

Scientific Computing International (美国科学计算国际公司)

SCI is a world leader in providing high resolution thin-film metrology systems and analysis software products to leading companies in the semiconductor, optoelectronics, data storage, display, MEMS, and optical coating industries. SCI offers metrology systems for thin-film material characterization, with models that range from table-top systems suitable for R&D to fully automated, standalone production tools, and software products for thin-film analysis and design. SCI is a privately held company headquartered in Carlsbad, California, with a global network of sales, service, and support offices strategically located in the United Kingdom, Germany, Taiwan, Singapore, Korea, and Japan.

SCI 是薄膜高分辨率测量仪器和分析软件的世界领先者,广泛应用于半导体,光电子,数据存储,显示器,MEMS 等工业领域.

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Company History(公司历史)

In 1993 SCI was founded to provide software products for thin-film analysis and design to the research and development community and the optical coating industry. SCI's FilmWizard™ software was introduced the same year.

In 1996, FilmWizard™ was recognized as the leading software package for thin film analysis and design.

In 1998, SCI expanded into the wafer metrology business and introduced the FilmTek™ line of thin-film metrology systems based on the reflection of broadband light.

In 1999, SCI developed and patented multi-angle differential power spectral density technology and introduced the FilmTek™ 4000, a metrology system with a resolution 100 times better than existing tools. The FilmTek™ 4000 quickly became the standard film metrology tool used in the production of integrated optical components for the optical telecommunications industry.

In 2000, the first fully automated, robotic FilmTek™ 4000 was installed. The FilmTek™ 4000 quickly became the standard film metrology tool used in the production of integrated optical components for the optical telecommunications industry.

In 2002, FilmTek™ instruments were improved with the capability of measuring down to 190 nm with small spot sizes (<50um).

In early 2003, SCI developed multi-angle differential polarimetry technology and introduced the FilmTek™ 4000EM-DUV, a metrology system which is far more sensitive to changes in very thin films, particularly films within multi-layer stacks, than existing metrology tools that rely on conventional ellipsometry or reflectometry techniques.

In July 2004, the first FilmTek 4000EM-DUV was shipped for the measurement of the most advanced 300mm Semiconductor films.

Currently SCI has an installed base of about 550 software packages and over 140 FilmTek™ instruments.

SCI continues to innovate and develop new technologies to provide the highest-resolution metrology tools available for our customers in the semiconductor, optoelectronics, data storage, display, MEMS, and optical coating industries.

SCI CUSTOMERS(SCI 客户列表):

The semiconductor industry 半导体工业: R&D for wafers sizes up to 8"

- Intel 美国英特尔公司
- ST Microelectronics 意法半导体公司
- Infineon 德国英飞凌尔公司
- Samsung semiconductor 韩国三星半导体公司

The University and R&D 大学和研究院:

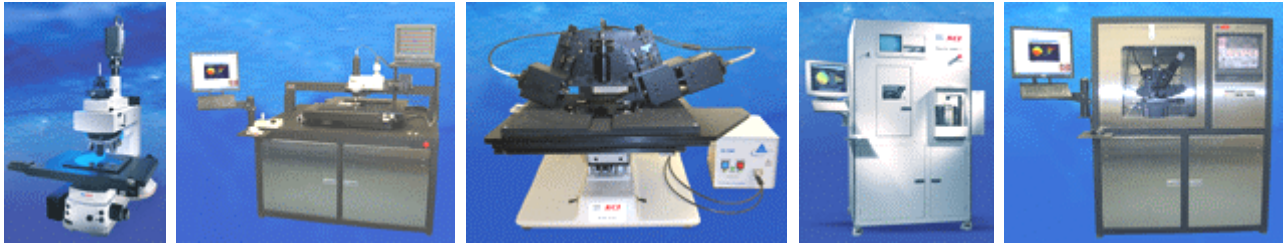
- Integrated Manufacturing Technologies Institute,Canada
- 加拿大集成制造技术学院
- Department of Chemistry,University of Oulu, Finland 芬兰奥鲁大学
- Department of Electrical and Communications Engineering,Helsinki University of Technology 芬兰赫尔辛基理工大学
- Lucent (30 台以上) 美国朗讯科技公司,
- MicroChem Corp., Newton MA

The display industry: for large panels (370mm x 470mm panels)

- ERSO in Taiwan
- Ness Display (Korean). 韩国 NESS
- Samsung (Korean) 韩国
- Symmorphix, Inc(USA) 美国
- more than 40 FilmTek systems to a major Japanese display company 日本

And so on

SCI Metrology Products(测量产品)



FilmTek™ spectrophotometry-based metrology systems from Scientific Computing International (SCI) have long set the standards for characterization of thin films. Now — our FilmTek™ 4000 Series "raises the bar" by delivering 100 times the resolution of the best non-contact method, and 10 times the resolution of the best prism coupler contact systems. It's the result of our patented DPSD™ (Differential Power Spectral Density) technique. And it's the latest example of how SCI is leading the thin film metrology field by raising performance to a new level — while offering systems that are truly affordable for virtually every application.

Widest Film Thickness, Layer & Spectral Ranges(很宽的薄膜厚度, 多层, 很宽的光谱范围)

FilmTek™ metrology systems come in a variety of configurations, and depending on the model can measure reflection, reflection and transmission, multiple angle reflection, spectroscopic ellipsometry, and polarimetry data. FilmTek™ systems provide peak performance from very-thin to very-thick films (up to 250 microns). It's achieved by high wavelength resolution detectors combined with low cone angle optical design and apertures to limit measurement spot size. Depending on the films involved, FilmTek™ systems can characterize up to fifteen layers. And they all offer a wavelength measurement range from 190 to 1700 nm using our proprietary dispersion model.

Easy-to-Use Computer Power(易使用的计算机功能)

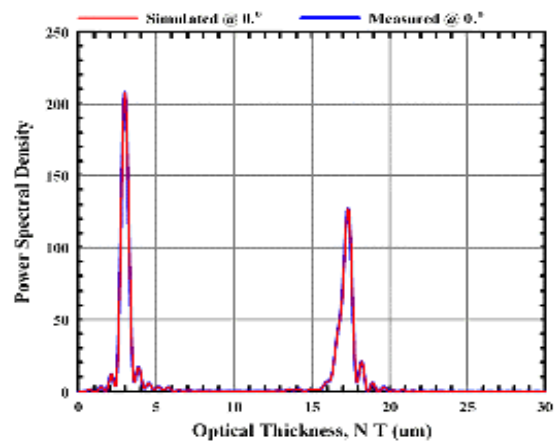
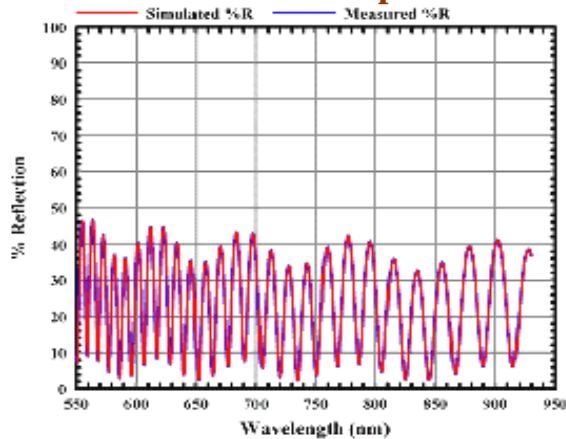
Our complete, turn-key systems are designed for simple, efficient, trouble-free push-button operation. The powerful software was designed to put measurements and answers just a click away. And to help characterize and control deposition processes, it includes such capabilities as 2D and 3D contour and surface graphic plotting, a customizable database interface, and the ability to be controlled by a host computer. Versatile, flexible, reliable standard and custom FilmTek™ systems are available in a variety of configurations — from manual table top models, to fully automated systems with robotic cassette transfer and pattern recognition. All are designed for optimum accuracy and repeatability. They're easy to calibrate and operate. And, with features like our unique optical design with no moving parts, they deliver long-lasting, reliable, trouble-free performance.

Affordable Systems for Virtually Every Budget(针对实际中每一预算的合理仪器配置)

A variety of configurations are offered in the standard FilmTek™ family. SCI also develops customized models to meet special needs. And they're all priced to fit most budgets.

- **FilmTek™ 1000** is the most affordable system for measuring reflection at normal incidence in the visible to NIR. (反射测量可见光常规入射到近红外)
- **FilmTek™ 1500** adds transmission mode measurements to reflection. (反射测量,同时增加了透射模式测定)
- **FilmTek™ 2000** augments those capabilities to encompass surface roughness and reflection at normal incidence from deep UV to NIR. (增加了表面粗糙度测量和深紫外到近红外测量)
- **FilmTek™ 2000M-DUV** has a small measurement spot size (5 μm) and measures optical properties from 190-1700 nm. (小光点直径 5 μm 测量和光学性能测量 190-1700 nm)
- **FilmTek™ 3000 / 3000M** measures transmission and reflection of films deposited on transparent substrates. It's ideally suited for measuring the thickness and optical constants of very thin absorbing films. The FilmTek™ 3000M has a small spot size (40 μm) and can be equipped with a large custom stage for flat panel display applications. (透明衬底沉积薄膜的透射和反射测量)
- **FilmTek™ 2000SE** is an affordable spectroscopic ellipsometer that measures from the deep UV to NIR. (深紫外到近红外测量的光谱椭偏仪)
- **FilmTek™ 4000** is our most advanced model for thick-film applications. It incorporates multiple detectors positioned at different angles of incidence — plus our patented multi-angle Differential Power Spectral Density analysis capability — to accurately measure the index of refraction with a resolution of 0.00002. That's 100 times the performance of the best non-contact method, 10 times that of the best prism coupler contact systems. The FilmTek™ 4000 can measure birefringence of anisotropic materials. With its hot plate option, it can characterize the index of refraction and thermal expansion of a film as a function of temperature. And its spectroscopic ellipsometer option allows measurement of very thin films. A prime application for this system is measuring the index of refraction and thickness of planar waveguide films. (折射系数分辨率 0.00002, 双折射各向异性材料测量, 热板)
- **FilmTek™ 4000EM-DUV** is our most advanced thin-film metrology system. It leverages the combination of new proprietary Multi-Angle Differential Polarimetry technology with SCI's patented Differential Power Spectral Density technology to provide an optical thin-film metrology tool with the best resolution, accuracy, and repeatability in the industry. The FilmTek™ 4000EM-DUV utilizes spectroscopic reflection (190nm-1700nm) of polarized light at multiple angles to independently measure film thickness and index of refraction. By independently measuring index and thickness, the FilmTek™ 4000EM-DUV is far more sensitive to changes in films, particularly films within multi-layer stacks, than existing metrology tools that rely on conventional ellipsometry or reflectometry techniques. Additionally, the FilmTek™ 4000EM-DUV has a small measurement spot size to allow for measurement directly on product wafers (measures within a 50x50 micron feature). (晶片 50x50 微米测量)

Reflectance and Power Spectral Density Analysis(反射系数和功率谱密度分析)



Analysis of polyimide film coating a thermal oxide film grown on a silicon wafer.

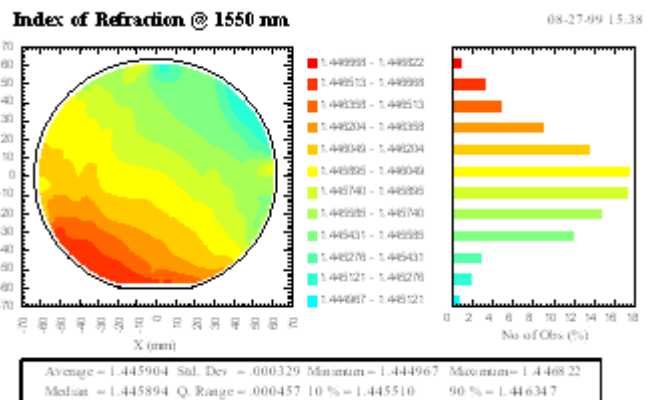
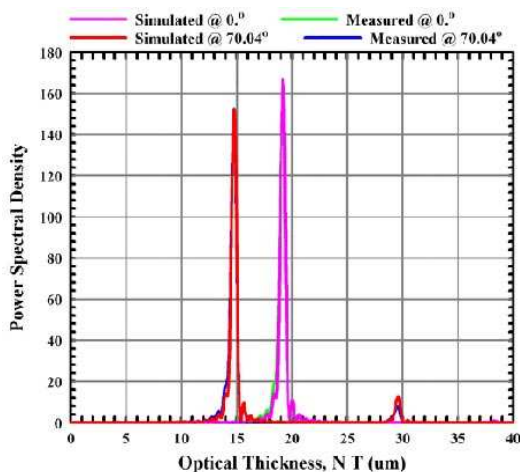
Power Spectral Density analysis of polyimide and oxide films.

热氧化物薄膜(生长在硅晶片上) 涂布聚酰
亚胺薄膜的分析

聚酰亚胺和氧化物薄膜的功率谱密度分析

FilmTek™ 4000 High Precision Measurement of Index(高精度测量系数)

This unique FilmTek™ 4000 capability employ's our patented DPSD (Differential Power Spectral Density) technique. Spectroscopic reflection data are gathered at normal incidence and 70 degrees. PSD processing results in two peaks in the Power Spectral Density domain. The ratio of their positions is a function of the index of refraction of the film, and the angle of incidence of the oblique measurement. This ratio is used to calculate the index. Once the index is known, the thickness can be calculated from the optical thickness of the normal incident peak.



Differential Power Spectral Density analysis of an oxide film.

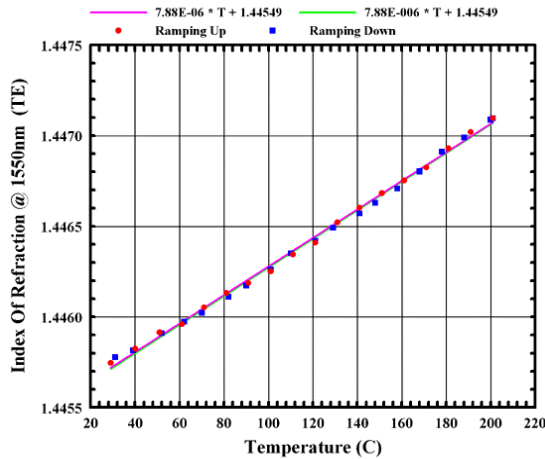
Index Map @ 1550nm of a doped oxide
measured with FilmTek™ 4000.

(氧化物薄膜微分功率谱密度分析)

(掺杂质的氧化物 1550nm 实测图)

SiO₂ Film Properties vs Temperature (SiO₂ 温度薄膜特性)

With the hot plate option, the FilmTek™ 4000 can characterize the index of refraction and thermal expansion of a film as a function of temperature.

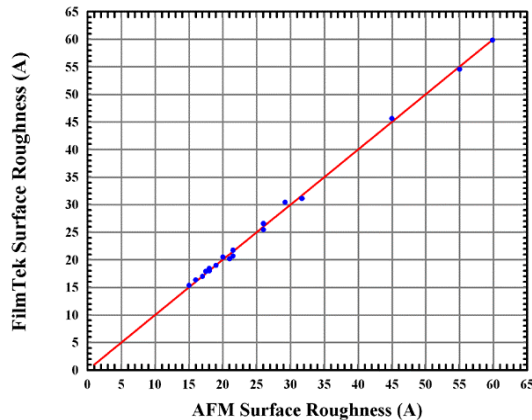


Measured by FilmTek™ 4000 with heating chuck during one heat-cool cycle.

