

COVALENT ACADEMY Q&A

Episode 1: Spectroscopic Ellipsometry – The Swiss Army Knife of Optical Characterization

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01

Q: Can ellipsometry be done on coatings on machined metal surfaces? What are the limitations?

A: In general, yes. In order to measure coating thickness requires semi-transparent and transparent coatings because the measurement beam must be able to transmit through the film, reflect off the metal substrate, and return back through the film to the detector. There aren't generally any limitations for this specific type of sample beyond the normal limitations for ellipsometry. For thicker films (>0.5 microns) reflectometry is typically a better option.

02

Q: Will we have access to the recorded webinar?

A: The recording will be available to our members. We will send out information in the near-future on how to sign-up. Thank you for asking!

03

Q: You start with linearly polarized light but the reflected beam could become circularly polarized, right? Can you characterize nk of birefringent materials?

A: Yes and yes. To be more specific, linear polarization and circular polarization are actually just two special "end point" cases of polarization states. The more general polarization state is usually somewhere between these and is called elliptical polarization. This is where ellipsometry gets its name. In fact, ellipsometry does not actually require the incident beam to be linearly polarized. It can have any polarization as long as this polarization is known since the measurement is really just detecting the relative change in polarization state from incident to reflected beams. Birefringent materials can be absolutely be characterized, however, the measurement and analysis is often more complex than it is for isotropic materials.

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04

Q: How can we use the ellipsometry to measure the thickness of polymeric film it should be around 7 to 10 nm? We are having problem while building the model and the data we got is eccentric.

A: It is difficult to address the root of this issue without more information. From your description, it sounds like it can be done, however. Perhaps the films are not homogeneous throughout their thickness? Another approach is to make a couple of samples of different thickness and attempt to create a model that can consistently model them all. Or you could use another technique (i.e. TEM) to verify and fix the thickness in your model so that you can focus the fitting entirely on determining the correct optical properties. If you'd like assistance building a model, feel free to reach out to us directly – we offer SE modeling as a service at Covalent.

05

Q: What are the units of k?

A: The extinction coefficient (k) is unitless (so is n). By contrast, describing light absorption in terms of the "absorption coefficient" (usually denoted alpha) is related to k by [alpha] = 4*pi*k/[lambda] where lambda is the wavelength. The absorption coefficient is typically reported in units of inverse cm.

06

Q: Regarding the instrumentation, could you speak more on what information you extract in the IR range? What changes are made to measure anisotropic samples?

A: In general, there is no difference in the basic principles and modeling of IR ellipsometry from any other spectral range. There are some practical considerations about sample size, thickness sensitivity, etc. that are different, mostly due to the longer wavelenths used, however. In IR ellipsometry, the models still consist of optical spectra (n,k) and layer thickness. However, the physical phenomena that are dominating the shape of the n&k are often from a different origin than the phenomena that influence the shape in other spectral regions. In the IR, we are usually looking at molecular vibration modes, phonon modes, and free carrier absorption. We will likely discuss this further in an future episode on more advanced ellipsometry topics.

07

Q: What are the limitations of the multilayer samples in terms of thickness and meterial?

A: Unfortunately, there isn't a single simple answer to this because it often depends on the details of the layers and materials. However, ellipsometry excels with samples consisting of layers that are about 500 nm or less. It can handle layers that are thicker, but the accuracy of the optical property results begins to be reduced at larger thicknesses. An additional limitation is that the materials must be either fully transparent or partly transparent in order to have sensitivity to any underlying layers.

08

Q: How do you consider roughness of thin films in trying to model the delta and psi curves?

A: Surface roughness is almost always described as a separate layer which is an effective medium approximation that consists of a combination of material identical to the underlying film and void.

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09

Q: We are using silicon wafer so it will have a silicon oxide layer and then a thin film of polystyrene film (around 7 nm). And for another sample on top of these film we'll have a film of PS-b-PMMA(around 100 nm).

A: Feel free to contact us directly about your project. We offer SE modeling services at Covalent and would be happy to assist with your project.

10

Q: Are Psi and Delta mirror images of each other?

A: No. Often they can look to be related because an absorption feature in the material will affect both of them at the same wavelengths, but they are completely different parameters. Delta is related to the phase change, and psi is related to relative amplitudes.

11

Q: Is "error function" what you see listed as MSE in the Woollam software?

