sigma-physik
Messtechnik

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SIG-500SP

A system for ex-situ mechanical stress measurements in thin films

Easy to handle and high resolving measurement system for determining the meachanical stress in nearly all thin film systems like dielectric and metallic coatings or paintings.

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Introduction

What makes the mechanical stress in thin films so interesting?

- Formation of cracks in the film
- Delaminating / adhesive strength
- Geometry of the substrate (deformations like bending)
- the measure and reproducibility depends on the process quality (QM)

For these reasons determining the mechanical stress is very important

- quality control and
- development of new films or film systems

Advantages of the SIG-500SP stress measurement system

Time:	Sample mounting is done in less than 30 sec.
Time:	Measuring the actual state of the sample is performed in less than 120 sec.
Financial:	The price is quite low compared to interferometers or devices from the SC industry
Spacial:	The system is very small, but stable. Like standard microscopes it can just be placed onto any desk.
Metrological:	Extremely high resolution and very good reproducibility
Flexibility:	the system can easily be transported to and used in other production sites. For this reason it is delivered in a special suitcase.
Operability:	No additional adjustments needed.
Software:	Measuring and analyzing tool included. Database based sample and project management.

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Additional advantages of the ex-situ-stress measurement system are:

Quality control and the development of new film systems:

- All data can easily be stored and recalled at any time. Included software allows comparison of different measurements with each other to keep an overview of your process.

- Stress data can be acquired in a very short time reducing the overall time required for development.

All these reasons make the ***SIG-500SP*** ex-situ stress measurement system a very effective device that can be used in nearly any coating laboratory.

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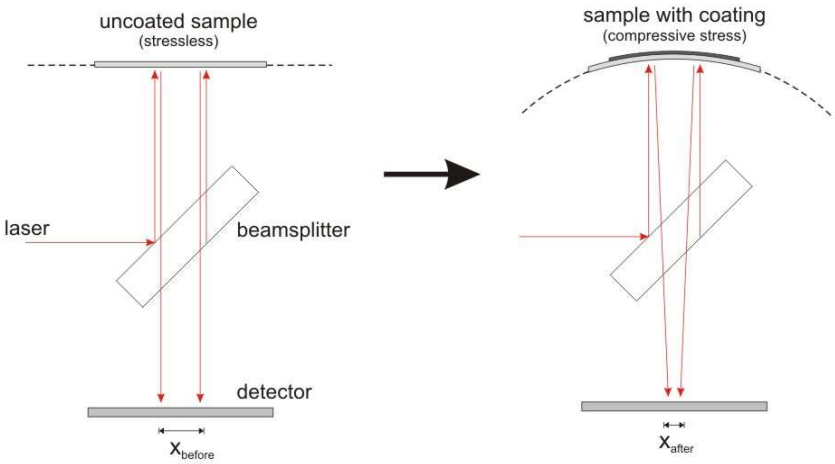
The principle of the stress measurements

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 (*Stoneys 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
Seperation 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)

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Resolution limits

The resolution limit of the ***SIG-500SP*** stress measurement system in units of stress has to be determined from

- the accuracy in measureing the distance between the two laser beams
- the reproducibility of sample positioning in multiple sample mounting / dismounting
- the substrate used in the experiment
- the thickness of the film

The distance between the two laser beams are measured by a line detector (CCD-arrray or PSD) which allows an accuracy of better than +-10µm.

The sample holder is tilted by 45° and the sample has only a 3-point contact with the holder. This allows the sample to slide easily into the same position everytime it is mounted. This reproducibility delivers a resolution limit of better +-25µm. This is the maximum variation in the measured laser beam distances.

To calculate the possible stress resolution one has to take into account the samples properties, which are:

- thickness of the substrate
- modulus of the substrate
- poisson ratio of the substrate
- thickness of the film

Example:

Applying an error of +-25µm Stoney's formula delivers stress resolution limits for a 100 nm film on Si substrates (E=130 GPa, □=0.45) with different thicknesses:

$d_{substrate}$ = 150 µm	+- 15MPa
$d_{substrate}$ = 250 µm	+- 43MPa
$d_{substrate}$ = 500 µm	+- 170MPa

In the case of a 500nm thin film these values can be devided by 5!

Therefore the right choice of the substrate thickness leads to the best resolution limit for the experiment of interest.

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Software

Features of the included software:

- Easy to use
- Projects, samples and substrates can be archived and recovered very easily
- Analyzing and comparison of samples can be done immediately following the data acquisition
- Sample data or project data can be exported into ascii files

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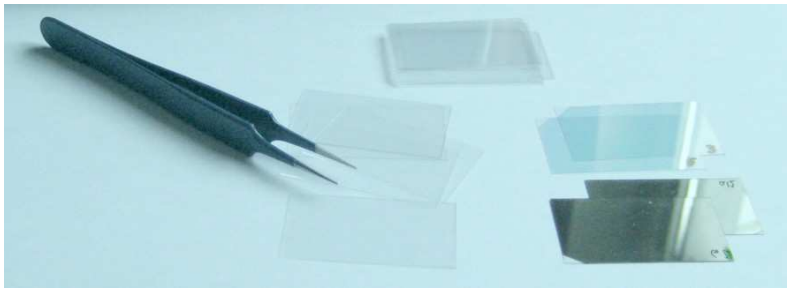
Substrates

Material and shape:

Nearly all materials, even transparent glass or plastics, are measurable. The only requirements of the substrates used in the device are:

- Minimum 20mm long and 5mm wide, or a diameter of 20mm
- Maximum 100mm and 100mm wide, or a diameter of 100mm
- One side of the sample has to be reflective to reflect the laser beams. The reflectivity of glass (ca. 5%) is sufficient.

The shape of the substrate depends on the wishes of the customer. A sample holder for the ***SIG-500SP*** can be ordered separately to satisfy customer requirements.



Thickness:

The user has to have a rough idea of the stress, then the proper substrate thickness can be used.

If the substrate is too thin for the stress in the film, the bending could be so large that the deflected laser beams will no longer hit the detector.

If the substrate is too thick it can be too stiff and will only bend a little due to the films internal stress. The deflection of the laser beams could then be too small for accurate measurement.

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Technical data

Resolution limit:	Better than +-15MPa at a 150µm Si substrate with a 100nm film (at constant temperatur conditions)
Substrates:	Nearly all materials, one side min. 5% reflectivity, typical thickness from 100µm to 1000µm
Sample holder:	Available for any substrate shape smaller than 100mm x100mm. Due to the 45° tilted installation a reproducibility of better than 0.1mm in sample positioning is achieved.
Detector:	PSD- or CCD-line detector
Laser:	1 diode laser module, class 3B, splitted into two parallel beams with a distance of 20mm

Caution:
The complete system is
"LASER CLASS 1 PRODUCT"

Dimensions:	45cm x 15cm 18cm
Weight:	18kg
Data aquisition:	Special software running on standard PC or laptop