(用加热卡盘进行热循环实测)

FilmTek™ Surface Roughness Measurement(表面粗糙度测量)

Fast, dependable, and non-contact, FilmTek™ measures surface roughness and damage with excellent correlation to other measurement techniques such as atomic force microscopy (AFM).



FilmTek™ 2000 vs AFM surface roughness measurement.

(FilmTek™ 2000-原子力测试仪表面粗糙度测量比较)

SCI Dispersion Model(散射模型)

Our dispersion model is derived from quantum mechanical principles and correctly obeys the Kramer-Kronig relationship. It is applicable to metallic, semiconductor, amorphous, crystalline, and dielectric materials. A broad array of single layer and multilayer films have been successfully analyzed, including: 可分析很多单/多层薄膜:

• SiNx 氮化硅薄膜	• DLC 类金刚石薄膜
• SiOxNx 氮氧化硅薄膜	• Low K Dielectrics 低介电薄膜
• Polysilicon 多晶硅薄膜	• High K Dielectrics 高介电薄膜
• PSG 磷硅酸盐玻璃薄膜	• Photoresist 光刻胶薄膜
• BPSG 硼磷硅酸盐玻璃薄膜	• Polyimide 聚酰亚胺薄膜
• ITO 锡铟氧化物薄膜	• SOG 玻璃上系统薄膜
• a-Si 非晶硅薄膜	• Porous Films 多孔薄膜
• a-c:H 氧化类金刚石薄膜	• Films used for manufacturing thin film heads

Substrate examples include: (衬底实例)

• Silicon 硅衬底	• GaAs 砷化镓衬底
• SOI 衬底	• Glass 玻璃衬底
• SOS 衬底	• Aluminum 铝衬底
• InP 氮化铟衬底	• Ge 锗衬底

By employing a dispersion model covering the entire wavelength range of the measurement, the number of variables or parameters required to model optical response is reduced, eliminating the potential for multiple solutions.

FilmTek™ Configurations(仪器配置)

We offer a variety of configurations and options to fit every need from R&D to high volume manufacturing in controlled environments.

They include:

- Standard probe head (<1 mm spot size) 标准探针头(光点直径<1 mm)
- Microscope based (down to 5 µm spot size) 显微镜(光点直径 down to 5 µm)
- Reflection mode measurements 反射模式测量
- Transmission mode measurements 透射模式测量
- Spectroscopic ellipsometry measurements 光谱椭圆偏光法测量
- Automated stage 自动化传送
- Cassette to cassette robotic transfer 盒到盒机器传递
- SMIF box
- Pattern recognition 模式识别
- Heating chuck 加热卡盘
- In-situ; for integration with process equipment
- Windows based operating system “Windows” 操作系统
- Menu-driven, user friendly software 易用的软件

SCI's products are offered in three categories; stand-alone FilmTek™ film metrology systems, film design and analysis software, and Integrated Metrology Modules. The latter is only offered to OEM companies on a project by project basis.

SCI FilmTek™ Systems(仪器型号及测试功能配置说明)

FilmTek™ systems are offered in a variety of configurations and capabilities in order to match every film measurement need and budget. These systems are computer controlled and offer full automation through simple to use recipe-based control software. The measurements are non-contact, and most can take place in as little as one second. The following table summarizes some of the features of the standard models. The large array of available options make it possible to tailor a FilmTek™ system according to the exact customer requirements.

Measurement Features 测量特征	FilmTek™ 1000	FilmTek™ 1500	FilmTek™ 2000	FilmTek™ 3000	FilmTek™ 2000SE	FilmTek™ 4000
Index of Refraction 折射指数 (at 2μm thickness)	±0.005	±0.005	±0.002	±0.002	±0.0002	±0.00002
Thickness Measurement Range 厚度测量范围	10nm-150mm	10nm-150mm	5nm-150mm	5nm-150mm	1Å-150mm	3nm-350mm
Maximum Spectral Range 最大光谱范围	380-1000nm	380-1000nm	190-1700nm	190-1700nm	190-1700nm	190-1700nm
Standard Spectral Range 标准光谱范围	380-1000nm	380-1000nm	240-860nm	240-860nm	240-1000nm	380-1000nm
Reflection 反射测量	✓	✓	✓	✓	✓	✓
Transmission 透射测量		✓		✓		
Optional Spectroscopic Ellipsometry 可选择的光谱椭圆偏光法测量					✓	✓
Power Spectral Density 功率谱密度测量	✓	✓	✓	✓	✓	✓
Multi-angle Measurements (DPSD) 多角度测量						✓
Both TE & TM Components of Index						✓
Multi-layer thickness 多层厚度测量	✓	✓	✓	✓	✓	✓
Index of Refraction 折射系数测量	✓	✓	✓	✓	✓	✓
Extinction (absorption) Coefficient 消光(吸收)系数	✓	✓	✓	✓	✓	✓
Energy band gap 能量带隙测量			✓	✓	✓	✓
Composition 成分测量			✓	✓	✓	✓
Crystallinity 晶状测量			✓	✓	✓	✓
Inhomogeneous Layers 非均匀层测量			✓	✓	✓	✓
Surface Roughness 表面粗糙度测量			✓	✓	✓	✓
A variety of options can extend these standard measurement capabilities.						

FilmTek™ 1000 and FilmTek™ 1500

FilmTek™ 1000 is the most affordable system for measuring reflection at normal incidence in the visible to NIR. FilmTek™ 1000 combines a fiber-optic spectrophotometer with revolutionary material modeling software to provide an affordable and reliable tool for the simultaneous measurement of film thickness, index of refraction, and extinction coefficient.

FilmTek™ 1000 是可见光常规入射到近红外的反射测量最优配置的仪器. FilmTek™ 1000 将 SCI 公司先进的材料建模软件结合光纤分光光度计, 提供经济的可靠的仪器用于同时测量: 薄膜厚度, 折射系数, 消光系数.

FilmTek™ 1500 measures both transmission and reflection at normal incidence. (常规入射时可同时测量透射和 反射).

可测量:

(Thickness Measurement Range 薄膜厚度测量\ Reflection 反射测量\ Transmission 透射测量\
Power Spectral Density 功率谱密度测量\ Multi-layer thickness 多层厚度测量\
Index of Refraction 折射系数测量\ Extinction (absorption) Coefficient 消光(吸收)系数)

FilmTek™ 1000 Features 特征

Versatile通用性:

FilmTek™ 1000 incorporates SCI's generalized material model with advanced global optimization algorithms for simultaneous determination of:

FilmTek™ 1000结合SCI公司先进的整体最优化算法的广义材料建模用于同时测定:

- Multiple layer thicknesses 多层厚度
- Indices of refraction [$n(\lambda)$] 折射指数
- Extinction (absorption) coefficients [$k(\lambda)$] 消光(吸收)系数

Low Cost低花费:

The cost of ownership of FilmTek™ 1000 is a small fraction of comparable instruments.

购买FilmTek™ 1000的花费相比较其他公司的仪器是较小的一部分.

No Special Knowledge Required无特殊知识要求,或简单,易操作:

FilmTek™ 1000 software is designed so that minimal experience in personal computers, thin film optical design, or measurement techniques is required.

FilmTek™ 1000软件设计目的是对个人计算机, 薄膜光学设计或测量技术能力要求较少.

Non-contact and non-destructive. 非接触和无破坏(性)的测量

Applications 应用

Virtually all translucent films ranging in thickness from 100 angstroms to approximately 150 microns can be measured with high precision. Typical applications include:

(可精确测量厚度从 100 埃到 150 微米的所有半透明薄膜)

Typical applications 典型应用:	
Semiconductor and dielectric materials 半导体和电介质材料薄膜	Computer disks 计算机磁盘薄膜
Multilayer optical coatings 多层光学涂层薄膜	Coated glass 有涂层的玻璃薄膜
Optical antireflection coatings 光学抗反射涂层薄膜	Laser mirrors 激光镜薄膜
Electro-optical materials 电镀光学材料薄膜	Thin Metals 薄金属薄膜
Example Films 薄膜范例:	
SiO _x 氧化硅薄膜	a-Si 非晶硅薄膜
SiN _x 氮化硅薄膜	a-C:H 氧化类金刚石薄膜
DLC 类金刚石薄膜	ITO 锡铟氧化物薄膜
SOG 玻璃上系统薄膜	Polysilicon 多晶硅薄膜
Photoresist 光刻胶薄膜	Polyimide 聚酰亚胺薄膜
Thin Metals 薄金属薄膜	Low K Dielectric Films 低介电薄膜
Example Substrates 衬底范例:	
Silicon 硅衬底	GaAs 砷化镓衬底
SOI 衬底	Glass 玻璃衬底
SOS 衬底	Aluminum 铝衬底

Technical Specifications 技术规格:

Film Thickness range: 薄膜厚度范围	10nm to 150μm
Wide spectral range: 宽光谱范围	380 to 950nm
Beam Spot Size: 聚束光尺寸	1-5mm (5mm is standard)
Optical Resolution: 光分辨率	0.3-2nm
Data acquisition and analysis Time: 数据捕获和分析时间	~5sec

Hardware 硬件:

FilmTek™ 1000 includes:

VIS/NIR spectrophotometer 可见光谱测量/近红外光谱测量分光光度计
VIS/NIR light source 可见光/近红外光光源
Fiber optic cables 光纤电缆
Fixed stage with optics 光学固定平台

Methodology

FilmTek™ simultaneously solves for refractive index $n(\lambda)$, extinction coefficient $k(\lambda)$, and thicknesses of multi-layer film structures. A self-consistent solution is obtained by using SCI's generalized dispersion formula to model fitted values of the dielectric function $\epsilon(\lambda)$. The SCI dispersion formula is quite general and applies to metallic, amorphous, crystalline, and dielectric materials (Figures 1-3). This approach allows the user to model complex multi-layer structures with reflection/transmission data. Global optimization methods are used to obtain the best solution while avoiding local minima and minimizing sensitivity to the user's initial guess of fitted parameters (*i.e.*, layer thickness). FilmTek™ optimizes both the reflectance and power density spectrum (FFT) simultaneously. This unique feature allows for accurate thickness determination over a wide range of thickness (10nm to 150 μ m).

FilmTek™同时测量折射指数 $n(\lambda)$, 消光系数 $k(\lambda)$, 多层结构厚度.使用 SCI 公司广义色散公式可以建模电介质函数 $\epsilon(\lambda)$ 拟合值, 是一致的解决方案. SCI 公司色散公式是相当广义的, 应用于金属(性)的, 非晶形, 晶状, 电介质材料. 这种方法允许用户建模复杂的多层结构的反射/透射数据. 整体最佳化方法用于获得最好的解决方案, 消除局部极小化和用户初期推测 (如: 层厚度)极小灵敏度的合适的参数. FilmTek™使反射系数和功率谱密度(FFT 快速傅氏变换算法) 同时最优化. 这种独特的优点允许对宽薄膜厚度范围(10nm to 150 μ m)进行精确的厚度测定.

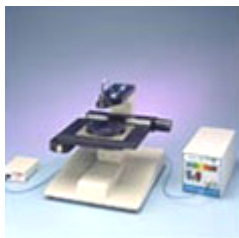
FilmTek™ 2000 and FilmTek™ 2000M

FilmTek™ 2000 is a breakthrough in thin film metrology technology. FilmTek™ 2000 combines a fiber-optic spectrophotometer with revolutionary material modeling software to provide an affordable and reliable tool for the simultaneous measurement of film thickness, index of refraction, and extinction coefficient. FilmTek™ 2000 provides unmatched accuracy, ease of use, and analytical power in a fully integrated package. Ideally suited for patterned device wafers, the FilmTek™ 2000M allows for measurement spot sizes as small as 5 μm

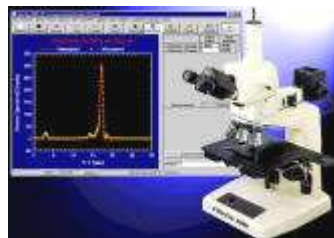
FilmTek™ 2000 是薄膜度量技术的突破. FilmTek™ 2000 将 SCI 公司专利的材料建模软件结合光纤分光光度计, 提供经济的可靠的仪器用于同时测量: 薄膜厚度, 折射系数, 消光系数. FilmTek™ 2000 提供无比的精确度, 易用性, 完全的完整的一揽子分析能力. FilmTek™ 2000 可达到小的光点直径(5 μm), 理想地用于图案晶片.

可测量: (Thickness Measurement Range 薄膜厚度测量\ Reflection 反射测量\
Power Spectral Density 功率谱密度测量\ Multi-layer thickness 多层厚度测量\
Index of Refraction 折射系数测量\ Extinction (absorption) Coefficient 消光(吸收)系数\ Energy band
gap 能量带隙测量\ Composition 成分测量\ Crystallinity 晶状测量\ Inhomogeneous Layers 非均匀层测量\
Surface Roughness 表面粗糙度测量)

(可同时测量厚度, 折射指数, 消光系数)



FilmTek™ 2000



FilmTek™ 2000M



FilmTek™ 2000M-DUV

FilmTek™ 2000 Features 特点:

Versatile 通用性:

FilmTek™ 2000 incorporates SCI's generalized material model with advanced global optimization algorithms for simultaneous determination of:

FilmTek™ 2000结合SCI公司先进的整体最优化算法的广义材料建模用于同时测定:

- Multiple layer thicknesses 多层厚度
- Indices of refraction [$n(\lambda)$] 折射指数
- Extinction (absorption) coefficients [$k(\lambda)$] 消光(吸收)系数
- Energy band gap [E_g] 能量带隙
- Constituent and void fraction 成分和空隙组分
- Surface roughness 表面粗糙度

Low Cost 低花费:

The cost of ownership of FilmTek™ 2000 is a small fraction of comparable instruments.
购买FilmTek™ 2000的花费相比较其他公司的仪器是较小的一部分.

No Special Knowledge Required 无特殊知识要求, 或简单, 易操作:

FilmTek™ 2000 software is designed so that minimal experience in personal computers, thin film optical design, or measurement techniques is required.

FilmTek™ 2000软件设计目的是对个人计算机, 薄膜光学设计或测量技术能力要求较少.

Complete "turn key" System完全的"开钥匙"系统:

A fully integrated spectrophotometer measurement system with calibration, acquisition, and analysis software.

带校准, 捕获, 分析软件的完全综合的分光光度计测量系统

Non-contact and non-destructive. 非接触和无破坏(性)的测量

Flexible灵活:

FilmTek™ 2000 hardware and software can be easily modified to satisfy unique customer requirements.

FilmTek™ 2000硬件和软件能容易地改进以满足独特的客户要求.

