Measurement of thick films in the thickness range from 1 to 24 µm

The accessible film thickness range in spectroscopic ellipsometry using SENTECH **SENresearch 4.0** ellipsometer family is extremely wide. The ellipsometers can measure thicknesses from thin films in the Angstrom range to extremely thick films of about 200 µm. The high spectral resolution of the **SENresearch 4.0** ellipsometer is key for the measurement of extremely thick films.

This application note will discuss the film thickness range from 1.0 µm to 14 µm of a photoresist film and a SiO_2 film of 25 µm thickness.

This particular film thickness range is accessible using the **SENresearch 4.0** ellipsometer using the basic DUV-VIS spectral range from 240 to 1000 nm. This spectral range is part in all ellipsometers of the **SENresearch 4.0** family.

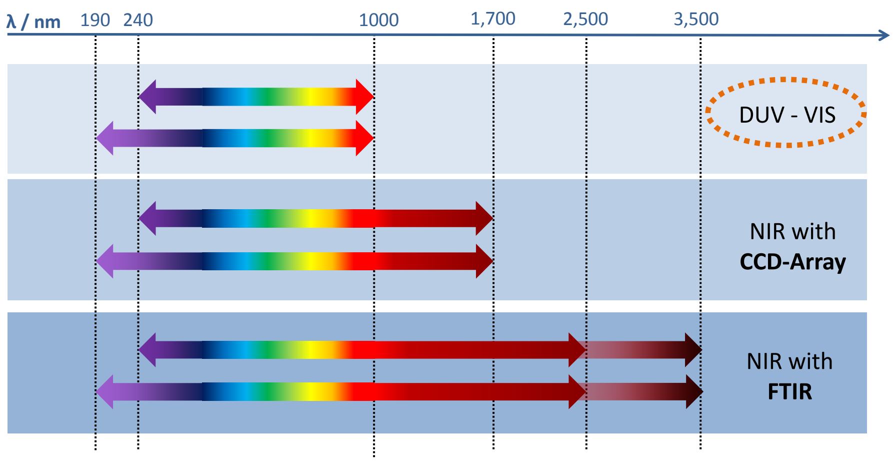

Image 1: ***SENresearch 4.0*** *spectral ranges*

Already the basic spectral range of the **SENresearch 4.0** ellipsometers of 240 to 1000 nm will give access to high film thickness of at least up to *25* µm.

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Measurement tool

The **SENreseach 4.0** spectroscopic ellipsometer is used for these measurements. The system is equipped with the basic DUV-VIS spectral range 240 to 1000 nm.

SpectraRay 4 is the SENTECH comprehensive measurement and analysis software. It is used to perform measurement, modeling, and fitting.

Image 2: **SENresearch 4.0** *spectroscopic ellipsometer*

Thick films and technical requirements

Photoresist films are deposited in a wide film thickness range from 1 to 14 µm. They are transparent in the VIS spectral range allowing the accurate measurement of film thickness and the dispersion of optical constants n, k.
Additionally a single SiO_2 film of 24 µm is prepared and measured.

The high film thickness causes sharp of interference fringes which must be resolved accurately by the spectroscopic ellipsometer. The DUV-VIS spectrometer of the **SENresearch 4.0** family features a high spectral resolution allowing access to thick films of at least up to 25 µm.

Photoresist with film thickness from 1 µm to 14 µm

Example: Photoresist / Si

Different film thickness of about **1** µm, **3** µm, **6** µm, and **14** µm of photoresist (PR) are prepared.

The optical constants of the photoresist are shown in the following graph.

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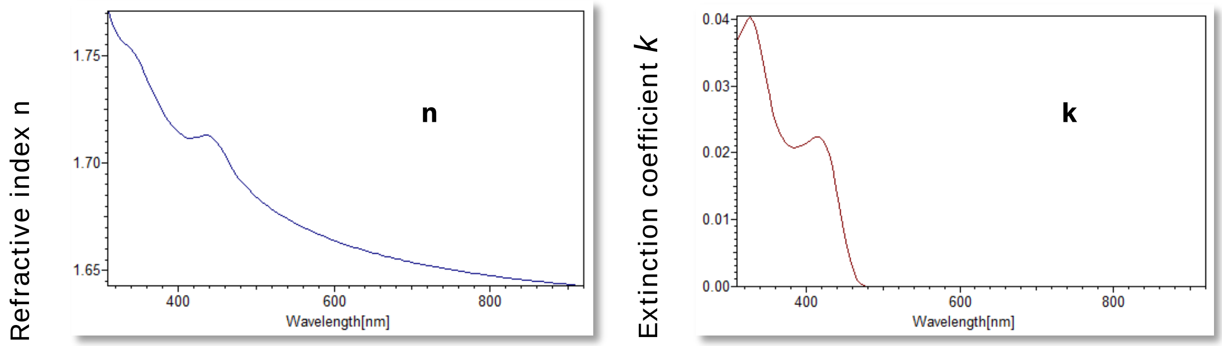

