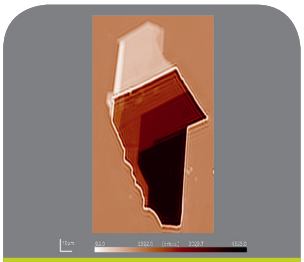
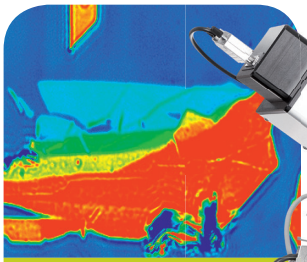
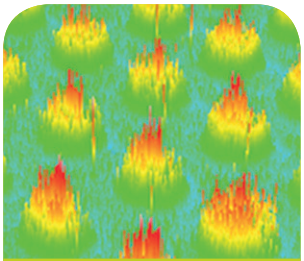
ACCURION
solutions for science

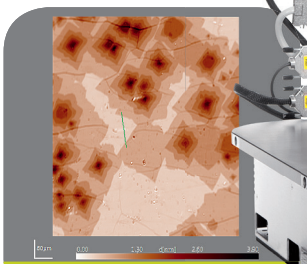
nanofilm_ep4

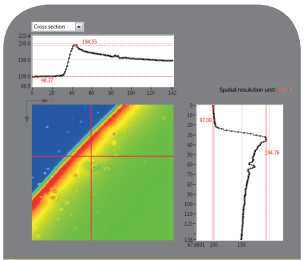
MICROSCOPIC THIN FILM METROLOGY AND VISUALIZATION

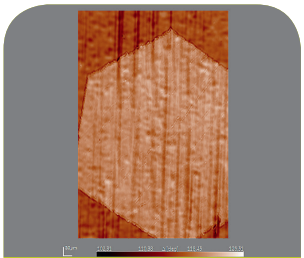

Hex. Boron Nitride on SiO_2

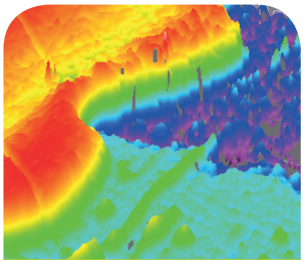

MoS_2 on Sapphire

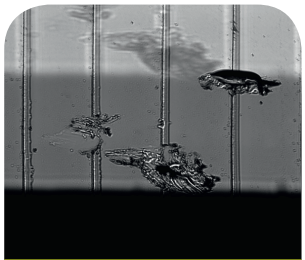

Protein Spots on Glass

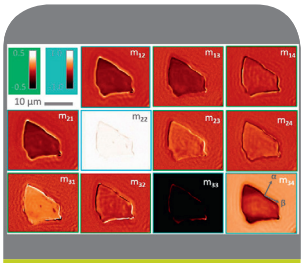

Graphene on SiO_2 (300 nm) | Si

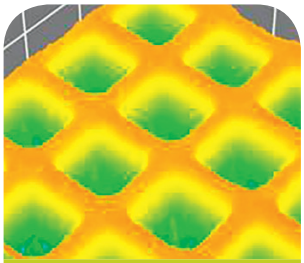

PCBM on SiO_2

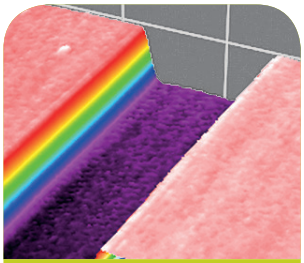

Graphene on Copper


Solar cell on PET


Transparent substrate


Black Phosphorus


SAM pattern


PMMA film on Si-Wafer


Monolayer

THE MICROSCOPIC WAY OF DOING ELLIPSOMETRY

nanofilm_ep4

Supported by:

Federal Ministry of Economics and Technology

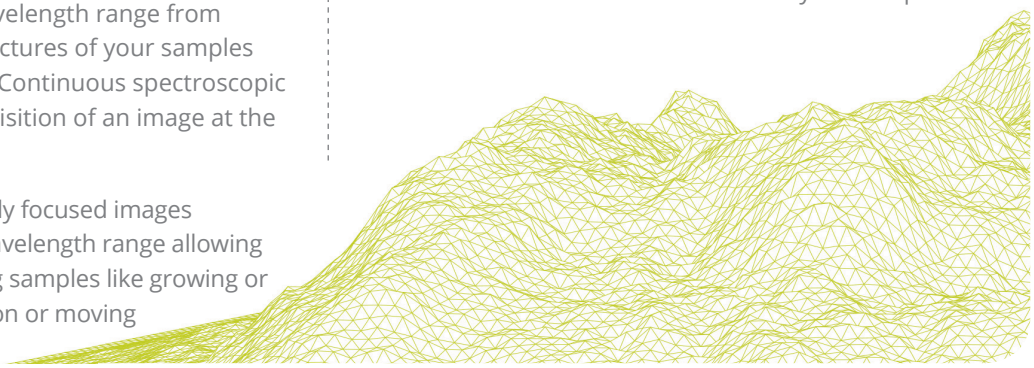
on the basis of a decision by the German Bundestag

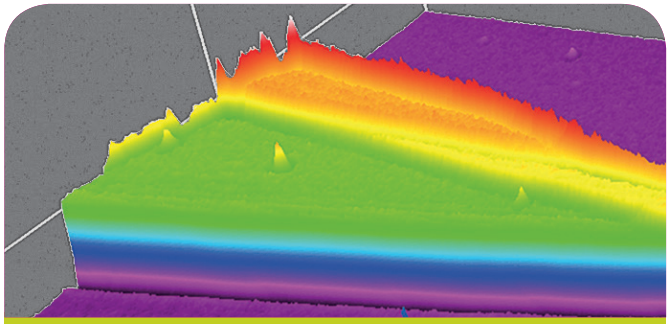
This new microscopic thin film, surface and materials metrology tool generation uses a combination of auto nulling ellipsometry and microscopy to enable surface characterization with a lateral ellipsometric resolution down to 1 micron.

The nanofilm_ep4 offers a variety of unique features that allow the visualization of your surface in real time. You will see in real time the structure of your sample on a microscopic scale. You can measure parameters like thickness, refractive index and absorption. You can receive maps of selected areas. You can combine the instrument with other technologies like AFM, QCM-D, reflectometry, Raman spectroscopy and many more to receive even more information from your samples. The nanofilm_ep4 is a modular instrument enabling configuration for your specific measurement tasks. The nanofilm_ep4, equipped with the standard laser can also be operated as a Brewster angle microscope, typically in LB applications

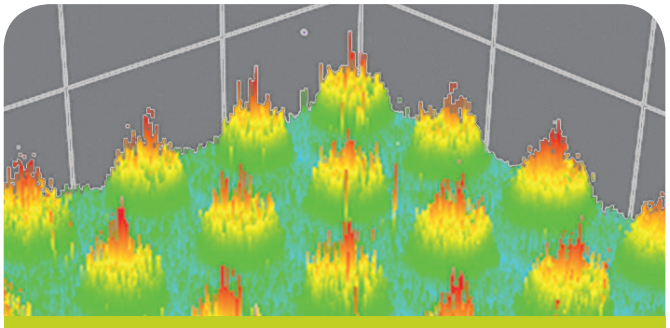
UNIQUE FEATURES:

- Ellipsometry with the highest lateral ellipsometric resolution available on the market: Objects down to 1 micron can be resolved. This feature allows the investigation of structured samples or tiny substrates.
- Real time ellipsometric contrast images providing a fast view of the surface, any defects or structures.
- Patented region of interest (ROI) concept allows the parallel investigation of multiple areas within the selected field of view.
- Imaging ellipsometry in the wavelength range from 250 nm to 1700 nm provides pictures of your samples over a wide wavelength range. Continuous spectroscopic measurements allows the acquisition of an image at the selected wavelength.
- Optional single shot full field fully focused images (UltraObjektive) in the visible wavelength range allowing the easy investigation of moving samples like growing or moving SAM's, protein interaction or moving monolayers on water surfaces.
- Knife edge illumination allows measurements on thin transparent substrates to avoid background reflection.
- An interesting range of accessories enable the instrument to work in a large variety of applications (SPR or solid/liquid cells, light guides for liquid/liquid interfaces, micro-fluidic, temperature control, electrochemistry cells, and many more).
- The technology integration platform allows the adaption of various alternative measurement technologies to receive even more information from your sample.