Optional features可选择的特征:

- Computer controlled automated stage 计算机控制自动化的平台
- Microscope based system for spot sizes as small as 5μm 显微镜光点直径 5μm
- Cassette to cassette wafer handling 盒到盒晶片操作

Applications 应用:

Virtually all translucent films ranging in thickness from less than 100 angstroms to approximately 150 microns can be measured with high precision. Typical applications include:

(可精确测量厚度从 100 埃到 150 微米的所有半透明薄膜)

Typical applications 典型应用:	
Semiconductor and dielectric materials 半导体和电介质材料薄膜	Computer disks 计算机磁盘薄膜
Multilayer optical coatings 多层光学涂层薄膜	Coated glass 有涂层的玻璃薄膜
Optical antireflection coatings 光学抗反射涂层薄膜	Laser mirrors 激光镜薄膜
Electro-optical materials 电镀光学材料薄膜	Thin Metals 薄金属薄膜
Example Films 薄膜范例:	
SiO _x 氧化硅薄膜	a-Si 非晶硅薄膜
SiN _x 氮化硅薄膜	a-C:H 氧化类金刚石薄膜
DLC 类金刚石薄膜	ITO 锡铟氧化物薄膜
SOG 玻璃上系统薄膜	Polysilicon 多晶硅薄膜
Photoresist 光刻胶薄膜	Polyimide 聚酰亚胺薄膜
Thin Metals 薄金属薄膜	Low K Dielectric Films 低介电薄膜
Example Substrates 衬底范例:	
Silicon 硅衬底	GaAs 砷化镓衬底
SOI 衬底	Glass 玻璃衬底
SOS 衬底	Aluminum 铝衬底

Technical Specifications 技术规格:

Film Thickness range: 薄膜厚度范围	3nm to 350 μ m (5nm to 150 μ m is standard)
Wide spectral range: 宽光谱范围	190 to 1700nm (240 to 860nm is standard)
Measurement Spot Size: 光点直径	5mm to 5 μ m (5mm is standard)
Spectral Resolution: 光谱分辨率	0.3-2nm
Data acquisition and analysis Time: 数据捕获和分析时间	~5sec 秒

Hardware 硬件:

FilmTek™ 2000 includes:

VIS/NIR spectrophotometer 可见光谱测量/近红外光谱测量分光光度计
VIS/NIR light source 可见光/近红外光光源
Fiber optic cables 光纤电缆
Manual sample stage with optics. X-Y stage for 100mm, 150mm and 200mm wafers is standard. 手动光学标本平台,用于 100mm, 150mm and 200mm 晶片
Pentium 4 based PC (512MB of RAM) with Windows™ XP Operating System

Methodology 方法

FilmTek™ 2000 simultaneously solves for refractive index $n(\lambda)$, extinction coefficient $k(\lambda)$, and thicknesses of multi-layer film structures. A self-consistent solution is obtained by using SCI's generalized dispersion formula to model fitted values of the dielectric function $\epsilon(\lambda)$. The SCI dispersion formula is quite general and applies to metallic, amorphous, crystalline, and dielectric materials (Figures 1-3). This approach allows the user to model complex multi-layer structures with reflection/transmission data. Global optimization methods are used to obtain the best solution while avoiding local minima and minimizing sensitivity to the user's initial guess of fitted parameters (e.g., layer thickness). FilmTek™ 2000 optimizes both the reflectance and power density spectrum (FFT) simultaneously. This unique feature allows for accurate thickness determination over a wide range of thickness (3nm to 350 μ m).

FilmTek™同时测量折射指数 $n(\lambda)$, 消光系数 $k(\lambda)$, 多层结构厚度. 使用 SCI 公司广义色散公式可以建模电介质函数 $\epsilon(\lambda)$ 拟合值, 是一致的解决方案. SCI 公司色散公式是相当广义的, 应用于金属(性)的, 非晶形, 晶状, 电介质材料. 这种方法允许用户建模复杂的多层结构的反射/透射数据. 整体最佳化方法用于获得最好的解决方案, 消除局部极小化和用户初期推测 (如: 层厚度) 极小灵敏度的合适的参数. FilmTek™ 2000 使反射系数和功率谱密度 (FFT 快速傅氏变换算法) 同时最优化. 这种独特的优点允许对宽薄膜厚度范围 (3nm to 350 μ m) 进行精确的厚度测定.

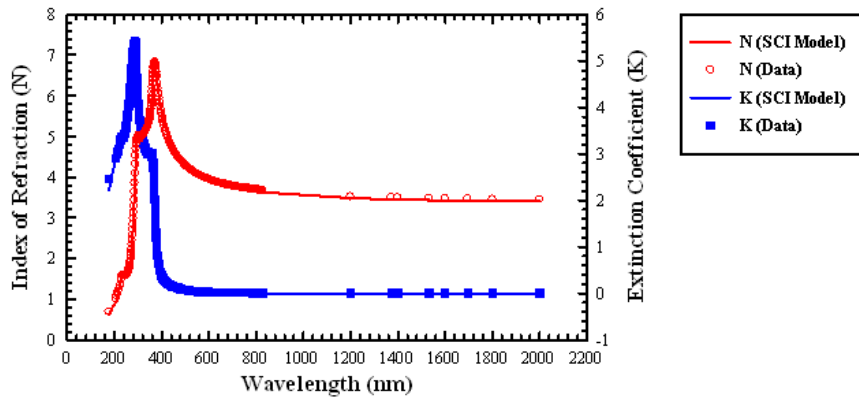


Fig. 1 n 折射指数 and k 消光(吸收)系数 spectra of Silicon

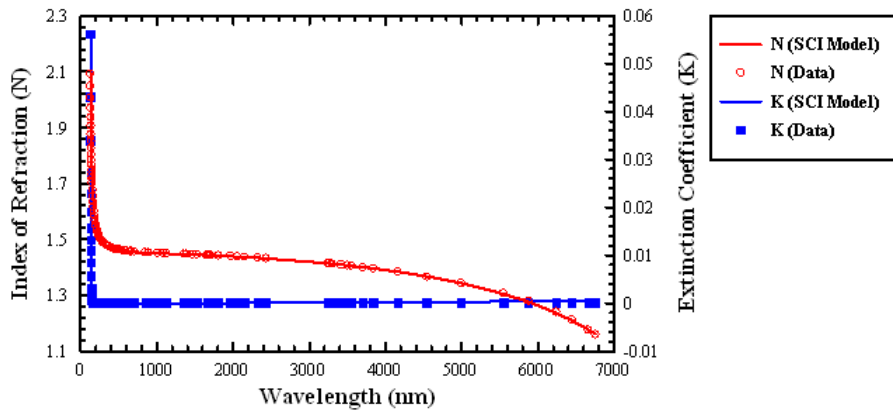


Fig. 2 n 折射指数 and k 消光(吸收)系数 spectra of SiO₂

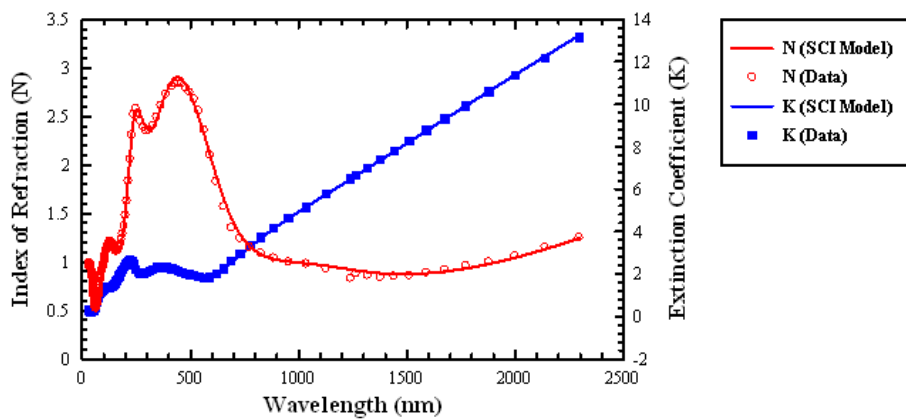


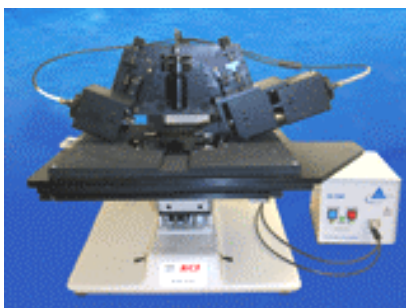
Fig. 3 n 折射指数 and k 消光(吸收)系数 spectra of Tantalum 钽

FilmTek™ 2000SE

FilmTek™ 2000SE is an affordable spectroscopic ellipsometer that measures from 190-1700nm. Based on a rotating compensator design, the FilmTek™ 2000SE is ideally suited for measuring the thickness and optical constants of very thin films. FilmTek™ 2000SE utilizes SCI's material modeling software to provide an affordable and reliable tool for the simultaneous measurement of film thickness, index of refraction, and extinction coefficient. 可测量:

(Thickness Measurement Range 薄膜厚度测量\ Reflection 反射测量\ Optional Spectroscopic Ellipsometry 可选择的光谱椭圆偏光法测量\ Power Spectral Density 功率谱密度测量\ Multi-layer thickness 多层厚度测量\ Index of Refraction 折射系数测量\ Extinction (absorption) Coefficient 消光(吸收)系数\ Energy band gap 能量带隙测量\ Composition 成分测量\ Crystallinity 晶状测量\ Inhomogeneous Layers 非均匀层测量\ Surface Roughness 表面粗糙度测量)

(测量 190-1700nm 的光谱椭偏仪,可同时测量厚度, 折射指数和消光系数)



■	Spectroscopic reflection (190nm-1700nm) of polarized light at multiple angles 偏振光多角度的光谱反射测量(190nm-1700nm)
■	Spectroscopic ellipsometry with rotating compensator design (300nm-1700nm) 回旋补偿设计光谱椭偏仪(300nm-1700nm)
■	Measures film thickness and index of refraction independently 薄膜厚度和折射指数测量
■	New Multi-Angle Differential Polarimetry (MADP) technology with SCI's patented Differential Power Spectral Density (DPSD) technology 基于 SCI 专利的示差功率谱密度技术的新多角度示差偏振测定技术
■	Ideal for measuring ultra-thin films (0.03 Å repeatability on native oxide) 理想的超薄膜测量仪器(天然氧化物 0.03 Å 重复性测量)
■	Ideal for measuring advanced thin films

FilmTek™ 2000SE Features特征

Versatile通用性:

FilmTek™ 2000SE incorporates SCI's generalized material model with advanced global optimization algorithms for simultaneous determination of:

FilmTek™ 2000SE结合SCI公司先进的整体最优化算法的广义材料建模用于同时测定:

- Multiple layer thicknesses 多层厚度
- Indices of refraction [$n(\lambda)$] 折射指数
- Extinction (absorption) coefficients [$k(\lambda)$] 消光(吸收)系数
- Energy band gap [E_g] 能量带隙
- Constituent and void fraction 成分和空隙组分
- Film gradient 薄膜梯度

Low Cost低成本:

The cost of ownership of FilmTek™ 2000SE is a small fraction of comparable instruments. 购买FilmTek™ 2000SE的花费相比较其他公司的仪器是较小的一部分.

No Special Knowledge Required无特殊知识要求,或简单,易操作:

FilmTek™ 2000SE software is designed so that minimal experience in personal computers, thin film optical design, or measurement techniques is required.

FilmTek™ 2000SE软件设计目的是对个人计算机, 薄膜光学设计或测量技术能力要求较少.

Complete "turn key" System完全的"开钥匙"系统:

A fully integrated spectrophotometer measurement system with calibration, acquisition, and analysis software.

带校准, 捕获, 分析软件的完全综合的分光光度计测量系统

Non-contact and non-destructive. 非接触和无破坏(性)的测量

Flexible灵活:

FilmTek™ hardware and software can be easily modified to satisfy unique customer requirements.

FilmTek™硬件和软件能容易地改进以满足独特的客户要求.

Optional features 可选择的特征:

- Computer controlled automated stage. 计算机控制自动化的平台
- Cassette to cassette wafer handling 盒到盒晶片操作

Applications 应用:

Virtually all translucent films ranging in thickness from 1 angstrom to approximately 150 microns can be measured with high precision. Typical applications include:

(可精确测量厚度从 1 埃到 150 微米的所有半透明薄膜)

Typical applications 典型应用:	
Semiconductor and dielectric materials 半导体和电介质材料薄膜	Computer disks 计算机磁盘薄膜
Multilayer optical coatings 多层光学涂层薄膜	Coated glass 有涂层的玻璃薄膜
Optical antireflection coatings 光学抗反射涂层薄膜	Laser mirrors 激光镜薄膜
Electro-optical materials 电镀光学材料薄膜	Thin Metals 薄金属薄膜

Example Films 薄膜范例:

SiO _x 氧化硅薄膜	a-Si 非晶硅薄膜
SiN _x 氮化硅薄膜	a-C:H 氧化类金刚石薄膜
DLC 类金刚石薄膜	ITO 锡铟氧化物薄膜
SOG 玻璃上系统薄膜	Polysilicon 多晶硅薄膜
Photoresist 光刻胶薄膜	Polyimide 聚酰亚胺薄膜
Thin Metals 薄金属薄膜	Low K Dielectric Films 低介电薄膜

Example Substrates 衬底范例:

Silicon 硅衬底	GaAs 砷化镓衬底
SOI 衬底	Glass 玻璃衬底
SOS 衬底	Aluminum 铝衬底

Technical Specifications 技术规格:

Film Thickness range: 薄膜厚度范围	1Å to 150µm
Wide spectral range: 宽光谱范围	190 to 1700nm (240 to 1000nm is standard)
Measurement Spot Size: 光点直径	2mm to 50µm (5mm is standard)
Spectral Resolution: 光谱分辨率	0.3-2nm
Data acquisition and analysis Time: 数据捕获和分析时间	~5sec 秒

FilmTek™ 2000SE Performance Specifications 性能规格

Film(s) 薄膜	Thickness 厚度	Measured Parameters 实测参数	Precision (1σ) 精度
Oxide / Si 氧化物/硅	0-1000 Å	t	0.03 Å
	1000-500,000 Å	t	0.005%
	1000 Å	t, n	0.2 Å / 0.0001
	15,000 Å	t, n	0.5 Å / 0.0001
	150,000 Å	t, n	1.5 Å / 0.00001
Photoresist / Si 光刻胶/硅	1000-5000 Å	t	0.02%
	1000-5000 Å	t, n	0.05% / 0.0002
Nitride / Si 氮化物/硅	1000-5000 Å	t	0.02%
	1000-5000 Å	t, n	0.05% / 0.0005
Polysilicon / Oxide / Si 多晶硅/氧化物/硅	850 Å / 55 Å	t Poly , t Oxide	0.2 Å / 0.1 Å
	850 Å / 55 Å	t Poly , t Oxide	0.2 Å / 0.0005

Hardware 硬件

FilmTek™ 2000SE is a complete system, which includes:

VIS/NIR spectrophotometer 可见光谱测量/近红外光谱测量分光光度计
VIS/NIR light source 可见光/近红外光光源
Fiber optic cables 光纤电缆
Autofocus 自动对光装置
Manual sample stage with optics. X-Y stage for 100mm, 150mm and 200mm wafers is standard. 手动光学标本平台,用于 100mm, 150mm and 200mm 晶片
Pentium 4 based PC (512MB of RAM) with Windows™ XP Operating System

Methodology 方法

FilmTek™ simultaneously solves for refractive index $n(\lambda)$, extinction coefficient $k(\lambda)$, and thicknesses of multi-layer film structures. A self-consistent solution is obtained by using SCI's generalized dispersion formula to model fitted values of the dielectric function $\epsilon(\lambda)$. The SCI dispersion formula is quite general and applies to metallic, amorphous, crystalline, and dielectric materials (Figures 1-3). This approach allows the user to model complex multi-layer structures with reflection/transmission or ellipsometric data. Global optimization methods are used to obtain the best solution while avoiding local minima and minimizing sensitivity to the user's initial guess of fitted parameters (*e.g.*, layer thickness). FilmTek™ optimizes both the ellipsometric and power density spectrum (FFT) simultaneously which allows for accurate thickness determination over a wide range of thickness (1Å to 10µm).

