

# Helios INLINE-tn

Coating Measurement of Solar Cells  
Thickness and Refractive Index of Silicon Nitride

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For wafer based solar cells the anti-reflective coating, surface passivation and diffusion barrier play an important role to achieve high solar cell efficiency and long term stability. Because of its excellent characteristics Silicon Nitride coating ( $\alpha\text{-SiNx:H}$ ) is widely used for this purpose.

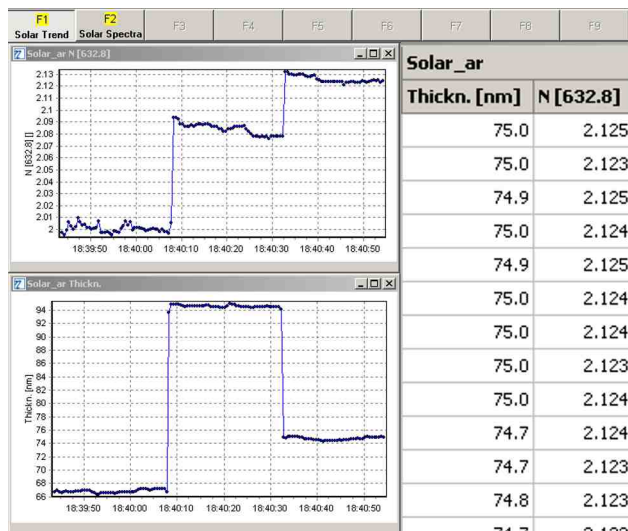
Process parameters such as the gas pressure and temperature of the cell during deposition have a strong influence on the layer thickness and the optical constants  $n$  &  $k$  of Silicon Nitride. Therefore, it is essential to gain detailed knowledge of the layer thickness and the optical constants  $n$  &  $k$  during the process. Conventional measurement technology can only measure Silicon Nitride layer properties offline and on polished wafers.

## Inline Measurement of Silicon Nitride

NXT offers unique equipment to measure layer thickness as well as refractive index of the Silicon Nitride layer. The Helios INLINE-tn system is designed for inline use and can be retrofitted in existing production lines!

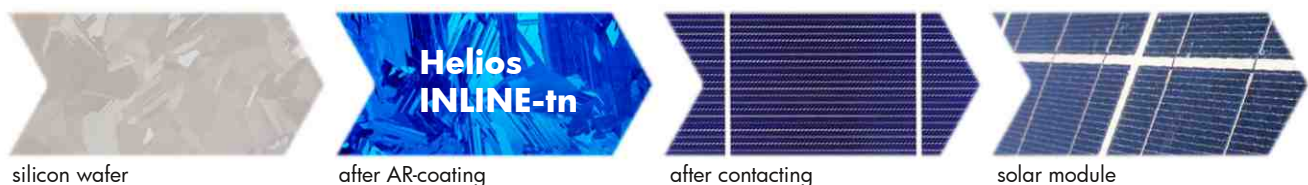
Improve the quality and efficiency of your cells, via finding and reducing the causes of process instabilities and inhomogeneities, such as coater inhomogeneities, coater drift and impact of sawing and texturing inhomogeneities.

## Measurement Example



Measurement of thickness and refractive index of Silicon Nitride. Scan over 3 wafers, wafers made with different process conditions

## Process Steps in which Helios INLINE-tn is used



## Highlights of Helios INLINE-tn

### MEASUREMENT OF SILICON NITRIDE

- Layer Thickness:  $d$
- Refractive Index:  $n$  (spectral)

### WORKS FOR PRODUCTION AND R&D

- inline / each individual wafer
- contactless and non-destructive
- static and dynamic measurement

### WORKS FOR ALL RELEVANT WAFER TYPES

- mc-wafers (polished, rough or textured)
- pc-wafers (polished, rough or textured)

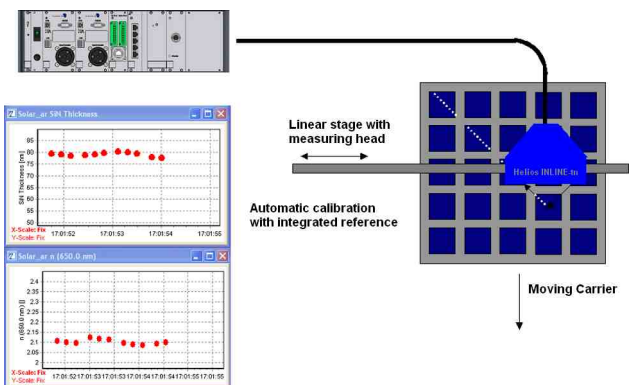
### WORKS FOR ALL RELEVANT KIND OF TEXTURES

