LittleFoot-TF

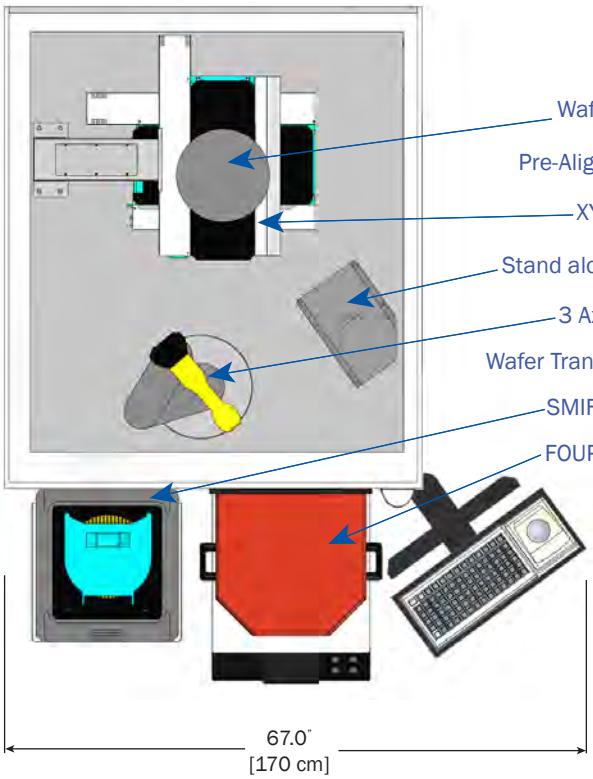
Ultra-High Resolution & Ultra-High Sensitivity, DUV-Vis-NIR Thin Film Measurement System with Reduced Footprint for 200 mm and 150 mm wafers

FULLY AUTOMATED, HIGH THROUGHPUT OPTICAL METROLOGY SYSTEM FOR SEMICONDUCTOR APPLICATIONS. APPROXIMATELY 40% REDUCTION IN FOOTPRINT COMPARED TO OTHER METROLOGY TOOLS.

n&k® the true measure

LittleFoot-TF

n&k OptiPrime Series
Conventional Wafer Handling Technology



LittleFoot Series
Revolutionary Wafer Handling Mechanism

KEY QUALITIES OF LITTLEFOOT-TF

- *~40% Smaller Footprint then Standard Tools Translates into Significant Savings in the Construction and Utilization of Wafer Fabs*
- *Optimized Polarized Reflectance Data*
  - *Wavelength Range: 190 – 1000 nm in 1 nm Intervals*
  - *Micro-Spot Technology*
- *Identical Analytical Capabilities as the n&k OptiPrime-TF*
- *Can be Configured for 200 mm (8") and 150 mm (6") Wafers*
- *Fully Automated*
- *Based on Patented 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 (Eg)*
  - *Interface and Surface Roughness*
- *Cognex Pattern Recognition Software*
- *No Re-Alignment Issue Upon Light Bulb Replacement*
- *Modular design – Easy to Maintain and Service*
- *GEM/SECS Communication Interface*
- *SEMI Standard and Third Party Certifications*

OPTICAL METROLOGY REQUIREMENTS FULFILLED BY LITTLEFOOT-TF

- *Optimized Signal-to-Noise Ratio & Large Dynamic Range of Detection*
- *Wide Wavelength Range (190-1000 nm) & High Resolution*
- *Physically Valid Model (Forouhi-Bloomer)*
- *User-Friendly, Proprietary Software*
- *Unlike competitive systems, the n&k LittleFoot-TF has the capability to analyze any new film without sending samples to the factory*

PHYSICAL CHARACTERISTICS

Dimensions (W x D x H):	*86 cm x 121 cm x 180 cm*
Weight (unpacked):	*300 Kg*
Facility Requirements:	*100 - 240 VAC, 50/60 Hz, 1Φ*
	Vacuum