FilmTek™同时测量折射指数 $n(\lambda)$, 消光系数 $k(\lambda)$, 多层结构厚度. 使用 SCI 公司广义色散公式可以建模电介质函数 $\epsilon(\lambda)$ 拟合值, 是一致的解决方案. SCI 公司色散公式是相当广义的, 应用于金属(性)的, 非晶形, 晶状, 电介质材料. 这种方法允许用户建模复杂的多层结构的反射/透射数据. 整体最佳化方法用于获得最好的解决方案, 消除局部极小化和用户初期推测 (如: 层厚度) 极小灵敏度的合适的参数. FilmTek™使反射系数和功率谱密度(FFT 快速傅氏变换算法) 同时最优化. 这种独特的优点允许对宽薄膜厚度范围(1Å to 10µm) 进行精确的厚度测定.

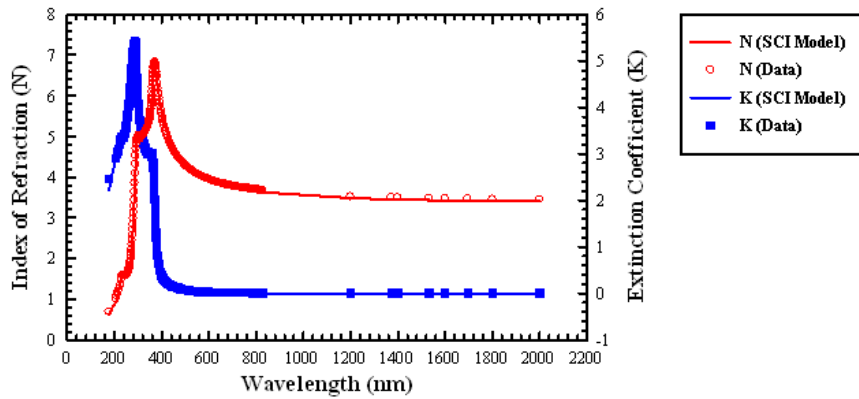


Fig. 1 n 折射指数 and k 消光(吸收)系数 spectra of Silicon

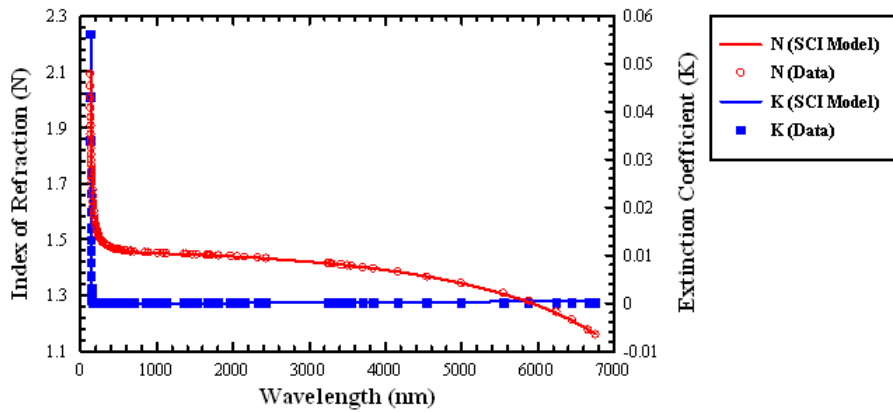


Fig. 2 n 折射指数 and k 消光(吸收)系数 spectra of SiO₂

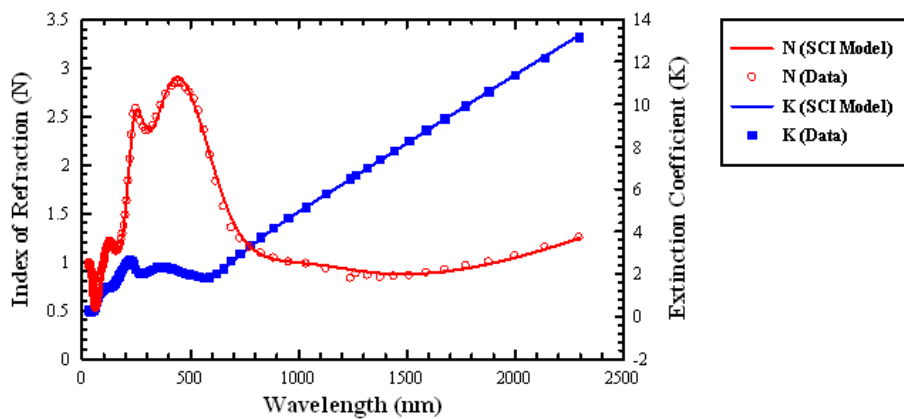


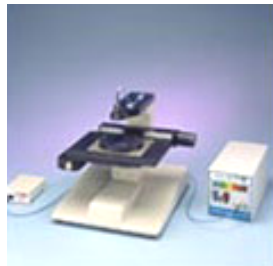
Fig. 3 n 折射指数 and k 消光(吸收)系数 spectra of Tantalum 钽

FilmTek™ 3000 and FilmTek™ 3000M

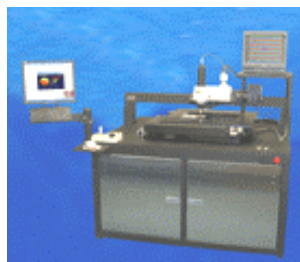
FilmTek™ 3000MUV measures transmission and reflection of films deposited on transparent substrates. It is ideally suited for measuring the thickness and optical constants of very thin absorbing films deposited on transparent substrates. FilmTek™ 3000MUV combines fiber-optic spectrophotometers with SCI's proprietary material modeling software to provide an affordable and reliable tool for the simultaneous measurement of film thickness, index of refraction, and extinction coefficient. With its patented parabolic mirror design, FilmTek™ 3000MUV achieves a small, achromatic spot size (50 μm). FilmTek™ 3000MUV provides unmatched accuracy, ease of use, and analytical power in a fully integrated package.

FilmTek™ 3000MUV对沉积于透明衬底的薄膜进行透射和反射测量. 理想地对沉积于透明衬底的很薄的薄膜进行厚度和光学常数测量. FilmTek™ 3000MUV将SCI公司专利的材料建模软件结合光纤分光光度计, 提供经济的可靠的仪器用于同时测量: 薄膜厚度, 折射系数, 消光系数. 使用SCI公司专利的抛物柱面(反射)镜设计, FilmTek™ 3000MUV可达到小的, 消色差光点直径(50 μm). FilmTek™ 3000MUV提供无比的精确度,易用性, 完全的完整的一揽子分析能力. 可测量:

(Thickness Measurement Range 薄膜厚度测量\ Reflection反射测量\ Transmission透射测量\ Power Spectral Density功率谱密度测量\ Multi-layer thickness多层厚度测量\ Index of Refraction折射系数测量\ Extinction (absorption) Coefficient消光(吸收)系数\ Energy band gap能量带隙测量\ Composition成分测量\ Crystallinity晶状测量\ Inhomogeneous Layers非均匀层测量\ Surface Roughness表面粗糙度测量)
(透明衬基沉积薄膜的透射和反射测量,适合平板显示器)



FilmTek™ 3000



FilmTek™ 3000M

FilmTek™ 3000MUV Features特征

Versatile通用性:

FilmTek™ 3000MUV incorporates SCI's generalized material model with advanced global optimization algorithms for simultaneous determination of:

FilmTek™ 3000MUV结合SCI公司先进的整体最优化算法的广义材料建模用于同时测定:

- Multiple layer thicknesses多层厚度
- Indices of refraction [$n(\lambda)$] 折射指数
- Extinction (absorption) coefficients [$k(\lambda)$] 消光(吸收)系数
- Energy band gap [E_g]能量带隙
- Constituent and void fraction成分和空隙组分
- Surface roughness表面粗糙度

Low Cost低花费:

The cost of ownership of FilmTek™ 3000MUV is a small fraction of comparable instruments. 购买FilmTek™ 3000MUV的花费相比较其他公司的仪器是较小的一部分.

No Special Knowledge Required无特殊知识要求,或简单,易操作:

FilmTek™ 3000MUV software is designed so that minimal experience in personal computers, thin film optical design, or measurement techniques is required.

FilmTek™ 3000MUV软件设计目的是对个人计算机, 薄膜光学设计或测量技术能力要求较少.

Complete "turn key" System完全的"开钥匙"系统:

A fully integrated spectrophotometer measurement system with calibration, acquisition, and analysis software.

带校准, 捕获, 分析软件的完全综合的分光光度计测量系统

Non-contact and non-destructive. 非接触和无破坏(性)的测量

Flexible灵活:

FilmTek™ 3000MUV hardware and software can be easily modified to satisfy unique customer requirements.

FilmTek™ 3000MUV硬件和软件能容易地改进以满足独特的客户要求.

Optional features可选的特征:

- Computer controlled automated stage 计算机控制自动化的平台

- Large custom stages for flat panel display applications 适合平板显示器应用的巨大定制平台

Applications应用

Virtually all translucent films ranging in thickness from less than 100 angstroms to approximately 150 microns can be measured with high precision. Typical applications include:

可精确测量厚度从100埃到150微米的所有半透明薄膜.

Typical applications 典型应用:	
Flat panel display 平板显示器薄膜	OLED 有机发光二极管薄膜
Semiconductor and dielectric materials 半导体和电介质材料薄膜	Computer disks 计算机磁盘薄膜
Multilayer optical coatings 多层光学涂层薄膜	Coated glass 有涂层的玻璃薄膜
Optical antireflection coatings 光学抗反射涂层薄膜	Laser mirrors 激光镜薄膜
Electro-optical materials 电镀光学材料薄膜	Thin Metals 薄金属薄膜

Example Films 薄膜范例:		
SiO _x 氧化硅薄膜	a-Si 非晶硅薄膜	Alq ₃ 八-羟基喹啉铝
SiN _x 氮化硅薄膜	a-C:H 氧化类金刚石薄膜	HIL 空穴注入层 Hole injection layer
DLC 类金刚石薄膜	ITO 锡铟氧化物薄膜	BEML
SOG 玻璃上系统薄膜	Polysilicon 多晶硅薄膜	GEML
Photoresist 光刻胶薄膜	Polyimide 聚酰亚胺薄膜	GETL
Thin Metals 薄金属薄膜	Color Dye 彩色染料薄膜	REML

Example Substrates 衬底范例:	
Silicon 硅衬底	GaAs 砷化镓衬底
SOI 衬底	Glass 玻璃衬底
SOS 衬底	Aluminum 铝衬底

Technical Specifications 技术规格:

Film Thickness range: 薄膜厚度范围	3nm to 350 μ m (5nm to 150 μ m is standard)
Wide spectral range: 宽光谱范围	240 to 1700nm (240 to 860nm is standard)
Measurement Spot Size: 光点直径	50 μ m
Spectral Resolution: 光谱分辨率	0.3-2nm
Data acquisition and analysis Time: 数据捕获和分析时间	~5sec 秒
Thickness Precision	$\pm 2\text{\AA}$
Index Precision	± 0.005

Hardware硬件:

FilmTek™ 3000MUV is a complete system, which includes:

FilmTek™ 3000MUV是一个完整的系统, 包括:

UV/VIS/NIR spectrophotometer 紫外/可见光谱测量/近红外光谱测量分光光度计
UV/VIS/NIR light source 紫外/可见光/近红外光光源
Fiber optic cables 光纤电缆
Autofocus 自动对光装置
Manual sample stage with optics. X-Y stage for 100mm, 150mm and 200mm wafers is standard. 手动光学标本平台,用于 100mm, 150mm and 200mm 晶片
Pentium 4 based PC (512MB of RAM) with Windows™ XP Operating System

Methodology方法论

FilmTek™ simultaneously solves for refractive index $n(\lambda)$, extinction coefficient $k(\lambda)$, and thicknesses of multi-layer film structures. A self-consistent solution is obtained by using SCI's generalized dispersion formula to model fitted values of the dielectric function $\epsilon(\lambda)$. The SCI dispersion formula is quite general and applies to metallic, amorphous, crystalline, and dielectric materials. This approach allows the user to model complex multi-layer structures with reflection/transmission data. Global optimization methods are used to obtain the best solution while avoiding local minima and minimizing sensitivity to the user's initial guess of fitted parameters (e.g., layer thickness). FilmTek™ optimizes both the reflectance and power density spectrum (FFT) simultaneously. This unique feature allows for accurate thickness determination over a wide range of thickness (3nm to 350 μ m).

FilmTek™同时测量折射指数 $n(\lambda)$, 消光系数 $k(\lambda)$, 多层结构厚度.使用SCI公司广义色散公式可以建模电介质函数 $\epsilon(\lambda)$ 拟合值, 是一致的解决方案. SCI公司色散公式是相当广义的, 应用于金属(性)的, 非晶形, 晶状, 电介质材料. 这种方法允许用户建模复杂的多层结构的反射/透射数据. 整体最佳化方法用于获得最好的解决方案, 消除局部极小化和用户初期推测 (如: 层厚度)极小灵敏度的合适的参数. FilmTek™使反射系数和功率谱密度(FFT快速傅氏变换算法) 同时最优化. 这种独特的优点允许对宽薄膜厚度范围(3nm to 350 μ m)进行精确的厚度测定.

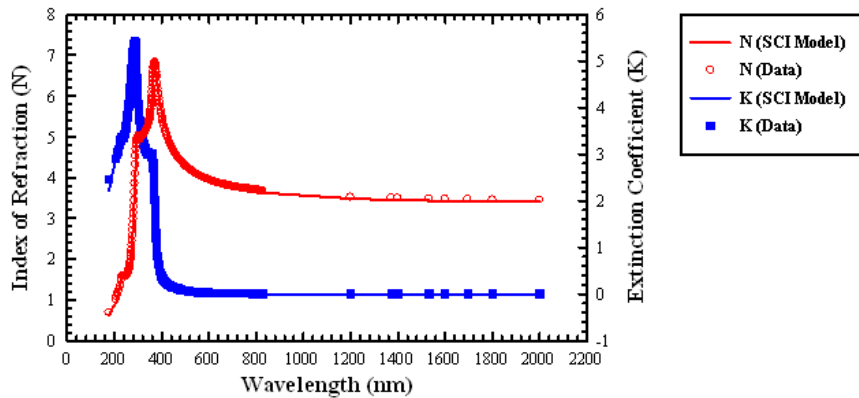


Fig. 1 n 折射指数 and k 消光(吸收)系数 spectra of Silicon

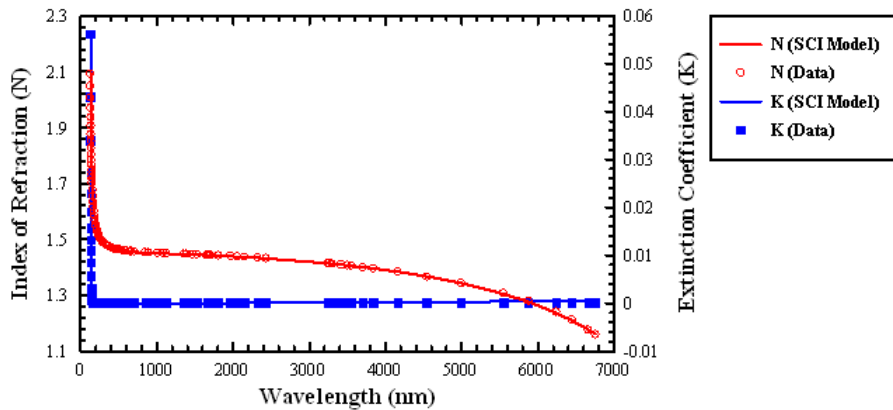


Fig. 2 n 折射指数 and k 消光(吸收)系数 spectra of SiO₂

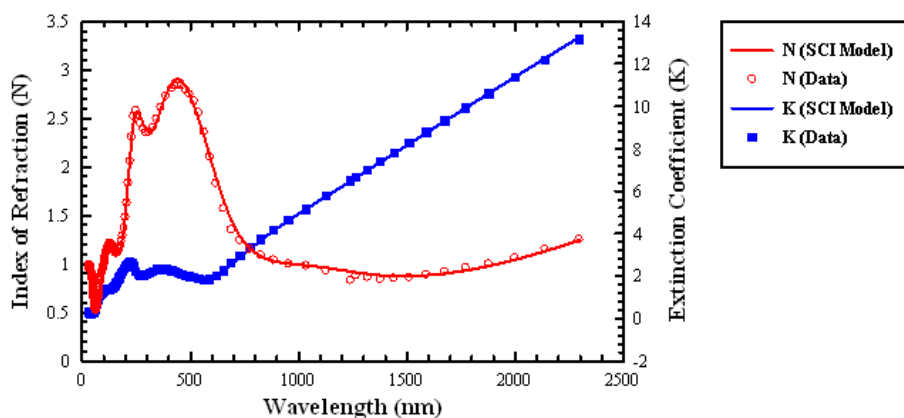


Fig. 3 n 折射指数 and k 消光(吸收)系数 spectra of Tantalum 钽

SCI's FilmTek 3000M for Large Panels 平板显示器 **Equipment & Metrology Performance Specifications**



Measurement Feature 测量特征

- The equipment provides for non-contact measurement
- 提供非接触式测量

Spot Size 光点直径

- The equipment is microscope type capable of measuring down to 40microns in diameter
- 显微镜能测量光点直径 40 微米.

