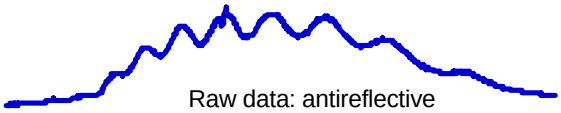


Raw data: antireflective
coating on prescription glasses

Luzchem

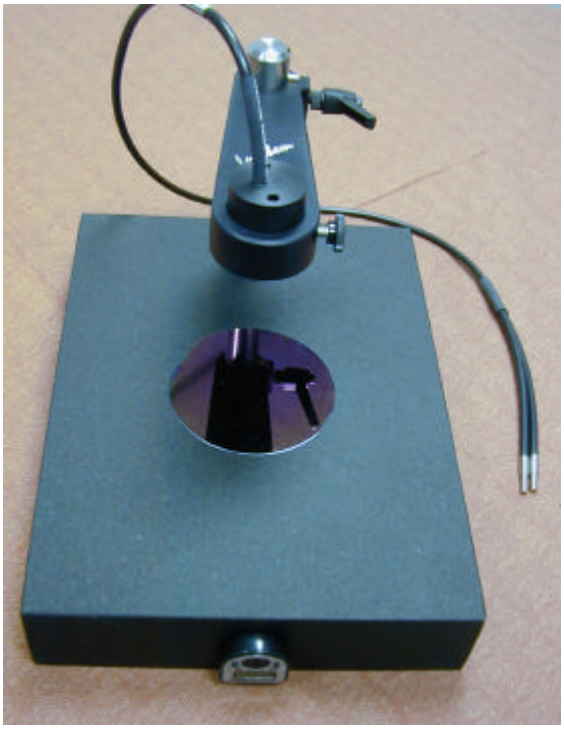
Shedding light on new ideas

Thin film analyzer (TFA-11)

Measurement of both film thickness and dissolution rates

Technical release

Luzchem's TFA-11 instrument combines the power of interferometric measurements of dry and wet thin film thickness, with a versatile, cost effective dissolution rate monitor. Among the types of samples tested with the TFA-11 are resists, antireflective coatings, UV protecting films (e.g., windows and windshields), and paint coatings on various surfaces.. Luzchem will be pleased to test your coatings prior to purchase.



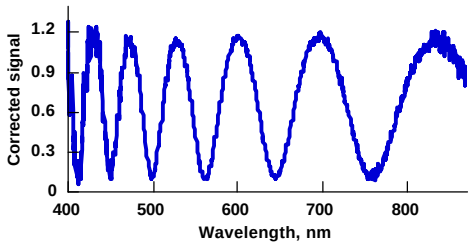
For dissolution studies Luzchem's unique design *(Patent pending)* requires only ca. 1 mL of developer, rather than the large volumes frequently needed.

Multiple measurements are possible on a single wafer; typically 4 in a 3 inch wafer and over 30 in an 8 inch wafer. Our multi-wavelength acquisition software allows the flexibility of deciding later which are the best wavelengths for a given application. You can easily export a thickness vs. time chart if you prefer to develop your own analysis software. Our software provides linear fitting and a flexible non-linear analysis suitable for many common dissolution patterns.

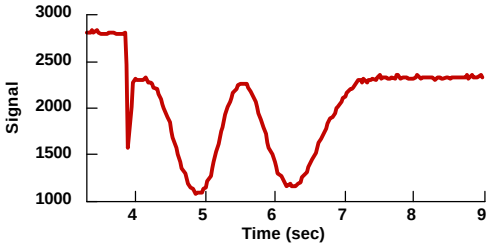
The TFA-11 can handle wafers up to 8 inches in diameter. The solid granite sample table offers exceptional mechanical and thermal stability. The precision machined Delrin head provides a convenient housing for the sensor system, with good chemical stability. The light source is a quartz halogen lamp, coupled with a flexible fiber that serves for light delivery, while restricting the wavelengths to > 390 nm, thus minimizing film degradation during analysis.

The 2048 diode array spectrometer has outstanding spectral resolution and can capture up to 10 full spectra per second. The USB interface permits installation of the hardware without actually opening the computer, or even switching it off.

The graphic software interface requires only a few minutes to learn the basic operating commands, while retaining the power for sophisticated data analysis. If this is not sufficient, the raw or processed data can be readily exported in ASCII format (tab delimited text).