Figure 1: Dispersion of n, k of photoresist

It is transparent in the spectral range from 480 to 920 nm. Below 480 nm a weak extinction can be observed.

Photoresist film thickness 0.913 µm

Model

Title	Thickness	State	Layer Type	Info [632,8 nm]
Air			NK layer	n=1,0000
Photoresist	913,12 nm		Tauc-Lorentz layer	n=1,6385 k=0,00026
Silicon			File layer	n=3,8739 k=0,01457

Figure 2: Optical model

The following graph shows the measured ellipsometric Ψ, Δ spectra of the photoresist / Si sample. On top of the measured spectra the fitted curves are shown in red. The fit quality is excellent; the modeled spectra perfectly fit the measured spectra.

The whole spectral range shows interference fringes originating from the transparent PR film. The number of fringes increases with film thickness.

Below 480 nm a distinct damping of the interference fringes especially visible in the Ψ spectrum is observed. This is due to the weak extinction of the PR film.

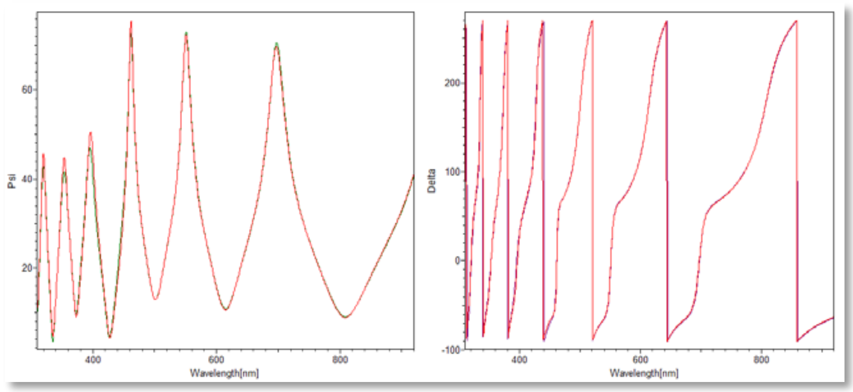

Figure 3: Ellipsometric spectra of 0.913 µm thick photoresist
The fitted spectral range is 310 to 920 nm

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Photoresist film thickness 3.096 µm

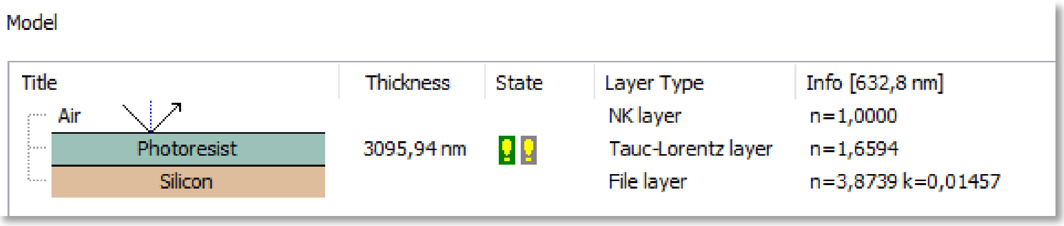

Figure 4: Optical model

The PR film is now about three times thicker resulting in three times more and also sharper interference fringes. The spectral resolution of the **SENresearch 4.0** is capable to fully resolve these fringes. The fit quality is excellent.

The damping of the fringes below 480 nm becomes more distinct due to the higher film thickness.