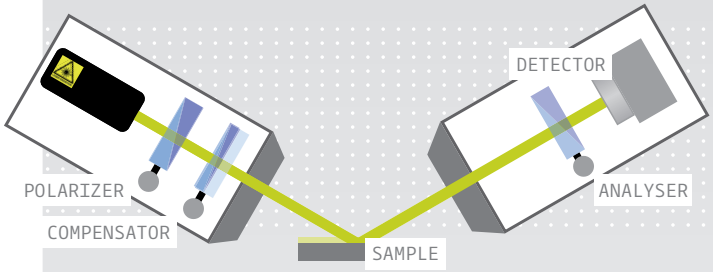


Materials research example: graphene layer



Bio application example: protein spots on glass

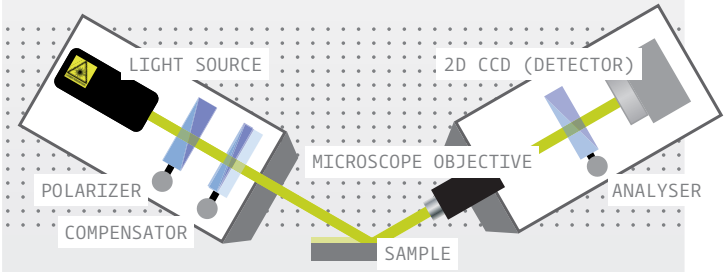
WHY USE ELLIPSOMETRY?



Ellipsometry analyzes the change of polarization of light reflected from a sample and yields information about thin film layers that are often even thinner than the wavelength of the probing light itself.

The change of amplitude and phase of the p and s components of the light after the reflection from the sample are depending on film properties like thickness, refractive index and absorption. Ellipsometry measures the change of the amplitudes and phases of s- and p-polarized light by rotating polarization components. The measured values are psi and delta. These values need to be put into a computer based model of the sample materials to calculate the thickness, refractive index, absorption and a variety of sample properties, including morphology, crystal quality, chemical composition or electrical conductivity. Ellipsometry is an established technology to measure multilayer film thickness, refractive index and absorption.

WHY USE IMAGING ELLIPSOMETRY?



Imaging ellipsometry combines microscopy and auto nulling ellipsometry. The microscopy aspect allows the direct visualization of your sample with an ellipsometric contrast image with a lateral resolution as small as 1 micron as well as the measurement of the ellipsometric parameters Delta and Psi with the highest lateral ellipsometric resolution also down to 1 micron.

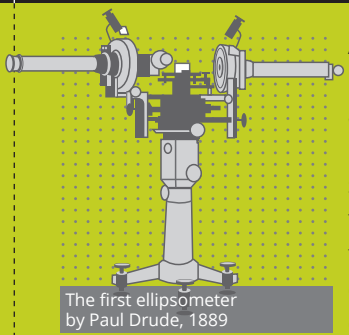
This enables resolving sample areas 1,000 times smaller than most micro spot equipped non-imaging spectroscopic ellipsometers. Imaging ellipsometry permits characterization of local sample parameter variation on a microscopic scale. This technology can measure the same ex-situ applications as non-imaging ellipsometers and many more. It is dedicated to applications where you have lateral structures in the range of 50 mm down to 1 micron. This includes patterned samples or where you have tiny samples like tips of a cantilever.

COMPARISON NON-IMAGING AND IMAGING ELLIPSOMETERS:

The lateral ellipsometric resolution of non-imaging ellipsometers is determined by the spot size of the light source at the sample surface. Non-imaging ellipsometers reflected light from the spot guided through the analyzing system to the detection system. Spot sizes are in the range 2 mm to 35 µm. All sample structures smaller than the spot size cannot be accurately detected. The instrument will average over all structures within the sampled spot. This can provide incorrect results if your sample is not completely homogeneous.

The enhanced lateral ellipsometric resolution of Imaging ellipsometry is a result of the combination of a high numerical aperture objective that images about a million sites on the illuminated sample area onto a high resolution 2 dimensional pixel detector array. This provides a resolution as small as 1 micron, depending on the wavelength of the illumination light.

COMPARISON NON-IMAGING AND MAPPING ELLIPSOMETERS:

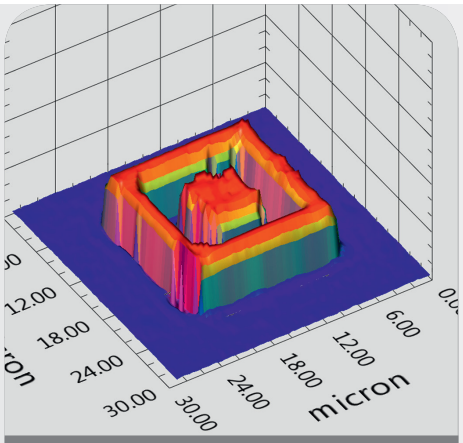


The first ellipsometer by Paul Drude, 1889

A mapping ellipsometer is a non-imaging ellipsometer with a motorized stage. Psi and delta readings are measured at one spot and then the table is moved to another sample location and the process is repeated until enough data is collected to construct a map of the sample.
The lateral resolution is determined by the spot size and the density of the sample grid. In addition to poor lateral resolution sampling time is directly related to the number of sample sites.
By contrast an imaging ellipsometer can take as many as one million readings in one short exposure with vastly better lateral resolution. The images obtained are maps of Delta and Psi. Compared to a mapping ellipsometer, maps are recorded with much higher lateral ellipsometric resolution. The acquisition time for a map can be much shorter in imaging ellipsometry.

THE HIGHEST LATERAL ELLIPSOMETRIC RESOLUTION

The combination of microscopy and auto nulling ellipsometry allows a lateral ellipsometric resolution as small as 1 micron.



Air | SiO_2 | Si
Thickness map

NEW FEATURE

IMAGING ELLIPSOMETRY IN THE WAVELENGTH RANGE OF 250 TO 1700 NM

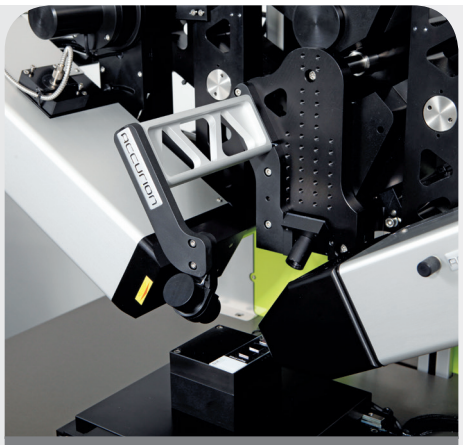
With the use of a grating monochromator now continuous spectroscopic measurements are possible.

EP4 equipped with a UV and NIR camera

NEW FEATURE

TECHNOLOGY INTEGRATION PLATFORM

Implementation of complementary technologies e.g. Raman, AFM etc. provide even more information on your sample

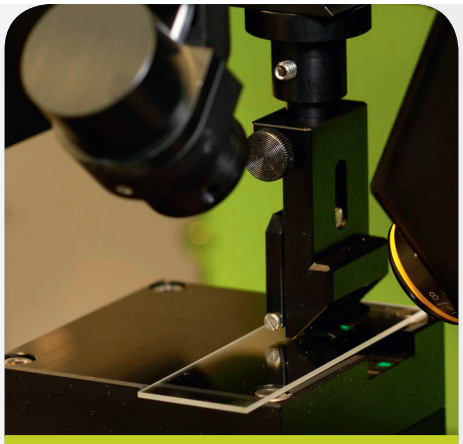


The new adaption platform

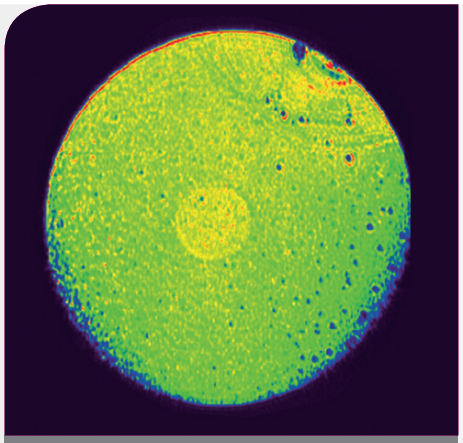
NEW FEATURE

VARIOUS UNIQUE FEATURES

A variety of further new features and accessories enabling ellipsometry for new applications.