A: Yes it is but there are many forms that can be used to generate the MSE depending on the model and needs.

12

Q: Does the reflection of light depend on the defects or localized states of the amorphous materials? For instance, the order in a crystalline material is long range order and I assume that the light reflection should have the same property irrespective of the location where the light gets incident.

Whereas, in the case of amorphous materials, it is mostly short range order and abundant with defects which will be different, so I was wondering how the detector can detect and analyze the reflected light for amorphous material?

A: Good question. The intensity of the specularly reflected beam is nearly entirely a function of the smoothness and flatness of the surface, not of the material phase. However, the optical properties of an amorphous material are different from those of the corresponding crystalline phase of that same material (look up the optical properties of amorphous vs crystalline Si for an excellent, easily accessible example). Since the measured ellipsometric spectrum (psi, delta) is sensitive to the optical properties of the material, it too will be different for amorphous and polycrystalline materials because it contains the information about the optical properties within it.

13

Q: Max may talk about this later, but i am wondering if you exclusively use WVASE32 or completease to do your modeling? If so, I do have a follow-up regarding this.

A: We use CompleteEASE for nearly all data analysis. Although the cases where the added flexibility of WVASE is required are decreasing as JA Woollam Co. further develops CompleteEASE features, we have access to and extensive experience with both.

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14 **Q: Do you calculate the mathematical area or absolute area between the model and the experimental data to guide the next step of iteration?**

A: Calling it "area" is actually a bit of an oversimplification I used to help make the general concept more accessible. The error functions root mean squares of the difference between model and measurement at each spectral point.

15 **Q: How do we go from k to alpha (or viceversa)?**

A: Alpha = 4*pi*k/lambda (lambda is wavelength)

16 **Q: Does the thickness of the material/sample matters?**

A: In a general sense, no. The modeling can handle a wide range of layer thickness. However, there are some limitations. These have been discussed in other answers, but generally, the accuracy of results begins to substantially degrade for films over ~500nm and the films must be transparent in at least part of the measured spectral range to get thickness results.

17 **Q: Can ellipsometry be used to interrogate surfaces of prisms, or other various optic shapes?**

A: If I understand your question correctly, i.e. can ellipsometry measure planar surfaces of prisms, then the answer is yes.

18 **Q: How much time it takes for measuring a 300 mm wafer for compositional uniformity? How many points are collected to map the whole wafer?**

A: The number of points (i.e. point density) is entirely customizable and would be chosen based on how fine a resolution you needed to know the uniformity. You can extrapolate this for any density you want using the basic benchmark that we can measure each point in ~3s.

19 **Q: What kind of water resistant coating was it?**

A: [Referring to the PCB coating example]. Sorry – proprietary customer information.

20 **Q: What area on PC board did you try to analyze? Was it a metal line?**

A: We specifically chose locations where there were no elements. It was the bare green board material (no metal lines).

21 **Q: Are we able to measure roughness in terms of Ra or Rz with method?**

A: An overall value of roughness can be determined – see other answers for more detail on how. The

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roughness is not specifically any Ra, Rq, Rz parameter, however. It usually has closest correspondence to Rz or Ra. If you are interested in differentiating between specific roughness parameters, a different surface profilometry technique would be required. Contact us if you have a specific project you'd like to discuss.

22

Q: Sometimes you will get the goodness of fit value, Chi square very low, but the extracted values are unrealistic, like negative loss. So, is it true that we cannot simply rely on Chi square alone find a good fit to experiment data?

A: Yes. As in most modeling, you need to consider the physical limitations of the model. Sometimes this type of thing can result from having an anisotropic material being modeled by an isotropic model. Or, in other cases, the model is not a good representation of the actual sample characteristics such as if the model uses a single homogeneous layer to model an inhomogeneous layer. Any insufficiencies in the model configuration will then manifest themselves as artifacts in the optical properties that are compensating for the insufficiency.

23

Q: What is the maximum thickness an ellipsometer can measure?

A: Depends on material -- typically a few microns.

24

Q: Why model the gradient of dip coating in discrete steps vs another function?

A: Gradients are most conveniently modeled as discrete steps that approximate a smooth variation. This is because the mathematics that calculate the optical effects of the model are based upon discrete layers and interfaces. When needed, the number of steps can be arbitrarily increased to better approximate a smooth variation.

25

Q: What maximum thickness you can work with? Does it matter if the material is transparent/opaque in visible(400nm-700nm)?

