OptiPrime-TF

Ultra-High Resolution & Ultra-High Sensitivity, State-of-the-Art DUV-Vis-NIR Thin Film Measurement System Based on Optimized Broad-Band Reflectometry

FULLY AUTOMATED, HIGH THROUGHPUT, LOW CoO THIN FILM OPTICAL METROLOGY SYSTEM FOR PHOTOLITHOGRAPHY, ETCH, DIFFUSION, CVD PLASMA FILMS, AND CMP MODULES

n&k® the true measure

OptiPrime-TF

UNPARALLELED ACCURACY AND VERSATILITY

ADVANCED METROLOGY MAKES CHARACTERIZING SINGLE & MULTI-LAYER FILM STACKS FAST AND EASY

- *Optimized Reflectance Data*
- *Wavelength Range: 190 – 1000 nm in 1 nm Intervals*
- *Micro-Spot Technology*
- *Can be Configured for 300 mm (12"), 200 mm (8"), 150 mm (6") Wafers*
- *Based on Patented All-Reflective Optics that Optimizes the Signal-to-Noise Ratio*
- *Strong Sensitivity to Sub-Nanometer Material Variations*
- *Thin Film Measurements:*
  - *Thickness*
  - *n and k (from 190 – 1000 nm)*
  - *Energy Band Gap (E_g)*
  - *Interface Roughness*
  - *Composition, for example:*
    - *%N, %H, %O in SiO_xN_y:H*
    - *%N in TiN_x*
    - *%Ge in $SiGe_x$*
  - *Microstructure, for example degree of crystallinity of:*
    - *Poly -Si*
    - *GST*
- *Cognex Pattern Recognition Software*
- *No Re-Alignment Issues Upon Light Bulb Replacement*
- *Modular Design – Easy to Maintain and Service*
- *GEM/SECS Communication Interface Third Party Certification*
- *SEMI Standards and Third Party Certification*
- *CE Marking*

KEY QUALITIES OF THE OPTIPRIME-TF

ACCURATE CHARACTERIZATION OF FILMS DEPOSITED ON PATTERNED AND UN-PATTERNED SUBSTRATES

By combining an all-reflective optical design for a micro-spot and field proven analysis software, the n&k OptiPrime-TF readily characterizes complex film structures

FAST AND EASY ANALYSIS IDEAL FOR SINGLE AND MULTI-LAYER STRUCTURES

The n&k OptiPrime-TF uses an intuitive graphical user interface and takes just seconds to completely characterize (that is, determine thickness and n and k spectra) single and multi-layer structures

OPTIMIZED SIGNAL-TO-NOISE RATIO THROUGHOUT THE ENTIRE 190-1000nm WAVELENGTH RANGE

With the n&k OptiPrime-TF's patented optical design, the complete spectral range from 190 to 1000 nm is measured with micro-spot technology and with optimized signal-to-noise

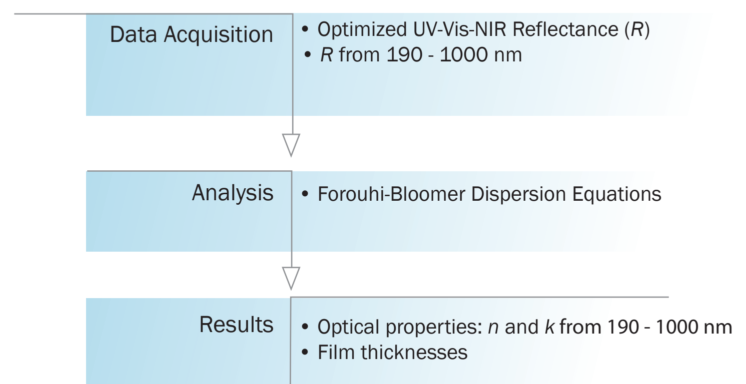
SIMULATION SOFTWARE

With the simulation software, the user can determine the effect of variations in film parameters (like n, k, or thickness) on the reflectance

PHYSICAL CHARACTERISTICS

Dimensions (W x D x H):	*112 cm x 202 cm x 189 cm*
Weight (unpacked):	*770 kg*
Facility Requirements:	*100 - 240 V, 50/60 Hz, 1Φ* *Vacuum, CDA (for FOUP Load Port)*