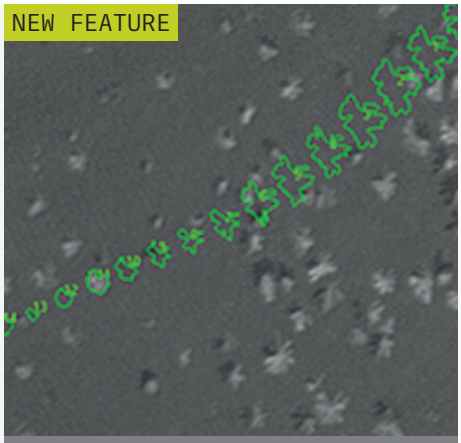


EP4 beam cutter – a nondestructive way to eliminate backside reflection



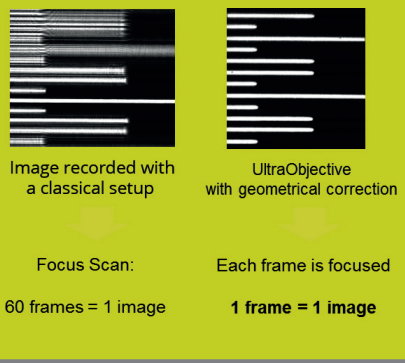
Air | As_2S_3 (fiber, core/clad)
Ellipsometric contrast micrograph

NEW FEATURE

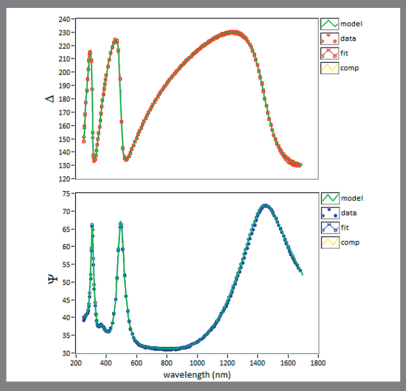


In detail: region of interest with variable shape

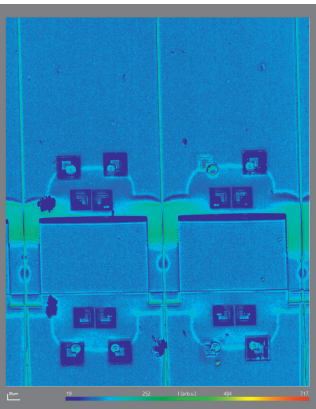
NEW FEATURE



The optional ultraobjective provides
overall focused images in real time

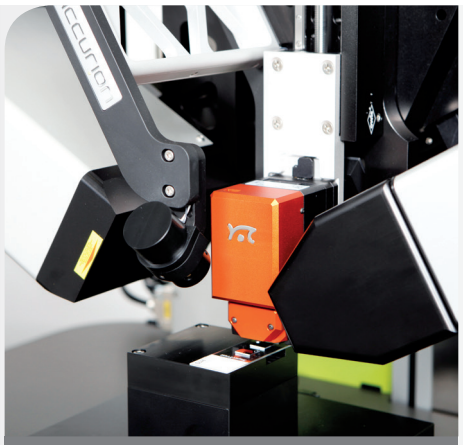


Air | Graphene | SiO_2 (300 nm) | Si
Wavelength Spectra of Delta and Psi



Air | Protein | cantilevers
Ellipsometric contrast micrograph
Lambda = 280 nm

Air | Protein | cantilevers
Ellipsometric contrast micrograph
Lambda = 1400 nm; (Si is transparent)



Integration of the Nanosurf NaniteAFM

Integration of a Micro Raman System (Horiba)

PLEASE
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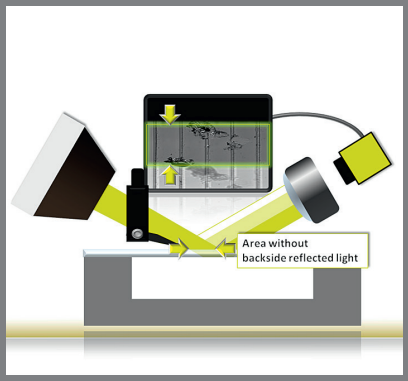
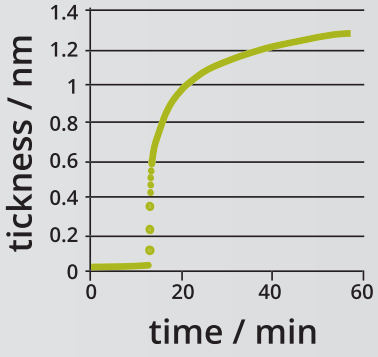
FOR YOUR
INTEGRATION
IDEAS!



Knife edge illumination allows the investigation
of thin transparent substrates

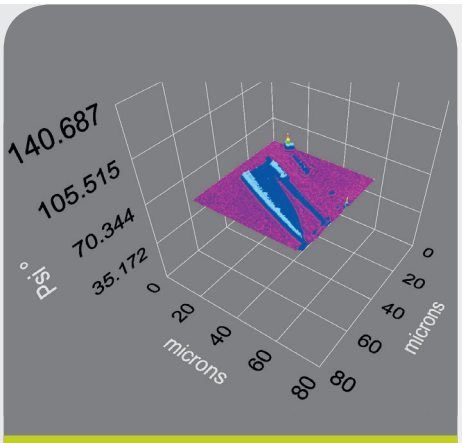
Toluene | Cetylpyridiniumbromid | water
Light guides enable measurements at the
liquid/liquid interface



Buffer | BSA | gold
Time dependent SPR measurements

GRAPHENE, 2D-MATERIALS

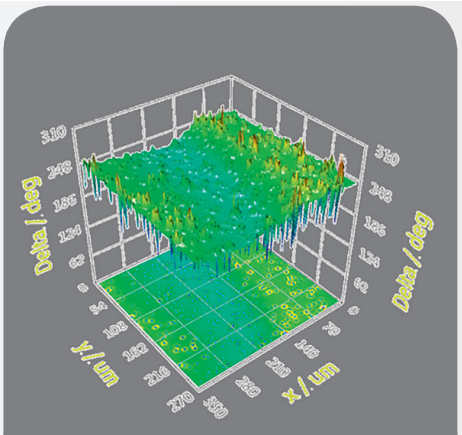
Imaging ellipsometry allows the direct visualization of your 2D-material flakes on various substrates/materials. It is possible to measure thickness and optical properties of different 2D-material layers in the micrometer scale.



Graphene | SiO_2 | Si
3D Psi map, lambda = 295 nm

SOLAR CELLS

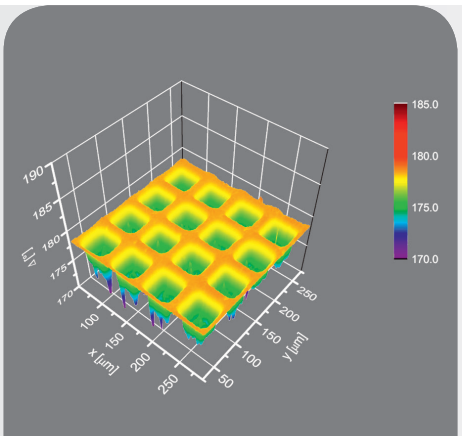
We visualize expected and unexpected structures or non-uniformities of your material on a microscopic scale. It is possible to measure thickness, optical properties and determine band gap energies as function of location on the sample. Knife edge illumination allows the investigation of organic solar cells on transparent foils like PET foils.



Air | Organic layer + ZnO nanoparticles | glass
3D Delta map

SELF-ASSEMBLED MONOLAYER (SAM)

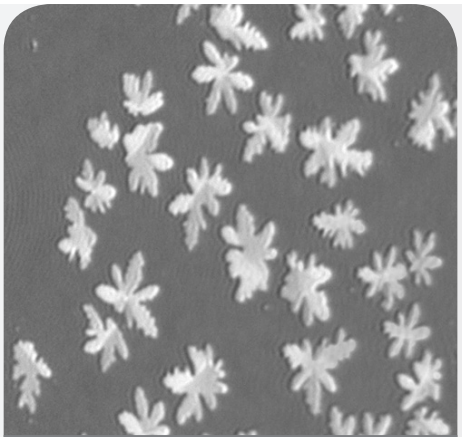
Imaging ellipsometry allows the real time visualization of lateral patterned SAMs of molecules with different chain lengths, head groups or different packing densities. You can measure the thickness of different areas of your SAMs in parallel. Thickness differences of only 0.2 nm on different positions on your pattern can easily be detected.