A: Maximum thickness is material dependent and there is no universal maximum thickness. The accuracy of the results and ease of modeling decrease with increasing film thicknesses after about 500nm (that's a rough benchmark). As long as the material is transparent in some portion of the measured spectrum, we can gain sensitivity to the thickness.

26

Q: What is the extra information from measurements at multiple angles compared to a single angle?

A: For isotropic samples, all information about the sample is contained in a measurement at a single angle. However, fitting a model to multiple angles ensures that the model is reproducing the measured data at multiple angles which can reduce correlation between fit parameters and ensure that the model result is consistent. With a single angle, it is possible to "coincidentally" fit the measured data well with a

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model that doesn't accurately describe the true sample properties. With multiple angles, the likelihood of this case is drastically reduced. For anisotropic samples, multiple angles of incidence can result in the measurement beam taking different paths through the sample which can help provide sensitivity to the anisotropy. Usually, however, a combination of a few strategic measurements are best for gaining sensitivity to anisotropic properties in a sample.

27

Q: With the laser confocal microscope is it possible to differentiate between the interface roughness and top coating roughness? Thanks

A: In principle, this tool can measure both surfaces (top surface and film-substrate interface) for transparent coatings. Our experience is that this is often challenging in practice and only works well for near-ideal samples (transparent coating, fairly smooth surfaces). In this case, however, the laser confocal measurement shown in the presentation was of the surface of an uncoated board.

28

Q: What is the limitaion of the choice of wavelength based on the surface roughness?

A: The shorter the wavelength, the more roughness adversely affects the signal intensity and results. Both the Woollam NIR-UV and IR instruments that Covalent uses, however, collect the entire spectrum for each measurement automatically. If part of the measurement is deemed unreliable due to poor intensity, it can be removed from analysis following the completion of the data acquisition.

29

Q: What makes ellipsometry better than WLRS?

A: Depends on the samples and application. WLRS assumes indices for most analysis.

30

Q: This is a little off topic, but have you seen peaks/throughs when performing optical 3D profilometry due to interference fringes?. How, were you able to remove/model them out? I use a ZeScope to perform optical profilometry.

A: Yes. We typically switch to a different technique if this becomes an issue rather than attempt to model/remove them.

31

Q: What is the minimum surface roughness that ellipsometry can detect?

A: Same as the minimum film thickness: sub angstrom but depends on the sample.

32

Q: How do you define the optical properties of surface roughness? Some effective refractive index models?

A: Correct. We use an effective medium approximation that mixes the optical properties of the underlying material with void. It depends on the material, morphology, roughness thickness, and other factors, but sometimes this is fixed at a 50%/50% mixture, other times the relative proportion of material and void can be a fit parameter.

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33

Q: What is the max thickness ellipsometry (up to 1000nm wavelength) can measure?

A: Other answers address this, but in general, it depends on the material and desired result accuracy. The accuracy decreases with increasing thickness. Typically, 500nm or less is a good benchmark to be within the range where ellipsometry is best suited, although it can handle films that are multiple microns thick depending on the application and desired results.

34

Q: Should there be other interfaces added? e.g. glass/TaN and TaN/roughness?

A: In modeling ellipsometry measurements, the simplest model that produces a good fit to the data is the best. Adding more layers and optical parameters to the models increase the possibility of correlation and incorrect results. In this case, the surface of the glass (as is typically the case for glass) is very smooth and there is no significant interface between it and the film.

35

Q: What if your substrate (which could be a wafer of known properties) has a layer of variable material (polycrystalline) and you are trying to measure a thin film deposited on top of all that? not sure how to model the layer in between. Should we charactarize that layer independently before the final thin film?

A: The best approach here would be to measure the substrate and first layer separately. Use those measurements to accurately determine the properties of that first layer. Then use those results to model measurements of the sample with the “first layer” and thin film while keeping the “first layer” properties fixed.

36

Q: I’ve struggled to use glass substrates for ellipsometry with visibly transparent thin films. Do you have a suggestion for what model to use for fitting glass?

A: It’s a little difficult to provide advice without knowing more about the films. Generally, the case that you are describing should be do-able. Feel free to contact us to discuss.

37

Q: For rough thin films like silver, how can I develop a model?