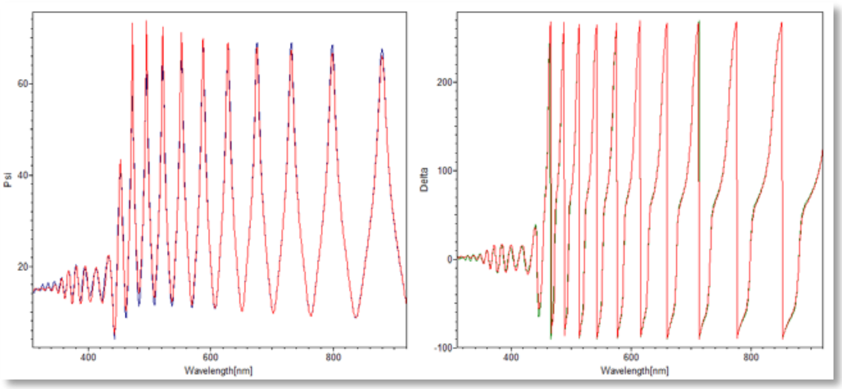

Figure 5: Ellipsometric spectra of 3.096 µm thick photoresist
The fitted spectral range is 310 to 920 nm

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Photoresist film thickness 5.175 µm

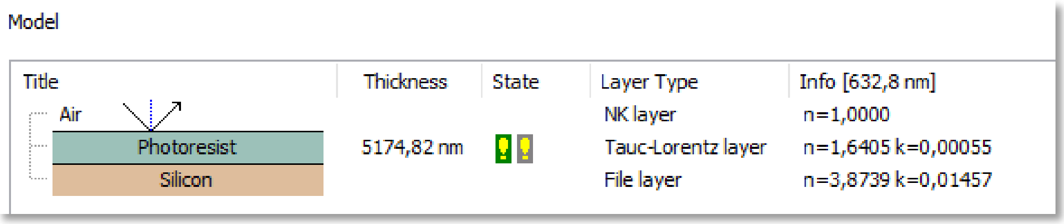

Figure 6: Optical model

The PR film is now more than 5 µm in film thickness. The fringes are still perfectly resolved. The film thickness and optical constants can still be determined accurately.

The damping of the fringes below 480 nm becomes more prominent due to the higher film thickness.

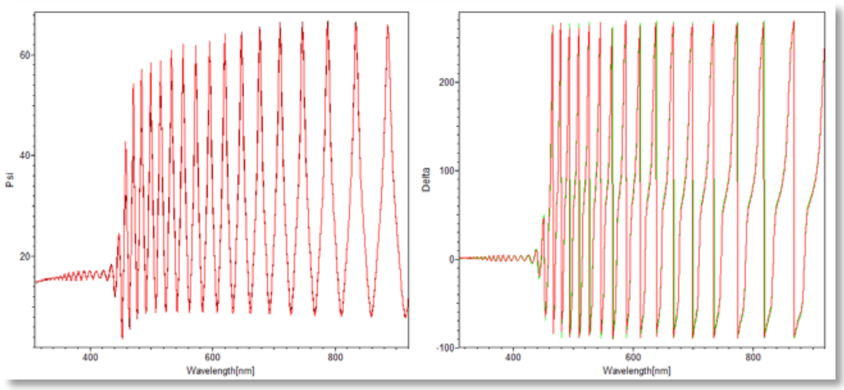

Figure 7: Ellipsometric spectra of 5.175 µm thick photoresist
The fitted spectral range is 310 to 920 nm

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Photoresist film thickness 13.600 µm

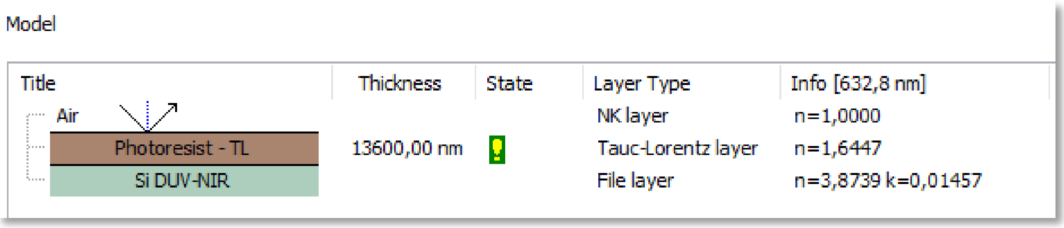

Figure 8: Optical model

The PR film is distinctly thicker than 10 µm. The number of fringes is increased drastically and a damping of the fringes can be observed due to the spectral resolution of the spectrometer which is 2.1 nm. This spectral resolution is now taken into account into the modelling and fitting procedure.