Interferogram obtained on a dry film of a commercial resist on silicon.



Dissolution of exposed 0.35 µm Novolak resist on a silicon wafer.

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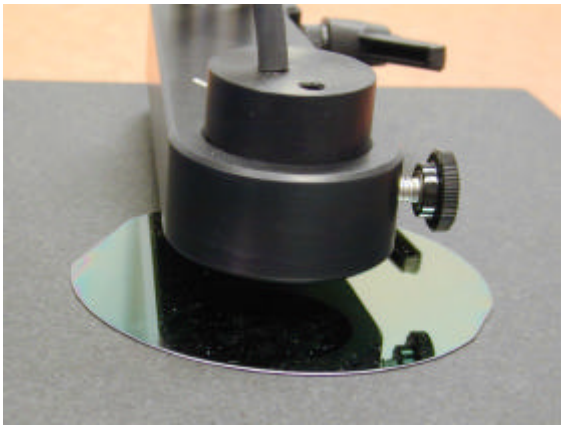
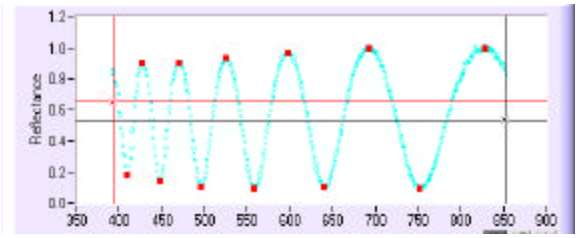
The TFA -11 can operate readily on typical silicon wafers, on transparent or fully reflective substrates. Its USB interface combines efficient data acquisition with simplicity. From about 70 nm to over 25 µm, the TFA-11 offers cost effective versatility, while minimizing developer usage. If you just need film thickness measurements, you will soon be able to choose our TFA-10 instrument, fully upgradable to the TFA-11 if the need arises.



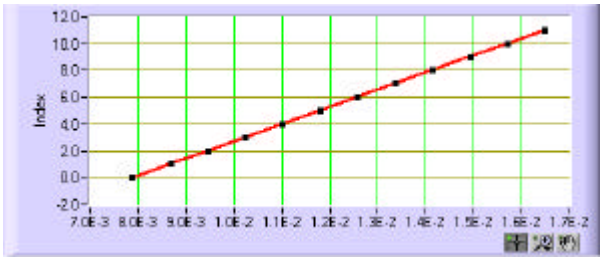
The next few pages illustrate the type of data and the versatile user interface.

Thickness analysis

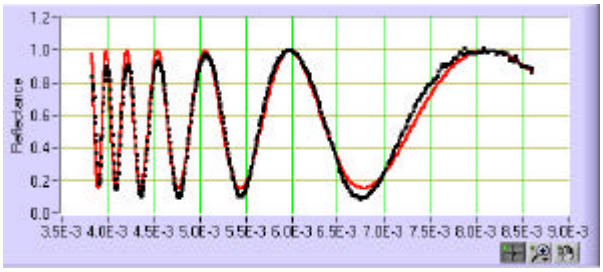
Determination of film thickness is based on the inferferogram obtained between 400 and 850 nm. For films over 250 nm thick it is normally possible to carry out the analysis on the basis of the peak position. For example, in the case of a Shipley 1813 resist the reflectance vs. wavelength plot would show several waves, i.e.,



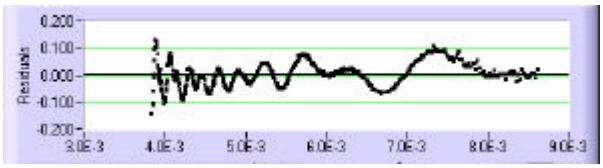
The film thickness can be derived from the slope of a plot of peak number against $4n/\lambda$ (where n is the refractive index), as shown below:



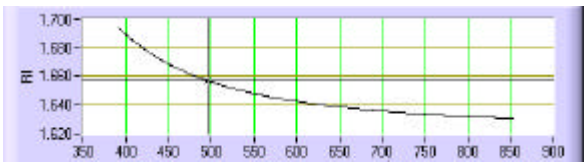
In this particular case the thickness obtained from this plot is 1279 nm. It is also possible to derive the thickness from a shape analysis of the interferogram. A plot of reflectance vs. $2n\pi/\lambda$ is shown below.



