SENTECH Instruments GmbH

SENperc PV

Thin Film Metrology in Solar Cell Quality Control

SENTECH in brief

SENTECH Instruments was founded in 1990 specializing in **Thin Film Metrology** and **Plasma Process Technology**
We are ISO 9001 (2015) certified

Our position in PV Quality Control

Strength

Non-invasive
optical metrology

Worldwide
service support &
applications labs

Experience

20+ years in
PV quality control

PV Market Share

> 500 PV metrology
tools worldwide

Growth

Extension building
since 2020

100+ employees

SENperc PV

Thin Film Metrology in Solar Cell Quality Control

Sven Peters

Challenge

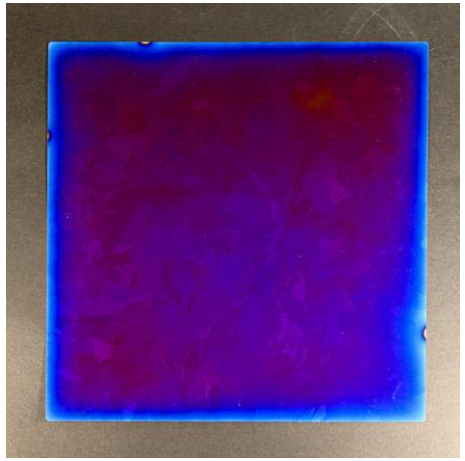
- Functional thin films in PERC solar cells show **process depending variations** in film thickness and optical constants
- They depend on **deposition line operating time** and cell location on the carrier
- Manufacturers request **a fast and non-invasive** measurement method to assure constant cell quality
- The measurement device must be **easy to operate**

Solution

- **SENperc PV** utilizes contactless optical methods for the accurate and precise measurement of both:
  - Film thickness
  - Optical constants
- Both determine quality of the solar cell: pass or reject
- Two step operation: place cell on device & push “Measure” button
- Measurement time is a couple of seconds
- Cell quality is shown to the operator
- Results are automatically saved into SQL database

Applications in PERC solar cells

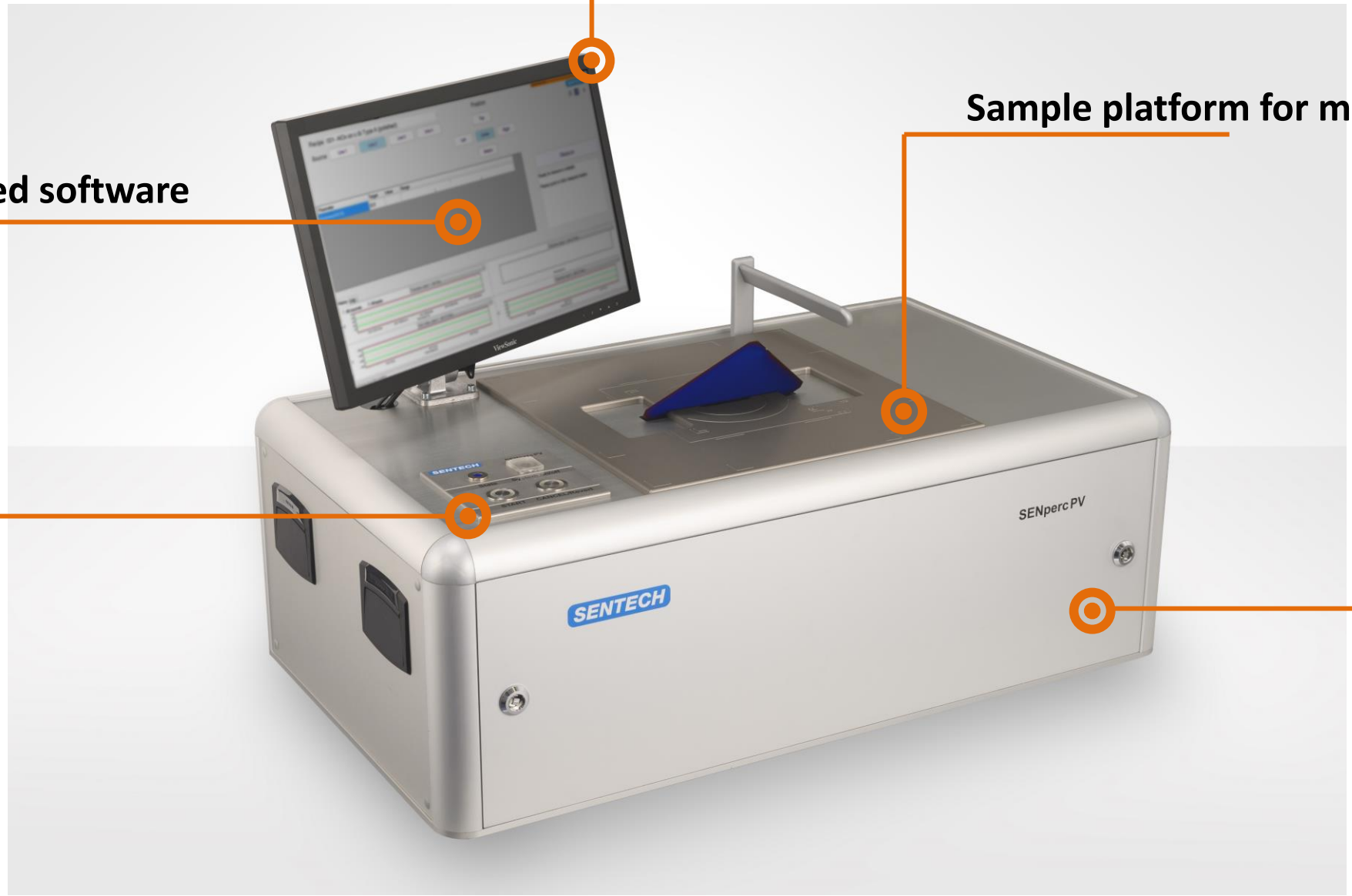
- AlO_x layer thickness on rear side
- SiN_x / AlO_x on damage etched Si
- SiN_x on textured front side