SYSTEM OPERATION FLOW



A FEW SELECTED MEASUREMENT EXAMPLES

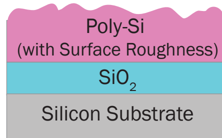
- *SiO_2*
- *a-Si*
- *TiN_x*
- *TiO_x*
- *Resist*
- *ARC*
- *Si_xGe_{1-x}*
- *a-Si / SiO_x*
- *SiO_x / Poly-Si / SiO_x*
- *SiO_x / Al*
- *SiN_x*
- *a-Si:H*
- *SiC_x*
- *BST*
- *Resin*
- *Polyimide*
- *SiN_x / SiO_x*
- *Poly-Si / SiO_x*
- *Resist / SiO_x*
- *SiN_x / SiO_xN_y*
- *SiO_xN_y*
- *Poly-Si*
- *Polymers*
- *SOI*
- *Thin Metal Films: Ti, Ag, Au, etc.*
- *SiO_x / SiN_x*
- *SiO_x / SiN_x / SiO_x*
- *SiO_x / TiN / Al*
- *CrSi / SiO_x*

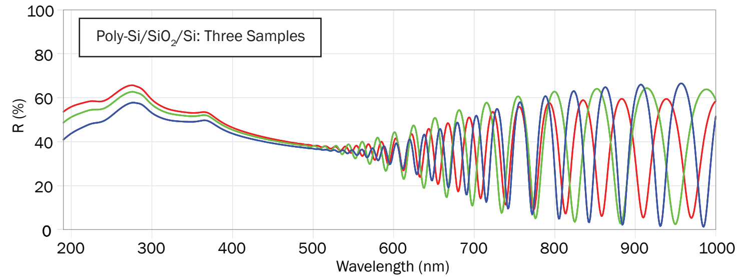
Thin Film Application Examples

The n&k OptiPrime-TF's covers both current and next generation thin film measurement demands for R&D and production: Ultra Thin Films and Residual Layers, Multi-Layer Stacks, Inhomogeneous Films, 193 nm and 248 nm ARCs and Resists, Low-κ Films, High-κ Films, and films deposited on practically any substrate (including rough surfaces).

ROUGH POLY-Si ON SiO_2

- The wide wavelength range (190 - 1000 nm) of the OptiPrime-TF is needed in order to simultaneously measure the surface roughness and film thickness values
- The data is sensitive to the *n* and *k* values of the Poly-Si layer, which can be measured to determine the silicon properties (from amorphous to crystalline)

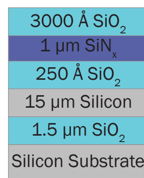


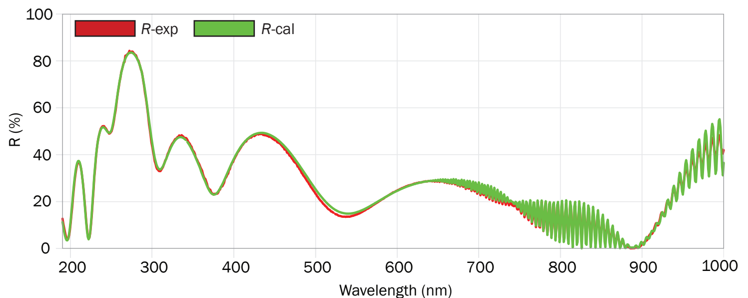


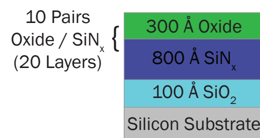
Spectra	Surface Roughness (Å)	Poly-Si Thickness (Å)	SiO_2 Thickness (Å)
Red	32	18245	505
Green	57	15078	622
Blue	85	21330	765

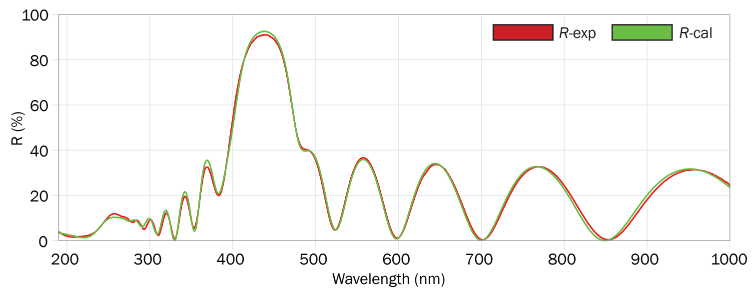
COMPLEX MULTI-LAYER FILM STRUCTURE

- Complex multilayer film stacks can be measured with the OptiPrime-TF
- Super structures, with sets of repeating layers, can be fully modeled in the analysis software
- Film stacks containing over 80 layers have been successfully measured



