SENTECH Instruments GmbH

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SE 800 E
UV-VIS SENresearch
Spectroscopic Ellipsometer

Spectral range: 240nm ... 1000nm

Product description

- **Very fast and precise ellipsometric analysis in a broad spectral range of 240 nm to 1000 nm**
- **STEP SCAN ANALYZER measuring mode combined with compensator and polarizer tracking for most accurate and complete sample analysis**
- **SpectraRay/3 - comprehensive software for spectroscopic ellipsometry including sophisticated multiple angle, multiple sample, and combined photometric data analysis, programmable customer interface and advanced reporting**
- **Easy operation for both, experts and beginners**
- **SENTECH material library and sample applications for efficient modeling**

SENTECH Erfolg durch Leistung

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1. General description

The UV/VIS spectroscopic ellipsometer **SE 800 E** measures thickness and optical parameters of bulk materials, single and multiple layers, interfaces and very thin films.
The **SE 800 E** is tailored for high demanding applications like the measurement of thin transparent films on glass, light emitting and semiconducting polymers, multiple layer stacks on absorbing and transparent substrates, AR coatings on window pane and advanced microelectronic applications like SOI, high-k and low-k materials. Anisotropic and non-uniform samples can be analyzed.

The **SE 800 E** is a high performance fast CCD array detector based spectroscopic ellipsometer in the UV/VIS/NIR range featuring both fast data acquisition and full spectral resolution.

The **SE 800 E** is based on the Step Scan Analyzer Principle. The reflected light is analyzed at fixed analyzer positions with an optical multichannel analyzer, consisting of a grating and a CCD array detector. The Step Scan Analyzer principle ensures an outstanding S/N ratio even for low light level applications

The **SE 800 E** ellipsometer setup actually contains two measurement setups: Polarizer – Sample – Analyzer (PSA) and Polarizer – Compensator – Sample – Analyzer (PCSA) assuring the measurement of the degree of polarization and to compensate for depolarization effects caused by non-uniform samples, rough surfaces, limited spectral resolution and focusing angle. Using a compensator the ellipsometric angle Δ can be measured in the whole range from 0 - 360 degrees with extreme accuracy and ultimate precision. Additionally the compensator is highly stabilized against changes of the environmental temperature to provide lowest drift and lowest measurement error even at Delta = 0 deg.

The **SE 800 E** data acquisition can be tuned for highest measurement accuracy for each individual application. The polarizer position is computer controlled and can be set to dedicated values according to the optical response of the sample (polarizer tracking).

Precise sample alignment is vital for highly accurate ellipsometric measurements. The **SE 800 E** features the Auto Collimating Telescope (ACT) for the tilt and an optical microscope for the focus of the sample.

The fast measurement of Ψ and Δ spectra makes the **SE 800 E** an ideal analytical tool for the determination of the optical and metrical constants of bulk material, single and multiple layers, layer stacks, interfaces, very thin and thick films.

Smooth operation of the instrument is guaranteed by SENTECH's controller concept. While the software runs on a state of the art PC under Windows 7 the complete hardware is separately controlled by its own embedded microcontroller.

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SENTECH's proprietary ellipsometer software **SpectraRay/3** comprises two modes of operation: recipe mode and interactive mode. The recipe mode allows for easy execution of repetitive applications. In interactive mode, ellipsometric measurements are enhanced by an interactive, guiding graphical user interface. The operation of **SpectraRay/3** is very intuitive and satisfies the demands for ease of use and multiple user operation.

SpectraRay/3 includes data acquisition, modeling, fitting, and extended reporting of ellipsometric, reflection, and transmission data. It supports variable angle, multi-experiment, and combined photometric measurements. **SpectraRay/3** contains a huge library of materials data based on SENTECH measurements and literature data as well. The large number of dispersion models allows modeling of nearly any type of material.
The scripting capability makes it very flexible to automate routine measurements, to tailor it for dedicated applications and to control third party hardware like sensors, heaters or a cryostat.

The **SE 800 E** comprises the mechanical setup with a manual goniometer for multiple angle measurements, the optical components, the optical fibers, an electronic rack, a desktop PC with Windows 7, and the SENTECH **SpectraRay/3** software. Light sources and detectors are coupled to the optical arms of the ellipsometer by optical fibers.