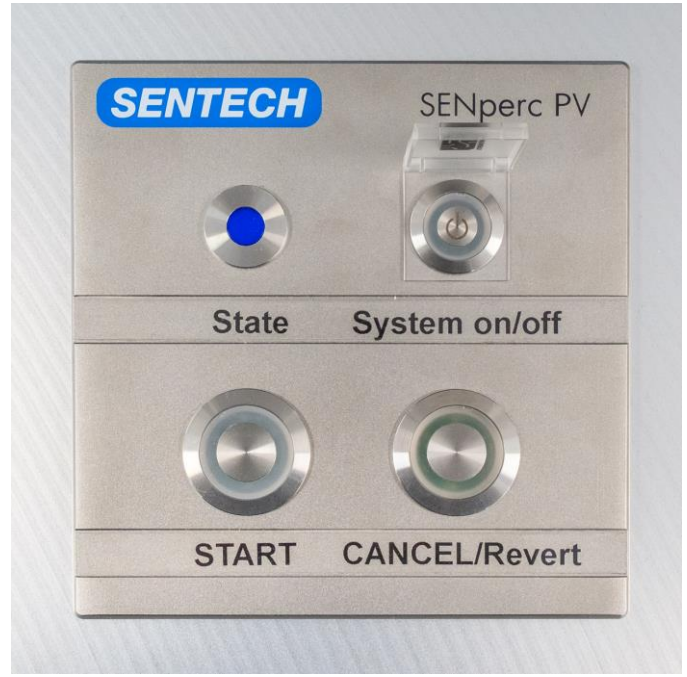
SENperc PV for other types of solar cells

