Measurlabs

Thin-film thickness measurements – a guide for method selection

Thickness is one of the fundamental properties of thin films. It affects the electrical, mechanical, and optical properties of the film, and is thus in a crucial role in its functionality.

Analyzing the thickness of developed films is an important part of product development for companies developing semiconductors, displays, medical devices, and electronics.

The thickness can be analyzed with several different methods like cross-sectional SEM and TEM, XRR, and ellipsometry. The selection is not always straight-forward, and in this guide we will discuss the benefits and limitations of each of these methods, and give insights on what factors to consider when making the selection.

Content

Why is method selection complex?

All analytical methods presented here come with their own limitations and capabilities of answering different research questions, and there is seldom a single correct answer for which method is the best choice. Instead, the selection depends on what methods are eligible for the type of material that will be analyzed, what other information you want to find out in addition to the film thickness, and how much money you are willing to spend on the analysis.

The factors that affect what methods are eligible for the material are the surface roughness of the film, the thickness range, and the material of the film and the substrate. These things thus need to be known at least approximately when selecting the method.

The limitations of XRR, SEM, TEM, and ellipsometry are presented in the sections below. Additional information that can be obtained with them are for example density, surface roughness, refractive index and structural properties of the film. For each method presented, also the additional information that it can offer is mentioned.

On the last page of this document you can find a summarizing table that hopefully helps you compare the methods and identify the most suitable one for your needs.

Thickness measurements with cross-sectional SEM

Scanning electron microscopy is a great method for analyzing the thickness of semiconductive thin-films. SEM works for both single- and multi-layer materials, and can in addition to the thickness also provide information about the surface morphology and elemental composition of the sample.

The method is suitable for conductive and semiconductive materials with a thickness between 100 nm and 100 µm. Non-conductive materials can be analyzed with the method if the sample is prepared with depositing a thin layer of conductive material on the surface.

It is good to note that for results on the elemental composition of the film, a SEM equipped with an EDS detector (energy dispersive spectroscopy) is required. The EDS detector measures the x-rays emitted from the sample when the electrons interact with it. As the detector analyses the x-ray spectrum, it recognizes the spectrums of individual elements and compounds and allows for their identification and quantification.

You can read more about SEM as an analytical method on our **SEM method page**.

Thickness measurements with cross-sectional TEM

Transmission electron microscopy is another method commonly used for analyzing conductive and semiconductive films. This method also works for both single- and multilayer materials in the thickness-range of a few nanometers to 100 nm.

Similarly to cross-sectional SEM, an EDS detector can also be attached to the TEM to obtain information about the elemental composition of the sample. With TEM you can also get valuable insight about the structure of the sample. The method thus offers a lot of information about the material, but the analyses are also clearly more expensive than the measurements done with SEM.

An important risk to consider with TEM is that the high voltage beam can burn and harm some materials. For example for polymeric and organic materials, the suitability of the material should be carefully considered before starting the analysis.

You can read more about TEM as an analytical method on our **TEM method page**.

Thickness measurements with XRR

X-ray reflectivity is a great method for analysis of layered materials. It allows not only the determination of the thickness of the film in total, but also gives information about the thickness and density of the individual layers in it. Surface roughness can also be measured as part of the thickness measurement with XRR.

The method is suitable for materials with a thickness smaller than 250 nm, optimally under 100 nm. For successful measurements, the thickness of the material must be at least one order of magnitude greater than the surface roughness of the film.

An important factor related to XRR is that the estimated composition and structure of the sample must be known for the analysis to be accurate. As the method relies on fitting the experimental XRR curve with the corresponding layer model using simulation, the analysis can result in large errors if the composition of the sample is unknown.

You can read more about XRR as an analytical method on our **XRR method page**.

Thickness measurements with ellipsometry

Spectroscopic ellipsometry is a commonly used method for thickness measurements of transparent and semitransparent single- and multilayer films.

The thickness-range where this method is suitable is between 1nm and 1000 nm. Ellipsometry also allows to calculate the refractive index of the film. The refractive index is the ratio of the velocity of light in a vacuum to its velocity in a specified medium, and gives information about how the material interacts with light passing through it.

You can read more about ellipsometry as an analytical method on our **ellipsometry method page**.

Get in touch to discuss thickness measurements!

Send us an email or contact us through our website to get in touch with our team of experts.

info@measurlabs.com

measurlabs.com

Guide sheet for method comparison

Method	Measurable film thickness range	Other sample requirements	Additional information obtained with method	Analysis cost / sample*
XRR	< 100 nm	The estimated structure and composition of the sample must be known prior to the analysis, and the thickness of the material must be at least one order of magnitude greater than the surface roughness of the film	Density, surface roughness	340 €
Cross-section TEM	Few nm - hundreds nm	The material must be conductive or semiconductive, but also non-conductive materials can be analyzed if first coated with a thin layer of conductive material.	Structure, also elemental analysis possible with EDS	2360 €
Cross-section SEM	hundreds nm - 500 µm	Similar to SEM, also requires the material to be conductive or semiconductive. The material needs to sustain the high voltage beam used in the analysis.	Surface morphology, also elemental analysis possible with EDS	827 €
Spectroscopic ellipsometry	< few µm	The material has to be transparent or semitransparent.	Refractive index	500 €

* The prices displayed are examples of starting prices, but the final analysis cost per sample may alter depending on sample material, the sample preparation methods included in the analysis, and the number of samples analyzed in one order. Please contact us at info@measurlas.com to request an offer for your specific analysis needs.

Measurlabs