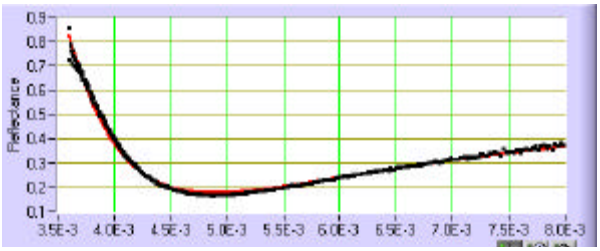
From this plot one obtains a thickness of 1271 nm. Note the deviations between the actual data (black) and the calculated fit (red). While the calculated peak positions are in excellent agreement, the amplitude is not. This is due to the fact that the Shipley 1813 resist absorbs in the blue region of the visible spectrum. These deviations contain information on the resist spectrum. A plot of residuals is shown below:



Our software also provides a plot of the refractive index vs. wavelength, calculated from the Cauchy coefficients. This is shown below for Shipley 1800 resists:



While both, peak position and shape analysis can generally be performed, the former is easier and faster for thicker films. For thin films, shape analysis can be performed even when there is insufficient information for peak position analysis. The following graph shows the data fit for a 98 nm film.



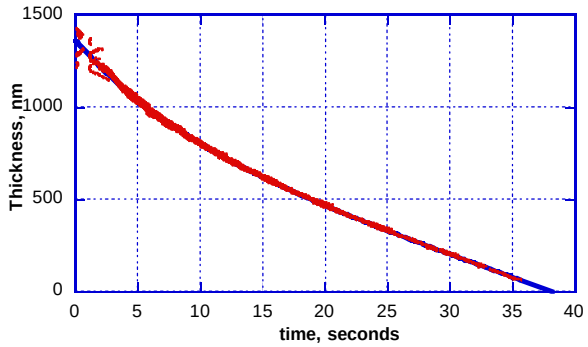
Thus, even when the film is too thin for peak position analysis the TFA-11 allows accurate thickness determination by analysis of the reflection curve shape. A conservative limit of 70 nm is included in our specifications, but thinner films can be analyzed for non-absorbing films yielding good signal-to-noise ratios

Dissolution rate analysis

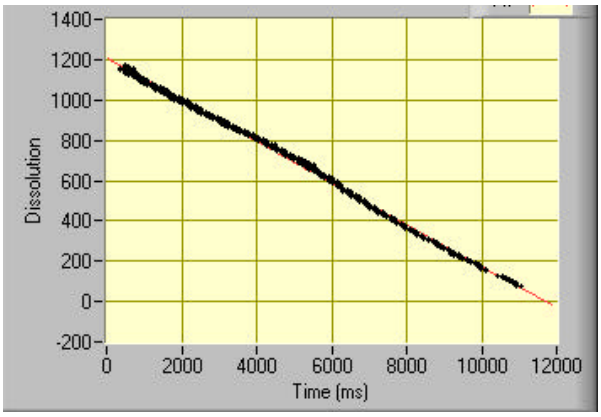
Dissolution analysis allows the key parameters to be automatically evaluated. The normal volume of developer is 1 ml; for a 1 micron film leads to a final concentration of 0.05% (v/v) of polymer in the developer medium. For example for a Shipley 1813 exposed resist we obtain:

Time to clear	38.0 sec
Thickness	1342 nm
Average rate	35.26 nm/s
Initial rate	76.70 nm/s
Final rate	23.18 nm/s

This dara are derived from the dissolution curve shown in the next page.
The next curve was obtained by peak analysis of reflectance vs. time curves obtained at many wavelengths. After each experiment, 450 of these curves (one every nanometer between at least 400 and 850 nm) are available for analysis. The operator selects the useful wavelength range and the data is processed automatically. In some cases, as in the example below, the data can be analyzed with a non-linear algorithm that provides the rich data given above. In all cases the data can be exported in ASCII format (tab delimited text) for analysis with other software packages, or for display in publication format.



In many cases a simple linear fit may be adequate, as shown in the next example.