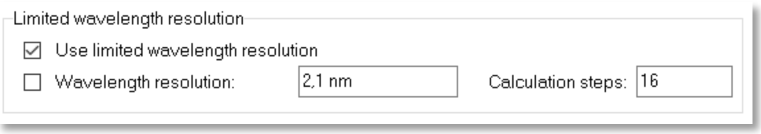

Figure 9: Setting of spectral resolution for the optical modeling

Therefore the fitted curve (red) still perfectly describes the measured spectrum and film thickness and optical constants can be determined accurately.

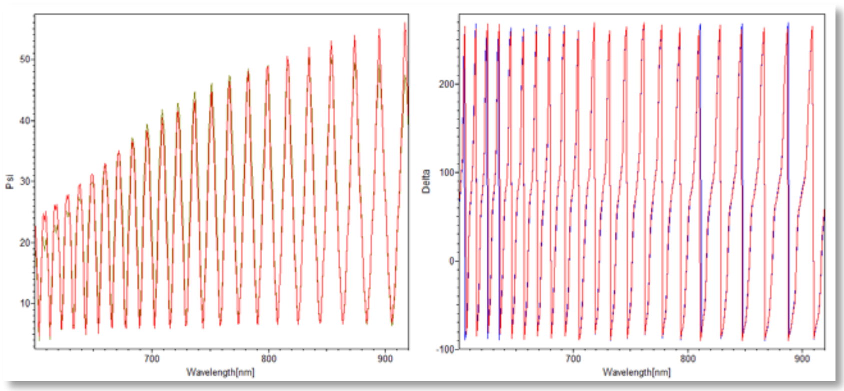

Figure 10: Ellipsometric spectra of 13.600 µm thick photoresist.
The fitted spectral range is 600 to 920 nm

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Erfolg durch Leistung

SiO_2 film thickness 23.990 µm

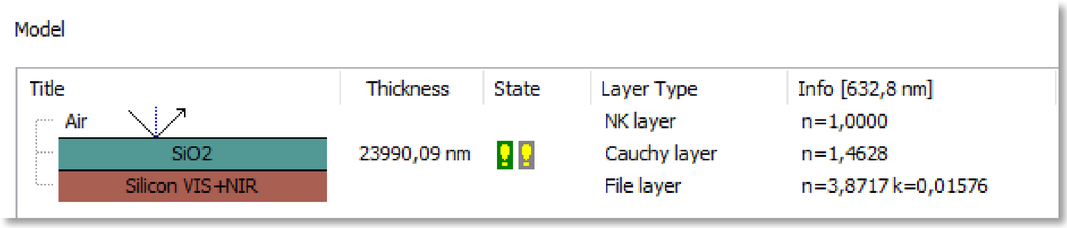

Figure 11: Optical model

The SiO_2 film is 23.990 µm in film thickness and is again distinctly thicker than the PR film. The fringes get sharper and effects of the spectral resolution (damping of the fringes) become more prominent.

The limited spectral resolution is again taken into account for the optical modeling. Therefore the measurement can still be modeled perfectly ensuring accurate results for film thickness and optical constants of the SiO_2 film.

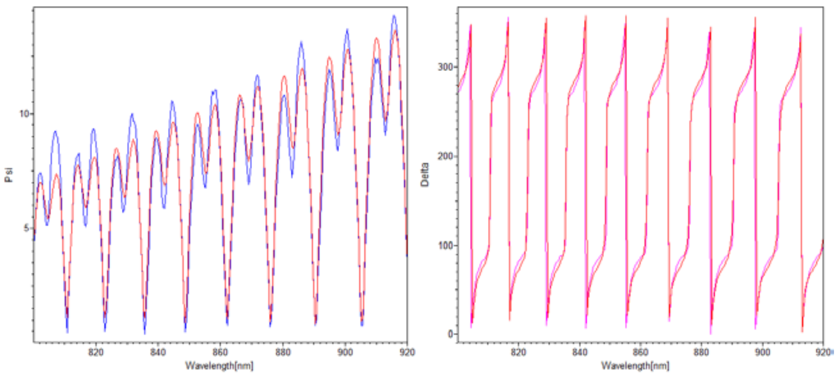

Figure 12: Ellipsometric spectra of 23.990 µm thick SiO_2.
The fitted spectral range is 800 to 920 nm