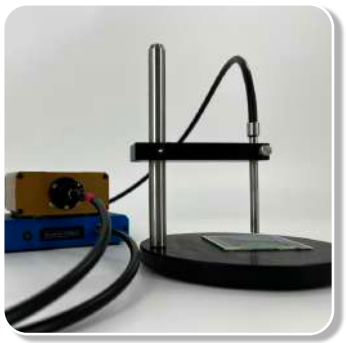
APP NOTE

Solar Cell Thin Film Thickness Measurement

Accurate thin film measurement is essential in solar and photovoltaic manufacturing to maximize energy conversion, coating performance, and production quality. Thin photovoltaic layers, transparent conductive oxides, and anti-reflective coatings directly influence solar cell efficiency and long-term device reliability.

StellarNet's spectroscopic reflectometry solutions use Transfer Matrix Method (TMM) modeling to accurately measure single-layer and multilayer photovoltaic films through non-contact, nondestructive optical measurements.



Key Solar & Photovoltaic Film Measurements

StellarNet solutions support thickness measurements for:

- Thin Film Thickness
- Reflectance
- Transmission
- Optical Absorption
- Layer Uniformity
- Optical Constants (n & k)
- Photovoltaic Characterization & Process Monitoring

Optimizing solar cell performance requires more than measuring thin film thickness alone. Engineers analyze a range of optical and material properties to maximize energy conversion efficiency, verify coating quality, improve device reliability, and support consistent manufacturing outcomes.

APP #1

Silicon Nitride
(SiNx)
Anti-Reflection Coating
(Perc Solar Cells)

Silicon nitride (SiNx) anti-reflection coatings are one of the most critical thin films used in crystalline silicon PERC solar cells. Besides reducing surface reflection to maximize light absorption, the SiNx layer also provides excellent surface passivation, improving cell efficiency and long-term reliability. Precise control of SiNx thickness directly impacts optical performance and overall power conversion efficiency. Spectroscopic reflectometry provides fast, non-contact measurement of silicon nitride coatings during process development and high-volume production, making it an ideal solution for inline quality control.

Typical Recipe:

- Air
- SiNx (75 nm)
- Crystalline Silicon (Bulk)

Recommended Spectrometer: 350–1000 nm (UV-VIS-NIR)

Why it's Important: Uniform SiNx coatings are essential for achieving consistent optical performance and effective surface passivation in PERC solar cells. Thin-film metrology verifies coating thickness across each wafer, enabling tighter process control, higher production yield, and more reliable device performance.

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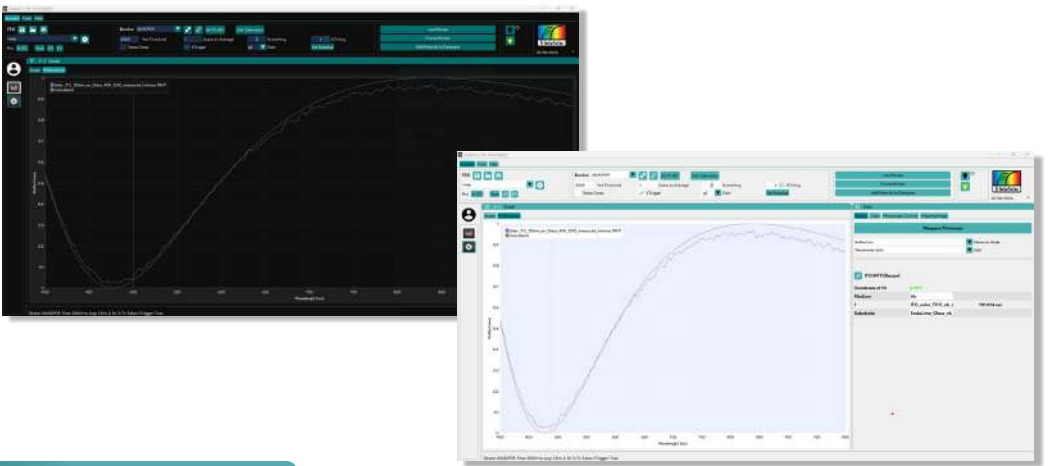
APP #2

Transparent Conductive Oxide (ITO)

Indium Tin Oxide (ITO) is widely used as a transparent conductive oxide (TCO) in thin-film solar cells, heterojunction (HJT) solar cells, and emerging photovoltaic technologies. ITO must provide both high optical transmission and low electrical resistance, making thickness control essential for maximizing device efficiency. Spectroscopic reflectometry enables rapid, non-contact measurement of ITO films on glass or photovoltaic substrates, supporting process optimization and production quality control.



Typical Recipe:

- Air
- ITO (120 nm)
- Glass (Bulk)

Recommended Spectrometer: 400–1000 nm (VIS-NIR)

Why its Important: ITO is commonly used as a transparent conductive oxide in thin-film solar cells. Measuring coating thickness helps maximize light transmission, verify conductive layer uniformity, and improve photovoltaic device efficiency.