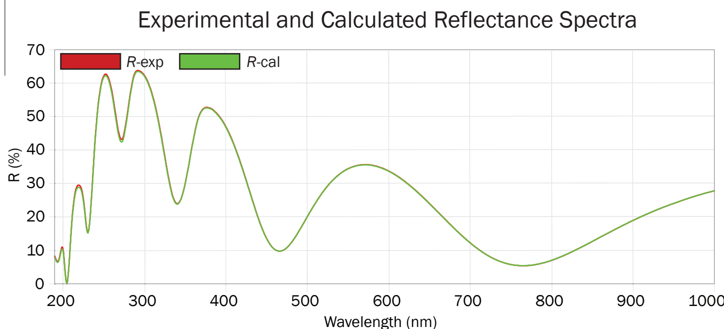


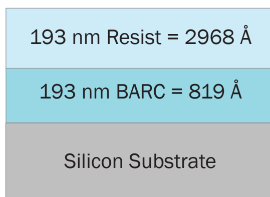




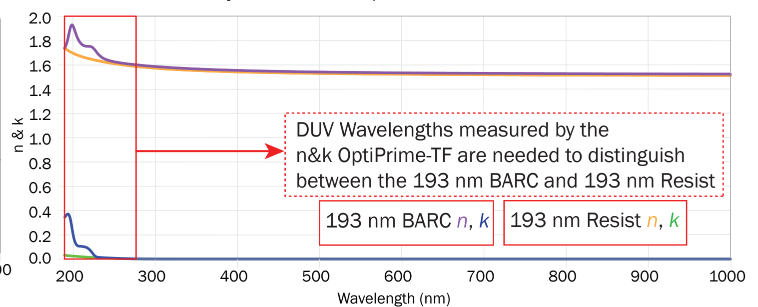
ADVANCED LITHOGRAPHY: RESIST / BARC / Si SUBSTRATE

Experimental and Calculated Reflectance Spectra





Results of Analysis: *n* and *k* Spectra of 193 nm BARC and Resist



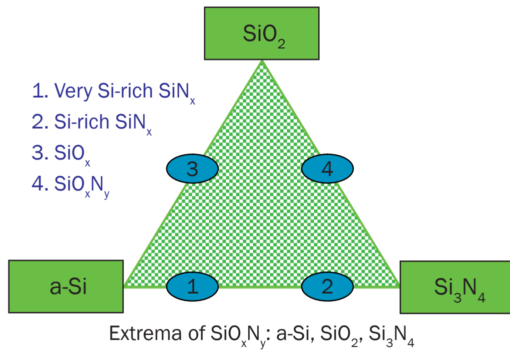
Thicknesses and *n* and *k* spectra of 193 nm BARC and Resist are simultaneously determined:

Thickness Results:
193 nm Resist = 2968 Å
193 nm BARC = 819 Å

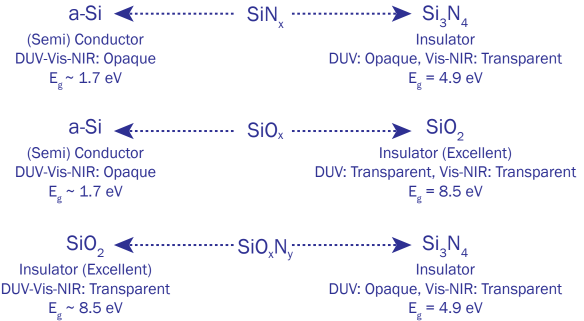
Thin Film Application Examples

COMPOSITION OF SiO_xN_y FILMS

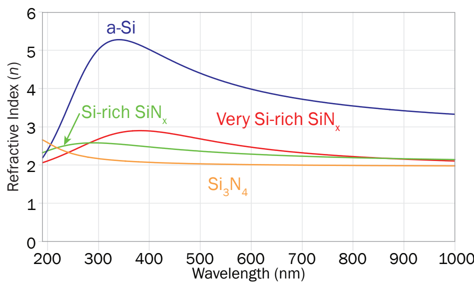
Based on results obtained by the n&k OptiPrime-TF for *n*, *k*, and E_g, the amounts of Si, O, and N in "SiO_xN_y" films can be properly adjusted to achieve desired electrical and optical properties for various applications: Overcoat, Interlayer Dielectric, Antifuse Material, and Anti-Reflective Coating (ARC).