2. Technical specifications

2.1 General:

Spectral Range:	240 nm - 1000 nm UV-VIS-NIR
Max. sample size:	6”, optional 8” and 300 mm
	Maximum substrate thickness 7 mm
	Larger and /or thicker samples on request
Substrate:	Opaque or transparent
Layers:	Software allows for an unlimited number of layers to be analyzed
	The practical number of layers that can be measured depends on the sample. More than five layers is possible for almost all samples

2.2 Optical and mechanical components:

Ellipsometer operation	**Combined PSA and PCSA setup:**
principle:	P: polarizer

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	C: compensator
	S: sample
	A: Step Scan Analyzer
Light source:	Deuterium Tungsten-Halogen combined lamp Lifetime: More than 1000 hours
Polarizer / Analyzer:	UV Glan Thompson prism
	Computer controlled Analyzer and Polarizer
	Extinction rate: 10^{-5}
	Angular precision: better than 0.01°
	SENTECH uses Step Scan Analyzer mode which results in an effective angular precision of better than 0.01°
Compensator	Highly stabilized
	The use of compensators enables the user to measure the ellipsometric angle Δ in the whole range from 0° to 360° with extreme precision.
Measurement spot:	Manually variable beam diameter from 4 mm to 1 mm
	Optional: micro spot 200 µm, Smaller spot size on request
Spectral discrimination:	For the UV/VIS region the detection is based on the Step Scan Analyzer (SSA) principle where no parts are moving during a measurement and fast CCD detection: The reflected light is analyzed at discrete analyzer positions with an optical multichannel analyzer, consisting of a grating and high performance CCD array detector.
Spectral resolution:	4 nm FWHM at 100 µm slit width
Sample stage:	Fixed sample stage with 150 mm sample platform, height- and tilt adjustable,
	Optional: mapping stages: • 50 mm x 50 mm, manual or motorized, • 150 mm x 150 mm motorized, • 200 mm x 200 mm motorized, • 300 mm (r, theta)-stage • Other stages on request,
	Vacuum chuck

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Sample holder for T measurements	Fast exchange with standard sample stage via quick lock 90deg measurement position of ellipsometer arms, sample is clamped to holder Minimal sample size 10 mm Other configurations on request
Goniometer:	Mechanical Goniometer variable from 40° to 90°, set in 5° steps, accuracy better than 0.02 ° Optional: Computer controlled goniometer, incident angle range from 40° to 90°, min. step width 0.002°,accuracy better than 0.01°, Extended angle range from 20° - 90°
Sample alignment:	Auto Collimating Telescope and optical microscope for sample alignment (focus and tilt) Optional: • Video camera to show the measuring area and the alignment procedure at the computer monitor
Measurement time:	Typical time for full ψ / Δ spectra of a sample is less than 10 seconds
Controller:	Modular unit with bench top ellipsometer optics and goniometer. Separate rack contains light source, ellipsometer controller with electronic boards and microcontroller unit , spectrophotometer
Computer:	State of the art HP desktop PC, monitor, keyboard, mouse, Windows 7 Operating system
Output device:	Inkjet printer compatible Software interface to export and import spectroscopic data. optional Network card
Power requirements	Rated voltage 115/230 VAC, auto select (100-132 VAC or 207-264 VAC) Rated frequency 50-60 Hz Rated Power 350 W

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Environment:	Cleanroom (Class 100) compatible

3. Data acquisition and analysis software: SpectraRay/3

Features:

SpectraRay/3 operating and analysis software comprises

- Interactive and recipe mode of operation
- Automated system Calibration
- Automatic setting up of optical and mechanical components
- Easy and guided software operation including data acquisition, modeling, fitting and reporting
- Complete experiments can be saved as recipes
- Recipe mode for routine applications
- Mapping module for computer controlled samples stages (description see also mapping options)
- Advanced reporting of measured and fitted spectra, measurement data, user comments, sample information in a Word-like environment

Measurement output:

- Ellipsometric angles ψ; Δ, Fourier coefficients s_1, s_2 vs. energy, wavelength or wavenumber (related to sample position, angle of incidence) of single or multiple angle or time dependent measurements
- Mueller matrix elements
- Polarized reflectivity R_p, R_s and transmission
- Dispersion relation
- Dielectric function
- Degree of polarization
- Graphic representations of measured and calculated ellipsometric spectra
- Data clipping to selected wavelengths and angles without changing original data
- Merge function for combining sets of different wavelength ranges
- Combine function for combining sets of different data in one file
- Reduction of data as modulo or average
- Extract angle traces from multiple angle and time dependent data

Modelling, simulation and fit:

SpectraRay/3 is able to fit any multilayer structure (single film, layer stack, periodical groups of stacks) for ψ, Δ; tan ψ, cos Δ and Fourier coefficients, transmission, reflection etc. This includes anisotropic

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substrates and layers (separate software license).