Measured Parameters 实测参数

- Measurement of transmission spectrum
- 透射光谱测量
- Measurement of reflective spectrum
- 反射光谱测量
- Measurement of CIE color coordinates of one color filter pixel; e.g. x-y, L-a-b
- CIE(国际照明委员会)彩色滤光像素颜色坐标,如: x-y, L-a-b
- Film characterization for single and multi-layer films including thickness and index values
- 单/多层薄膜厚度和系数值特性

Stage 平台

- Mountable substrate size is 470mm x 370mm.
- 可安放衬底尺寸 470mm x 370mm
- The stage is horizontal type
- 水平平台
- The substrate should be placed on the stage manually
- 衬底手动放置在平台上.
- The method for holding of the substrate on the stage to be agreed by customer and SCI
- 衬底在平台上的固定方法由客户定制.
- The stage movement allows for full scan of the substrate
- 平台移动可允许完整的衬底扫描.
- The measured points can be set in the program by the user
- 实测点用户可编程.

- The equipment provides the control of the stage movement both automatically and in manual mode, in the X-Y directions
- 自动或手动模式进行 X-Y 方向平台移动控制
- In the manual control mode of the stage, the stage can be moved by either a joystick or by the use of a button in the program
- 手动模式进行平台移动,可用操纵杆或程序按钮控制.

Auto-Focus 自动调焦

- The equipment provides for auto-focus capability
- A CCD camera system shows the image for focus-adjustment and the selection of the measurement area

Computer System 计算机系统

- Pentium IV based computer, 2.8 GHz, 512M DRAM, CD-Write, 17" flat panel display, (or better)
- Windows XP operating system

Facilities Requirements 设备要求

- A floor space of 2 meters x 2 meters 基底距离 2 米 X 2 米
- Temperature range of $23 \pm 2^{\circ} \text{C}$ 温度范围 $23 \pm 2^{\circ} \text{C}$
- Humidity range of $43 \pm 5\%$ 湿度范围 $43 \pm 5\%$
- Cleanliness of class 100 or better 清洁等级 100 或更好
- Electrical power of 110VAC, 50-60 Hz, 20A
- House vacuum for holding the substrate in place on the stage.
- Note: A small vacuum pump can be supplied by SCI at no charge if so requested by the customer
-

Performance Specifications 性能规格

Item 项目	Spec 规格
Range of wavelength 波长范围	400nm - 1000nm
Accuracy of color filter CIE coordinate 彩色滤光 CIE 座标系精度	$x, y = \pm 0.02$
Repeatability of color filter CIE coordinate 彩色滤光 CIE 座标系可重复性精度	$x, y = \pm 0.01$
Accuracy of film thickness measurement 薄膜厚度测量精度	larger of $\pm 1\%$ or 1 nm
Repeatability of film thickness measurement 薄膜厚度测量可重复性精度	larger of $\pm 1\%$ or 1 nm
Accuracy of transmissive spectrum measurement 透射频谱测量精度	$\pm 3\%$
Repeatability of transmissive spectrum measurement 透射频谱测量可重复性精度	$\pm 3\%$
Accuracy of reflective spectrum measurement 反射频谱测量精度	$\pm 3\%$
Repeatability of reflective spectrum measurement 反射频谱测量可重复性精度	$\pm 3\%$

FilmTek™ 4000 (SCI 最先进厚膜仪器)

FilmTek™ 4000 is our most advanced model for thick-film applications. It incorporates multiple detectors positioned at different angles of incidence — plus our patented multi-angle Differential Power Spectral Density analysis capability — to accurately measure the index of refraction with a resolution of 0.00002. That's 100 times the performance of the best non-contact method, 10 times that of the best prism coupler contact systems. The FilmTek™ 4000 can measure birefringence of anisotropic materials. With its hot plate option, it can characterize the index of refraction and thermal expansion of a film as a function of temperature. And its spectroscopic ellipsometer option allows measurement of very thin films. A prime application for this system is measuring the index of refraction and thickness of planar waveguide films.可测量:

(Thickness Measurement Range 厚度测量范围\ Reflection 反射测量\ Transmission 透射测量\
Optional Spectroscopic Ellipsometry 可选择的光谱椭圆偏光法测量\ Power Spectral Density 功率谱
密度测量\ Multi-angle Measurements (DPSD) 多角度测量\ Both TE & TM Components of Index \
Multi-layer thickness 多层厚度测量\ Index of Refraction 折射系数测量\ Extinction (absorption)
Coefficient 消光(吸收)系数\ Energy band gap 能量带隙测量\ Composition 成分测量\
Crystallinity 晶状测量\ Inhomogeneous Layers 非均匀层测量\ Surface Roughness 表面粗糙度测量)

(折射指数分辨率 0.00002, 可测量各向异性双折射材料, 可加热平台用于温度变化时表现

折射指数-热膨胀特性, 最好的应用是测量平面波导薄膜的折射指数和厚度)



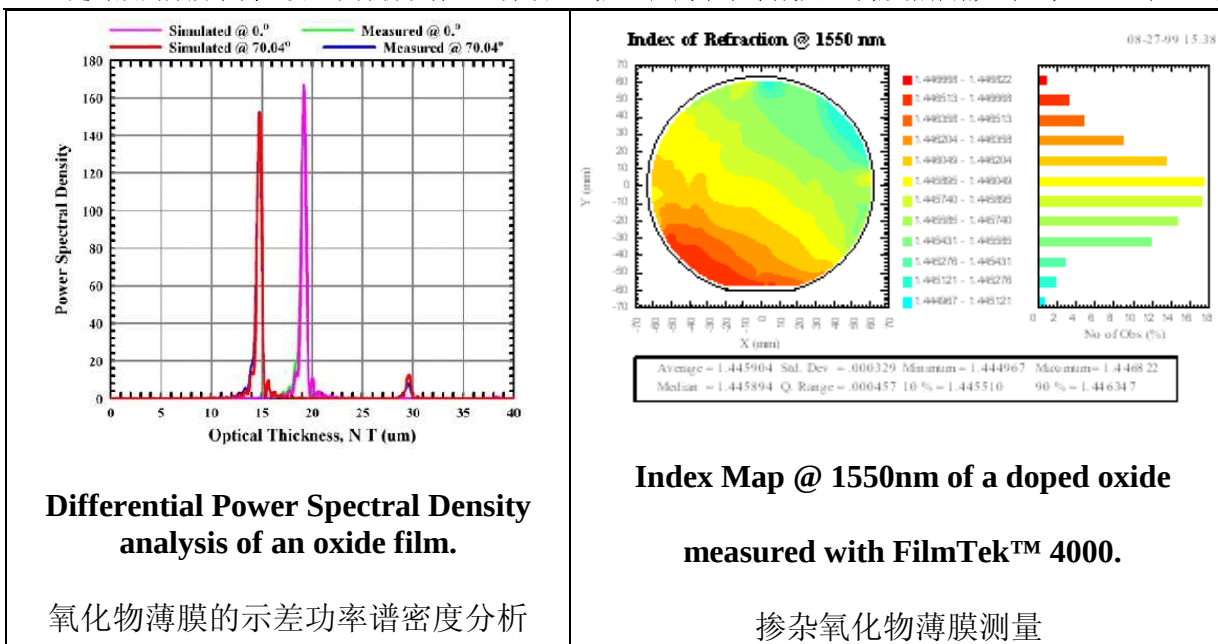
FilmTek™ 4000



FilmTek™ 4000-A

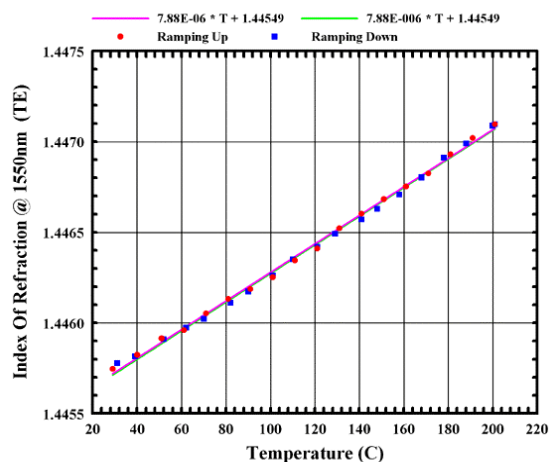
FilmTek™ 4000 High Precision Measurement of Index(高精度测量指标)

This unique FilmTek™ 4000 capability employs our patented DPSD (Differential Power Spectral Density) technique. Spectroscopic reflection data are gathered at normal incidence and 70 degrees. PSD processing results in two peaks in the Power Spectral Density domain. The ratio of their positions is a function of the index of refraction of the film, and the angle of incidence of the oblique measurement. This ratio is used to calculate the index. Once the index is known, the thickness can be calculated from the optical thickness of the normal incident peak.



FilmTek™ 4000 Features 特征

■	Versatile: FilmTek™ 4000 incorporates SCI's generalized material model with advanced global optimization algorithms for simultaneous determination of: <table><tr><td>- Multiple layer thicknesses from 1Å to 350µm 多层厚度测量</td></tr><tr><td>- Optical properties from 190nm-1700nm 光学特性</td></tr><tr><td>- TE 横电场 and TM 横电场 indices of refraction [$n(\lambda)$] 折射指数</td></tr><tr><td>- Extinction (absorption) coefficients [$k(\lambda)$] 消光(吸收)系数</td></tr><tr><td>- Energy band gap [E_g] 能量带隙</td></tr><tr><td>- Constituent and void fraction 成分和空隙组分</td></tr><tr><td>- Surface roughness 表面粗糙度</td></tr></table>	- Multiple layer thicknesses from 1Å to 350µm 多层厚度测量	- Optical properties from 190nm-1700nm 光学特性	- TE 横电场 and TM 横电场 indices of refraction [$n(\lambda)$] 折射指数	- Extinction (absorption) coefficients [$k(\lambda)$] 消光(吸收)系数	- Energy band gap [E_g] 能量带隙	- Constituent and void fraction 成分和空隙组分	- Surface roughness 表面粗糙度
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- Surface roughness 表面粗糙度								
■	No Special Knowledge Required: FilmTek™ 4000 software is designed so that minimal experience in personal computers, thin film optical design, or measurement techniques is required. (简单,易操作)							
■	Complete "turn key" System: A fully integrated spectrophotometer measurement system with calibration, acquisition, and analysis software.							
■	Non-contact and non-destructive. (非接触和无破坏(性)的测量)							
■	Flexible: FilmTek™ 4000 hardware and software can be easily modified to satisfy unique customer requirements.							
■	Optional features: <table><tr><td>- Spectroscopic ellipsometry option for thin films 薄膜光谱椭偏仪选件</td></tr><tr><td>- Cassette to cassette wafer handling 盒到盒晶片操作</td></tr><tr><td>- Heating/cooling chuck 加热/冷却卡盘</td></tr><tr><td>- 300mm, FOUP 正面打开的统一标准箱, and SMIF 标准机械接口 compatible</td></tr></table>	- Spectroscopic ellipsometry option for thin films 薄膜光谱椭偏仪选件	- Cassette to cassette wafer handling 盒到盒晶片操作	- Heating/cooling chuck 加热/冷却卡盘	- 300mm, FOUP 正面打开的统一标准箱, and SMIF 标准机械接口 compatible			
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SiO₂ Film Properties vs Temperature 二氧化硅薄膜温度特性

Measured by FilmTek™ 4000
with heating chuck during one
heat-cool cycle.
在冷却循环中使用加热卡盘进
行测量

Applications 应用:

Virtually all translucent films ranging in thickness from 1 angstrom to approximately 250 microns can be measured with high precision. Typical applications include:

(可精确测量厚度从 1 埃到 250 微米的所有半透明薄膜)

Typical applications 典型应用:	
Semiconductor and dielectric materials 半导体和电介质材料薄膜	Computer disks 计算机磁盘薄膜
Multilayer optical coatings 多层光学涂层薄膜	Coated glass 有涂层的玻璃薄膜
Optical antireflection coatings 光学抗反射涂层薄膜	Laser mirrors 激光镜薄膜
Electro-optical materials 电镀光学材料薄膜	Thin Metals 薄金属薄膜
Example Films 薄膜范例:	
SiO _x 氧化硅薄膜	a-Si 非晶硅薄膜
SiN _x 氮化硅薄膜	a-C:H 氧化类金刚石薄膜
DLC 类金刚石薄膜	ITO 锡铟氧化物薄膜
SOG 玻璃上系统薄膜	Polysilicon 多晶硅薄膜
Photoresist 光刻胶薄膜	Polyimide 聚酰亚胺薄膜
Thin Metals 薄金属薄膜	Low K Dielectric Films 低介电薄膜
Example Substrates 衬底范例:	
Silicon 硅衬底	GaAs 砷化镓衬底
SOI 衬底	Glass 玻璃衬底
SOS 衬底	Aluminum 铝衬底

Technical Specifications 技术规格:

Film Thickness range: 薄膜厚度范围	1Å to 350µm (3nm to 250µm is standard)
Index resolution	2×10^{-5}
Wide spectral range: 宽光谱范围	190 to 1700nm (240 to 1000nm is standard)
Spectral Resolution: 光谱分辨率	0.3-2nm

Methodology 方法

FilmTek™ simultaneously solves for refractive index $n(\lambda)$, extinction coefficient $k(\lambda)$, and thicknesses of multi-layer film structures. A self-consistent solution is obtained by using SCI's generalized dispersion formula to model fitted values of the dielectric function $\epsilon(\lambda)$. The SCI dispersion formula is quite general and applies to metallic, amorphous, crystalline, and dielectric materials (Figures 1-3). This approach allows the user to model complex multi-layer structures with reflection/transmission data. Global optimization methods are used to obtain the best solution while avoiding local minima and minimizing sensitivity to the user's initial guess of fitted parameters (*e.g.*, layer thickness). FilmTek™ optimizes both the reflectance and power density spectrum (FFT) simultaneously. This unique feature allows for accurate thickness determination over a wide range of thickness (1Å to 350µm).

