Product information

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SIG-500SP

ex-situ measurements of mechanical stress in thin films

This system was especially built to be a great support in R & D as well as in the quality control of coating processes. Because of the compact design – it ranges at the size of standard microscopes – the system can be installed nearly everywhere in every laboratory. The sample holder is constructed to enable the experimenter to mount the sample with a very high accuracy and reproducibility in only a few seconds. The measurements itself are also done within seconds. Therefore even extensive series of measurements are done in shortest timescales and provide reasonable results. The software has also long-term measurement features to observe effects like thermal stress or consumption of gases.

Details

Resolution:	Better than +-15 MPa in a 100nm thin film coated on a 150µm thick Silicon substrate
Substrates:	Nearly all materials. One mirroring side with a reflectivity of at least 3%. Typical thicknesses range from 100 microns to 1000 microns.
Sample holder:	Available for substrate shapes smaller than 100mm x 100mm. Due to the 45° slope the samples can be positioned with an accuracy better than 0.1mm.
Detector:	CCD line detector
Laser / Optic:	650nm diode laser module. Other wavelengths available. Beam splitter produces two beams with a separation of 20mm. LASER CLASS I.
Size:	45cm**x**15cm**x**18cm (main device), 20cm**x**15cm**x**8cm (electronic)
Weight:	20kg
Software:	Special Software with data export to e.g. ".csv"-files. The complete history of measurements is saved in a clear structured database.

SIG-500SP – furnace extension

Measurement of thermal stress in thin film / substrate systems

This furnace is directly mounted on the SIG-500SP system to analyze the temperature dependence of the stress in the system. The sample is placed inside the furnace. While it heats up to temperatures around 600°C the system measures continuously the mechanical stress. With the proper series of measurements one can determine the coefficient of thermal expansion of the film. The furnace can also be removed quickly to have the device in its original state.

Details

Furnace:	Halogen furnace (600W) T_{max} up to 600°C
Substrates:	Nearly all materials. One mirroring side with a reflectivity of at least 3%. Typical thicknesses range from 100 microns to 1000 microns.
Sample holder:	The sample holder of the SIG-500SP is replaced by an optical extension. The sample is mounted inside the furnace on top of three glass rods.
Laser / Optic:	The standard optic is extended by a special deflection unit.
Size:	30cm**x**25cm**x**50cm
Weight:	7kg
Software:	The control of the furnace is done be an special module in the standard measurement software of the SIG-500SP.

SIG-2000SP

in-situ measurement of mechanical stress in thin

SIG-2000SP was developed to measure the stress in thin films already during the coating process using a reference substrate. The system can be plugged to nearly every coating system. The principle is that two laser beams are going into the coating chamber onto one mirroring side of the substrate which reflects them back into the device. By this the curvature change is detected during the film growth. In the case of a moving sample (e.g. rotating on a calotte) the high speed detector is fast enough to provide reliable data every time the sample passes through the laser beams. The trigger mechanism is realized in the system itself, but also external trigger signals can be used.

Details

Resolution:	Better than +-30 MPa in a 100nm thin film coated on a 150µm thick Silicon substrate
Substrates:	Nearly all materials. One mirroring side with a reflectivity of at least 3%. Typical thicknesses range from 100 microns to 1000 microns.
Sample holder:	Available for substrate shapes smaller than 30mm x 30mm..
Detector:	CCD line detector – optional high-speed
Laser / Optic:	650nm diode laser module. Other wavelengths available. Beam splitter produces two beams with a separation of 10mm.
Size:	12cm**x**12cm**x**25cm
Weight :	6kg
Software:	Special Software with data export to e.g. ".csv"-files. The complete history of measurements is saved in a clear structured database.
Mounting:	To connect the system to the coating system, flanges and adapters are provide by sigma-physik

SERVICE

We measure the stress for you

We measure in order of our customers the stress in the thin film systems. Also the thermal stress or the coefficient of thermal expansion can be determined.

For this purpose the customer receives reference samples placed in a sample holder fitting into the coating system. These samples are previously measured by sigma-physik. The data are stored in our database. Now the customer only has to coat the samples in the process of interest. Afterwards the sample holder is sent back to sigma-physik and a second determination of the samples' curvatures is done. The results are listed in the members' area of the homepage (www.sigma-physik.de/services) or will be sent by email or mail.