- HJT
- TOPCON
- Perovskites

SENperc PV – Main Components



SENperc PV – Control Panel

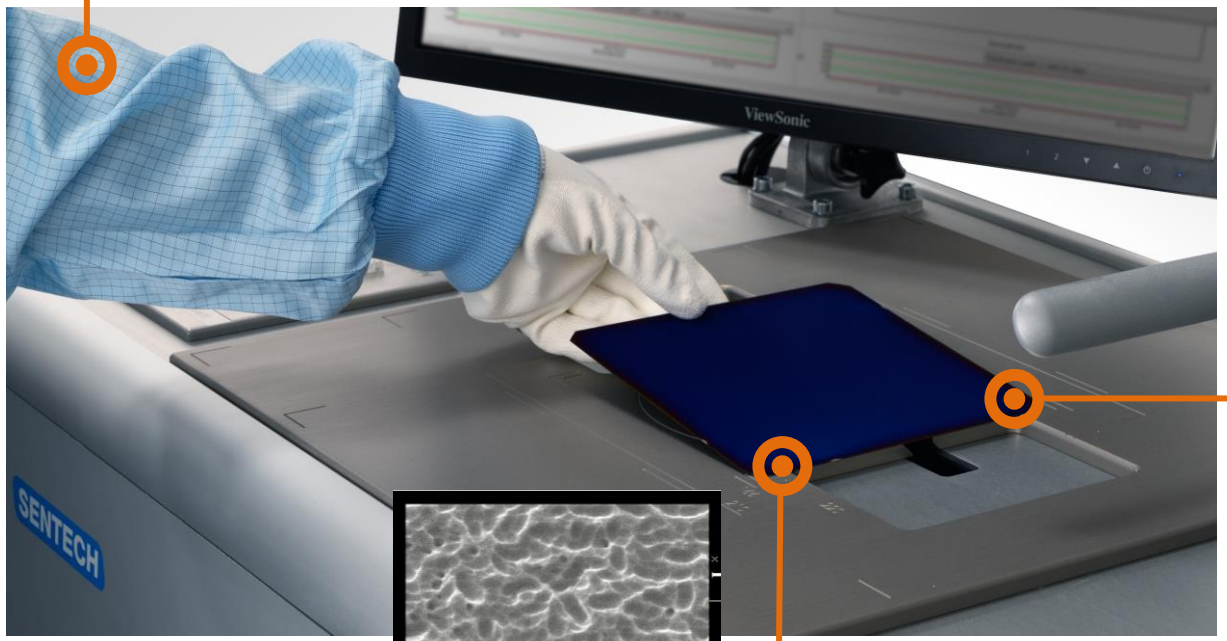


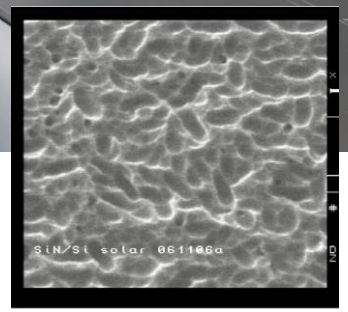
SENperc PV – Placing the Solar Cell

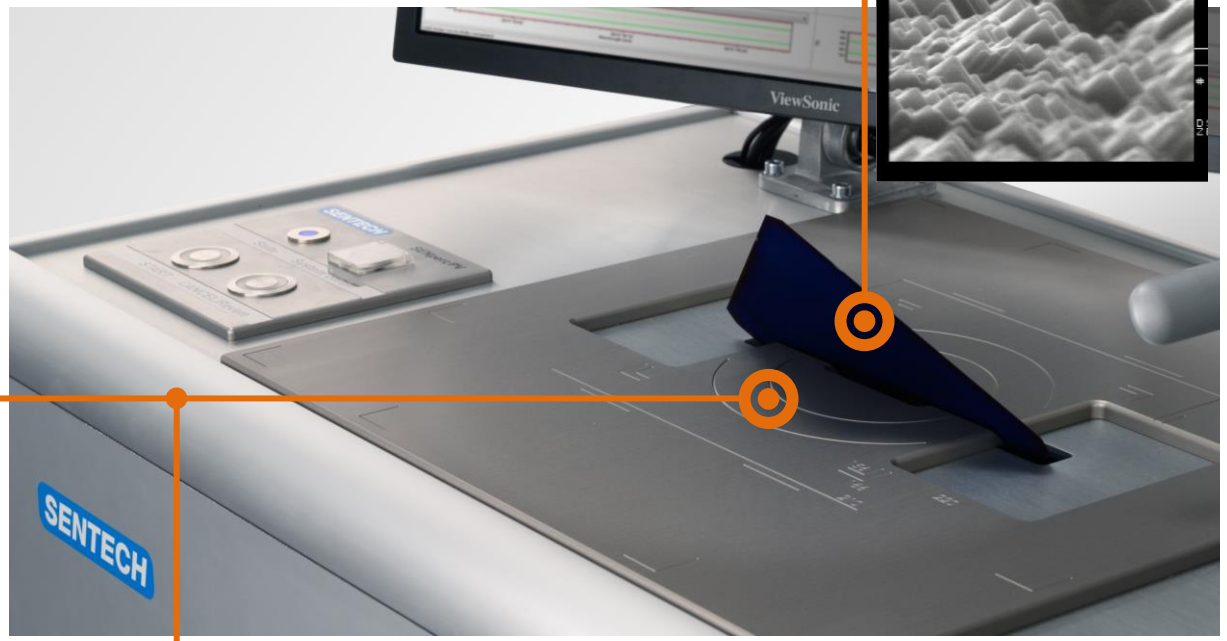
Conventional setup

SENperc easy cell alignment setup

Inclined cell mount for alcaline textured cells with pyramids







Sample self-alignment

Flat position for acidic textured or polished cell surfaces


SE800-PV
SE800-PV
SENTECH
SENTECH Instruments GmbH

SENperc PV – Operation

SENTECH

SENperc Operation

Click here to watch the video:
https://bit.ly/2Vqze7h

