of n&k

Offline measurement of thickness and n&k is the key to:

→ High layer homogenity for all TFS types
→ Material, process and stack design
→ Detailed coating analysis

Xelas-tfs enables producers of TFS to:

- Design new materials, processes and layer stacks by the advanced, unique function Optical Modelling
- Check the layer quality by detailed knowledge of variations and drifts, as well as changes in material properties n&k
- Be prepared for any TFS cell model of the future, including types still under R&D
- Keep production conditions stable and increase production/process yield

Product Specifications

MEASUREMENT	
Measurement Parameters	Layer thicknesses of single layers and stacks / spectral refractive + absorption index (n&k)
Wavelength Range	390 ~ 1050nm or 320 ~ 800nm (other ranges on request)
Thickness Range	2 ~ 5000nm
Refractive Index Range	0.01 ~ 10.00 (all materials possible)
R+T Accuracy	± 0.4%
Thickness Accuracy	± 0.5nm (range 2nm-40nm) ± 1.0nm (range 40nm-200nm) ; ± 2.0nm (range 200nm-500nm) ± 4.0nm (range 500nm-5000nm)
Thickness Repeatability	3σ < 0.1nm (range 2nm-500nm) 3σ < 1.0nm (range 500nm-1000nm) 3σ < 2.0nm (range 1000nm-5000nm)
Refractive Index Accuracy	Silicon-layers : ± 0.03 ; Conductive layers : ± 0.03 ; Dielectric layers : ±0.02 ; Others ± 0.03
Refractive Index Repeatability	3σ < 0.01

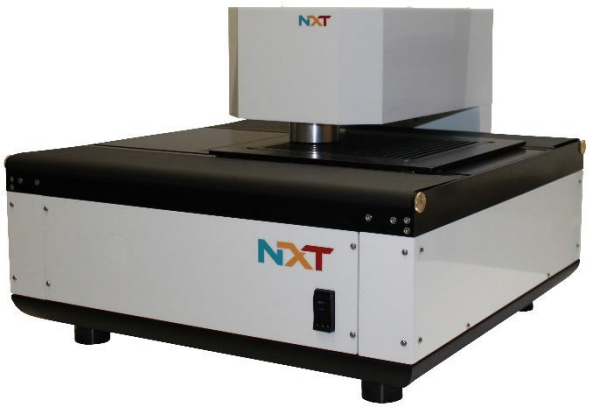
HARDWARE	
Measurement Geometry	White light reflectance (R) and transmittance (T) in normal incidence (0°)
Measurement Spot Size	~ 1mm
Measurement Speed	≤ 1.0 sec. / point for thickness ; approx. 0.3-1.0 min. / point for n&k
Sample Sizes	10x10mm to 250x280mm (larger sample sizes are possible on request)
Required Positioning Accuracy of sample	Within ± 1mm height and within ± 0.6° tilt
Environment	Temperature range: 5-45°C (50-90°F), Humidity: < 80% (non-condensing)
Power	AC 100 ~ 240V; 50/60 Hz
Dimensions W/D/H (Width/Depth/Height)	Spectrometer and light source rack : W= 553mm ; D= 600mm ; H= 822mm Manual x-y-table : W= 670mm ; D= 842mm ; H= 269mm Housing for automated x-y-scanning table: W= 580mm ; D= 650mm ; H= 414mm

PC / SOFTWARE	
Measurement Functions	Layer thicknesses / refractive + absorption index / value history / mapping
PC Requirements	Windows® 7 / 8 / 10, 8 GB RAM, >500 GB hard disc space, Intel i7 >Gen3 recommended

* Photo on title page supplied by ZSW/Stuttgart - Germany

Standard Setup Types (more types on request)

Xelas SCAN-tfs



Xelas LAB-tfs

System for automated SCAN x-y-scanning table (left) / Spectrometer and light sorce rack excluding operating PC with manual LAB x-y-table (right)

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