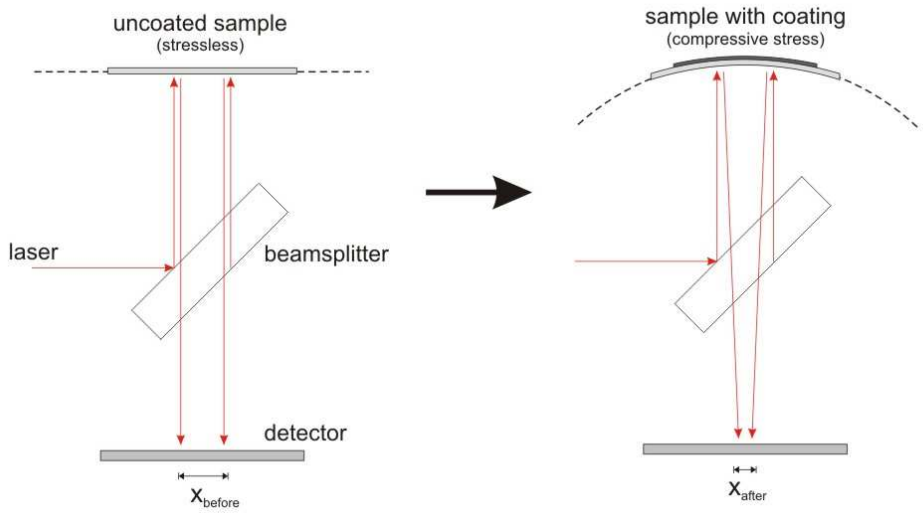
Details

Single order:	One sample holder with three samples chosen by the customer
Monthly order:	The customer receives monthly one or more sample holder.
Weekly order:	The customer receives monthly one or more sample holder.
R&D order:	The customer receives once 10 or more sample holders and sends them back depending on the needs. Measurement results are available within 24 hours after sigma-physik receives the samples.
Substrates:	Nearly all materials. One mirroring side with a reflectivity of at least 3%. Typical thicknesses range from 100 microns to 1000 microns.

Appendix A

General principle of measuring the mechanical stress in thin films

To determine the mechanical stress in a thin film, the curvature of a reference substrate is observed. The stress in the film is connected to the bending of the sample. Therefore the curvature of the sample is measured before the coating process and stored in the database. After the process the substrate is measured again. The change of the bending of the sample is a measure for the stress.



The curvature of the sample can be calculated from the value of the deflection of two initially parallel laser beams reflected by the sample. In the ***SIG-500SP*** stress measurement system the distance between these two laser beams is measured.

Knowing all experimental data, the stress σ_{film} can be calculated using the following formula (*Stoney's formula*):

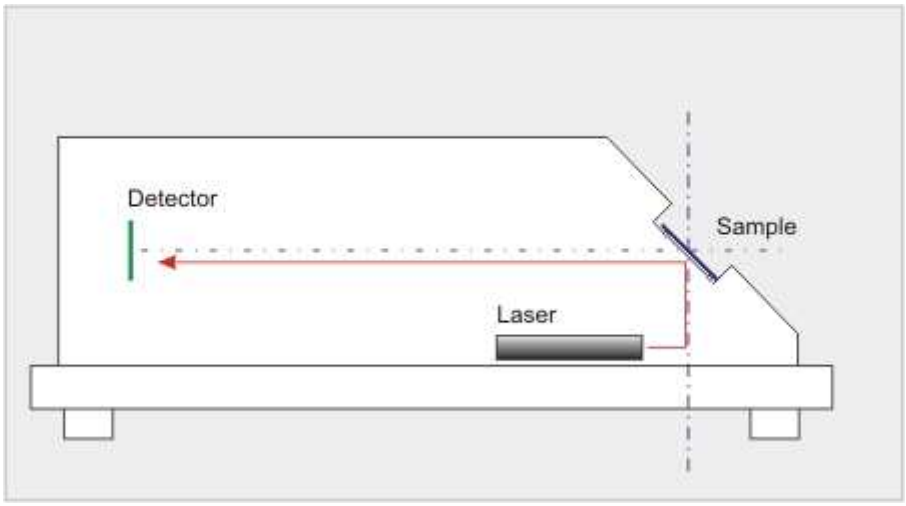
$$\sigma_{film} = \frac{(x_{after} - x_{before})}{12\ L\ a} \cdot \frac{E_{substrate}}{1-\nu_{substrate}} \cdot \frac{d^2_{substrate}}{d_{film}}$$