A: Again, without knowing more of the specific sample details, it’s a little difficult to say for sure. Silver can be a little tricky because of the fact that it readily oxidizes in atmosphere. Also, the roughness layers of metals can occasionally be a bit more complex than those of other materials due to resonant effects in isolated metal particles / grains. This is a potentially complex issue that you should contact us with should you want more assistance.

38

Q: What are the major sources of error when we try to fit an anisotropic sample with a simple model? I tried this a lot.

A: Typically k goes negative and an unrealistic n.

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39

Q: When you say that you measure the substrate first, what do you actually measure in terms of model? a random film with zero thickness?

A: We simply measure a bare substrate with no film that is identical to those used with the films. To model this, we exclude any film layers (which is technically the same as a random film with zero thickness because anything with zero thickness means there is nothing there). Almost always, bare substrate models are simple: a single layer or a single layer with small roughness.

40

Q: What if the material is in-plane anisotropic? How does the model incorporate that?

A: This can be modeled by describing the optical properties in one in-plane direction as different from those in the orthogonal in-plane direction. The more important thing for measuring a sample of this kind is to measure the sample at multiple azimuths (i.e. rotate it on the stage between measurements) in order to gain sufficient sensitivity to the properties in each direction.

41

Q: Sorry, let me be clear: say you have 50 nm of transparent aluminum oxide on top of a machined aluminum part with Ra 8 or 16 or 32 uinches. Is that substrate surface roughness too high to get enough signal?

A: That level of roughness is pushing the limits of our ability to get signal from the substrate. Some of this depends on whether you mean 50 nm of conformal coating on the roughness surface or 50 nm bulk coating thickness above the roughness. This is a complex application and you should contact us directly to discuss further should you want to pursue.

42

Q: The actual thickness should be TiN+rougness or TiN?

A: It really depends on how you define thickness. A common metric we like to use is “effective thickness” which is the bulk film layer thickness plus 0.5*roughness thickness (assuming the roughness layer is modeled as 50% material / 50% void).

43

Q: How do you get the composition from the index of refraction?

A: Composition changes change the optical index and the relationship between the index of refraction and composition can be “calibrated” by complimentary characterization that is sensitive to the composition. Once known, this relationship can be used to directly determine composition in ensuing measurements.

44

Q: What are the upper and lower limits of film reflectivity required for ellipsometry measurements?

A: There is no upper limit. The source intensity can be modulated to keep the intensity on the detector within acceptable limits. There isn’t a universal answer for the lower limit as well, but basically anything that specularly reflects enough light to measure psi and delta can work. At really low reflectivities, the data becomes quite noisy, however.

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45

Q: What are the pros and cons of ellipsometry compared to other techniques such as SIMS, XRR, TEM?

A: This is too general a question for this format since there are many factors that would influence this comparison. If you have a specific application in mind, don't hesitate to contact us to discuss the best characterization method for what you are trying to determine.

46

Q: What is the size of the light spot of the Ellipsometer? and what's the minimum pattern size it can measure?

A: The "raw beam" is ~5 mm in diameter. The interaction area with the sample spreads in the plane of incidence due to measurement at oblique angle of incidence. We have focusing optics available to focus this beam down to ~300 microns in diameter. The same spreading occurs in this configuration as well. The minimum pattern size that can be measured is therefore features that are a little larger than about 300 x 500 microns. The JA Woollam company has focusing optics that can focus to an even smaller beam spot. I forget how small their smallest offering is, but I encourage you to contact them for more information.

47

Q: Thanks Chris. My follow up is regarding modeling anisotropy using BIAXIAL model in WVASE32. I'm wondering if at some point you or Max may discuss strategies for modeling unique/unknown anisotropic materials and whether you've encountered any issues with this?

A: We will likely address this in a future episode.

48

Q: What are the major sources of error for fitting an anisotropic sample with simple model?

A: The optical model in the isotropic case assumes properties in any direction are the same. For an anisotropic material, this is not true and this affects both psi and delta and changes with wavelength. In general, this results in incorrect values of n and k as the optical properties are attempting to compensate for the fact that the model is not accurately describing the true nature of the sample.

49

Q: Hi, Is there any model for measuring the thickness of SU-8 on silicon wafer?

A: I have not measured any SU-8 samples yet, but we would be happy to discuss this further. Please contact us directly and we can discuss this.

50

Q: Are the models for graded films (where you could "mix" your own films) available in the Woolam software?