- Large material library (more than 200 data sets), user expandable and application adaptable
- Large set of dispersion relations to describe the optical properties of layers and bulk materials: data file (data table), 2D table, Cauchy, Sellmeier, Schott, Drude-Lorentz, Lorentz, Urbach, Leng, Tauc-Lorentz, Cody-Lorentz, Brendel, Hamberg, Sernelius, Forouhi-Bloomer, Afromovitz, Tanguy, spectral combination layer for combining different dielectric models, user defined dispersion formula, dispersion formula for uniaxial and biaxial anisotropic materials, dispersion formula for periodic layer stacks
- Each layer of a model stack can be a homogeneous film, an interface, a surface roughness, a homogeneous growing layer, an index gradient (effective medium approximations: Maxwell-Garnett, Bruggemann, Lorentz-Lorenz, Clausius-Mossotti)
- Material gradients can be modeled by one of the following type of functions: linear, exponential, error function like, Gaussian (symmetrical or asymmetrical) like, parabola like.
- Fast regression algorithms for fitting calculated spectra to measured spectra
- Graphical representation of fitted spectra

Fit of composite data:	The fit algorithm does not only allow fitting of ellipsometric data but also transmission and reflection spectra as well. The fit can be based on multiple measurements (Ψ,Δ, R, T) and different samples with same layer material. External data of other instruments can be imported as ASCII data and analysed / fitted
Fit parameters:	Customer defined, depending on the model. There is no fundamental limit for the number of fit parameters or layers in a layer stack. Fit parameters could be e.g.: film thickness, refractive index, extinction coefficient, constituent fractions, incident angle, composition profile, temperature, and time.
Fit statistics:	Fit error and correlation matrix are calculated. Device -, wavelength - and sample alignment errors can be taken into account.
File management functions:	The software is based on Windows 7 and provides full file management functions.
User management:	The software provides full user level management and allows user

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	specific assignment of rights on a function level basis.
Recipe module:	Push button operation of routine applications (recipes), A recipe includes the hardware settings, measurement conditions, model and measured data. A set of standard recipes is delivered with the software. New recipes can be built up by adapting already existing recipes or importing corresponding data from the interactive operation part of **SpectraRay/3** after a new ellipsometric application was solved. A measurement can be directly started after loading a new recipe. All settings can be optimized / set by the user (password based user management available). The measured results (measured and fitted spectra, fit parameters) are shown in the operation window of the module. Recipes can be used in mapping applications as well if computer controlled mapping is available
Customized user interface:	**SpectraRay/3** includes a software package to develop user defined measuring and operation routines based on an easy to use script language.

4. Optional items

SE 802	Computer controlled goniometer, precision 0.01°
SE 800-3	Micro spot option, 200 µm spot diameter in the UV/VIS, 100 µm spot on request
SE 800 NIR-FTIR	Spectral extension into NIR, up to 2500 nm For the NIR a Fourier Transform Infrared (FTIR) Spectrometer is used. Applying FTIR ellipsometry adds speed, high resolution and a high signal to noise ratio. It provides automatic wavelength calibration as well. Spectral resolution: 1 cm^{-1} up to 64 cm^{-1} (0.06 ... 2 nm @800 nm; 0.5 nm ... 18 nm @ 2500 nm)
SE 800 NIR Z	Spectral extension into NIR, up to 1700 nm InGaAs diode array detector Spectral resolution 6 nm at 50 µm slit width
SE 61	Video camera for alignment in lieu of eyepiece, frame grabber, microscopic image
SE PXY	Manual x-y stage with 50 mm travel
SE PSV	Vacuum chuck in lieu of standard sample stage

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SE PSD	Rotational element with quick lock in lieu of standard sample stage
SE 800-PST	Sample holder with quick lock for transmission measurements
SE 14	Mapping stage, x = 50 mm, y = 50 mm sample stage (including vacuum chuck), 150 mm sample platform extensive mapping software to define scan raster and to display scans in various ways
SE 15	Mapping stage, x = 150 mm, y = 150 mm sample stage (including vacuum chuck), 150 mm sample platform extensive mapping software to define scan raster and to display scans in various ways Resolution: 4 µm step width
SE 16	Mapping stage, x = 200 mm, y = 200 mm sample stage (including vacuum chuck), 200 mm sample platform extensive mapping software to define scan raster and to display scans in various ways
SE 17	Mapping stage, r,ϑ-stage for 300 mm wafers, 150 mm travel length (including vacuum chuck), 300 mm sample platform extensive mapping software to define scan raster and to display scans in various ways
SE AF	Autofocus option in combination with SE 800 mapping option
SE AFT	Auto height and tilt adjustment
SE 800-30	Reflectometer based on FTPadv, spectral range 450-920 nm, 80 µm spot size
SE 20	Liquid cell for in situ measurements, Teflon, one pair of windows liquid at rest
SE CFH26	Liquid cell 26 ml volume heated up to 70°C, incidence angles 50°, 60°, 70°, fluid flow, Cells with other parameters on request
SE K20	SENTECH thin film test wafer, nominal 20 nm SiO2 on Si
SE K100	SENTECH thin film test wafer, nominal 100 nm SiO2 on Si
SE K400	SENTECH thin film test wafer, nominal 400 nm SiO2 on Si
SE 51	Second SpectraRay license for work station
SE 5A	SpectraRay/3 license for anisotropic sample analysis