J.A. Woollam Co., Inc.

Ellipsometry Solutions

Mission

For over 100 years, Lincoln, Nebraska has been a world center of ellipsometry expertise. In 1987, the J.A. Woollam Company was founded to provide commercially available, high quality instrumentation, software and support to the world ellipsometry community.

Initially, the North American research market dominated our business. Very quickly it expanded to include universities, industrial laboratories, and manufacturing worldwide. Today, over fifty employees are dedicated to continued development and manufacture of quality instruments and outstanding customer support. Sustained efforts year after year have made the Woollam Company a world leader in ellipsometer technology and application expertise.

In 2012, we celebrated twenty-five years of business. We want to thank all of our customers, business associates, and friends around the world for their continued support and loyalty. These twenty-five years have been enormously satisfying as we continue to serve the needs of many wonderful people.

From the beginning, we focused our business exclusively on ellipsometry, allowing us to become world-renowned in hardware, software, applications, and support. Our instruments now measure vacuum ultraviolet to far infrared to the terahertz spectral range. We serve numerous technical disciplines including fundamental materials research, lithography, semiconductor processing, optical coatings, data storage, flat-panel displays, polymer chemistry, biomaterials, nanomaterials science, photovoltaics, and more.

Our business is to help solve problems in research, development, and manufacturing. A strong and growing part of our business is to engineer special instruments and systems to meet individual customer needs. Many become new products. Examples are vacuum ultraviolet ellipsometers, in-line ellipsometers, and in-situ ellipsometry for control of thin films. Another example is where our instruments are integrated into other company products to enhance total value and usefulness to the ultimate customers.

Our focus remains the same as when we started: provide the world's best ellipsometers coupled with technical support and in-depth knowledge of their use. We look forward to many more years working with and serving you.

John A. Woollam

About Us

Our People

A business is only as good as its people. From initial customer contact to post-sale support, the Woollam Company strives to keep close contact with our customers. Our dedicated team of over 50 employees and network of worldwide representatives are committed to providing the personal attention and service you expect from a small company of dedicated individuals.

—Measurement & Applications—

Our Focus

Concentrating on one technology allows the Woollam Company to remain focused on spectroscopic ellipsometry, instrumentation, software, applications, and support. Instruments are designed, assembled, tested, shipped, programmed, and supported at our facility in Lincoln, Nebraska. Keeping all activities at one location maintains quality through close cooperation throughout the company. Our network of international representatives is extremely well trained to extend our focus on quality and service worldwide.

Instrument Testing

Our Customers

We recognize our customers are the reason for our success. Our customer base forms an extended family of users including top researchers, professors, scientists, engineers, and students throughout the world. We value customer feedback and use it to improve our products. We learn as much from our customers as they learn from us.

Short Course for Woollam Customers

What Makes Us Different

Support

J.A. Woollam has 10 applications engineers to support customers in North America. Each is an expert at ellipsometry measurements and data analysis for a wide variety of sample types. In fact, our group has measured over 17,000 samples for customers since 1987.

Software

We pride ourselves in making our software easy to use, yet still have the functionality to analyze even the most complex samples. Because we constantly use the software while developing customer applications, we design and modify the software for optimum measurements and data analysis in a user-friendly platform.

Built to last

We regularly hear from customers that have been using the same J.A. Woollam Ellipsometer for 10, 15, and even 20+ years. We stand by our products and want customers to trust they will get many years of quality use. This devotion to customers has led to our policy of providing free software upgrades for years (even decades) later - so each customer can be using our latest technology.

Dedication

We have over 50 employees dedicated to the advancement of spectroscopic ellipsometry. Because ellipsometry is our only focus, we concentrate all efforts on making the most advanced spectroscopic ellipsometers in the world.

Proven

For over 25 years we have been supplying World-class spectroscopic ellipsometers. The real proof comes from our customers - they are performing top-notch research at Universities, Government Labs and Companies around the world. We encourage you to contact existing Woollam customers and read their publications for evidence of this commitment to excellence.