FilmTek™同时测量折射指数 $n(\lambda)$, 消光系数 $k(\lambda)$, 多层结构厚度. 使用 SCI 公司广义色散公式可以建模电介质函数 $\epsilon(\lambda)$ 拟合值, 是一致的解决方案. SCI 公司色散公式是相当广义的, 应用于金属(性)的, 非晶形, 晶状, 电介质材料. 这种方法允许用户建模复杂的多层结构的反射/透射数据. 整体最佳化方法用于获得最好的解决方案, 消除局部极小化和用户初期推测 (如: 层厚度) 极小灵敏度的合适的参数. FilmTek™使反射系数和功率谱密度 (FFT 快速傅氏变换算法) 同时最优化. 这种独特的优点允许对宽薄膜厚度范围 (1Å to 350µm) 进行精确的厚度测定.

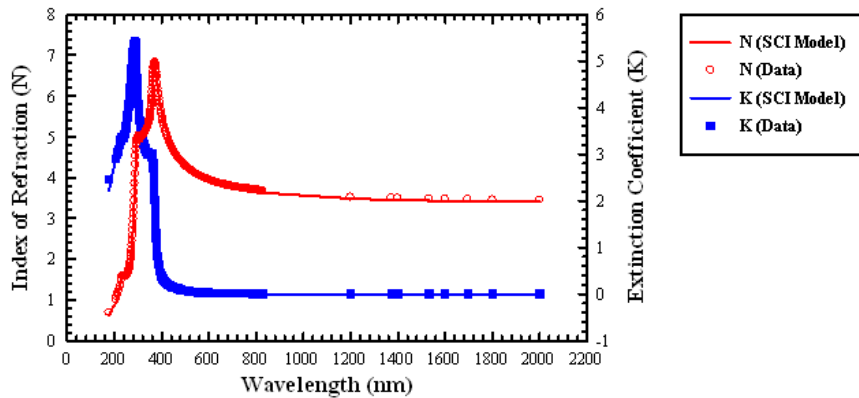


Fig. 1 n 折射指数 and k 消光(吸收)系数 spectra of Silicon

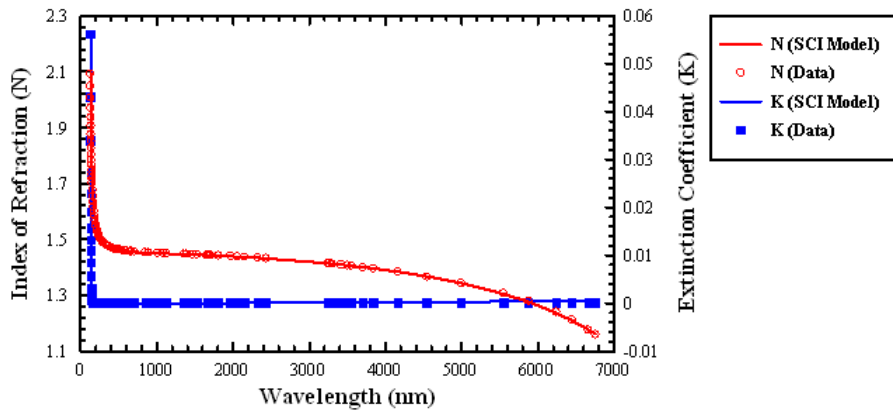


Fig. 2 n 折射指数 and k 消光(吸收)系数 spectra of SiO₂

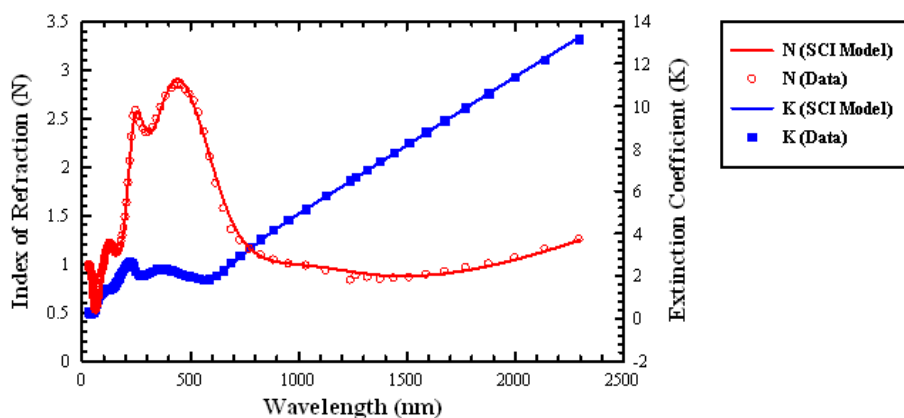
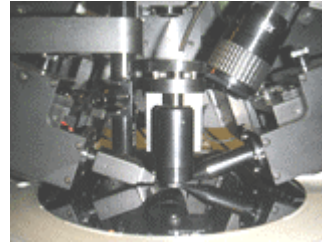


Fig. 3 n 折射指数 and k 消光(吸收)系数 spectra of Tantalum 钽

FilmTek™ 4000EM-DUV



FilmTek™ 4000 EM-DUV FilmTek™ 4000 EM-DUV Optical Head

FilmTek™ 4000 EM-DUV Features 特征:

■	Spectroscopic reflection (190nm-1700nm) of polarized light at multiple angles 多角度偏振光光谱反射
■	Spectroscopic ellipsometry with rotating compensator design 回转补偿设计的光谱椭圆偏光法
■	Small spot (measures within a 50x50 μm feature) 小点
■	Measures film thickness and index of refraction independently 独立测量薄膜厚度和折射系数
■	New Multi-Angle Differential Polarimetry (MADP) technology with SCI's patented Differential Power Spectral Density (DPSD) technology 基于 SCI 专利的示差功率谱密度技术的新多角度示差偏振测定技术
■	Ideal for measuring advanced thin films
■	Optional features: - Cassette to cassette wafer handling 盒到盒晶片操作 - 300mm, FOUP 正面打开的统一标准箱, and SMIF 标准机械接口 compatible

300mm Optical Thin-Film Metrology System for Advanced Thin Films

先进薄膜的 300mm 光学薄膜测量系统

Setting a new standard for thin-film metrology capability and performance, the FilmTek™ 4000EM-DUV leverages the combination of new proprietary Multi-Angle Differential Polarimetry (MADP) technology with SCI's patented Differential Power Spectral Density (DPSD) technology to provide an optical thin-film metrology tool with the best resolution, accuracy, and repeatability in the industry. By providing superior precision and accuracy, FilmTek™ 4000EM-DUV enables tighter thin-film process control during production of the latest-generation IC's to increase overall device yield and performance. In addition to providing tighter thin-film process control, FilmTek™ 4000EM-DUV enables chip manufacturers to accelerate their transition to future technology nodes through characterization and accurate measurement of advanced thin films.

(FilmTek™ 4000EM-DUV 在最新集成电路生产中紧密控制薄膜加工过程以提升器件性能)

中电网 EMD (半导体设备与材料部) 网址: www.chinaemnet.com

联系人: 刘健博 电话: (021)61021225-827 传真: (021)52353710 E-mail: liujianbo@ChinaECNet.com
 地址: 上海市普陀区宁夏路 201 号绿地科创大厦 21 楼 B、C 座 邮编: 200063

Manufacturing advanced IC devices at sub-130nm design rules requires the use of complex films that must be highly uniform. To maintain tight control over the processes used to build these films requires metrology systems that can monitor extremely thin films that are often within a multi-layer film stack (*e.g.*, high-k and oxide-nitride-oxide films). Additionally, some processes result in gradients through the thickness of the film that must be monitored for optimum device performance (*e.g.*, implant damage and low-k films). Existing metrology tools that rely on conventional ellipsometry or reflectometry techniques are limited in their ability to detect film changes for these applications.

在多层薄膜堆叠(如:高 K 和氧化物氮化物氧化物薄膜)中紧密监视薄膜加工过程

The FilmTek™ 4000EM-DUV enables high-precision thickness and material characterization measurements for accurately monitoring advanced thin films such as high-k film stacks, oxide-nitride-oxide (ONO), low-k films, 193nm photoresist, 193nm anti-reflective coatings (ARC and BARC), thick and thin silicon-on-insulator (SOI), silicon germanium (SiGe), and amorphous carbon films. In addition to measuring film thickness and index of refraction [$n(\lambda)$], the FilmTek™ 4000EM-DUV can simultaneously determine extinction coefficients [$k(\lambda)$], surface roughness and damage, porosity, crystallinity, birefringence and stress, and energy band gap [E_g].

(高 K 薄膜堆叠,氧化物氮化物氧化物 ONO 薄膜, 低 K 薄膜, 193nm 光刻胶, 193nm 抗反射涂层(ARC and BARC), 厚/薄绝缘硅(SOI), 硅锗(SiGe), 无定形碳薄膜)高精度厚度和材料特性测量.

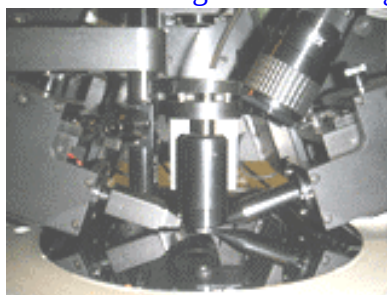
FilmTek™ 4000EM-DUV 可同时测量薄膜厚度, $n(\lambda)$ 折射指数, $k(\lambda)$ 消光系数, 表面粗糙度及损伤, 孔隙, 晶状, 双折射和应力, [E_g]. 能量带隙

Combining proprietary Multi-Angle Differential Polarimetry (MADP) technology with SCI's patented Differential Power Spectral Density (DPSD) technology, the FilmTek™ 4000EM-DUV utilizes spectroscopic reflection (190nm-1700nm) of polarized light at multiple angles to independently measure film thickness and index of refraction. By independently measuring index and thickness, the FilmTek™ 4000EM-DUV is far more sensitive to changes in films, particularly films within multi-layer stacks, than existing metrology tools that rely on conventional ellipsometry or reflectometry techniques. Additionally, the FilmTek™ 4000EM-DUV has a small measurement spot size to allow for measurement directly on product wafers (measures within a 50x50 micron feature).

FilmTek™ 4000EM-DUV Performance Specifications 性能规格

Film(s) 薄膜	Thickness 厚度	Measured Parameters 实测参数	Precision (1 σ) 精度
Oxide / Si 氧化物/硅	0-1000 Å	t	0.03 Å
	1000-500,000 Å	t	0.005%
	1000 Å	t, n	0.2 Å / 0.0001
	15,000 Å	t, n	0.5 Å / 0.0001
	150,000 Å	t, n	1.5 Å / 0.00001
Photoresist / Si 光刻胶/硅	1000-5000 Å	t	0.02%
	1000-5000 Å	t, n	0.05% / 0.0002
Nitride / Si 氮化物/硅	1000-5000 Å	t	0.02%
	1000-5000 Å	t, n	0.05% / 0.0005
Polysilicon / Oxide / Si 多晶硅/氧化物/硅	850 Å / 55 Å	t Poly , t Oxide	0.2 Å / 0.1 Å
	850 Å / 55 Å	t Poly , t Oxide	0.2 Å / 0.0005

FilmTek™ 4000 EM-DUV Module Integrated Metrology Modules 集成测量模块



SCI provides customized versions of FilmTek™ products that can be integrated into other metrology tools and process equipment. These modules are offered to equipment manufacturers in order to enhance the performance of their products and to provide total solutions to the end users. Please contact SCI for further information regarding FilmTek™ Integrated Metrology Modules.

Software Products 软件产品

[Film Wizard™](#) [FilmMonitor™](#) [FilmEllipse™](#) [Software Demos™](#)

SCI offers diverse tools for optical thin film design, material analysis, ellipsometry, and spectrophotometry. SCI's current optical thin film software includes:

Film Wizard™ is the most powerful, versatile, and user friendly thin film software on the market. Film Wizard™ combines optimization and synthesis design capabilities with powerful tools for analyzing spectroscopic and ellipsometric data, modeling thin film layers, and performing regressions to determine actual thicknesses and indices of multi-layered thin film structures.

(光谱分析和椭圆偏光法分析, 薄膜层建模, 实际厚度和多层薄膜结构指数回归曲线)

Film Wizard™

Film Wizard™ supports direct importing of target data from several commercial spectrophotometers and ellipsometers. If your particular spectrophotometer or ellipsometer is not currently supported by Film Wizard™, SCI will customize Film Wizard™ to import your ASCII data files at no additional cost. If you have other special requirements that can not be readily implemented with the macro language embedded in Film Wizard™, SCI would be happy to provide a quote for the necessary customization.

(Film Wizard™ 支撑几种商用分光光度计和偏振光椭圆率测量仪的目标指示数据输入)

FilmMonitor™

FilmMonitor™ is an optical deposition monitor software tool used to translate multi-layered thin film designs into optical monitor run sheets. FilmMonitor™ supports multiple wavelengths, multiple chips, as well as thickness and index tooling factors.

(光沉积监控软件工具用于多层薄膜设计转化为光监控管理表)

FilmEllipse™

FilmEllipse™ is an easy to use production oriented software package for the analysis and acquisition of ellipsometric data. FilmEllipse™ allows the user to find solutions to a wide range of applications not typically covered by the software bundled with commercially available ellipsometers.

(用于分析和捕获椭圆偏光数据的工艺型可定向软件包)

Services 服务

Custom Software Development

SCI will completely customize its products for a customers specific needs. Quotes are available upon request.

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联系人: 刘健博 电话: (021)61021225-827 传真: (021)52353710
地址: 上海市普陀区宁夏路 201 号绿地科创大厦 21 楼 B、C 座

E-mail: liujianbo@ChinaECNet.com
邮编: 200063

Film Wizard™ (Optical Thin Film Software光学薄膜软件)

[Design](#) 设计| [Materials](#) 材料| [Analysis](#) 分析| [Optimization](#) 优化| [Synthesis](#) 综合| [Results](#) 计算结果| [Macro](#) 宏

Film Wizard™ Professional is the most powerful, versatile, and user friendly software package ever to be offered to the thin film engineer/scientist. It combines optimization and synthesis design capabilities with powerful analytical tools for interpreting spectroscopic and ellipsometric data, modeling of film layers, and performing regressions to determine actual thicknesses and indices of deposited layers. In particular, Film Wizard™:

(光谱分析和椭圆偏光法分析, 薄膜层建模, 实际厚度和多层薄膜结构指数回归曲线)

■	Incorporates five new optical thin film synthesis methods including Needle Synthesis. 合并五种新光学薄膜综合方法, 包括针综合
■	Provides seven optimization algorithms, three of which are global. 提供七种最优化算法, 三种是全局优化.
■	Provides a constrained optimization option where the user may input maximum and minimum bounds for any variable that is optimized. 当用户为任何一个需要最优化的变量输入最大和最小范围时, 提供强制最优化选项
■	Computes and optimizes transmittance, reflectance, absorbance, transmitted phase, reflected phase, ellipsometric parameters ($\tan(\psi)$, $\cos(\Delta)$, ψ , Δ), optical density, user defined targets (e.g., $T_s/R_p - R_s/T_p$), electric field, and color coordinate targets. 最优化能见度, 反射系数, 吸收比,透射相位, 反射相位, 椭圆偏光参数等.
■	Incorporates several unique material/layer models (Rugate, EMA, Graded, User Defined Index, and Super Lattices) which give the thin film designer more power and flexibility to determine solutions of complex design and material characterization problems. 合并几种独特的材料/层模型给予薄膜设计工程师有力的灵活的确定材料特性.
■	Provides excellent 2D, contour, and 3D graphics. 2D, 轮廓, 3D 图形
■	Incorporates a VB style Macro Language. 合并 Visual Basic 语言.
■	Includes on-line help.

