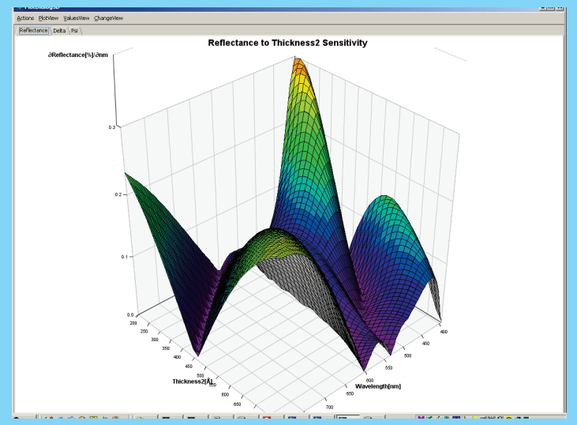
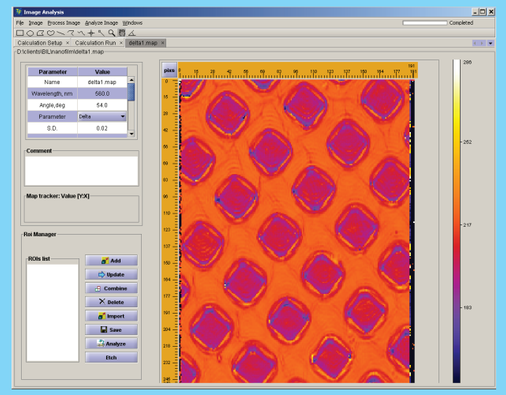
Optical thin-film measurements are indirect, they are measuring optical response (reflectivity, transmittance or ellipsometry parameters) - not the filmstack properties themselves. One needs to create an optical model of the filmstack structure and solve the “inverse“ problem in order to find the values of actual physical properties (like thicknesses of the layers and optical constants of the layer’ materials) of interest. This accomplished but finding the best fit of measured data to simulated result generated by floating selected filmstack parameters. The “measured” parameters are inferred from this best fit. Frequently, in order to get reliable results, it is important to check the validity of selected optical model, parameters correlation and sensitivity of the measured data to parameters of interest in the context of the specific instrument and measurement recipe.

TFCompanion simplifies these tasks and makes them transparent by combining analytical tools for interpretation of the measured data. Simulation and sensitivity analysis allows to test and optimize the measurement strategy e.g selection of spectral range, resolution, angle and/or measurement method. Error Estimator enables estimation of the measurement’ precision (short term repeatability) based on measurement recipe and the sample. Development of a reliable and comprehensive measurement strategy and, at the same time, mitigation the trade-offs between measurement accuracy and time/throughput can be accomplished using these tools quickly and easily.

In addition, TFCompanion provides many features that dramatically increase productivity and ease of use. For example, Global Search algorithm allows to use a single filmstack model for the full range of film thicknesses. This algorithm includes the “thick film algorithm“ based on PSD/FFT analysis and the thickness order search. “Multiple filmctacks“ algorithm allows to add several filmstacks to calculation recipe and use one model/recipe for a range of sample types. Batch processing enables unattended processing of a large number of measurement.

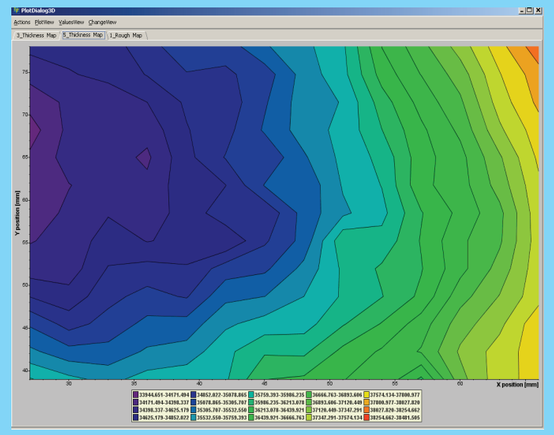
TFCompanion provides flexible configuration of features, capabilities and access levels. Software supports standalone and connected modes. In standalone mode the measured data can be imported and analyzed off-line. In connected mode, data can acquired directly from the spectrometer or send via TCP/IP (socket) interface (other integration mode are available). Administrator, Engineer and Operator User level provide different access privileges and features.

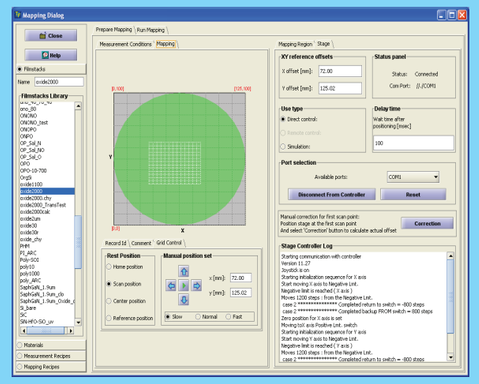


**Sensitivity Analysis**

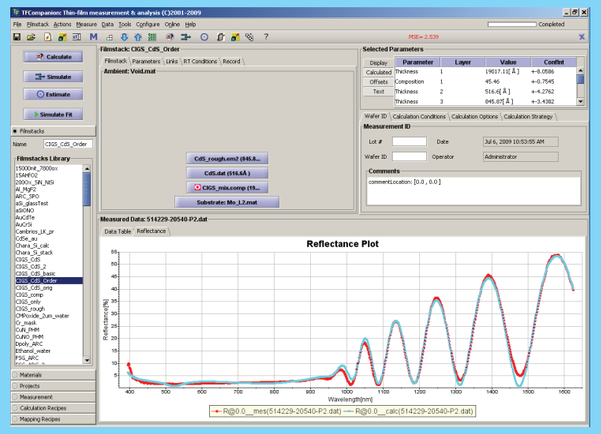
**Image Analysis**





**Thickness mappings results (200pts)**

**Mapping setup and analysis**




Data Analysis: fit of measured to generated data.