SENperc PV – User Interface for Solar Cell Qualification

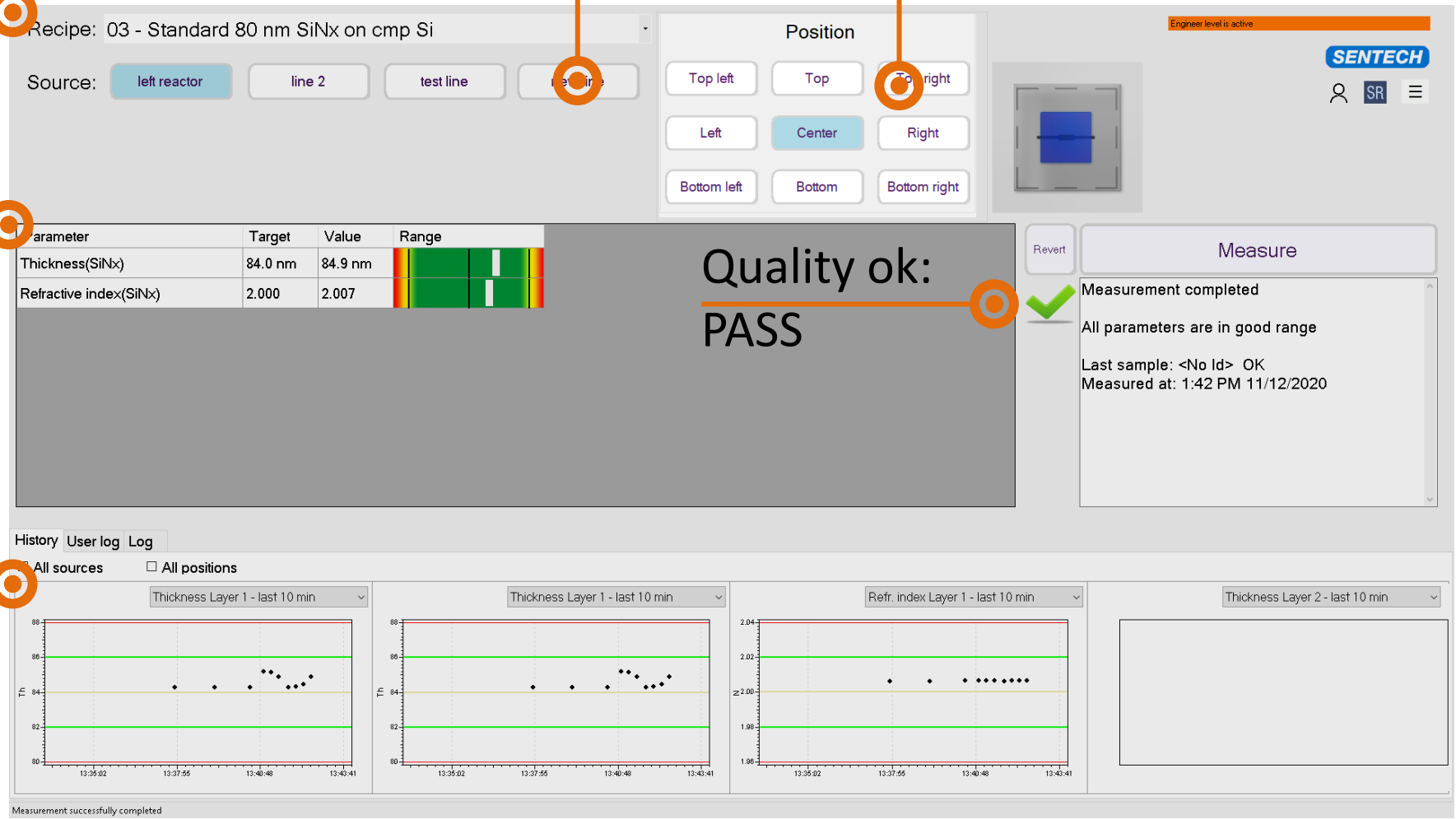
Recipe selection

Reactor selection

Measurement position selector

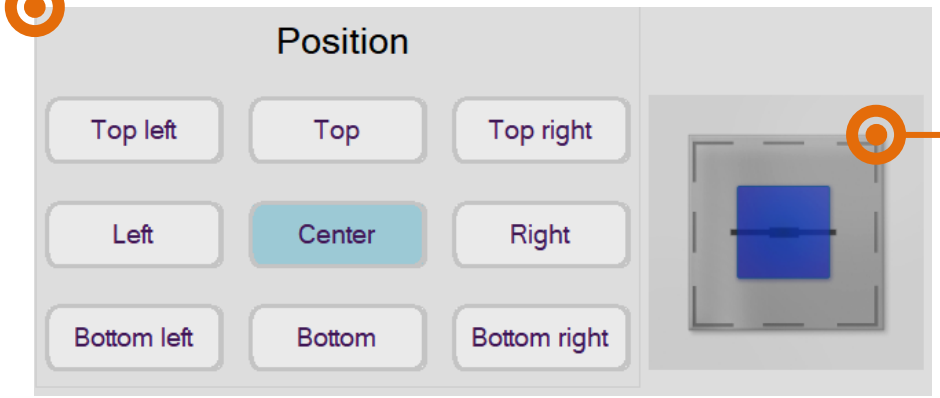
Results

SQL database



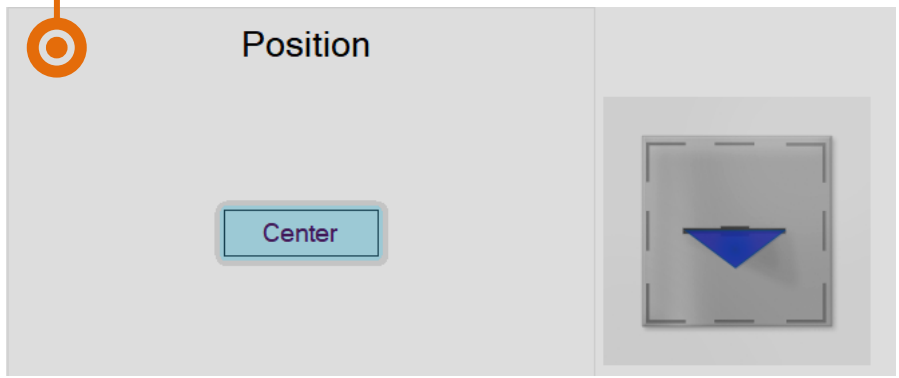
SENperc PV – User Interface – Position Selection

Up to 9 positions can be selected for flat cell positioning



Visualization

Center position with inclined cell mount



SENperc PV – User Interface - Detailed View

Current result

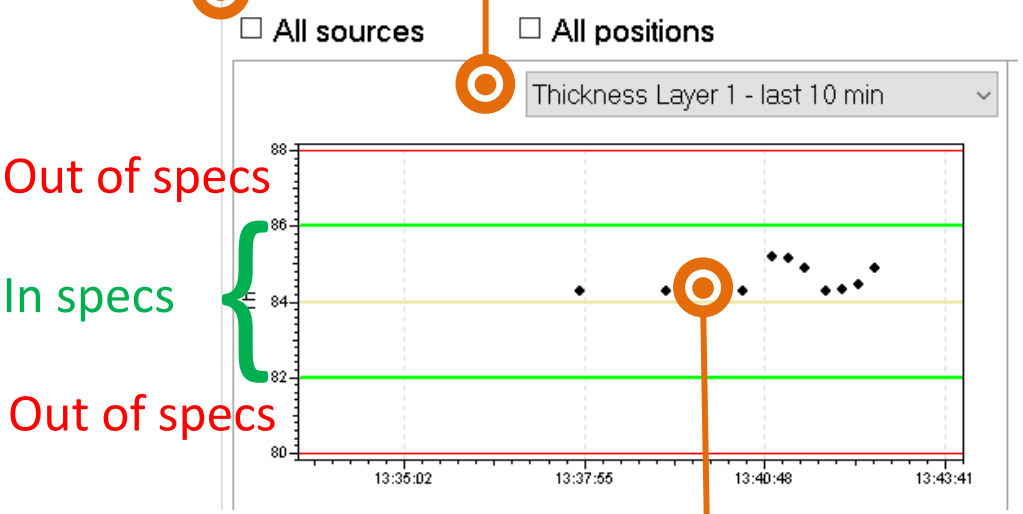
Thickness in range

Parameter	Target	Value	Range
Thickness(SiNx)	84.0 nm	84.9 nm	
Refractive index(SiNx)	2.000	2.007	