- isotropic chemically etched
- anisotropic chemically etched
- RIE (Reactive Ion Etched)

### WORKS FOR ALL RELEVANT DEPOSITION PROCESSES

- PE-CVD
- Magnetron Sputtering

## Installation Example



Diagonal scanning over a 5x5 carrier with solar cells

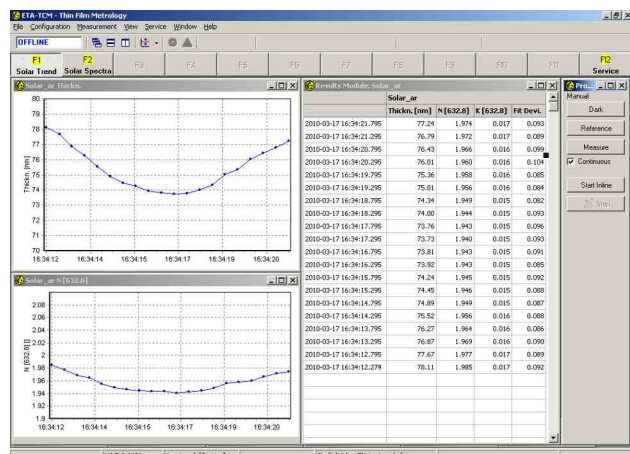
## Inline Operation

The system is preferably mounted inline, directly after the coating. The scanning can be configured for measuring every individual wafer (few points on every wafer), or for measuring just 1 diagonal line over the carrier (many points on a few wafers on a diagonal line).

The system can also be mounted at a single belt, after individualizing the wafers to a single stream on a transportation belt (multi channel system on request).



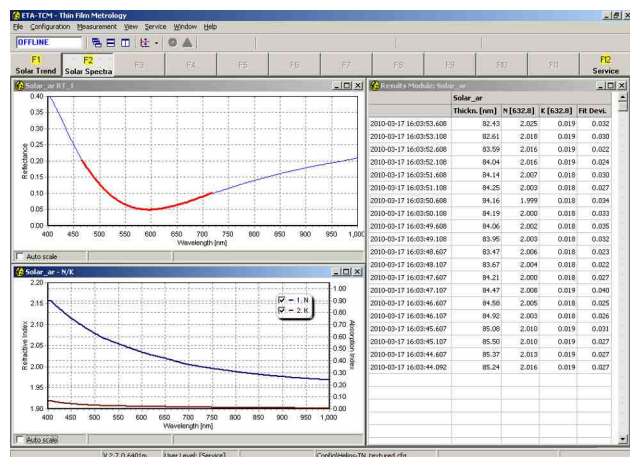
## Presentation Examples



Textured mono wafer with SiN-coating. 20 point diagonal scan. Trend display of thickness and refractive index.

|                         | Thickn. [nm] | N [632.8] | K [632.8] | Fit Dev. |
|-------------------------|--------------|-----------|-----------|----------|
| 2010-03-17 16:34:21.795 | 77.24        | 1.974     | 0.017     | 0.093    |
| 2010-03-17 16:34:21.295 | 76.79        | 1.972     | 0.017     | 0.089    |
| 2010-03-17 16:34:20.795 | 76.43        | 1.966     | 0.016     | 0.099    |
| 2010-03-17 16:34:20.295 | 76.01        | 1.960     | 0.016     | 0.104    |
| 2010-03-17 16:34:19.795 | 75.36        | 1.950     | 0.016     | 0.085    |
| 2010-03-17 16:34:19.295 | 75.01        | 1.956     | 0.016     | 0.084    |
| 2010-03-17 16:34:18.795 | 74.34        | 1.949     | 0.015     | 0.082    |
| 2010-03-17 16:34:18.295 | 74.00        | 1.944     | 0.015     | 0.093    |
| 2010-03-17 16:34:17.795 | 73.76        | 1.943     | 0.015     | 0.096    |
| 2010-03-17 16:34:17.295 | 73.73        | 1.940     | 0.015     | 0.093    |
| 2010-03-17 16:34:16.795 | 73.81        | 1.943     | 0.015     | 0.091    |
| 2010-03-17 16:34:16.295 | 73.92        | 1.943     | 0.015     | 0.085    |
| 2010-03-17 16:34:15.795 | 74.24        | 1.945     | 0.015     | 0.092    |
| 2010-03-17 16:34:15.295 | 74.45        | 1.946     | 0.015     | 0.088    |
| 2010-03-17 16:34:14.795 | 74.89        | 1.949     | 0.015     | 0.087    |
| 2010-03-17 16:34:14.295 | 75.52        | 1.956     | 0.016     | 0.088    |
| 2010-03-17 16:34:13.795 | 76.27        | 1.964     | 0.016     | 0.086    |
| 2010-03-17 16:34:13.295 | 76.87        | 1.969     | 0.016     | 0.090    |
| 2010-03-17 16:34:12.795 | 77.67        | 1.977     | 0.017     | 0.089    |
| 2010-03-17 16:34:12.279 | 78.11        | 1.985     | 0.017     | 0.092    |