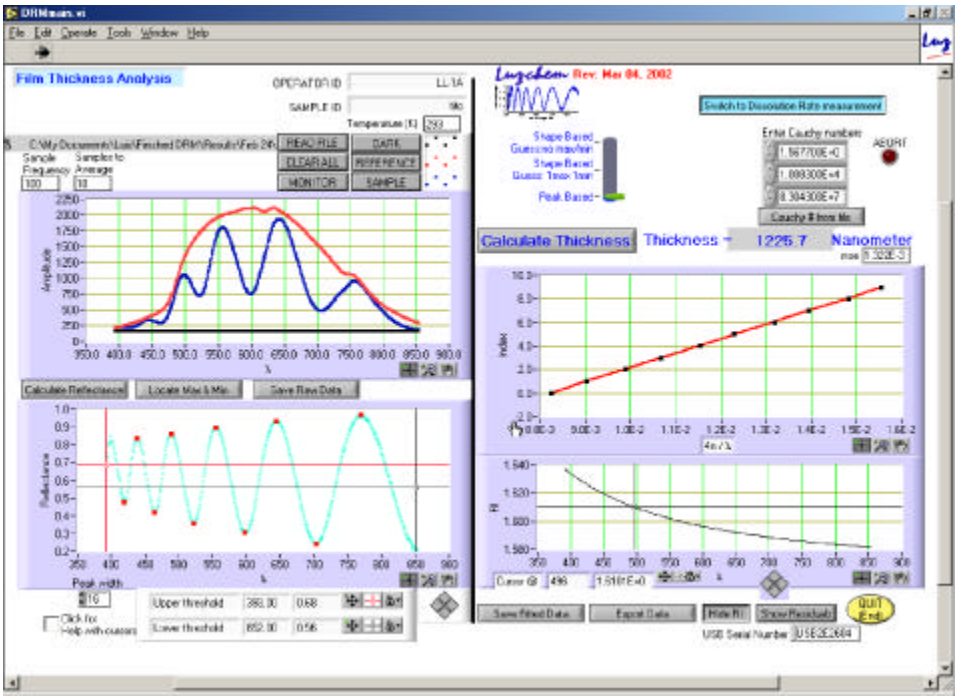


In this case we obtain:

Time to clear	11.85 sec
Thickness	1209 nm
Average rate	102.1 nm/s

For comparison, a separate thickness determination yields 1225 nm. If a non-linear analysis is performed on this sample, the data indicate that well over 90% of the dissolution occurs by a linear process, thus suggesting to the end user that this type of analysis may be appropriate.

We have successfully measured samples with times-to-clear as short as 2 seconds and as long as 1 hour.



Above: Typical TFA-11 screen during thickness data acqusition (left) and analysis (right)

The following table provides a summary of a selection of samples tested using the Luzchem TFA-11 system.

Label	Material	Thickness in nm			Dissolution data (rates R, in nm/s)					
		nominal	peak	shape	thick[a]	ttc	R_{in}	R_{end}	R_{av}	%linear
XX-1A	pHOST	1236	1226	1216	1211	12.20	103.8	103.8	99.2	98.6
XX-2A	pHOST	402	395	401	401	3.71	221	72	114.7	63
XX-3	HS/TBA[b]	945	926	921	897	3242	0.39	0.25	0.28	87
XX-4	HS/TBA[b]	402	389	392	383	985	0.63	0.37	0.39	90
XX-5	HS/TBA[b]	215	(209)[c]	195	186	333	1.04	0.37	0.56	66
XX-6	HS/TBA[b]	98	na	99.0	94	51[d]			1.84	Linear fit
Shipley 1827	Exposed	-	2450	2420	2493	83.5	77.6	20.9	29.8	67
Shipley 1813	Exposed	-	1279	1271	1307	37.4	80.6	24.7	35.0	70
Shipley 1805	Exposed	-	299	291	274	3.87	42.2	98.2	70.6	58

[a] Thickness based on the extrapolated dissolution curve.

[b] HS/TBA: hydroxystyrene (65%): *tert*-butyl acylate (35%)

[c] Peak analysis based on only two points, shape analysis should be preferred.

[d] Extrapolated.

Luzchem also plans to offer instruments with single capability, that is thickness determination only, or dissolution rates only. These instruments will be available in the summer of 2002. Luzchem is accepting orders for the TFA-11, and offering attractive introductory discounts and extended software maintenance.

Luzchem also offers a wide range UV exposure units and resist baking tools

Visit our website for more details