Refractive index in range

SQL database

Selectable time period: minutes → months



Out of specs

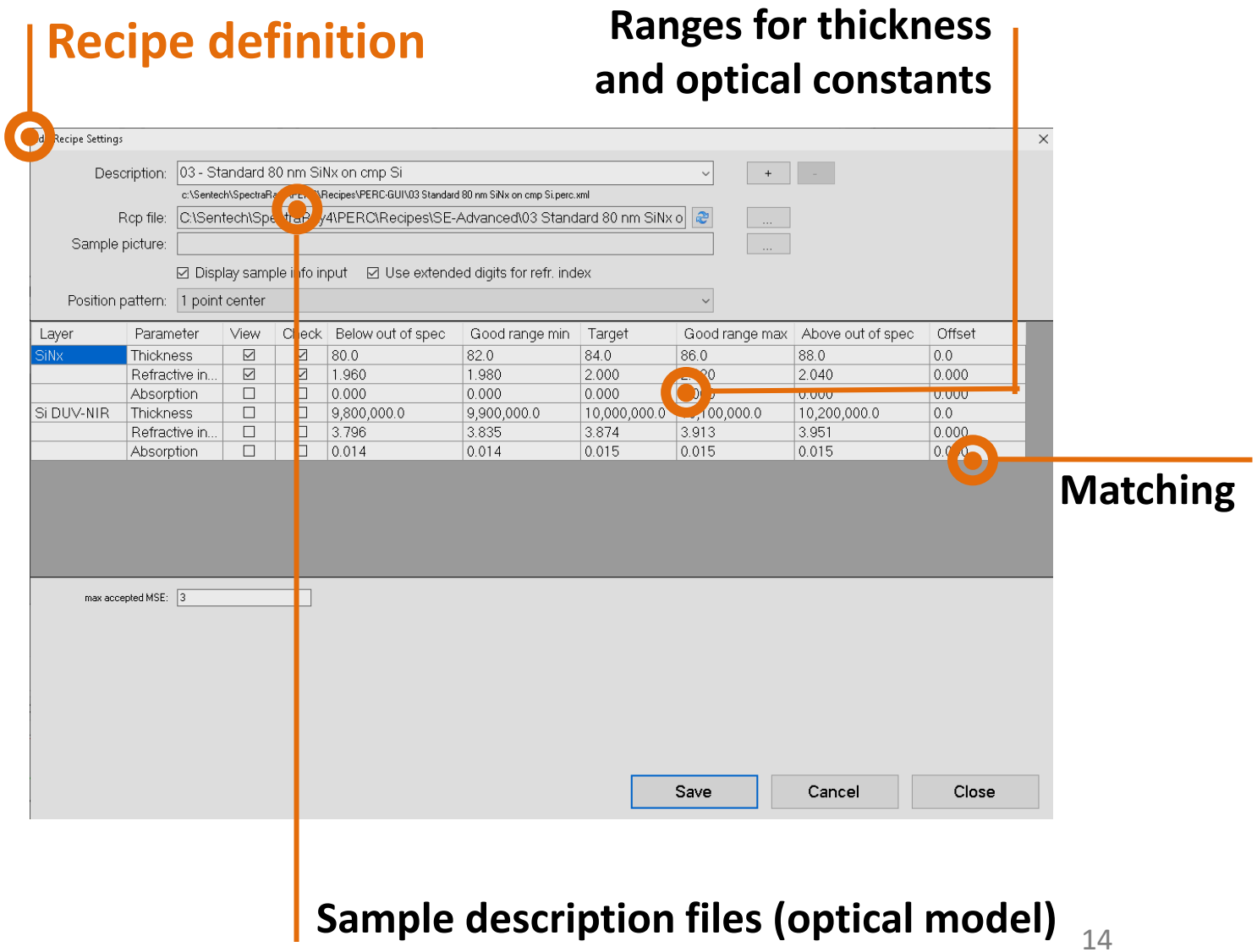
In specs

Out of specs

Recent results

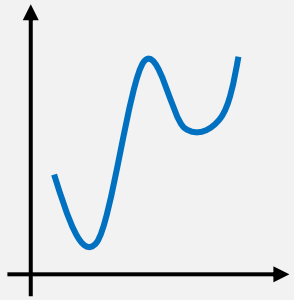
SENperc PV – Recipe creation

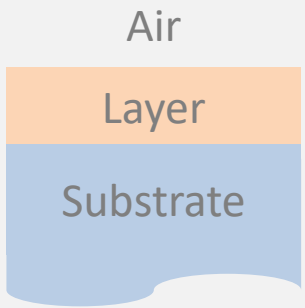
- SENTECH offers recipe creation as a service
- New recipes can be created by the customer
- Recipes can be customized



SENperc PV – The technology behind it …

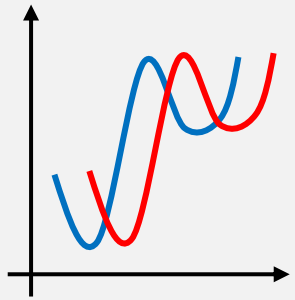
1. Measurement	2. Modeling	3. Input	4. Before fit	5. After fit	6. Output