SYSTEM OPERATION FLOW

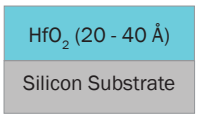
Data Acquisition	• Polarized UV-Vis-NIR Reflectance (*R*) • *R* from 190 - 1000 nm
Analysis	• Forouhi-Bloomer (FB) Dispersion Equations
Results	• Optical properties: *n* and *k* from 190 - 1000 nm • Film thickness

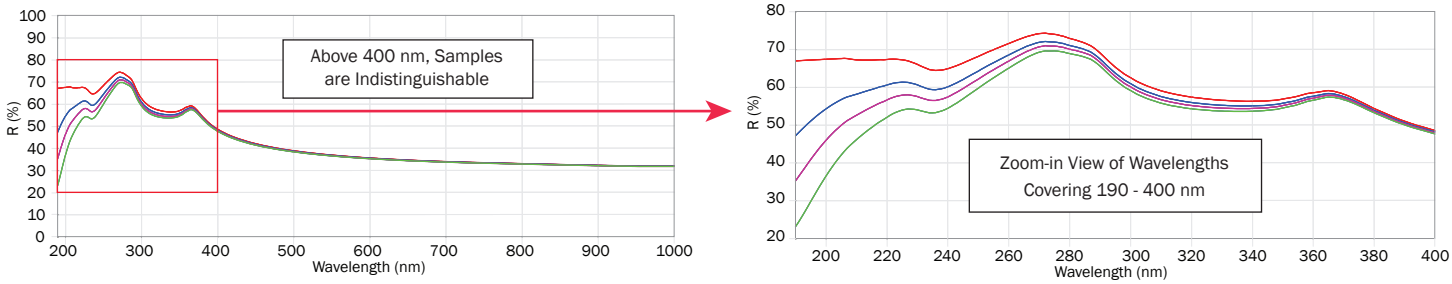
Thin Film Application Examples

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

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

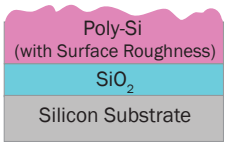


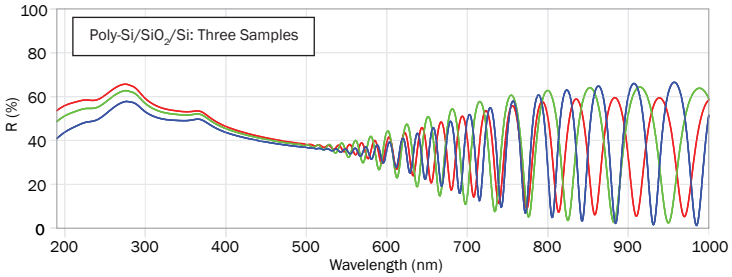


Results of Analysis: — Bare Si, — 19.7Å HfO_2 /Si, — 32.1Å HfO_2/Si, — 41.0Å HfO_2/Si

ROUGH POLY-Si ON SiO_2

- The wide wavelength range (190 - 1000 nm) of the LittleFoot-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)

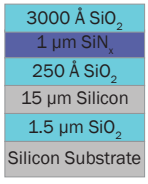


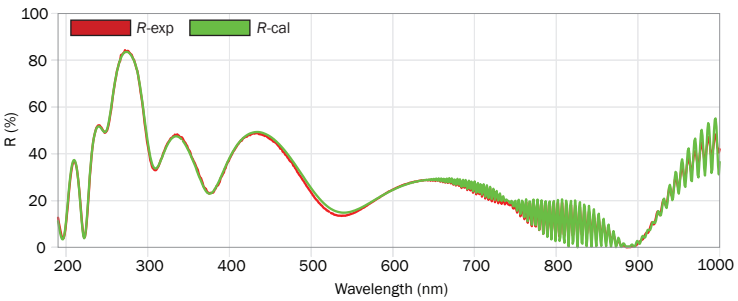


Spectra	Surface Roughness (Å)	Poly-Si Thickness (Å)	SiO_2 Thickness (Å)
Red	32	18245	505
Green	57	15078	622
Blue	85	21330	765