J.A. Woollam Patents

Innovation

Our R&D group is working on every aspect of ellipsometry. We have introduced new products to extend the current capabilities of SE - extending to the widest wavelength range available: from vacuum ultraviolet to terahertz. With continual evolution of each instrument and software, you can count on the most sophisticated and powerful ellipsometer systems. Our work has culminated in over 140 patents that distinguish our technology.

Worldwide Sales & Support

We serve our customers worldwide through a network of well-trained representatives. Each representative focuses within a specific geographical region, establishing close ties with customers as well as local support and training in their countries.

We maintain a close partnership with our representatives worldwide. Woollam Company engineers often visit our representatives in their respective countries to attend seminars and visit customers. They visit our office in Lincoln regularly for updated training.

Our Family of Representatives

Europe

LOT-QuantumDesign
www.lot-qd.com

United Kingdom

LOT-QuantumDesign
www.lot-qd.co.uk

Japan

J.A. Woollam Japan Corporation
www.jawjapan.com

Korea

WizOptics
www.wizoptics.com

Australia

Scientific Solutions
www.scisol.com.au

Taiwan

Titan Electro-Optics Co., Ltd.
www.teo.com.tw

Singapore

Crest Technology
www.crest-technology.com

India

Sinsil International
www.sinsilinternational.com

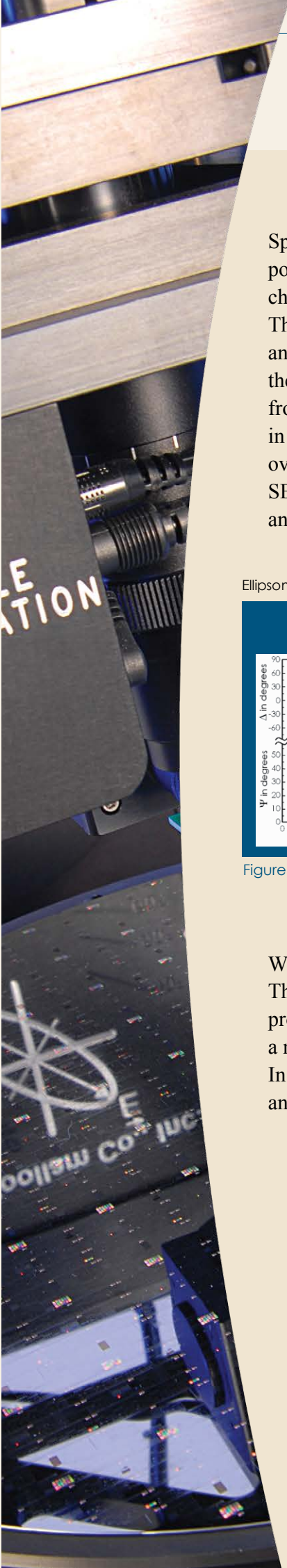
China

Genuine Optronics, Ltd.
www.gen-opt.com

Israel

Vacuum System & Technology
www.vacuumltd.com

Dedication



Spectroscopic Ellipsometry

Spectroscopic Ellipsometry (SE) uses polarized light at many wavelengths to characterize thin films and bulk materials. The light probes each layer; reflecting and transmitting at every interface until the total reflection contains information from each layer. SE allows measurement in a transparent region for films that absorb over other portions of the spectrum. Thus, SE can fully characterize multi-layered and structurally complex materials.