Thickness and refractive index data on the textured mono wafer.

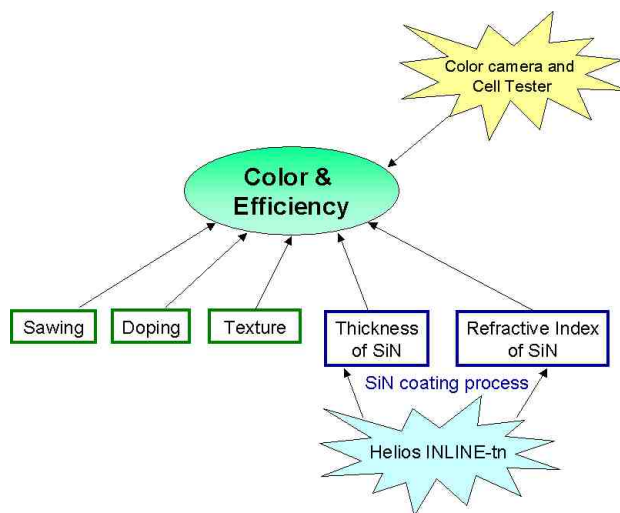


Textured poly wafer with SiN-coating. 20 point diagonal scan. Spectral Reflectance curve, spectral refractive index curve and measured data

## Optimize your process parameters

Cell tester/sorter and color cameras are needed for final quality check of the cells, but do not provide direct information, which process parameter is out of the desired process window.

Optimizing a production process means, to measure and optimize each single process parameter. This gives full process control and optimized results. The Helios INLINE-tn is designed to give full process control for 2 key process parameters: Thickness and Refractive Index of the AR-coating.



## Benefits and ROI of the Helios INLINE-tn

### Reduce down-time of your production line

After stopping the line and then re-starting it, the time for getting the production stable into the process window again can be minimized.

This saves material, time  
and ....money

### Save material by sorting out bad wafers early in the production process

Solar wafers with bad quality of the AR-coating can be sorted out directly after the coating. This saves money, since expensive further process steps can be avoided.

This saves material  
and ....money

### Save labor time for offline testing

The inline process control makes an additional offline testing of thickness and refractive index obsolete.

This saves equipment, labor time  
and .... money

### Improve quality and increase efficiency

Reach a more narrow process window of refractive index and layer thickness. This leads to less variation of the color of the cells and to higher efficiency of the solar cell  
..... higher value of your solar cells

## Calculation Example

A production line produces

- 25 MW of solar cells per year
- cells with average efficiency of 17%
- cells with an average selling price of 1 EURO/cell

Assumed, that the inline measuring system leads to an increase of the average efficiency from 17% -> 17,1%. then this gives a ROI of 150 T€/year

..... earn more money on your cells

## Product Specifications

### Measurement

| Measurement Parameters      | Layer Thickness /<br>Refractive Index of SiN<br>(SiO <sub>2</sub> and dual layer<br>on request) |
|-----------------------------|---|
| Thickness Range             | 45nm ~ 120nm  |
| Refractive Index Range      | 1,9 ~ 2,35  |
| Thickness Accuracy          | ± 1nm   |
| Refractive Index Accuracy   | ± 0,02  |
| Thickness Resolution        | < 0,1nm   |
| Refractive Index Resolution | < 0,004   |
| Measurement Speed           | < 0,2 s/point<br>(dynamically, on the flight)   |