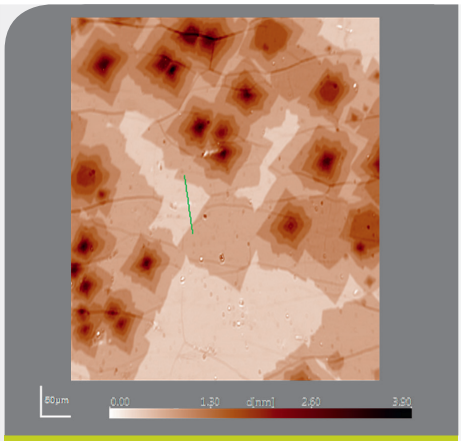
Air | SAM pattern (OTS) | SiO_2 (native) | Si
3D Delta map

MONOLAYER

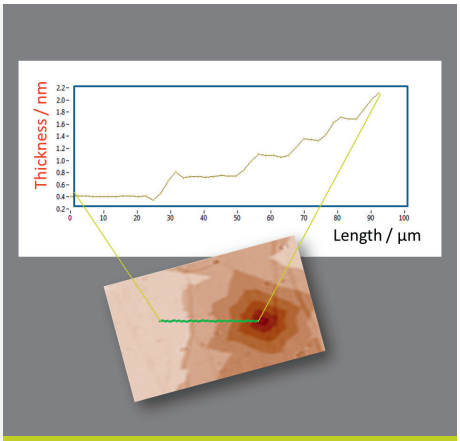
Using the unique ultraobjective allows the investigation of floating monolayers or any kind of moving or growing film with an overall focused real time image. You can see anisotropy of domain texture and structure as well as you can determine the thickness of the monolayers in the nanometer scale. The following images are showing monopalmitoyl-rac-glycerol at the air-water interface, compression speed = 180 $Å^2$/min · molecule.



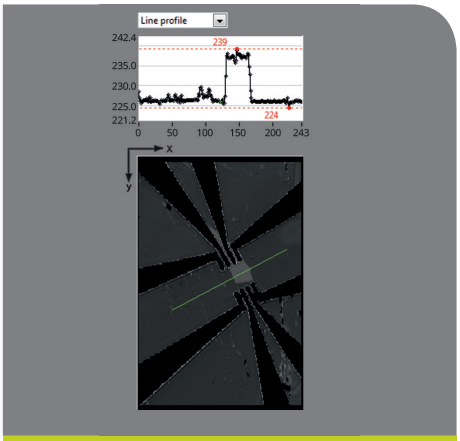
Air | Monopalmitoyl-rac-glycerol | water
BAM image (180 $Å^2$/min · molecule)



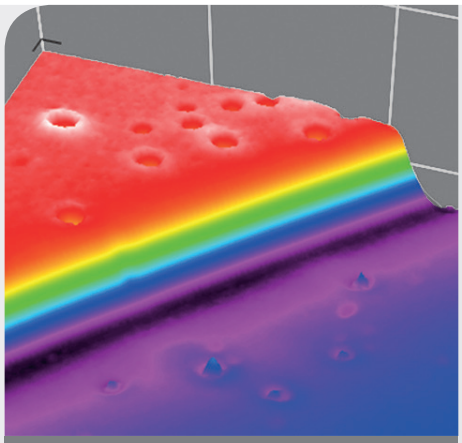
Air | Graphene | SiO_2 (300 nm) | Si
Thickness map (Graphene)



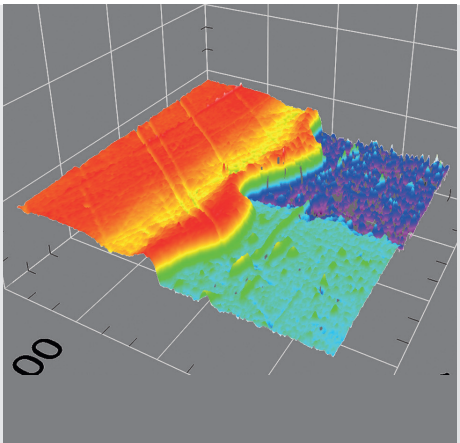
Air | Graphene | SiO_2 (300 nm) | Si
Thickness profile Graphene



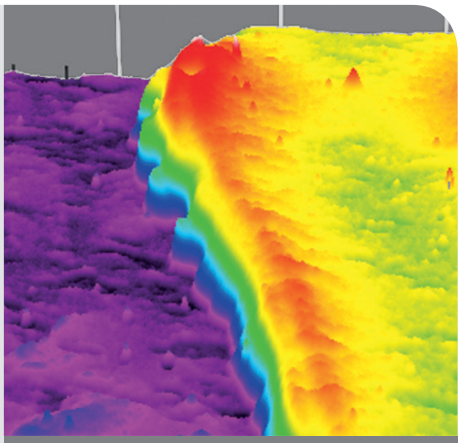
Air | Graphene | SiO_2 (300 nm) | Si
Delta map with responding Profile



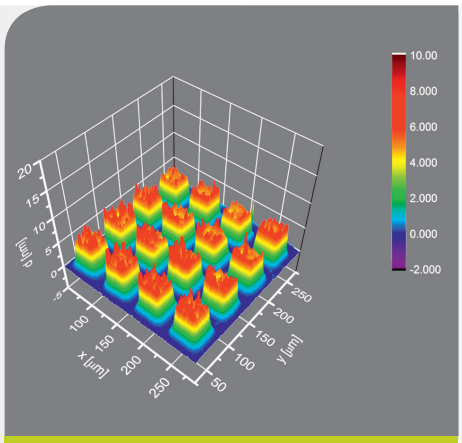
Air | PCBM (spincoated) | Si
3D Delta map



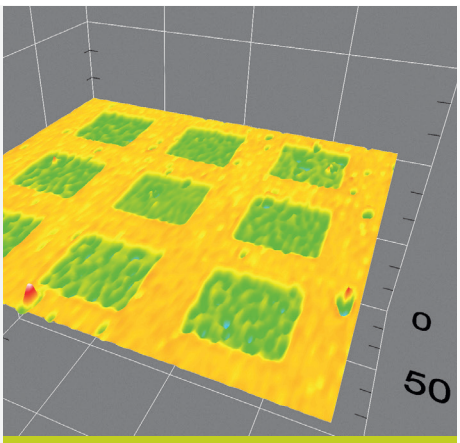
Air | Photoactive layer | PET foil
3D Psi map (with knife edge illumination)



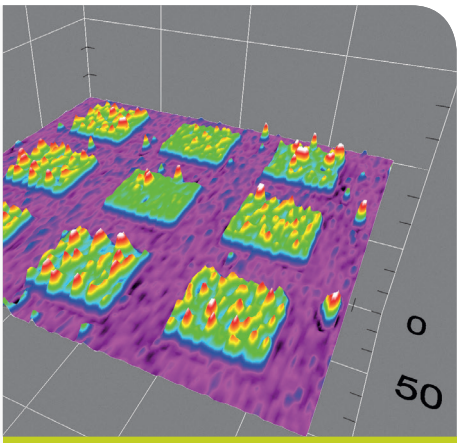
Air | PEDOT| ITO | PET foil
3D thickness map



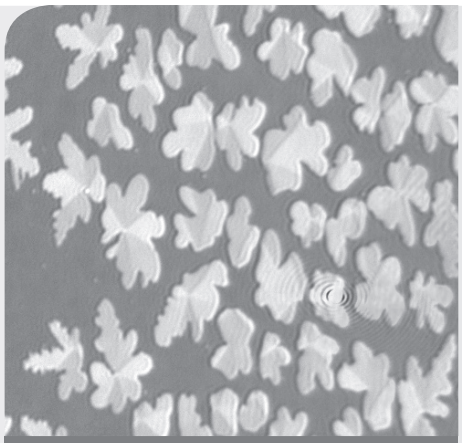
SAM pattern (OTS) | SiO_2 (native) | Si
3D thickness map



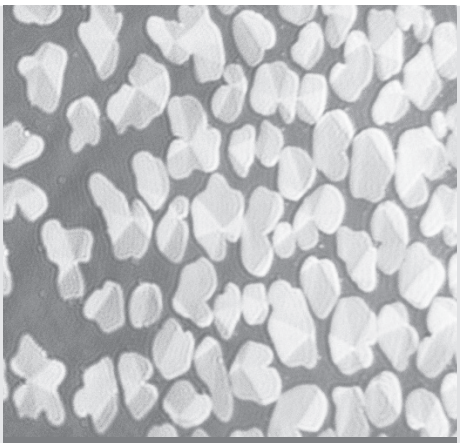
SAM pattern (Hexadecanthiol+PEG-SH) | gold
3D Delta map



SAM pattern (Hexadecanthiol+PEG-SH) | gold
3D thickness map



SP (Surface pressure) = 4.2 mN/m
A (Mean molecular area) = 37.23 Å²



SP = 4.4 mN/m
A = 36.8 Å²

SP = 4.4 mN/m
A = 36.9 Å²

PROTEIN INTERACTION

Imaging ellipsometry can perform kinetic measurements of protein binding. All proteins within the field of view can be measured in parallel.