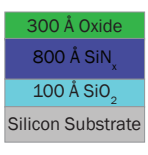
COMPLEX MULTI-LAYER FILM STRUCTURE

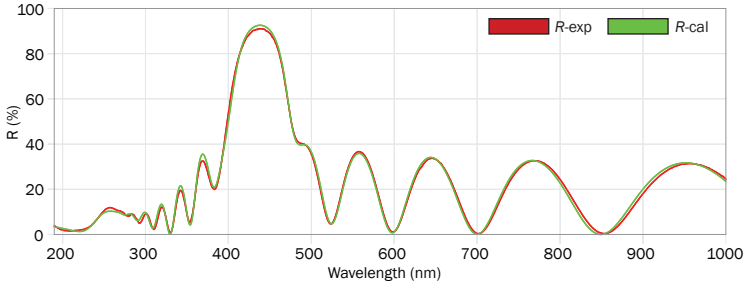
- Complex multilayer film stacks can be measured with the LittleFoot-TF
- Super structures, with sets of repeating layers, can be fully modeled in the analysis software
- Film stacks containing over 80 layers have been successfully measured





10 Pairs Oxide / SiN_x (20 Layers)

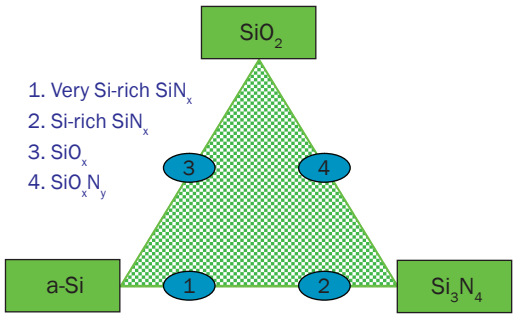




Thin Film Application Examples

COMPOSITION OF SiO_xN_y FILMS

Based on results obtained by the n&k LittleFoot-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 applications such as: Overcoat, Interlayer Dielectric, Antifuse Material, and Anti-Reflective Coating (ARC).



Extrema of SiO_xN_y: a-Si, SiO_2, Si_3N_4

a-Si ⟷ SiN_x ⟷ Si_3N_4

(Semi) Conductor
DUV-Vis-NIR: Opaque
E_g ~ 1.7 eV

Insulator
DUV: Opaque, Vis-NIR: Transparent
E_g = 4.9 eV

a-Si ⟷ SiO_x ⟷ SiO_2

(Semi) Conductor
DUV-Vis-NIR: Opaque
E_g ~ 1.7 eV

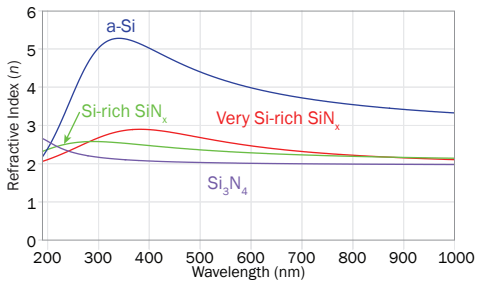
Insulator (Excellent)
DUV: Transparent, Vis-NIR: Transparent
E_g = 8.5 eV

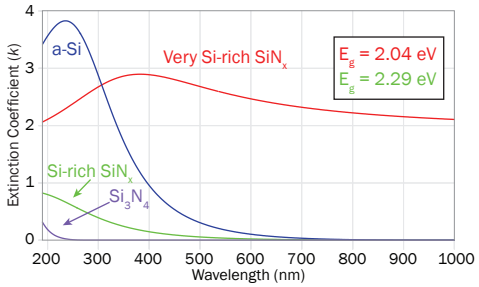
SiO_2 ⟷ SiO_xN_y ⟷ Si_3N_4

Insulator (Excellent)
DUV-Vis-NIR: Transparent
E_g ~ 8.5 eV

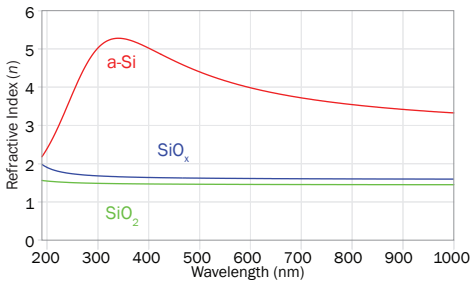
Insulator
DUV: Opaque, Vis-NIR: Transparent
E_g = 4.9 eV