### Measuring Geometry

|                       |   |
|-----------------------|---|
| Optical Setup         | synchronized; 2-channel<br>Reflectance spectrometry;<br>oblique incidence of light;<br>automatic, integrated<br>reference |
| Measurement Spot Size | ~ 5mm x 8mm (elliptically)  |
| Measuring Distance    | 10 mm (free distance)   |
| Distance Tolerance    | ± 2mm   |
| Tilt Tolerance        | ± 2°  |

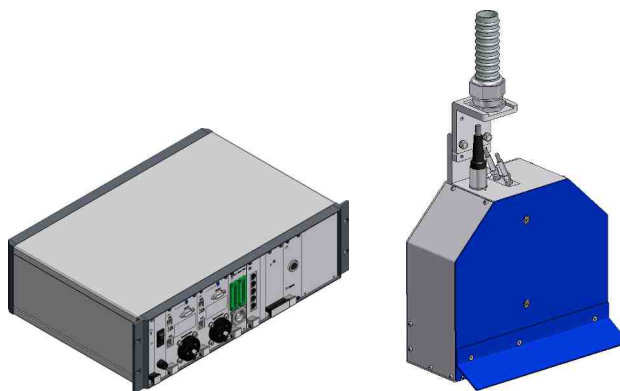
### Hardware

|                       |  |
|-----------------------|--|
| Spectrometers         | 2x diode line spectrometer,<br>380nm - 1050nm, 16 Bit  |
| Light Source          | Halogen, 20 Watts                                      |
| Line Interfaces       | TCP/IP, Digital I/O                                    |
| Power                 | AC 100~240V; 50/60Hz                                   |
| Environment           | Temperature: 10-50°C,<br>Humidity: <90% (non-condens.) |
| Motorized Linear Unit | not included; on request                               |

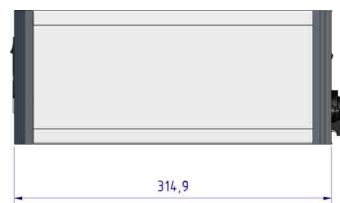
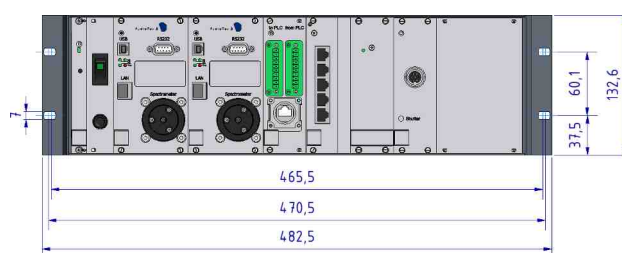
### PC / Software

|                    |   |
|--------------------|---|
| PC Requirements    | Windows® 7 / 8 / 10,<br>8 GB RAM, >500 GB HDD   |
| Software Functions | Reflectance Spectra,<br>Thickness Measurement,<br>Refractive Index Measurement,<br>Trend Displays,<br>Customizable Screensets,<br>Data Storage and Transfer,<br>Various Trigger Functions,<br>..... |

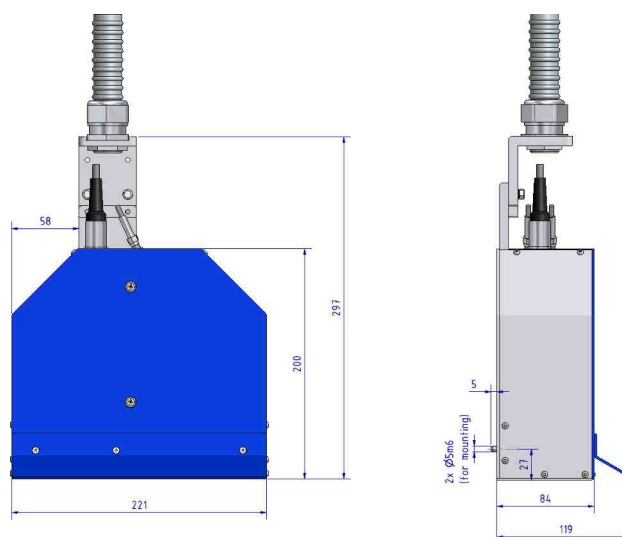
## System Dimensions (in mm)



Equipment Overview:  
Rack with spectrometers (left) and inline measuring head (right)



Rack with Spectrometers, power supplies, LAN-Hub, Interfaces;



Inline measuring head with integrated reference