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APP #3

Perovskite Solar Cell Multilayer

Perovskite solar cells consist of multiple functional thin-film layers that work together to achieve high photovoltaic efficiency. Critical layers such as the electron transport layer (TiO_2), perovskite absorber, hole transport layer (Spiro-OMeTAD), and transparent conductive oxide must all be carefully controlled during manufacturing. Spectroscopic reflectometry combined with Transfer Matrix Method (TMM) modeling enables accurate multilayer thickness measurement, providing valuable process feedback for research, pilot production, and next-generation solar cell manufacturing.

Typical Recipe:

- Air
- Spiro-OMeTAD (180 nm)
- Perovskite (520 nm)
- TiO_2 (40 nm)
- ITO (150 nm)
- Glass (Bulk)

Recommended Spectrometer: 400–1000 nm (VIS-NIR)

Why is it important: Perovskite solar cells contain multiple thin-film layers that must work together to maximize light absorption and charge transport. Non-contact optical metrology verifies multilayer thickness and coating uniformity, helping manufacturers optimize efficiency, improve process control, and accelerate the development of next-generation photovoltaic technologies.

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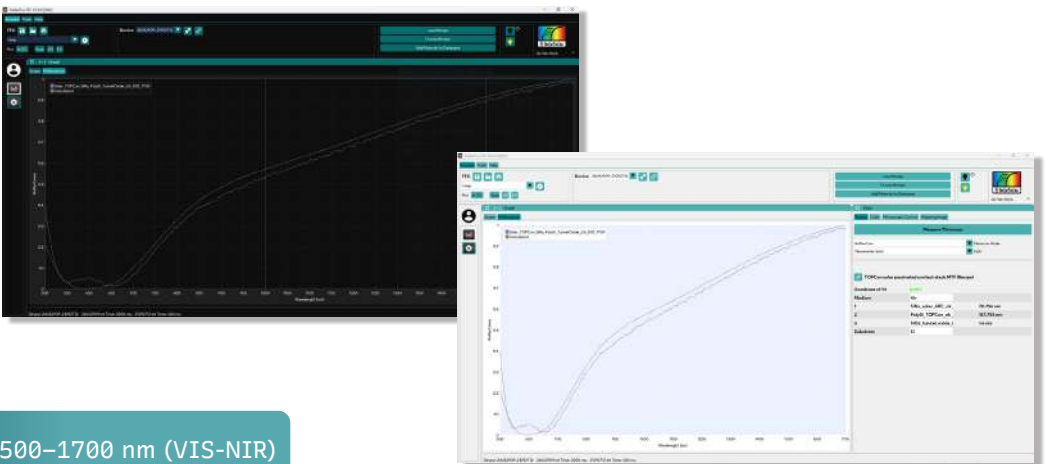
APP #4

TOPCon Solar Cell Passivated Contact

Tunnel Oxide Passivated Contact (TOPCon) technology is one of the fastest-growing high-efficiency silicon solar cell architectures. The device consists of an ultra-thin tunnel oxide, doped polysilicon contact layer, silicon nitride anti-reflection coating, and crystalline silicon substrate. Because each layer contributes to carrier transport, passivation, and optical performance, precise thickness control is essential for achieving maximum conversion efficiency. Spectroscopic reflectometry provides rapid, nondestructive characterization of these multilayer structures, making it an effective solution for both research laboratories and large-scale manufacturing environments.



Typical Recipe:

- Air
- SiNx (75 nm)
- Poly-Si (160 nm)
- SiO_2 Tunnel Oxide (1.6 nm)
- Crystalline Silicon (Bulk)

Recommended Spectrometer: 500–1700 nm (VIS-NIR)

Why is it important: TOPCon solar cells rely on ultra-thin tunnel oxide and polysilicon passivated contact layers to maximize carrier selectivity and reduce recombination losses. Accurate, non-contact thin-film thickness measurements verify layer uniformity, optimize cell efficiency, and improve manufacturing yield through precise process control.

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Summary: Broad Solar Cell Thin Film Measurement Capability

StellarNet spectroscopic reflectometry systems provide a versatile solution for photovoltaic thin-film metrology by supporting UV, VIS, NIR, and UV-VIS-NIR spectrometer configurations. Combined with Transfer Matrix Method (TMM) analysis, the system delivers fast, non-contact, nondestructive film thickness measurements across a wide range of photovoltaic technologies.

From conventional crystalline silicon solar cells to advanced perovskite and heterojunction devices, StellarNet accurately measures anti-reflection coatings, transparent conductive oxides, tunnel oxides, polysilicon, transport layers, absorber layers, and other multilayer photovoltaic structures.

This broad measurement capability supports research, process development, quality control, and high-volume solar cell manufacturing, providing accurate, repeatable thin-film characterization throughout the photovoltaic manufacturing process.

Why Engineers Choose StellarNet

For more than three decades, StellarNet has helped researchers, engineers, and manufacturers transform light into actionable engineering intelligence. Our modular thin film metrology systems combine high-performance optical measurement, flexible system configurations, rapid customization, and US-based engineering support to help solve complex measurement challenges across the global photonics industry.

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