Design 设计

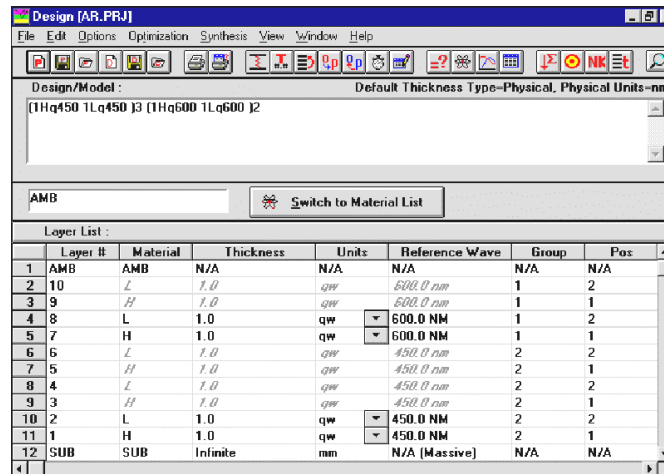
Film Wizard™ allows the user to construct designs with up to 1000 discrete layers (infinitely many layers if Super Lattices are employed). As many as 26 different materials may be specified. The thicknesses may be physical, optical, massive or mixed.

用户可构造 1000 离散层(无穷层超晶格). 可指定 26 种不同材料.

Layers may be input either individually {1L 2H 1L 2H}, as stacks of repeated layers enclosed in parenthesis { (1L 2H)2 }, or as stacks of repeated groups within groups { ((1H 1L)5 2L)3 4H}. Layers may also be specified as quarter waves at different design wavelengths {1Lq450 1Hq650}. A spreadsheet style layer list allows editing of thickness, reference wavelength, material, and thickness type (i.e., massive, optical, or physical).

层可个别{1L 2H 1L 2H}输入, 重复层堆栈{ (1L 2H)2 }输入, 或重复组{ ((1H 1L)5 2L)3 4H}输入. 层也可按不同设计波长{1Lq450 1Hq650}输入. 电子数据表可编辑厚度, 参考波长, 材料, 厚度类型(i.e., massive, optical, or physical).

Film Wizard™ allows the user to specify several important design options. In particular, the angle of incidence may be defined in vacuum or the actual incident medium, the substrate backside may or may not be included, and angle matching may be used in specifying optical thickness. Designs can be reversed or converted from physical to optical and back with a click of a button. When saving a project, Film Wizard™ saves the design, the optimization settings, the design parameter options, and the material list along with all material coefficients and index.



Main Design Menu with Layer List Option Displayed. 主设计菜单

Materials 材料

Film Wizard™ offers the user unparalleled choices in defining up to 14 different material types to use in a design. Film Wizard™ incorporates a large library of NK files for the more widely used materials which the user can edit and expand. Material types can also be defined by equation, either user-defined or one of the following:

Film Wizard™ 提供用户空前的选择, 在一个设计中可定义上到 14 种不同的材料类型. Film Wizard™ 合并巨大的 NK 文件库用于更广泛地用户可编辑可扩展的材料. 材料类型可用方程式定义, 或用户自定义, 或下列各项:

Sellmeier 塞米尔方程	Drude+Lorentz Oscillator 洛伦兹振荡器
Cauchy 柯西	EMA 有效介质近似理论
Cauchy Exponential 柯西指数	Graded 梯度
Temperature Dependent Cauchy 柯西指数-温度关系	Rugate 有折痕的
Drude 德路得模型	Super-Lattice 超晶格
Lorentz Oscillator 洛伦兹振荡器	User Defined 自定义

The user simply specifies the appropriate coefficients and the program calculates the correct indices. In addition to the above mentioned material types, Film Wizard™ provides an EMA material model which is defined as a homogeneous mixture of up to 5 different materials. The EMA material model is very useful in modeling alloys, surface roughness, cermets, and polycrystalline materials such as polysilicon.

Film Wizard™ 提供 EMA 有效介质近似理论材料模型, 可定义为上到 5 种不同材料的均匀混合物. EMA 有效介质近似理论材料模型, 在建模合金, 表面粗糙度, 金属陶瓷, 多晶材料如多晶硅非常有用.

The Graded Material (Layer) model is similar to the EMA model in that it is a mixture of two materials; however, in the graded material the mixture ratio may be specified at different depths within the layer. The mixture ratio throughout the Graded Layer is assumed to be a linear interpolation of the mixture ratios at the user specified "nodes". Up to 100 nodes are allowed.

梯度材料模型类似于 EMA 有效介质近似理论模型, 是两种材料的混合物. 梯度材料混合比率由层中不同深度指定.

The Rugate model allows the user to specify a layer with a sinusoidal index of refraction profile. Film Wizard™ also supports temperature dependent materials. Both the temperature dependence of the index of refraction and the thermal expansion may be specified.

折痕模型允许用户以折射轮廓系数指定层.

The screenshot shows a software window titled "Material" with a menu bar (File, Edit, Type, Window, Help). Below the menu bar is a "Material:" dropdown menu set to "E" and a "Switch To NK Table" button. A toolbar with various icons is located below the menu bar. The main area is a "Coefficient Table" with the following parameters:

Coefficient Table	
Minimum Wavelength	400.00
Maximum Wavelength	700.00
Number Of Waves	31
Number Of Oscillators	1
HF Dielectric Const.	2.00000
Plasma Freq. (eV)	3.00000
Collision Freq. (eV)	0.20000
Center Energy [1] (eV)	3.00000
Amplitude [1] (eV)	3.00000
Vibrational Freq. [1] (eV)	0.20000

At the bottom, there is a "Material Type:" dropdown set to "Drude + Lorentz Oscillators." and a large text area containing the mathematical formula for the refractive index n :

$$n = \infty \left(1 + \sum \frac{A_j^2}{(E_{center})^2 - E^2 + i\Gamma_j} - \frac{\omega_p^2}{E(E + i\Gamma)} \right)$$

Material Input Form. 材料输入表格

Analysis 分析

Twelve different performance parameters can be evaluated during the analysis portion of the program, namely:

十二种不同的性能参数能在程序分析中评估, 也就是:

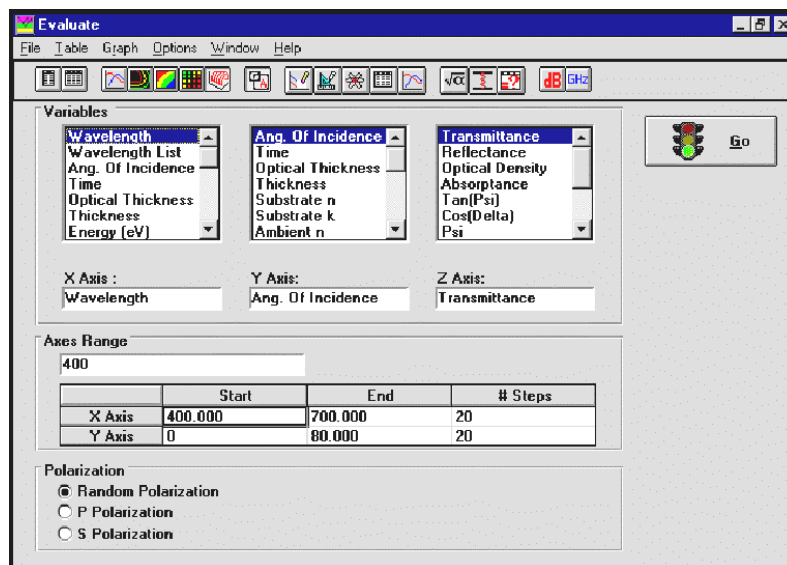
- | | |
|------------------------|---|
| Transmission 透射参数 | Ellipsometric Parameters $\tan(\psi)$, $\cos(\Delta)$ 椭圆偏光参数 |
| Reflection 反射参数 | Ellipsometric Parameters ψ , Δ 椭圆偏光参数 , |
| Absorbance 吸收参数 | Optical Density 光密度 |
| Transmitted Phase 透射相位 | Electric Field 电场 |
| Reflected Phase 反射相位 | User Defined Function 用户定义功能 |

S, P, and Random Polarizations may be simultaneously evaluated and displayed. The analysis may be performed with one or two independent variables.

S, P, 和任意偏振可同时评估显示.这种分析用一或两个独立变量完成.

Independent variables include 独立变量包括:

Wavelength 波长
Angle of Incidence 入射角度
Thickness of any Layer 任何层厚度
Thickness of the thin film stack 薄膜堆叠厚度
Index of Refraction (n or k) of any material. 任何材料折射指数



Evaluation Input Form评估输入表格.

Optimization/Modeling 优化/建模

Film Wizard™ provides a great deal of flexibility in specifying targets. An unlimited number of optimization targets is possible. Targets may include any individual or multiple combination of:

Transmission 透射参数	Ellipsometric Parameters Tan(ψ), Cos(Δ) 椭圆偏光参数
Reflection 反射参数	Ellipsometric Parameters ψ , Δ 椭圆偏光参数 ,
Absorbance 吸收参数	Optical Density 光密度
Transmitted Phase 透射相位	Electric Field 电场
Reflected Phase 反射相位	User Defined Function 用户定义功能

For each target the user may specify polarization, angle of incidence, weight, and target value. In addition the user may specify up to three user defined target equations using the above mentioned parameters as terms (e.g., $T_s/R_p - R_s/T_p$).

偏振, 入射角, 重力, 目标值可指定.

Each target may be specified as equality or inequality (i.e., =, >, or <). Targets may be imported from spectrophotometer and ellipsometer data files. Targets can be automatically generated if desired. Color coordinate targets are also fully supported.

可输入分光光度计和偏振光椭圆率测量仪数据文件.

Another unique feature of Film Wizard™ is the choice of seven different optimization methods:

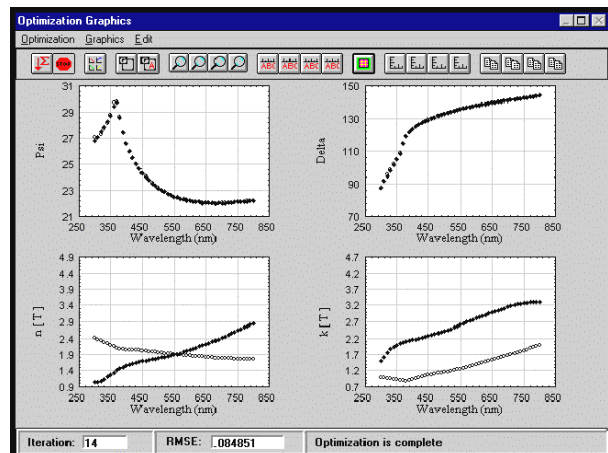
Film Wizard™ 另一独特的特色是七个不同的最优化方法:

Modified Levenberg-Marquardt (a nonlinear gradient method) 非线性梯度方法
Modified Simplex (a non-gradient method) 非梯度方法
Pattern search (Hooke-Jeeves) 模式搜索
Golden Section
Global Modified Levenberg-Marquardt 全局修正 Levenberg-Marquardt 算法
Global Simplex
Statistical Monte Carlo. 蒙特卡罗法统计(随机抽样统计)

Global optimization allows the user to avoid local minima and obtain the best design (solution). Additionally, a constrained optimization option is provided so the user may input maximum and minimum bounds for any variable that is optimized. Consequently, the thin film engineer/scientist can restrict the optimization to produce solutions that are practical and reasonable. Also unique are the choices of coupled thickness (pick-up) variables, bounded indices, symmetric design, and worst case scenario. Optimization variables include layer thickness, indices, angle of incidence, index equation coefficients, Rugate parameters, graded layer parameters, EMA coefficients, user defined coefficients, and super lattice thickness'. Optimization variables may all be varied simultaneously. Up to four graphs may be displayed during optimization, and other applications can be run while optimization is executing in the background. The code implements double precision calculations for greater accuracy and control of round off errors in large designs.

最优化变量包括层厚度, 入射角, 指数方程系数, 折痕参数,

Use	Wavelength(nm)	Angle	Op	Target	Weight	Type
1	400.000	0	=	0	1.000	% Transmission R
2	400.000	45.000	=	100.000	1.000	% Reflection R
3	400.000	65.000	=	1.000	1.000	User Defined #1
4	403.529	0	=	0	1.000	% Transmission R
5	403.529	45.000	=	100.000	1.000	% Reflection R
6	403.529	65.000	=	1.000	1.000	User Defined #1
7	407.122	0	=	0	1.000	% Transmission R
8	407.122	45.000	=	100.000	1.000	% Reflection R
9	407.122	65.000	=	1.000	1.000	User Defined #1
10	410.778	0	=	0	1.000	% Transmission R
11	410.778	45.000	=	100.000	1.000	% Reflection R
12	410.778	65.000	=	1.000	1.000	User Defined #1
13	414.502	0	=	0	1.000	% Transmission R
14	414.502	45.000	=	100.000	1.000	% Reflection R
15	414.502	65.000	=	1.000	1.000	User Defined #1
16	418.293	0	=	0	1.000	% Transmission R
17	418.293	45.000	=	100.000	1.000	% Reflection R
18	418.293	65.000	=	1.000	1.000	User Defined #1
19	422.154	0	=	0	1.000	% Transmission R



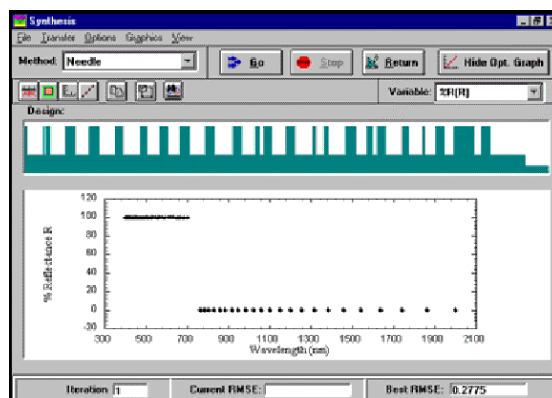
Sample of Spectroscopic Targets.
分光镜样例

Sample of Ellipsometry Optimization Results.
椭圆偏光法最优化计算结果样例

Synthesis 综合

Film Wizard™ incorporates five optical thin film synthesis methods: MultiBranch, Stochastic, Pattern Search, Flip-Flop and Needle Synthesis. These synthesis algorithms automate the design of optical coatings. No initial design is required. Apart from the specification of the desired optical performance of the coating, the only input data necessary are the substrate and ambient materials and a list of thin film materials (up to 26 different materials) that may be employed in the design. The Needles Synthesis algorithm is particularly useful in finding design solutions for unusual and difficult optical coating problems.

Film Wizard™ 合并五种光学薄膜综合方法: MultiBranch 多分支, Stochastic 随机的, Pattern Search 模式搜索, Flip-Flop 双稳态多谐振荡 and Needle Synthesis 针综合.



Needle Synthesis Examples 针综合例子

These designs were generated automatically using Film Wizard™ Needle synthesis, starting from a single layer.