With:

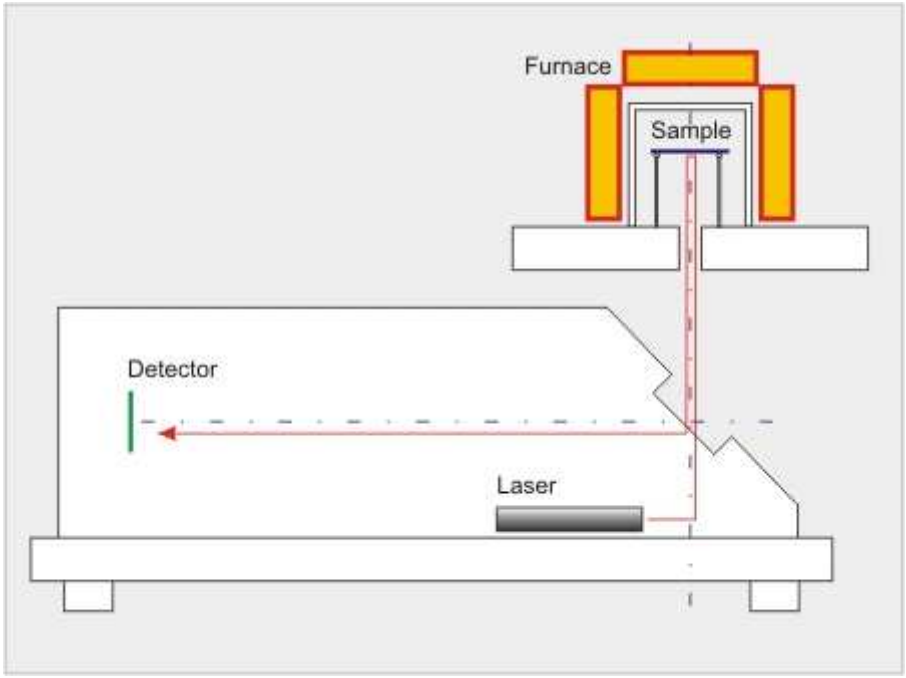
Thickness of the substrate:	$d_{substrate}$
Thickness of the thin film:	d_{film}
Modulus of the substrate:	$E_{substrate}$
Poisson ratio of the substrate:	$\nu_{substrate}$
Distance sample – detector:	L
Separation of the two laser beams:	a (initially – at the sample)
	x_{before} (before the coating – at the detector)
	x_{after} (after the coating – at the detector)