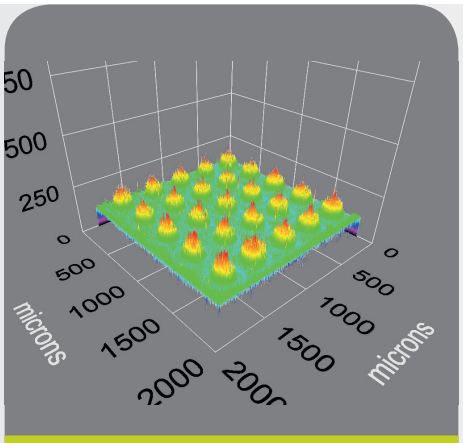
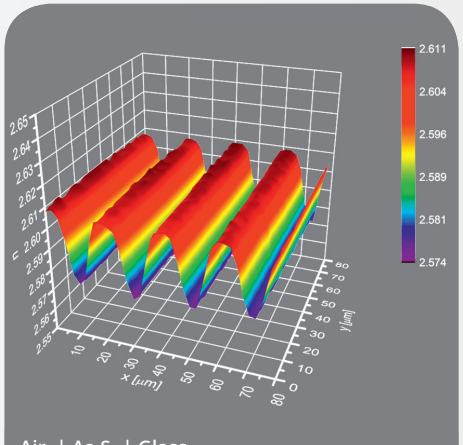


Image scan of protein spots on glass

VARIOUS FURTHER APPLICATIONS

A wide selection of samples with structures can be visualized and measured with the unique technique of imaging ellipsometry. If you do not find your application in this overview, feel free to contact the Accurion team for specific information.

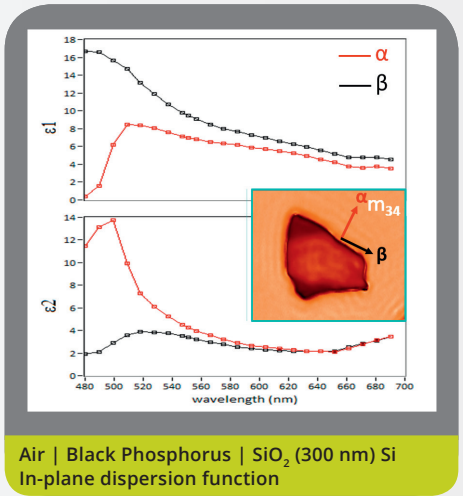


Air | As_2S_3 | Glass
Refractive index map at 658 nm

ANISOTROPIC THIN-FILMS

The ep4 Mueller-Matrix upgrade offers quantitative characterization of anisotropic thin films and substrates:

- refractive index and absorption for uniaxial or biaxial linear anisotropic materials
- orientation of the optical axes, both in-plane and out of plane
- micrographs of normalized 3x4-Mueller Matrix

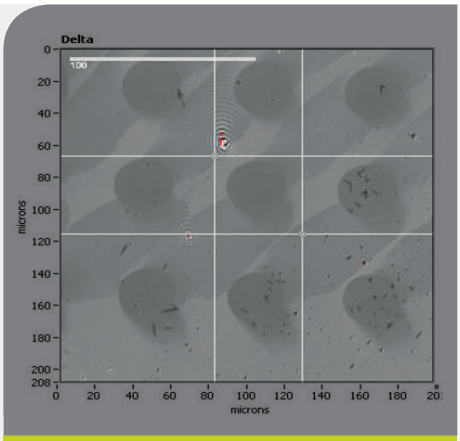


Air | Black Phosphorus | SiO_2 (300 nm) Si
In-plane dispersion function

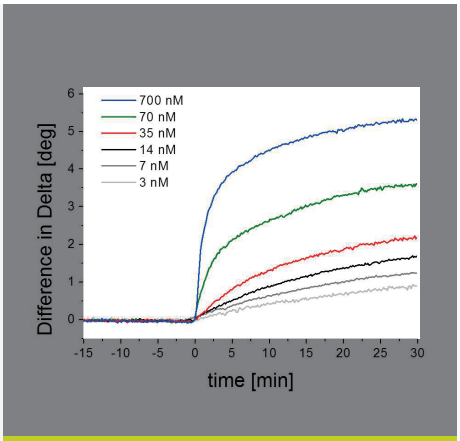
BREWSTER ANGLE MICROSCOPY

Brewster angle microscopy is a subset of the imaging ellipsometer. The instrument can be used to visualize monolayer at the air/water interface with typical LB accessories like troughs etc.

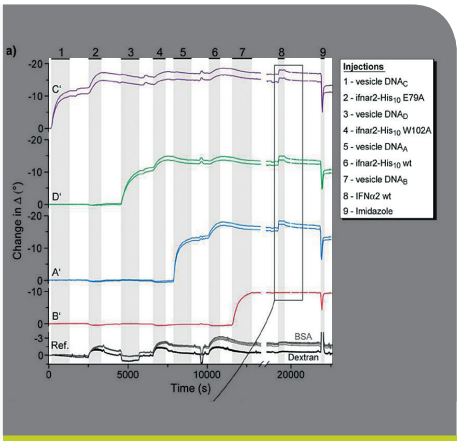
Nanofilm_ep4 equiped with a nanofilm_ultraobjective



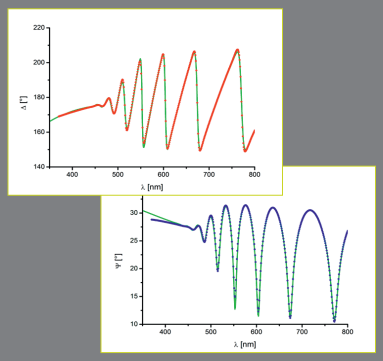
Delta map protein spots



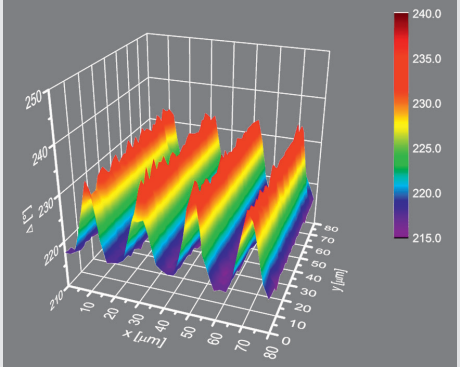
Antigen/antibody interaction: Binding of poly-clonal anti-Rabbit IgG to immobilized Rabbit IgG



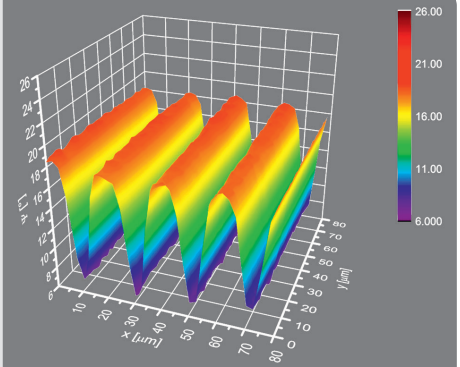
DNA – bar-coding of vesicles for bio chip application



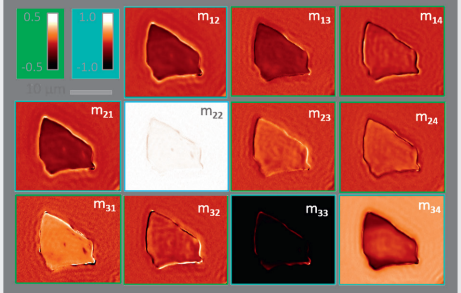
Air | patterned As$_2$S3 | Glass
Wavelength spectra of Delta and Psi



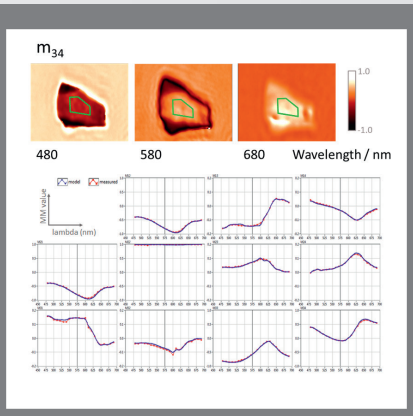
Air | patterned As$_2$S$_3$ | Glass
Delta maps



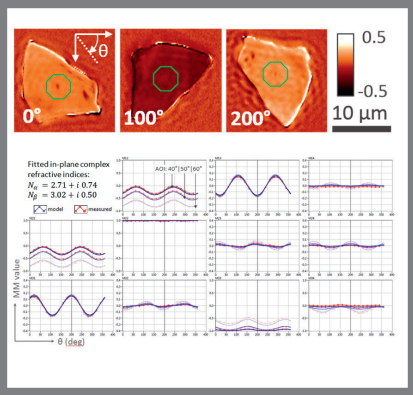
Air | patterned As$_2$S$_3$ | Glass
Psi maps