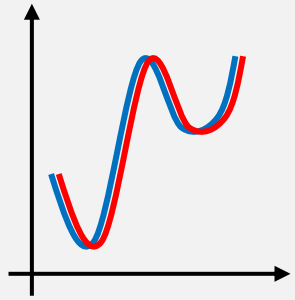
Assumption:

- **Thickness**
- **Optical constants**



Measured spectrum

Modeled spectrum



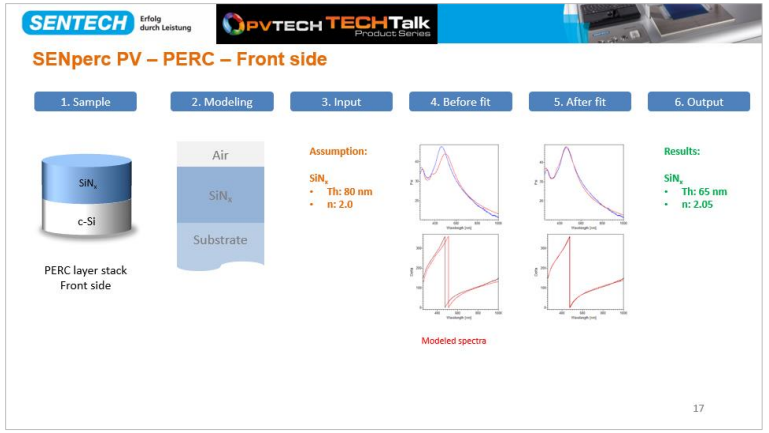
Results:

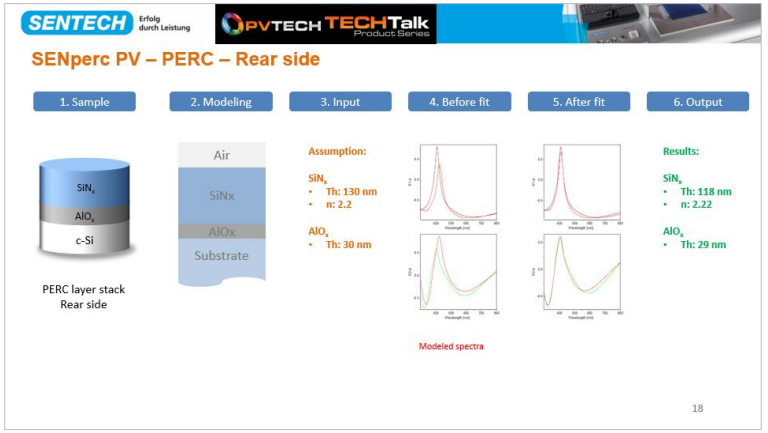
- **Thickness**
- **Optical constants**

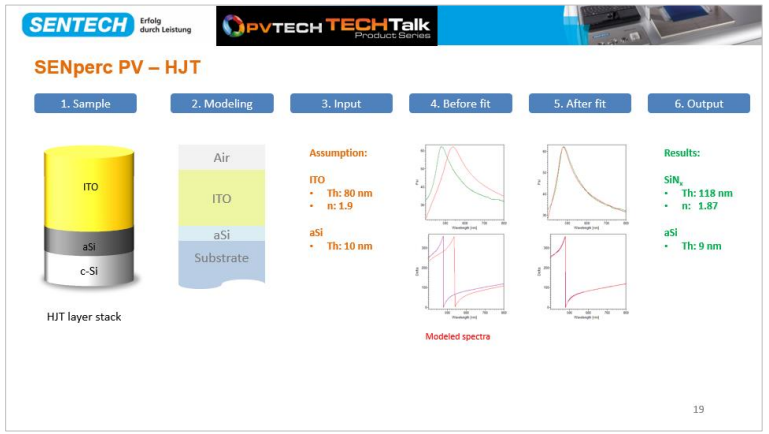
Fit procedure reduces deviation between mode an meas. by changing the model parameters

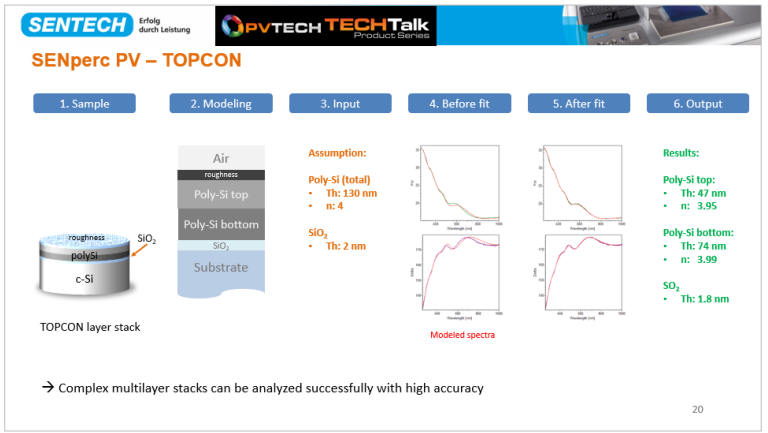
- Measurement yields a pair of optical spectra
- Optical modeling is used describing the thickness and optical constants of the solar cell films
- Fitting procedure matches measurement and model for extracting thickness and optical constants