Filmstack parameters are inferred from the best fit.
Filmstack: 0.135 µm CdS/ 1.9µm CIGS.
Surface roughness: 85nm;
CIGS composition: ~ 45% Se

All 4 parameters are inferred from the best fit.

**Integration Options:**

1. Modbus compiant protocol (TCP/IP) - server mode
2 .Text command protocol (TCP/IP) - server and desktop mode
3. Direct integration with selected hardware (spectrometers, position sensors, stanges) using control and data acquisition module

| Feature | Standard Version | Advanced Version | Comment |
|---|---|---|---|
| Simulation: Simulation of optical response as a function of Wavelength, Angle and filmstack parameters | ✓ | ✓ | |
| Simulation: Sensitivity to wavelength, angle and any filmstack parameter | ✓ | ✓ | |
| Simulation : Simulation of finite wavelength and angle resolution | ✗ | ✓ | |
| Calculation: Modifies Marquardt-Levenberg (global) method | ✓ | ✓ | |
| Calculation: Thick film algorithm (PSD/FFT) | ✗ | ✓ | Typically for dielectic materials thickness>3um |
| Calculation: Multi-filmstack calculation strategy | ✗ | ✓ | One recipe for wide range of parameters variation |
| Surface roughness, scaling and offset correction | ✓ | ✓ | Determine optical roughness |
| Calculation: Backside reflection/Incoherent layer | ✗ | | Thick transparent substrate |
| Calculation: Inhomogeneous layer(optical properties profile) | ✗ | ✓ | |
| Calculation: Multi sample calculation | ✗ | ✓ | |
| Calculation: Batch calculation | ✗ | ✓ | |
| Calculation: Linked layers and materials | ✗ | ✓ | Repeated layers in heteroscrtuctures, etc. |
| Materials: Tabular (NK table) and selected parametrized materials: Cauchy(3 types), Sellmeier(2 types), EMA (2 ands 3 constituents) | ✓ | ✓ | |
| Materials: Parameterized materials (Lorentz, Drude-Lorentz,,Code-Lorentz,Tauc -Lorentz, Cody-Lorentz-Urbach,Exciton, Afromovitz,Classical oscillators, Binary compound) | ✗ | ✓ | |
| Materials: Extended materials Database | ✓ | ✓ | |
| Materials: Import/Export of the materials | ✓ | ✓ | |
| Materials: Tabular/Parameterized materials fit/ conversion | ✓ | ✓ | |

Semiconsoft, Inc, 2012
tel. +1.617.388.6832 email: info@semiconsoft.com
fax.+1.508.858.5473 http://www.semconsoft.com

# TFCompanion

***Software for Thin Film Analysis***

Supports Spectroscopic and Imaging Ellipsometry, Reflectance and Transmittance data analysis

Three main functions:

**Calculate**: Determine filmstack parameters based on measured data

**Simulate**: Measurement sensitivity to and optical response from filmstack

**Estimate**: Measurement precision/repeatability and optimize measure ment recipe

Flexible:

Data Imported from files, transferred over TCP/IP or directly acquired from spectrometer

Supports Windows, Linux and Mac OS

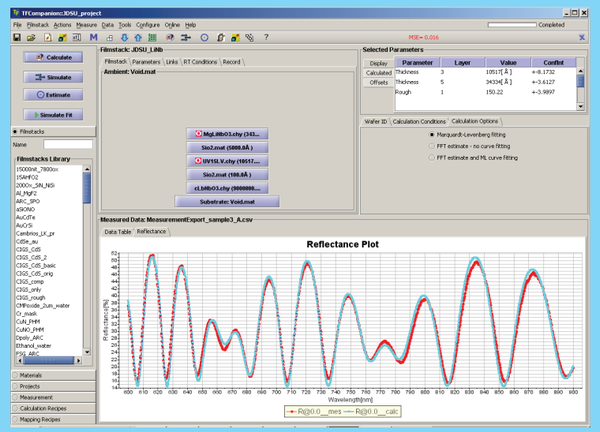
Desktop or server mode

Extensive materials library (500+ materials); new materials can be easily added or imported

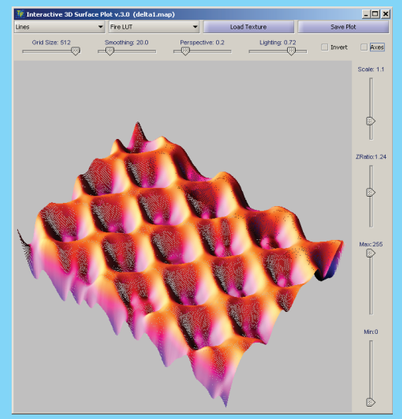
Wide range of parameterized material types to represent dispersion of dielectric, semiconductors, metals and compound materials: from Cauchy and EMA to Drude-Lorentz and Cody-Lorentz-Urbach

Advanced features that include Calculation Strategy, Global Search and Thick Film Algorithm enable the use of one recipe for wide range of filmstacks

"Preflight" Error Estimate check allows optimization of the measurement strategy. Parameters Correlation and Confidence Intervals information guides the data analysis optimization




LiNbO3 stack (5 layers)



10 x 10 um etched pattern in SiO2 (Imaging Ellipsometry)