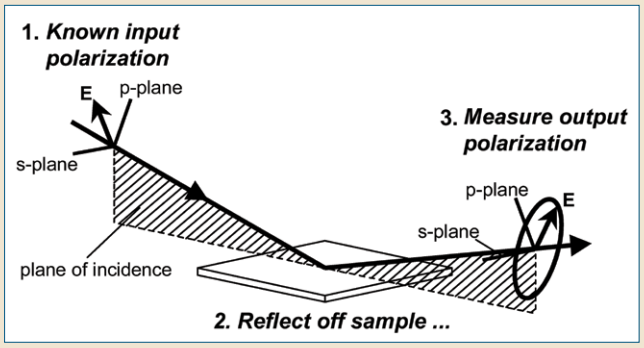


Figure 1

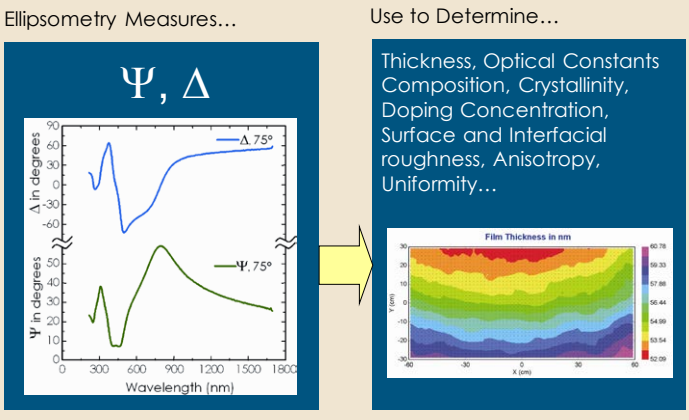


Figure 2

The most common application of SE is determination of thickness and optical constants, commonly called n & k values. However, these properties are not directly measured. Ellipsometry data describes the change in polarization for reflected or transmitted light as an amplitude ratio (Ψ) and phase change (Δ). Thickness and optical constants are determined through regression analysis, where a proposed layer structure is compared and "fit" to find the best match to experimental measurement.

We have developed SE instruments to cover the spectrum from vacuum ultraviolet to far infrared. The optical properties of materials vary dramatically over this range, as short UV wavelengths produce electronic transitions and long wavelengths vibrate the lattice or molecular bonds within a material. Figure 3 shows the optical constants of an organic film over this entire spectrum. In the figure, notice strong IR absorptions due to molecular vibrations, the transparent visible and NIR, and strong UV absorptions due to electronic transitions.

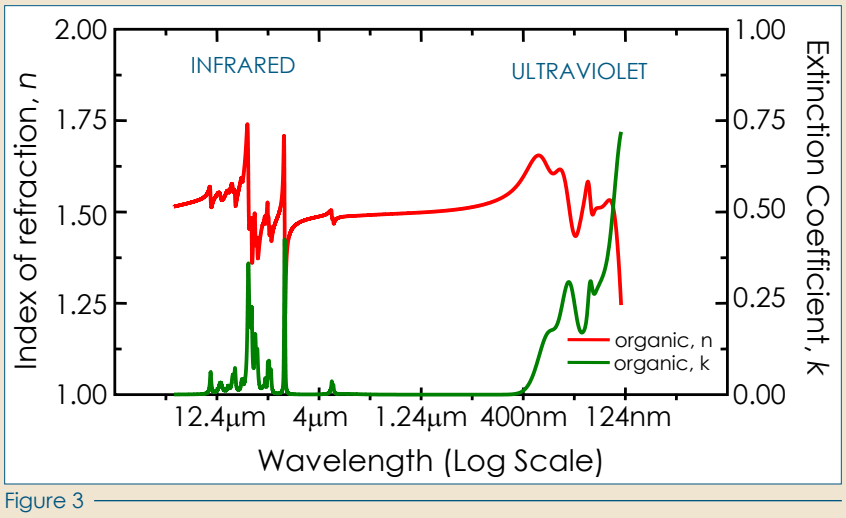


Figure 3

The shape and position of material absorption features provides information regarding material properties – process conditions, crystallinity, composition, conductivity, and more. Spectroscopic ellipsometry is used to analyze compound semiconductor films such as $Al_xGa_{1-x}As$ and $Hg_{1-x}Cd_xTe$, where UV absorption shifts with composition, *x* (Figure 4). The UV absorption also varies for polycrystalline silicon films, depending on crystallinity (grain size and shape). Figure 5 shows optical constants for various organic films used in OLED applications. Infrared absorption increases for metals, doped semiconductors and transparent conducting oxides as conductivity increases. Spectroscopic ellipsometry is used to monitor sheet resistance in films such as Indium Tin Oxide (Figure 6).