A: Yes. Any layer can be modified to be a graded film in JAW CompleteEASE. Right click on the layer name and select "Grade Layer." There are many ways of applying grading to layers.

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51

Q: Regarding bulk polymer thickness: Is it on top of Si substrate? how do you decouple the bulk polymer and surface layer?

A: It is not on top of a Si substrate. It is simply a thick (many mm) slab of polymer. In this case, we decouple the bulk polymer and surface layer by modeling as 2 layers. Originally, we attempted to model the sample as a single semi-infinite (substrate) layer. When this was unsuccessful, we knew that there was more complexity to the sample in the form of the surface layer.

52

Q: How did you calculate reflectance on slide 31?

A: In practice, it is a convenient feature built in to the Woollam software. A more general answer to your question is that it is a simple extension of the same mathematics that we use to calculate the interaction and propagation of the light beam through the sample layers. The same mathematics based on the Fresnel coefficients and Beer's Law that we use to calculate psi and delta from the model can be used to simply calculate the reflected intensity relative to the incident intensity.

53

Q: Will the Q&A's also be made available? I'm finding them useful but it's hard to focus on the webinar at the same time.

A: Absolutely. But you know that by now because you are reading this.

54

Q: Is it possible to get transmittance spectra for each layer in a multi layered system? If so, and you did this in your IR instrument, can you essentially get thickness measurements and IR spectra of each layer in the film?

A: Obviously, the details of the multi-layer stack would be relevant to the feasibility, but the general answer is that transmittance spectra is not really necessary to determine those parameters. You can typically determine the thickness and optical properties of layers in a stack with ellipsometry measurements alone. If I am not understanding what you are looking for, please contact us directly and we'd be happy to discuss. The complexity of the stack will have a large influence on what measurements / sample configurations will be necessary to determine the properties you seek.

55

Q: What are the best methods for determining incorrect fits in a model? Eg. even for a simple single film structure often a similar fit can be achieved both with and without roughness or with/without absorption.

A: There is no universal answer, however the case you describe is by no means a rare one. Common strategies are to measure multiple samples, ideally of different thicknesses, and find a common model that will fit them all well. Or consult literature for what a realistic model would be for the sample details. Or validate your model with a complementary measurement (AFM, SEM, TEM). Once validated, you can feel confident applying that model to future samples.

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56

Q: Is the roughness reported average roughness or RMS roughness?

A: Since we are describing the roughness as a homogeneous effective medium approximation mixing the optical properties of a material and void, there isn't always a clear roughness parameter analogue. Mean roughness and RMS roughness are often the most similar roughness parameters to the value determined by ellipsometry, but the results can vary by sample. For a more detailed understanding of specific roughness parameters, a separate type of surface profilometry would be necessary.

57

Q: Is the technique applicable to thin films of nanocoposite where the nanoparticles can scatter light?

A: In general, yes. This would be a fairly complex system to model, but similar samples have been measured and modeled before so there is an established modeling technique for this type of sample.

58

Q: What model was used to extract the band gap in the final example?

A: The optical properties of the CdS were described as the sum of multiple Tauc-Lorentz oscillators. This is an admittedly crude model for a polycrystalline material such as CdS since the Tauc-Lorenz model is designed for amorphous and disordered semiconductors. There are more accurate models available that are tailored to crystalline and polycrystalline semiconductors, but there is sort of increasing efforts with diminishing returns effect at play with this modeling. Tauc-Lorentz oscillators have many desirable characteristics that make them easy to use and, consequently, we obtained reasonable results quickly with this modeling approach without using the absolute best but far more complex modeling practices.

59

Q: Is there some SE study on 2d material, such as graphe, TMD material?

A: Absolutely. I encourage you to do a search on the literature of SE applied to 2D materials. You will find plenty.

60

Q: When fitting multiple values (ie- thickness, n & k) what is the minimum amount of data needed? I have been told previously that you will want at least 1 more data scan than # of paramters being fit. For example, if I were fitting thickness, n & k on a sample I would measure at least 4 angles on a VASE elliposmeter since I want to fit 3 values. Is this the correct approach?