SENperc PV – Application Examples …



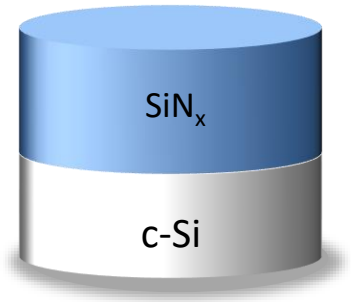




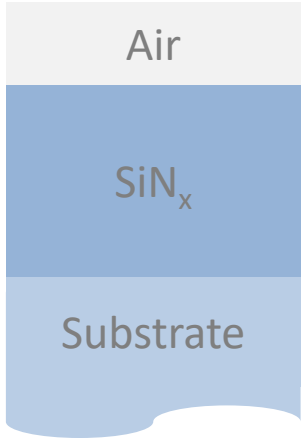


SENperc PV – PERC – Front side

1. Sample | 2. Modeling | 3. Input | 4. Before fit | 5. After fit | 6. Output

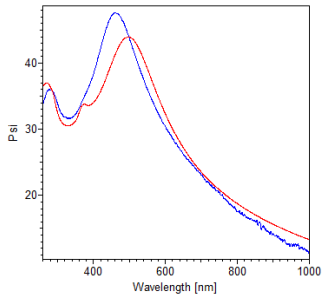


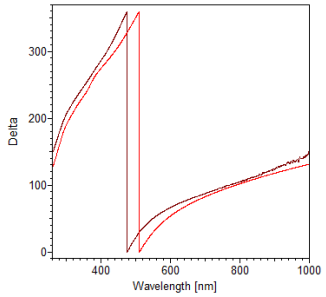
PERC layer stack
Front side



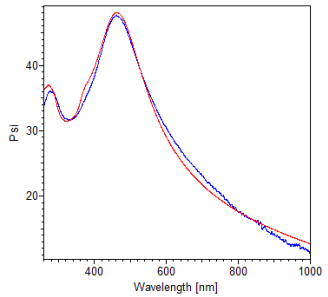
Assumption:

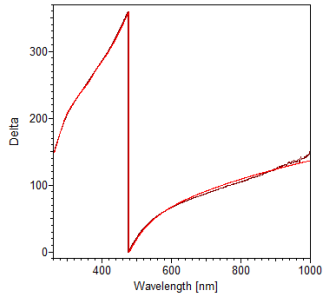
SiN_x
- **Th: 80 nm**
- **n: 2.0**





Modeled spectra



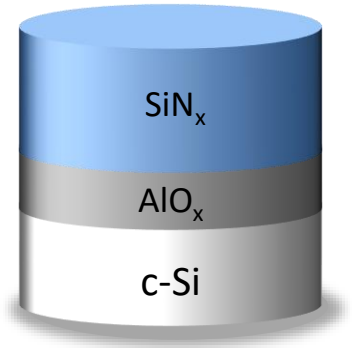


Results:

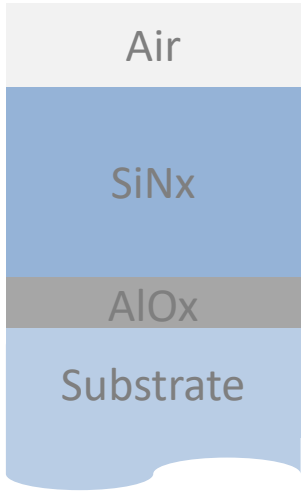
SiN_x
- **Th: 65 nm**
- **n: 2.05**

SENperc PV – PERC – Rear side

1. Sample | 2. Modeling | 3. Input | 4. Before fit | 5. After fit | 6. Output



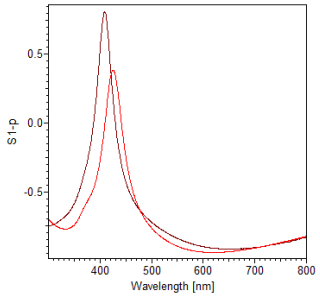
PERC layer stack
Rear side

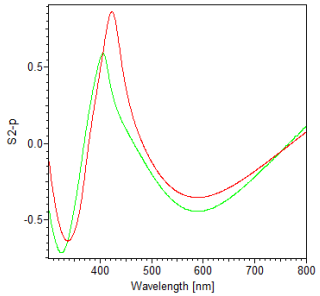


Assumption:

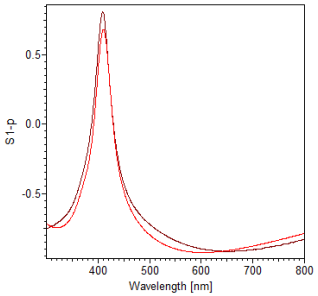
SiN_x
- **Th: 130 nm**
- **n: 2.2**

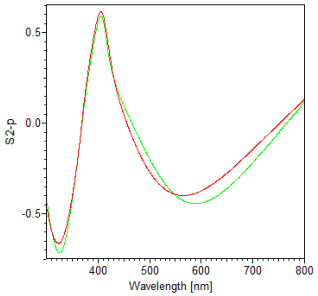
AlO_x
- **Th: 30 nm**





Modeled spectra





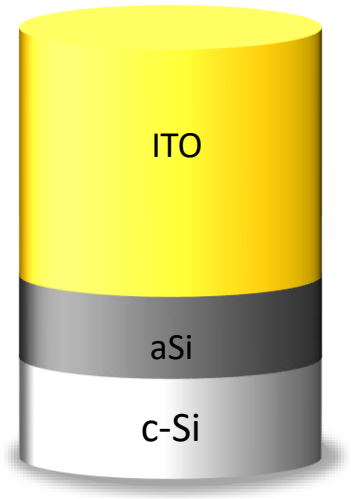
Results:

SiN_x
- **Th: 118 nm**
- **n: 2.22**

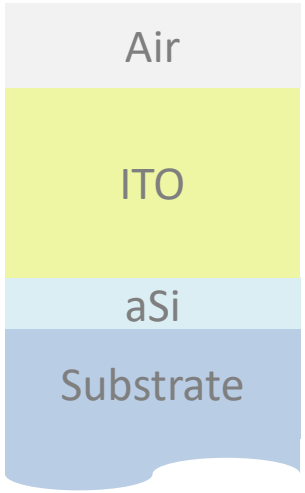
AlO_x
- **Th: 29 nm**

SENperc PV – HJT

1. Sample | 2. Modeling | 3. Input | 4. Before fit | 5. After fit | 6. Output



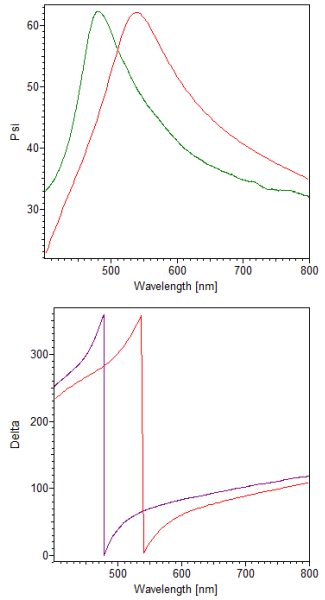
HJT layer stack



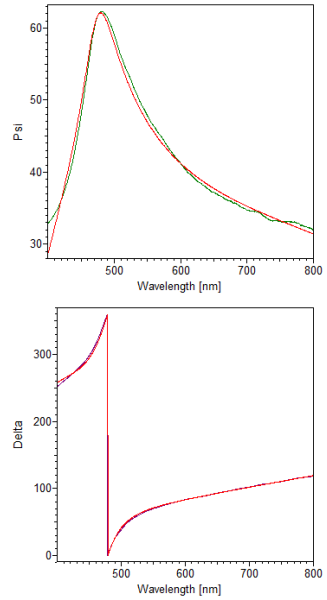
Assumption:

ITO
- **Th: 80 nm**
- **n: 1.9**

aSi
- **Th: 10 nm**



Modeled spectra



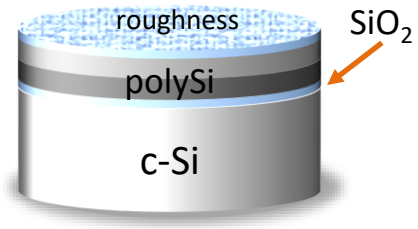
Results:

SiN_x
- **Th: 118 nm**
- **n: 1.87**

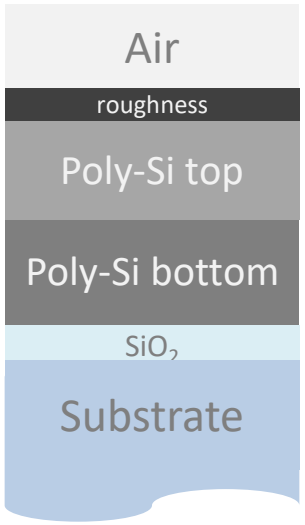
aSi
- **Th: 9 nm**

SENperc PV – TOPCON

1. Sample | 2. Modeling | 3. Input | 4. Before fit | 5. After fit | 6. Output



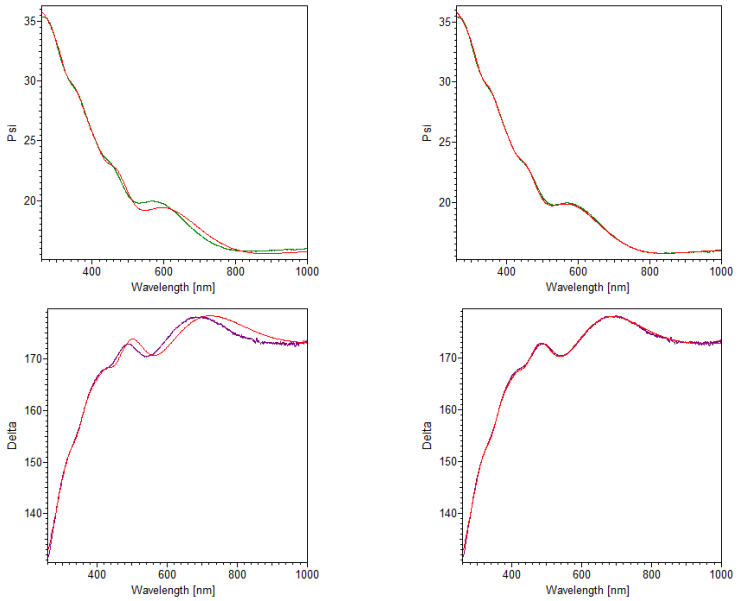
TOPCON layer stack



Assumption:

Poly-Si (total)
- **Th: 130 nm**
- **n: 4**

SiO_2
- **Th: 2 nm**



Modeled spectra

Results:

Poly-Si top:
- **Th: 47 nm**
- **n: 3.95**

Poly-Si bottom:
- **Th: 74 nm**
- **n: 3.99**

SO_2
- **Th: 1.8 nm**

→ Complex multilayer stacks can be analyzed successfully with high accuracy

Conclusion

- SENperc PV for fast and accurate solar cell quality control
- Solar cell self-alignment
- Recipe-oriented user interface
- Push button operation
- Integrated SQL database
- Various solar cell applications
- Future-proof for emerging cell designs