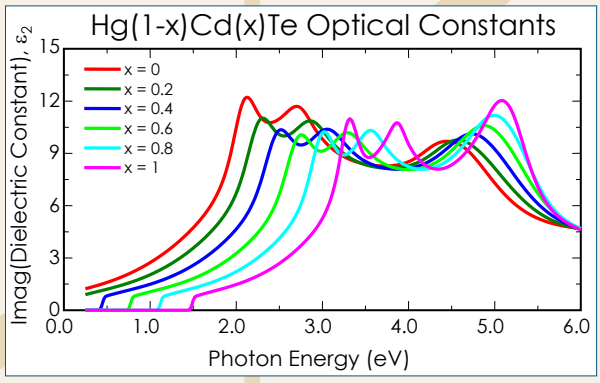


Figure 4

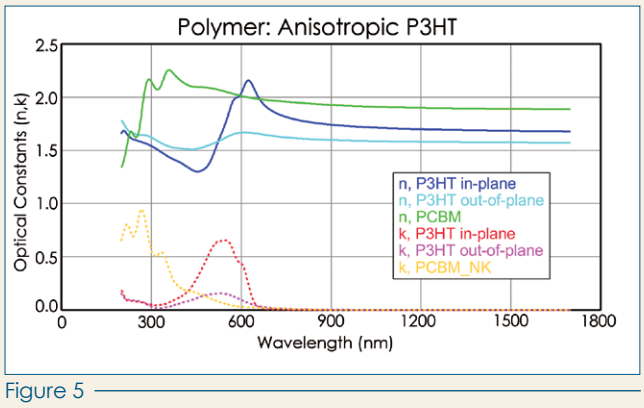


Figure 5

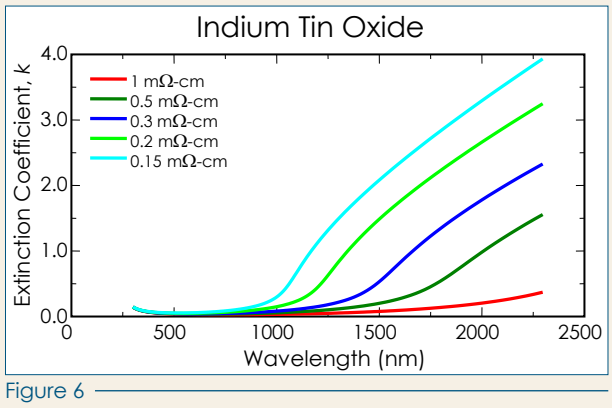


Figure 6

Applications

Spectroscopic ellipsometry measurements are flexible and can be applied to different types of materials, including semiconductors, metals, dielectrics, and organics. For this reason, SE has found application in a variety of industries and research areas.

Optical Coatings

- SiO_2, TiO_2, Ta_2O_5, Al_2O_3, MgF_2, anti-reflection coatings and stacks, SnO_2, ITO, electrochromics, photochromics, beamsplitters, and both a-plane and c-plane retarders.

Displays

- a-Si, poly-Si, micro-crystalline-Si, OLED layers including both small-molecule and polymer layers such as P3HT:PSS, PEDOT, PCBM, NPB, etc., color filters, ITO, MgO, viewing angle compensation films, polyimide, and liquid crystal tilt profiles.

Photovoltaics

- Crystalline, polycrystalline and thin film cells, SiN_x, a-Si, textured Si, CdS, CIGS and CdTe.

Semiconductors

- Oxides and Nitrides, Resists, photomasks, SiON, low-K dielectrics, high-K gate dielectrics, SOI, SiGe, II-VI and III-V ternary and quaternary compounds.

Chemistry/Biology

- Organic films, self-assembled monolayers, Langmuir Blodgett films, protein adsorption studies, glass transition temperature studies in polymers, and ATR ellipsometry in the infrared.

Data Storage

- Diamond-like carbon film, phase-change media for recordable media, and magneto-optics.

Ellipsometers

Largest variety of spectroscopic ellipsometers in the world.

M-2000®

The M-2000 line of spectroscopic ellipsometers are engineered to meet many demands of thin film applications. Advanced optical design, large spectral range, and fast data acquisition combine in an extremely powerful and versatile tool.

M-2000 ellipsometers are ideal for applications where speed and accuracy are required. This ellipsometer truly excels for in-situ monitoring, quality control, uniformity mapping, and general purpose thin film characterization.