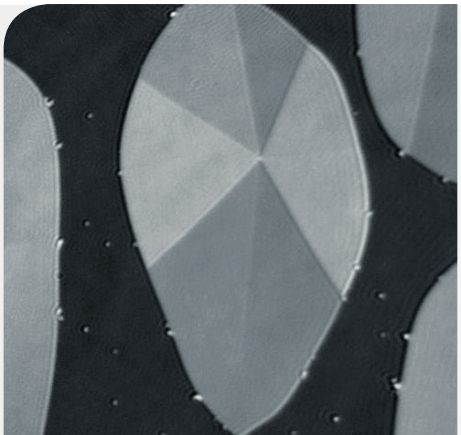
Micrographs of 3x4-Müller-Matrix, normalized (m_{11} = 1)



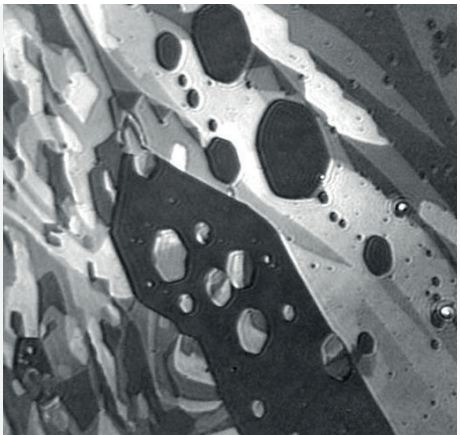
Spectroscopic Mueller-Matrix measurement



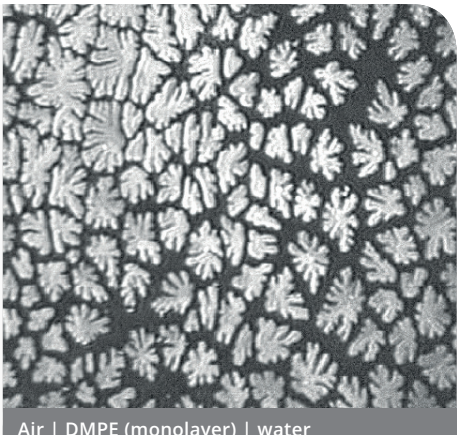
Orientation of optical axes obtained from Mueller-Matrix θ-scan



Air | Monopalmitoyl-rac-glycerol | water
BAM micrograph, SP 4.22 mN/m



Air | Ethyl stearate (monolayer) | water
BAM micrograph, Field-of-view ca. 600 µm



Air | DMPE (monolayer) | water
BAM micrograph during first-order phase transition

IMPROVED SOFTWARE CAPABILITIES

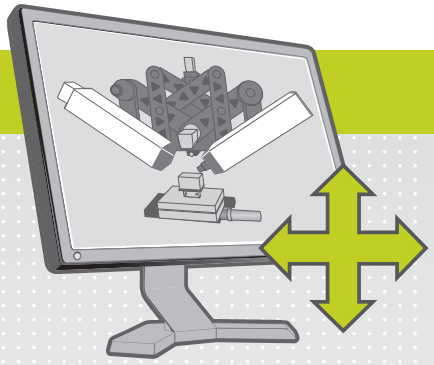
The nanofilm_ep4 software is modular. Separate software modules simplify the instrumental operation and enables parallel or offline analysis of collected data on a computer remote from the instrument.

The “EP4Control” software manages the operation of the ep4 system. It is an interactive and easy to use control unit and automatization tool.

The new “AccurionServer” software manages the documentation of your ep4 measurements including data from accessories and supported complementary measurement technologies. It is a sophisticated data and analysis module to enable a deeper understanding of complex systems.

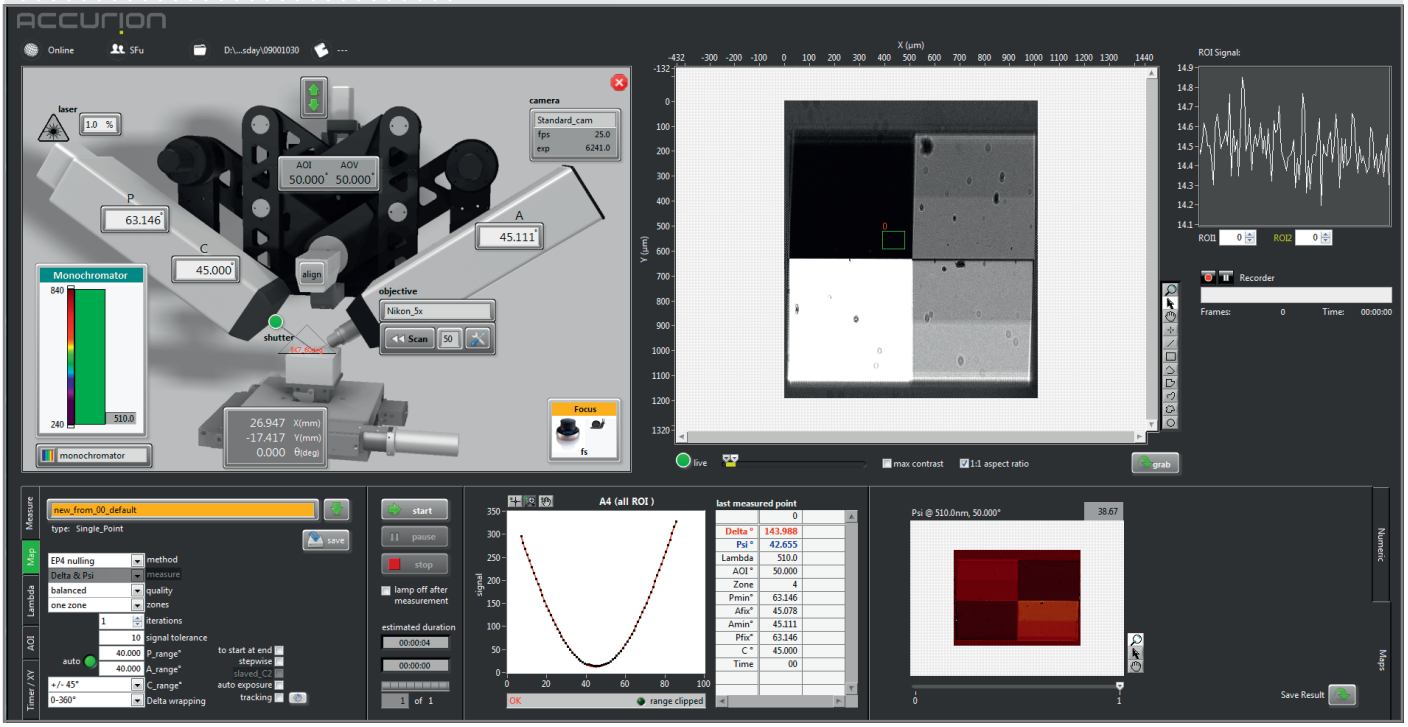
AccurionServer

- Organizes all supported data sources including accessories and optional complimentary measurement technologies and interfaces between instruments and software packages.
- Organizes the data storages structure (easy to use user structure).



EP4Control

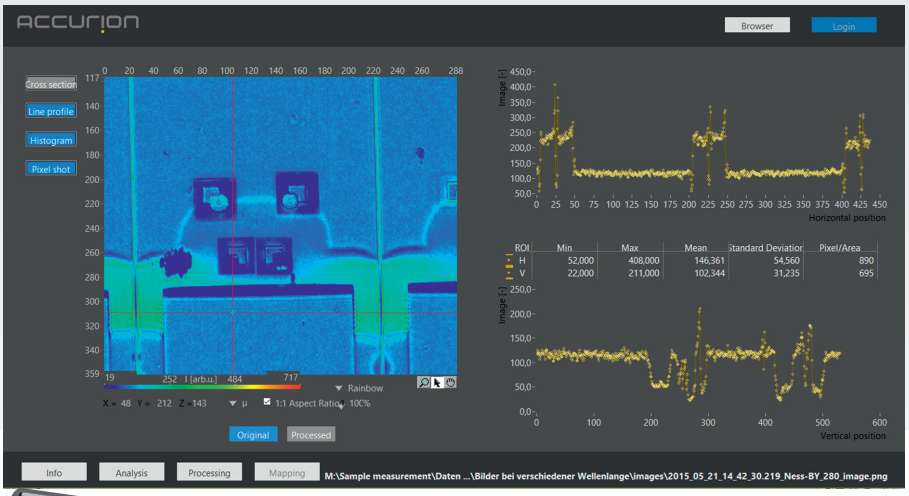
- Including image processing features: background correction (automatic), black level correction, geometric correction, signal tracking (overall brightness correction), default session storage and many more ...
- Operating the instrument (control of moving components, taking images, performing measurements, process automization, ...)