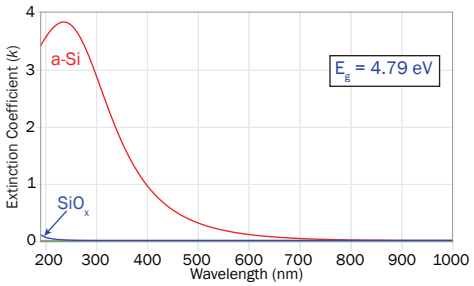
The graphs below show the *n* and *k* spectra and E_g of (1) Very Si-rich SiN_x, (2) Si-rich SiN_x, (3) SiO_x, and (4) SiO_xN_y compared to the extrema of SiO_xN_y, as measured by the n&k LittleFoot-TF. Note that n&k LittleFoot-TF measures film thickness simultaneously with each *n* and *k* spectra.



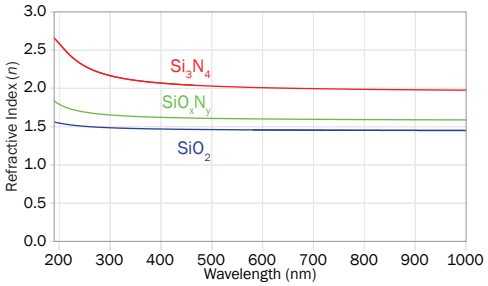


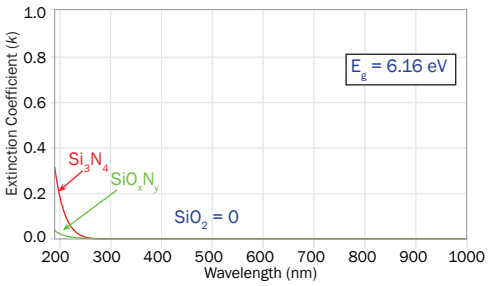
The *n* and *k* spectra of very Si-rich SiN_x and Si-rich SiN_x fall between the *n* and *k* spectra of a-Si and Si_3N_4 in the lower wavelength regions of the spectra





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

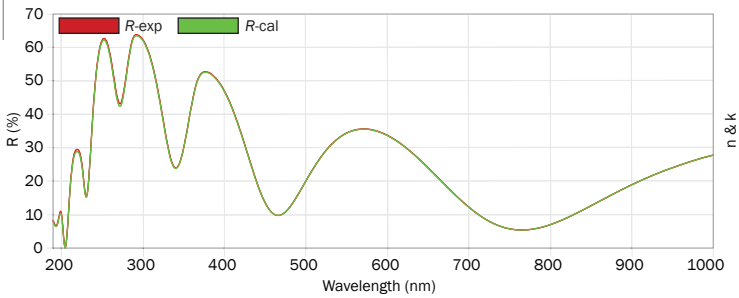




The *n* and *k* spectra of SiO_xN_y fall between the *n* and *k* spectra of SiO_2 and Si_3N_4

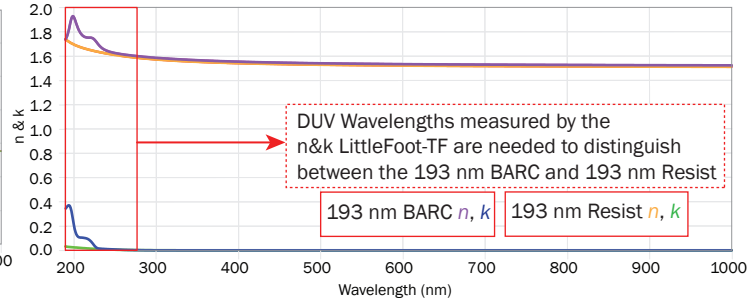
ADVANCED LITHOGRAPHY: RESIST / BARC / Si SUBSTRATE

Experimental and Calculated Reflectance Spectra



193 nm Resist = 2968 Å
193 nm BARC = 819 Å
Silicon Substrate

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

n&k Technology
www.nandk.com