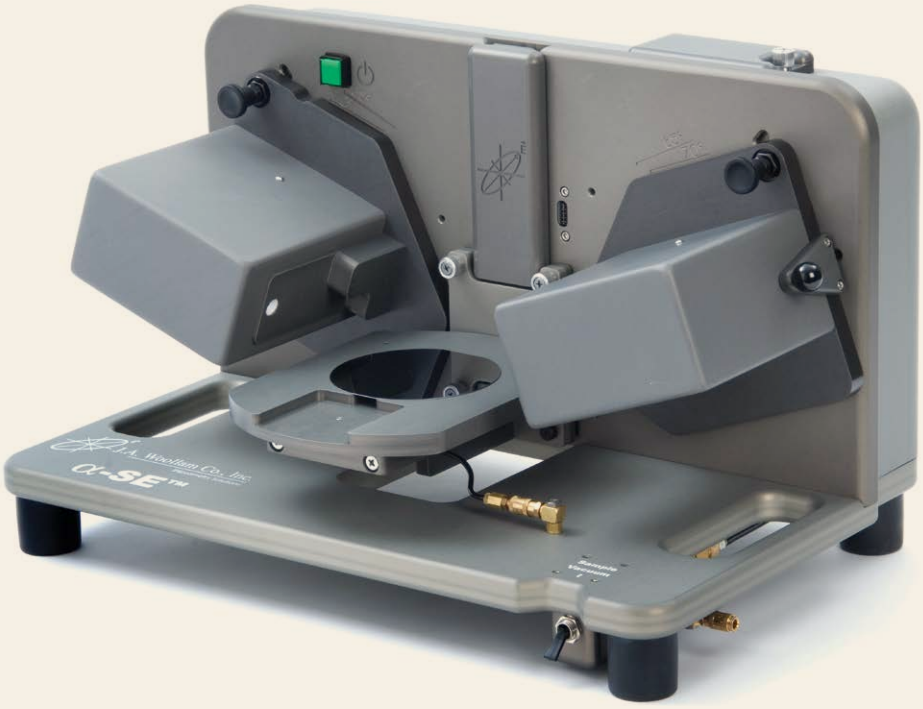
AccuMap-SE®

The AccuMap-SE combines a high-speed M-2000 spectroscopic ellipsometer with fast mapping for large panels. The broad spectral range of the M-2000 is well suited for mapping all thin films in photovoltaic, architectural windows,and flat panel display applications.

Innovation

alpha-SE®

Need to measure thin film thickness and index? The alpha-SE provides an easy solution. It combines advanced measurement and analysis technology into an entry-level system. The alpha-SE is suitable for measuring transparent films and substrates, metals, semiconductors and more.



RC2®

The RC2 design builds on 20 years of experience. A near-universal solution for the diverse applications of spectroscopic ellipsometry. It combines the best features of previous models with innovative new technology:

- DUAL rotating compensators for high accuracy, high speed, and complete Mueller-matrix measurements.
- Patented achromatic compensators for optimized performance over a wide spectral range.
- Advanced light source and spectrometer design for improved measurement data.