A: The general spirit of what you have been told is correct, but the details are not strictly correct. As I mentioned in an earlier answer, all information about a sample is theoretically contained in a single angle measurement. Adding more angles helps to decrease correlation between parameters and ensure the best possible sensitivity to the sample properties. Each angle added, however, does not add an entire measurements' worth of new information. Keep in mind that if you are collecting spectroscopic measurements on a VASE instrument, you likely have hundreds of data points. If your optical properties are being described by a parametric equation, you probably only have 5-20 (ish – can depend on sample)

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free parameters in addition to the thickness. That means that you actually have far more "knowns" than "unknowns." Usually, for a basic case of a thin film on substrate, more than three angles of incidence is unnecessary.

61

Q: How did you correct for the backside reflection from the glass substrate? Also, how would you proceed if your film had a similar index to that of the substrate (assuming you cannot refabricate your sample set on a different substrate)?

A: The preferred method for dealing with backside reflections is to eliminate them entirely by physically roughening the backside with an abrasive. If that is not possible, a mathematical backside reflection correction can be applied to the modeling which essentially accounts for the depolarization induced by the incoherent combination of frontside and backside reflections. If your film has a similar index to that of the substrate and you have no option of re-fabricating, the best you can do work to develop a model that remains as unique as possible (low error bars and low parameter correlation). A possible approach could be to measure the sample with an alternative technique (cross sectional electron microscopy, for instance to determine thickness) in order to find alternative means of knowing parameter values you can fix in your model.

62

Q: Can you tell anything about the crystalinity of a film sample with ellipsometry?

A: Yes, but indirectly and it is often a relative measure, rather than a directly quantitative measure. The degree of crystallinity in a sample (average grain size, for instance) will affect the shape of the optical properties. Absorption features will be broader and less "distinct" with smaller grain sizes or more disorder. Thus, these absorption features can be modeled with parametric models where the broadening parameter is a proxy for degree of crystallinity. This has been well established in literature. This is often best used as a relative measure, however, in comparing multiple samples to each other.

63

Q: The figures show data spanning ~300nm to ~1600um. What is the resolution of the data points?

A: About 1.5 nm.

64

Q: It would be very interesting to hear in the future about how powders can be analyzed by ellipsometry.

A: Thank you for the feedback. We will very likely include it in a future episode because we agree – it is a very interesting application.

65

Q: What happens if my beam is larger than my sample?

A: We can focus the beam down to ~300 microns which should be sufficient for nearly all samples.

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66

Q: Are you using focusing probes on your ellipsometer?

A: We can. We will always opt to not use focusing probes if possible because it's simply another optical element in the beam path that needs to be accounted for. However, for samples where this is necessary, yes we can use focusing probes.

67

Q: Are there any difficulties or consideration for measurement of optical transparent (VIS) film on glass?

A: The modeling can be difficult (or impossible) if the film properties are VERY close to those of glass. Otherwise, no. This type of sample can be handled.

68

Q: What is next week's seminar on surface roughness? Is it for surface roughness measurement with ellipsometry?

A: No. It will be a general discussion of surface roughness measurement that will discuss the many pros and cons of the different types of instruments that we have available at Covalent Metrology that are capable of measuring surface roughness.

69

Q: Do you use bandwidth compensation in your models?

A: We find that it is typically not necessary for most samples, but will use it in cases where the instrument bandwidth is found to be affecting the measurements.

70

Q: Does humidity and temperature in atmosphere will influence the transmission of light , which will influence the accuracy of measurements for a samples?

A: For measurements on the tools we use at Covalent Metrology, no. Even further into the ultraviolet, however, this becomes a serious issue, however. The JA Woollam Company makes an instrument designed to mitigate humidity effects in the ultraviolet, however called the VUV-VASE. This uses a nitrogen-purged measurement chamber to eliminate unwanted atmospheric absorption.

71

Q: Can you comment on measuring/fitting the semicrystalline polymer films?

A: This is a fairly general question that will depend strongly upon the details of the film Please contact us directly if there is a project you'd like to discuss.

72

Q: Roughness and mapping do you also use other metrology tool to help with Ellipsometer?

A: Yes. We will frequently use the results of measurements on a separate instrument to help guide our modeling of ellipsometry measurements. Examples of this are determining the roughness or

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layer thickness with another tool and then using that known value in our fitting of ellipsometric measurements. This is one of our strengths at Covalent. We are able to use the results of multiple complementary characterization techniques together to enhance the accuracy and quality of the overall results we obtain.

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Q: Will you email us for future seminars?

A: Yes. In the immediate future they will be every week on Wednesdays at 11 AM PDT. You will receive an email if you are in our database.

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