Appendix B

Principle of SIG-500SP



Principle of SIG-500SP with furnace extension



Appendix C

Software

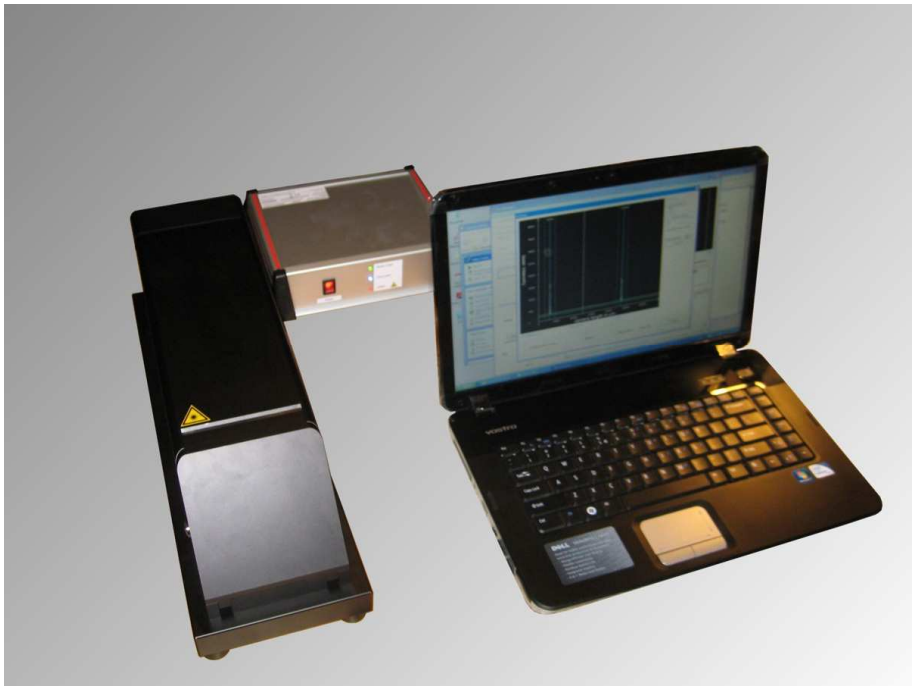
The software of the stress measurement system allows you to measure and archive very easily the results of a lot of different samples. The results are saved immediately into a database. You can create different projects which contain a certain number of samples. Each sample is saved together with the physical parameters thickness, material, Young's modulus and Poisson ration of the substrate. Also the thickness of the film can be entered. With this set of parameters the mechanical stress in the thin film is calculated using stoney's equation. You can do single measurements or configure long term measurements. Each result and also each sample or project can be deleted if it is necessary.

Beyond the pure measurement skills the software has an easy and clear way to store and archive all experimental results. For this there is a structure of projects containing samples. Each result is stored inside a wide database and can be found and loaded very easily. For further calculations with other office applications there exists an export tool to create different kinds of text files out of the projects or single samples.

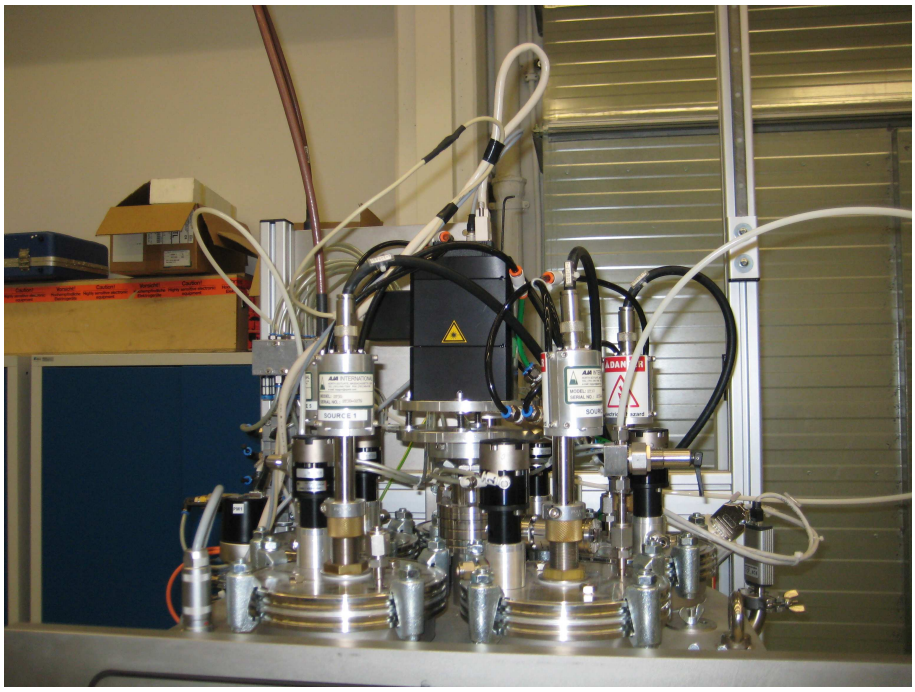
Appendix D

Some pictures

Ex situ SIG-500SP with electronic and measuring laptop:



In Situ SIG-2000SP mounted on top of a coating system:



Appendix E

Some references

BERLINER GLAS

Bte
BEDAMPFUNGSTECHNIK

INTERPANE
GLASS FOR LIFE

LEYBOLD OPTICS

Merck KGaA, *Darmstadt, Germany*

IMP
INSTITUT FÜR
MATERIALPHYSIK