Ellipsometers

VASE®

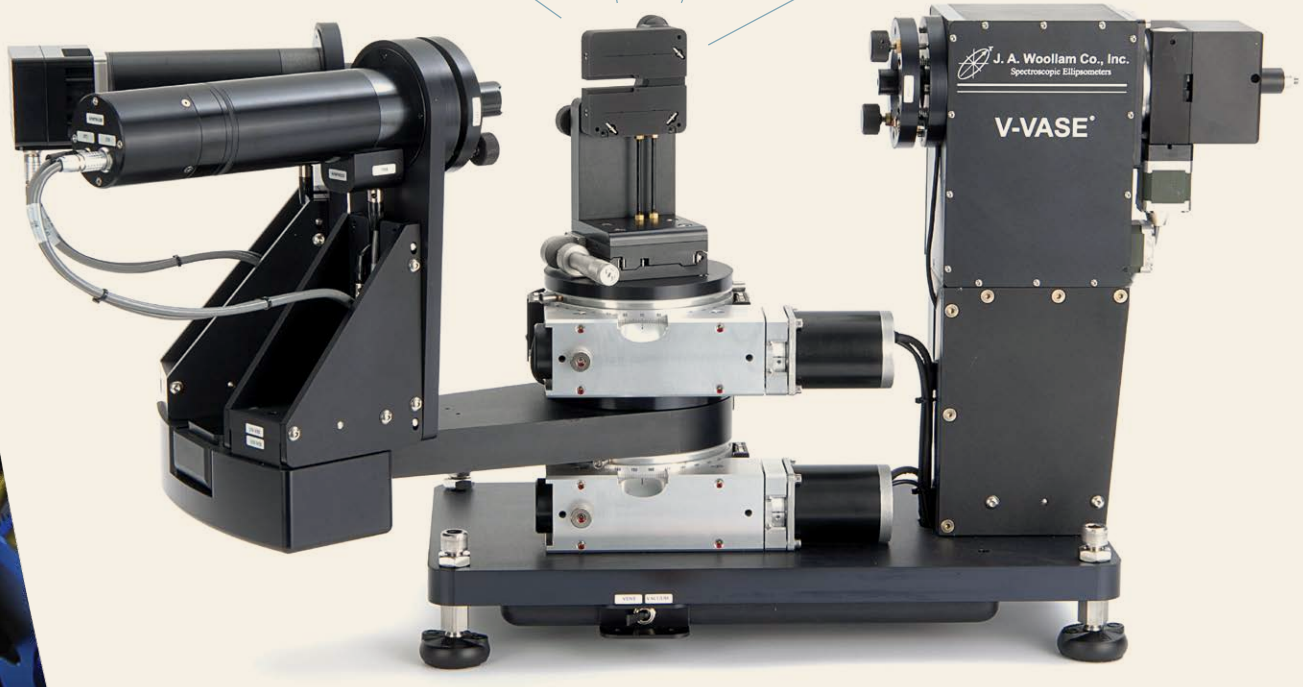
The VASE is our most powerful and versatile ellipsometer for research on all types of materials: semiconductors, dielectrics, polymers, metals, multilayers, and more. It combines high accuracy and precision with a wide spectral range from 190 to 3200 nm. Variable wavelength and angle of incidence allow flexible measurement capabilities.

Translation Stage

Cryostat

Focusing Probes

Liquid Cell



Gen-I

Cryostat

IR-VASE®

The IR-VASE is the first and only spectroscopic ellipsometer to cover the wide spectral range from 2 to 30 microns (333 to 5000 wavenumbers). It is used to characterize both thin films and bulk materials.

Gen-II

Gen-I

VUV-VASE®

The VUV-VASE measures from vacuum ultraviolet (VUV) to near infrared (NIR). This allows incredible versatility to characterize all types of materials. It has been the standard spectroscopic ellipsometry tool used for advanced lithography applications since its introduction. Wide spectral coverage from 142-2500 nm also make it a premier tool for new materials characterization, such as wide-bandgap semiconductors.

Research & Development

While some aspects of spectroscopic ellipsometry are mature technologies, there is always room for growth and we are excited about future possibilities. New innovations continue to improve measurement speed, accuracy, and wavelength range for future ellipsometers. As instruments improve and spectral ranges expand, they enable new and exciting applications. Software also plays an important role. We are working to simplify routine operations while expanding the powerful capabilities to model ever more complex structures. Below are a few exciting areas that represent current state-of-the-art.

In-Line Production Monitoring

In-line monitoring of rigid or flexible samples in constant motion requires rapid data acquisition. The M-2000 is ideal for this application - with the full spectrum acquired in a fraction of a second. We have developed the InLine-SE for roll-coating applications. The InLine-SE has translation capability to scan laterally and monitor uniformity across the entire substrate width.

TeraHertz Ellipsometry

The THz-VASE instrument utilizes a backward-wave oscillator (BWO) light source and a wide spectral range Golay cell as the detector. It scans wavelength-by-wavelength across various frequency ranges – operating from 0.11 to 1.45 THz via frequency multipliers added to the base tube (0.11 to 0.165 THz).

THz applications include basic research of free carrier dynamics in semiconductors, novel sensing devices, and security systems. Not only can THz-VASE be used directly for research in these areas, there is also a need to characterize the optical properties of substrates, films and devices designed for THz applications. It will be exciting to watch as THz characterization develops for new applications.