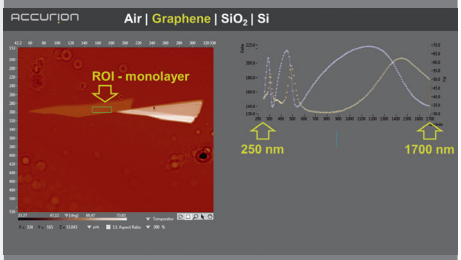


AccurionDataStudio

- Processing all data (images, measurement results, kinetics, structure description, etc.).
- Independent from the instrument and allows to analyze your data on your office PC.

- **Special features (examples):**
  - Batch fitting: calculating delta/psi maps into thickness maps is done automatically in the background while using the instrument (pixel by pixel analysis).
  - Images can be saved continuously also as movies with all information of the measurement parameters.

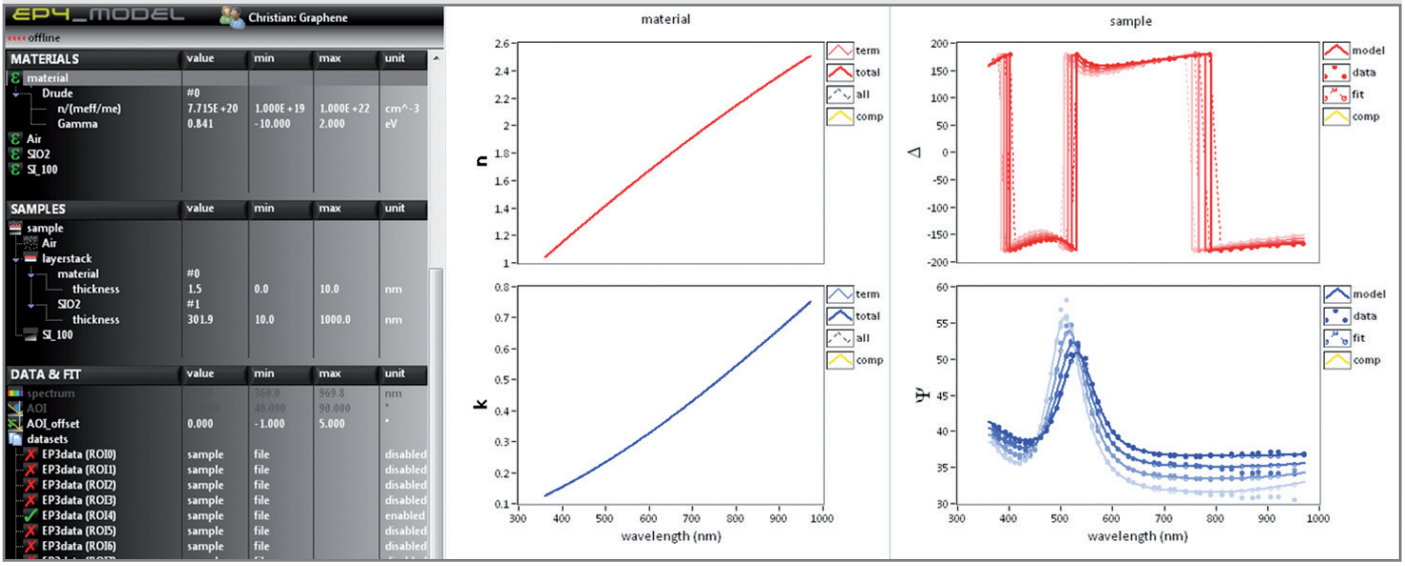




New option: Pixel shot based on a stack of spectroscopic maps

EP4Model

- Analyzing and fitting your measured data with a large selection of dispersion functions.
- Modeling of complex thin film systems and fitting of your measured data with the chosen model.
- Simulation of the fitting to follow the effect of any parameter in the model.
- Modelling of refractive indices (uniaxial, biaxial) and the orientation of optical axes of anisotropic materials (based on 11 elements of a normlized Mueller Matrix).



CONFIGURATION POSSIBILITIES

The new imaging ellipsometer nanofilm_ep4 is a modular instrument where you can select a configuration optimized for your measurement needs.

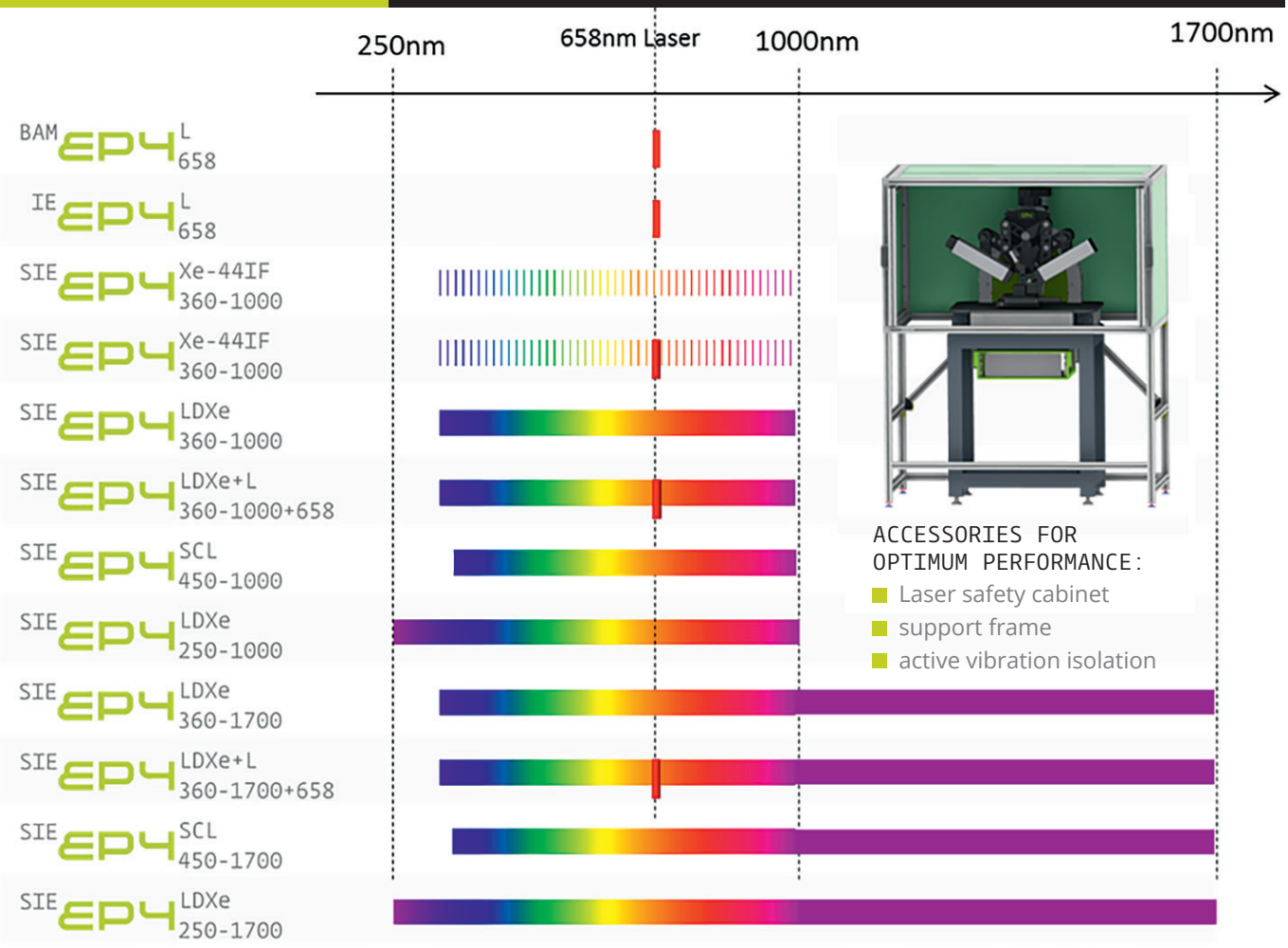
TYPE
Spectroscopic Imaging Ellipsometer

LIGHT SOURCE
Laser Driven Xenon Lamp plus additional Laser

SIE EP4 LDXe+L 360-1700+658

WAVELENGTH RANGE
Limited by light source/mono-chromator, cameras and optics

EP4 CONFIGURATION	WAVELENGTH RANGE



ACCESSORIES FOR OPTIMUM PERFORMANCE:

- Laser safety cabinet
- support frame
- active vibration isolation

IE EP4 L 658

IE EP4 L 658

SIE EP4 LDXe+L 360-1700+658

LIGHT SOURCE	TECHNICAL DESCRIPTION	WHAT IS IT GOOD FOR?
OPTIONAL **Laser (L)** 658 nm, 50 mW	Broadband laser for highest image quality (other laser or multi laser solutions on request)	A laser is required for low reflective surfaces like glass or more in general low reflecting situations. Examples are insulator surfaces directly at the Brewster angle, surfaces close to the nulling conditions or close to the SPR resonance angle. You find these conditions in LB-experiments with LB films, SAMs, sub mono layers or in i-SPREE experiments.
OPTIONAL **Xenon lamp with 44 interference filters (Xe-44IF)** 360 – 1000 nm	**Xenon Arc lamp Filter wheel** 44 interference filters, one green broadband filter, one white light position Filters Band width: 6 – 12 nm	The 44 wavelengths enable classical ellipsometric measurements. These includes the thickness of thin transparent films (< 1 nm and 1 µm) and materials with straight forward optical properties.
OPTIONAL **Laser driven Xenon light source (LDXe)** with Grating Monochromator	**Laser-stabilized Xenon Arc lamp** Continuous output, 200 – 2000 nm **Grating Monochromator** Center wavelength precision: < 1 nm includes three gratings: Grating Band width 250 – 750 nm: 10 nm 400 – 1050 nm: 6 nm 1050 – 1700 nm: 18 nm Gratings with smaller band width are available on request	The higher spectral resolution makes the detection of optical properties like band gaps, excitons or other absorption centers possible. The light source is also essential for instruments with UV- and NIR capability. The high brilliance of the light source offers in general better signal to noise ratio than a classical Xe-lamp with filter wheel.
OPTIONAL **Super continuum laser (SCL)** 450 – 1000 nm 450 – 1700 nm	**Super continuum laser** Monochromatic output, no additional monochromator needed Center wavelength precision = 1 nm band width: 2 nm FWHM @ 450 nm 8 nm FWHM @ 1000 nm	One benefit of a super continuum laser is the highest spectral resolution with band width down to 2 nm resulting in a higher coherent length than the other light sources, that enables additional application like the thickness determination of thicker films. Another benefit is the high brilliance that enables a better signal to noise ratio especially on smallest samples.

IMAGING OPTICS	TECHNICAL DESCRIPTION	WHAT IS IT GOOD FOR?
Focus scanner	Allows realtime images at variable angles of incident (< 80°) and is compatible with all objectives. **Lateral resolution:** < 1 micrometer (see chart objectives)	The focus scanner is part of the standard ep4 detection arm. It is also used for focusing of ultraobjectives. In standard objectives, it collects focused images stripes to form an overall focused image. Focus scans take 2 – 5 sec, depending on the required image quality.
OPTIONAL **Ultraobjective** (add-on, easy to exchange by customer, upgradable) *New*	New Scheimpflug set up for receiving an overall focused image/live video **Lateral resolution:** 2 micron **Usable angle of incident range:** 52° – 57°	• Overall focused real time image • Faster measurement; faster mapping • multi spot array, improved image quality • good for moving objects / kinetics (e.g. floating Monolayer on water) This is an optional exchange unit you may use in your focus scanner unit

CAMERAS	TECHNICAL DESCRIPTION	WHAT IS IT GOOD FOR?
Standard camera *New*	High quality, monochrome GigE CCD camera. **Wavelength:** 360 –1000 nm 1392 × 1040 pixel, 12 bits, max. 25 frames per second (fps)	Usually the CCD is used in 2 × 2 binning mode to improve the signal and is operated at 20 fps.
OPTIONAL **NIR camera** (only with NIR upgrade)	InGaAs FPA, cooled, GigE interface. **Wavelength range:** 900 – 1700 nm, 320 × 256 pixels, 25 fps fixed	For spectroscopic measurements in the NIR. This camera is added to the standard or the UV camera. Allows measurements e.g. for telecommunication materials, water absorption and many more.
OPTIONAL **UV camera** (only with UV upgrade) *New*	Back-illuminated CMOS; CameraLink interface. **Wavelength:** 200 – 1000 nm, 1280 × 1040 pixels, 25 fps	For spectroscopic measurements in the UV. Camera will be operated in 2 × 2 binning mode by default. This camera replaces the standard camera in all configurations that operate < 360 nm. The camera link interface board is included.
OPTIONAL **Adaption package for second camera** *New*	Switchable mirror or dichroic filter for camera selection (via software). Optical camera adaptation. Mechanical mounts.	For broad range spectroscopy a secondary camera is being used. Optics for both cameras provide a similar, position adjusted FOV. By this, seamless switching of the camera during spectral measurements is enabled.
OPTIONAL **Alternative cameras**		The modular software concepts allow integration of various other cameras. Especially all GenICam cameras are supported. Some cameras may require additional PC boards (camera link).

OBJECTIVES FOR USE WITH FOCUS SCANNER	SPECIFICATION OF THE EP4, EQUIPPED WITH THE FOLLOWING OBJECTIVES:	WHAT IS IT GOOD FOR?
OPTIONAL **2 × objective**	**Lateral ellipsometric resolution:** 10 µm **FOV:** 2 mm × 2 mm, depends on AOI	Long distance objectives with high numerical apertures. FOV (field of view) is based on standard camera. The FOV is quadratic for this camera at 42° AOI. At different AOI, the FOV becomes rectangular depending on the angle. Resolution is defined at 400 nm. Not applicable for UV !
OPTIONAL **5 × objective**	**Lateral ellipsometric resolution:** 4 µm **FOV:** 800 µm × 800 µm, depends on AOI	
OPTIONAL **10 × objective**	**Lateral ellipsometric resolution:** 2 µm **FOV:** 400 µm × 400 µm, depends on AOI	
OPTIONAL **20 × objective**	**Lateral ellipsometric resolution:** 1 µm **FOV:** 200 µm × 200 µm, depends on AOI	
OPTIONAL **50 × objective**	**Lateral ellipsometric resolution:** 1 µm*) **FOV:** 70 µm × 70 µm, depends on AOI Only suitable for small samples (approx. 20 × 20mm)	
OPTIONAL **Nanochromat** *New*	**Lateral ellipsometric resolution:** 2.5 µm **FOV:** 600 µm × 600 µm, depends on AOI	**UV/IR objective** Necessary for all measurements that include wavelength between 250 and 360 nm

*) lateral resolution of the microscopic image down to 0.6 µm

ADAPTABLE TECHNOLOGIES

Nanofilm_ep4 with adapted Nanosurf Nanite AFM

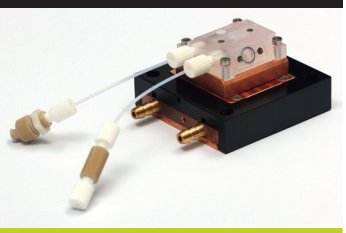
Q-Sense QCM-D E1 module integrated in the imaging ellipsometer

Further adaption of technologies like Raman spectroscopy, white light interferometry, reflection spectroscopy and others are possible.

PLEASE FEEL FREE TO CONTACT THE ACCURION TEAM TO DISCUSS THE ADAPTION OF A TECHNOLOGY.

SELECTED ACCESSORIES

In situ SPR cell allowing kinetic SPR measurements



Solid-liquid cells for ellipsometry at the solid liquid interface

Light guide enables measurements at liquid/liquid interfaces and solid/liquid interfaces at variable angles between 40° and 72°

UNIQUE ACCESSORIES	TECHNICAL DESCRIPTION	WHAT IS IT GOOD FOR?
OPTIONAL **Knife edge illumination** (only combined with spectroscopic option) *New*	Mechanic plate with a sharp edge movable into the light beam to provide an illuminated area in correspondence of the thickness of the transparent substrate.	Unique feature: Allows measurements of thin transparent substrates to avoid backround reflection. Only for spectroscopic measurements. AOI measurements possible without mechanical adjustment.

TECHNICAL SPECIFICATION	
Ellipsometer Type	Brewster Angle Microscope (BAM) Imaging Ellipsometer (IE) in PCSA configuration Spectroscopic Imaging Ellipsometer (SIE) in PCSA configuration
Open Frame-Setup	Rugged aluminum frame construction with integrated multi-axis alignment. Separate electronic control unit.
Imaging Optics	Automatic focus scanner for high-resolution ellipsometric contrast images and maps, 10 × objective (image width – 400 µm, lateral resolution – 2 µm (other objectives with larger field-of-view or higher lateral resolution are available) **Ultraobjective for overall focused images (optional):** 2 µm lateral resolution, angle of incident range: 52° – 57°.
Motorized Goniometer	Patented software controlled motorized goniometer **Angle-of-incidence range:** 38 – 90° **Angle resolution:** 0.001° **Absolute angle accuracy:** 0.01° **Speed of motion:** ~ 5° / sec.
Z-lift	10 cm travel range, 1 µm repeatability, 0.5 µm resolution
Electronics	Up-to-date monitor and Windows® PC Embedded Linux operating system (internal only) Communication with host PC via dedicated 100 Mbit Ethernet
Power Supply	Voltage: 100 – 240 V ~, 50 / 60 Hz, max. current: 10 A

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