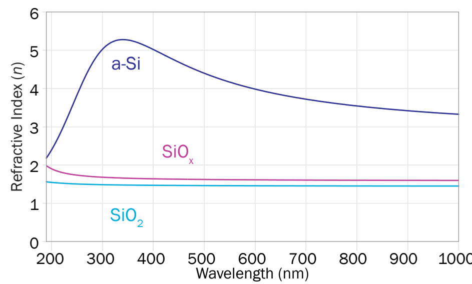


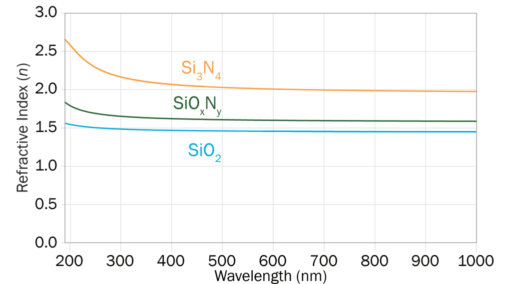
Extrema of SiO_xN_y: a-Si, SiO_2, Si_3N_4

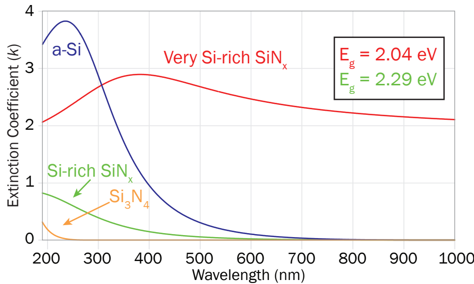


The graphs below show the *n* and *k* spectra and E_g of (1) Very Si-rich SiN_x, (2) Si-rich SiN_x, (3) SiO_x, and (4) SiO_xN_y compared to the extrema of SiO_xN_y, as measured by the n&k OptiPrime-TF. Note the n&k OptiPrime-TF measures film thickness simultaneously with each *n* and *k* spectra.

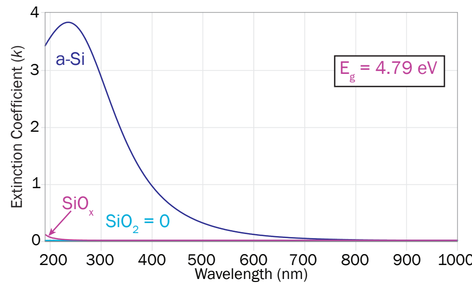




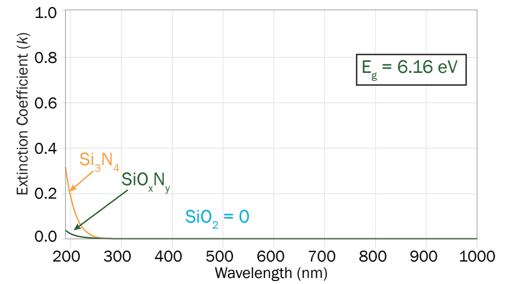




The *n* and *k* spectra of very Si-rich SiN_x and Si-rich SiN_x fall between the *n* and *k* spectra of a-Si and Si_3N_4 in the lower wavelength regions of the spectra



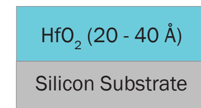
The *n* and *k* spectra of SiO_x fall between the *n* and *k* spectra of a-Si and SiO_2

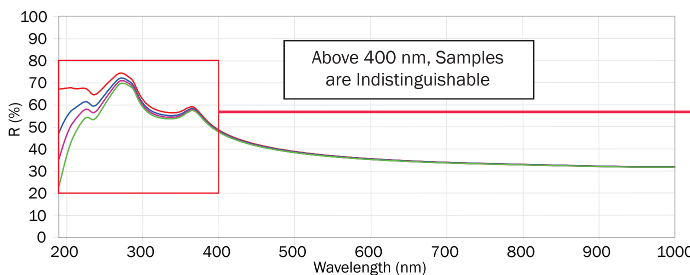


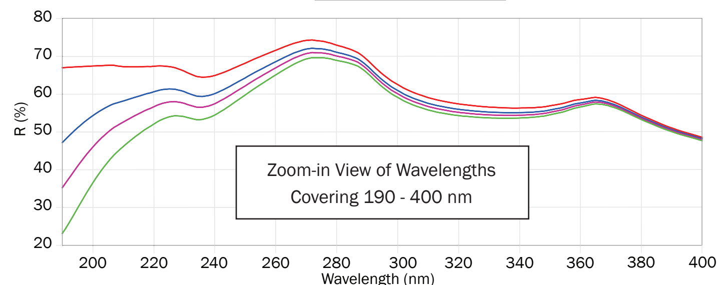
The *n* and *k* spectra of SiO_xN_y fall between the *n* and *k* spectra of SiO_2 and Si_3N_4

HIGH-K GATE INSULATORS: ATOMIC LAYER DEPOSITION (ALD)

- DUV wavelengths are necessary in order to distinguish the ultra-thin HfO_2 films
- Measurement examples of HfO_2 on a Si-Substrate demonstrates that the tool has plenty of sensitivity in the DUV for this measurement







Results of Analysis: — Bare Si, — 19.7Å HfO_2/Si, — 32.1Å HfO_2/Si, — 41.0Å HfO_2/Si