Immersed polarized beamsplitter 490-700nm 浸渍偏振分光镜

Boudot filter 滤光片

Hot mirror 热镜

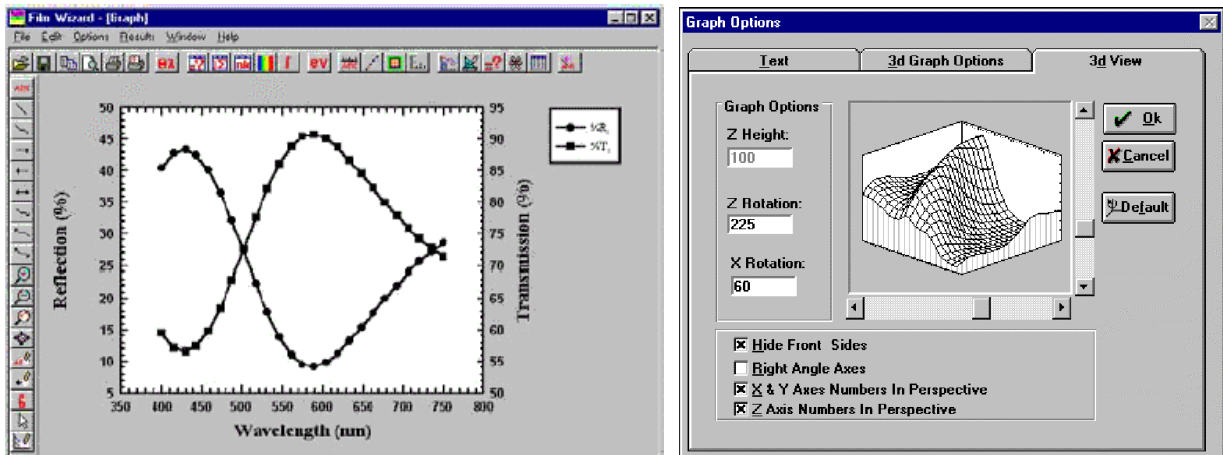
Two channel wavelength division multiplexer

MultiBranch Synthesis Example 4 layer wide angle antireflection coating

Results 结果

All results can be displayed graphically or in tabular form. Line, xy scatter, area contour, line contour, patch, and surface plots are all available. Results may be printed or saved as files. Many user options to label and edit graphs are available. A few of the options includes overlay plots, linear/log scale, merging plots from saved graphs, and attachment of labels and arrows. Also, the use of subscripts and superscripts is available in legends, graph titles, and labels. The graph data can be easily imported or exported to other software programs. In addition, the user may manually edit the graph data or apply user defined equations.

所有结果图形显示或表格形式.



Sample XY Plot with Two Y Axes.

The User Can Dynamically Change the Perspective of a 3d Plot.

Macro Language 宏语言

A macro language is provided which allows the user to extend the capabilities of Film Wizard™ by providing a VB style basic language which a) offers full support for modern BASIC; b) supports in-code creation of custom dialog boxes using standard Windows controls such as: buttons, checkboxes, groupboxes, listboxes, option buttons, and text-edit controls; c) supports OLE Automation, which allows the macro language to programmatically access software components from other applications; d) offers the ability to declare and call any Windows API or external DLL function from within the macro language.

Visual Basic 语言, OLE 对象链接和嵌入自动操作, Windows 应用程序接口, 外部的 DLL 动态链接库功能.

System Requirements 系统需求

Microsoft Windows 98, Me, 2000, NT, or XP. Minimum hardware needed: 486-based PC, 16 MB RAM, Math coprocessor, VGA card, mouse, and 20 MB of hard disk space. Faster Pentium systems are, however, recommended.

FilmMonitor™ (Monitor Deposition Software) 监视沉积软件

FilmMonitor™ is a thin film software tool used to translate multi-layered thin film designs into optical monitor run sheets. FilmMonitor™ combines the ease of use with powerful and versatile features. In particular, FilmMonitor™:

FilmMonitor™ 是将多层薄膜设计转变为光学监视管理表的薄膜软件工具.

FilmMonitor™ quickly creates easy to understand optical monitor run sheets for the optical coating technician/operator.

FilmMonitor™ 为光学涂层技术员/操作员很快创立容易理解的光学监视管理表

Designs may be imported from Film Wizard™ or input directly into FilmMonitor™.
从 Film Wizard™ 设计输入或直接输入 FilmMonitor™.

Up to 100 monitor chips may be employed in a design. Chip material and angle of incidence may be separately specified for each individual chip.
一个设计中可监视上到 100 个芯片. 芯片材料和入射角可个别指定.

FilmMonitor™ supports monitoring of transmittance, reflectance, and ellipsometric parameters ($\tan(\psi)$, $\cos(\Delta)$, ψ , Δ) at multiple wavelengths.

FilmMonitor™ 支持监视: 透射, 反射系数, 椭圆偏光, 参数($\tan(\psi)$, $\cos(\Delta)$, ψ , Δ)

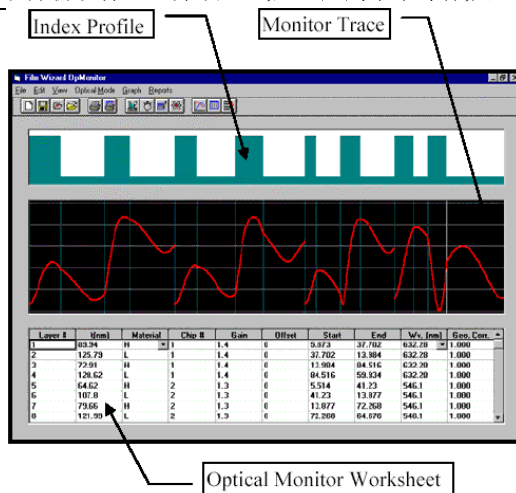
FilmMonitor™ supports output in absolute or relative units. In relative mode, gain and offset may be adjusted at the start of each layer.

FilmMonitor™ 支持绝对或相对单位输出. 相对模式, 每层起始增益和偏移可调整.

Optical Monitor Worksheet 光监视工作表

FilmMonitor™ allows the user to import Film Wizard™ projects or input designs directly into FilmMonitor™. Once the design is loaded, FilmMonitor™ automatically displays the index profile, the expected monitor chart, and fills the optical monitor worksheet. Each design may employ up to 100 optical monitor chips. Chips may be of different materials and have varying angles of incidence. One of the most attractive FilmMonitor™ features is the flexibility it gives the user interactively adding chips, changing film thicknesses, materials, gains, offsets, tooling factors, and wavelengths. FilmMonitor™ allows the user to monitor transmittance (T_r , T_s , and T_p), reflectance (R_r , R_s , and R_p), and ellipsometric parameters ($\tan(\psi)$, $\cos(\Delta)$, ψ , Δ) at multiple wavelengths. The user can also select the output to be in absolute or relative units. In relative mode, gain and offset may be adjusted at the start of each layer. The user can also specify various tooling factors to account for unequal deposition rates and indices of refraction between the optical monitor chip and the work.

FilmMonitor™ 最吸引人的特征为用户交互式适应性: 可增加芯片, 变化薄膜厚度, 材料, 增益, 偏移, 加工因子, 波长. FilmMonitor™ 允许用户监控透射(T_r , T_s , and T_p), 反射(R_r , R_s , and R_p), 椭圆参数($\tan(\psi)$, $\cos(\Delta)$, ψ , Δ).



FilmMonitor™ Worksheet Window 工作表窗口

Design Options 设计选项

FilmMonitor™ allows the user to construct designs with up to 500 discrete layers. The thicknesses may be physical, optical or mixed. Designs are automatically converted from optical to physical. Layers may be input either individually {1L 2H 1L 2H}, as stacks of repeated layers enclosed in parenthesis { (1L 2H)2 }, or as stacks of repeated groups within groups { ((1H 1L)5 2L)3 4H}. Layers may also be specified as quarter waves at different design wavelengths {1Lq450 1Hq650}. As many as 26 different materials may be specified per design. A spreadsheet style material list allows loading and editing the material properties.

FilmMonitor™ 允许用户可构造 500 离散层。厚度类型(i.e., massive, optical, or physical). 层可个别{1L 2H 1L 2H}输入, 重复层堆栈{ (1L 2H)2 }输入, 或重复组{ ((1H 1L)5 2L)3 4H}输入. 层也可按不同设计波长{1Lq450 1Hq650}输入. 可指定 26 种不同材料. 电子数据表可编辑厚度, 参考波长, 材料.

The screenshot displays the 'Edit Design' window. It features a table with columns for material properties. The table is as follows:

Layer #	Start	End	Material	Chop #	Gain	Offset	Start	End	Vol. Loss	Resp. Corr.
1	63.94	125.73	L	1	1.4	0	37.702	13.884	632.20	1.000
2	125.73	125.73	L	1	1.4	0	37.702	13.884	632.20	1.000
3	125.73	125.73	H	1	1.4	0	11.884	64.516	632.20	1.000
4	125.73	125.73	L	1	1.4	0	64.516	58.324	632.20	1.000
5	125.73	125.73	L	2	1.3	0	5.514	41.23	546.1	1.000
6	125.73	125.73	L	2	1.3	0	41.23	13.877	546.1	1.000
7	125.73	125.73	H	2	1.3	0	13.877	72.268	546.1	1.000
8	125.73	125.73	L	2	1.3	0	72.268	64.870	546.1	1.000

FilmMonitor™ Design Window 设计窗口

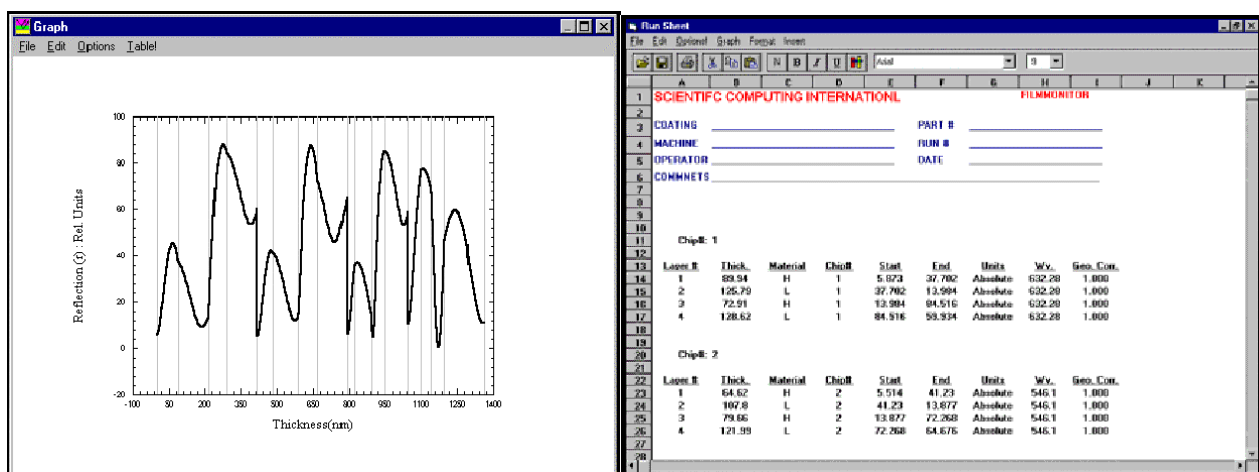
Materials 材料

FilmMonitor™ incorporates a large library of NK files for the more widely used materials which the user can edit and expand. Material types can also be defined by one of the equation/models:

Film Wizard™ 提供用户空前的选择, 在一个设计中可定义上到 14 种不同的材料类型. Film Wizard™ 合并巨大的 NK 文件库用于更广泛地用户可编辑可扩展的材料. 材料类型可用方程式定义, 或用户自定义

Optical Monitor Run Sheet 光监视运行表

FilmMonitor™ gives the user a great deal of flexibility in generating optical monitor run sheets. User may customize a run sheet by inserting text and pictures, formatting fonts, and selecting the fields that will appear in the run sheet. Also, run sheets may be saved as templates for subsequent run sheets. The user has the option to quickly generate graphs of expected output versus deposition time or thickness of the stack/chip. FilmMonitor™ graphs are fully customizable. A few of the options include line style and color, font size and color, linear/log scale, and subscripts and superscripts in legends and graph titles. The graphs may also be copied as metafiles or bitmaps to the clipboard.



Customizable Monitor Chart

Customizable Run Sheet

Minimum System Requirements 最低系统要求

Microsoft Windows 98, Me, 2000, NT, or XP. Minimum hardware needed: 486-based PC, 16 MB RAM, Math coprocessor, VGA card, mouse, and 10 MB of hard disk space. Faster Pentium systems are, however, recommended.

FilmEllipse™

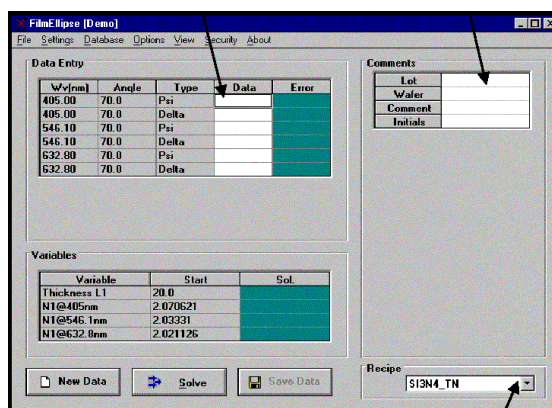
FilmEllipse™ is an easy to use production oriented software tool for the analysis and acquisition of ellipsometric data. FilmEllipse™ allows the user to find solutions to a wide range of applications not typically covered by the software bundled with commercially available ellipsometers. In particular, FilmEllipse™: (分析和捕获椭圆偏光数据的工艺型可定向软件包)

■	Simultaneously solves for complex indices ($n+ik$) and thicknesses of multi-layer film structures.
■	Allows the user to enter ellipsometric and spectrophotometric data collected at multiple wavelengths and angles of incidence.
■	May be operated in either an engineering or manufacturing mode. The manufacturing mode requires little or no experience in personal computers or thin film optics.
■	Gives unique self-consistent layer thickness solutions. Most commercially available three wavelength ellipsometers treat each wavelength independently, which results in three different thickness solutions (one for each wavelength). FilmEllipse™ uses the fact there can physically only be one thickness value and calculates a thickness which consistently fits all three wavelengths.
■	Global Solution/Optimization methods are used to obtain the best solutions, thereby avoiding local minima and minimizing sensitivity to measurements errors.
■	Maximum and minimum bounds may be placed on any unknown thickness or index of refraction.
■	Gives the user flexibility in customizing FilmEllipse™ for entry and storage of user defined fields.
■	Automatically saves and groups experimental data, instrument parameter settings, layer structures, and comments in a user defined database for later analysis. This feature is important in performing statistical process control and instrument calibration.

Ease of Use 易用

FilmEllipse™ is designed to be operated in either an engineering or manufacturing mode.

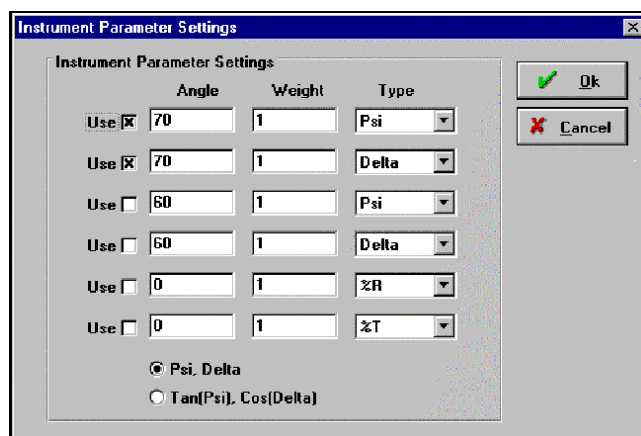
The manufacturing mode is specifically designed such that little or no experience in personal computers, thin film optics, or ellipsometric techniques is required. In this mode the user interacts with a single window (shown below) to open pre-defined recipes which automatically load all instrument parameters and layer settings. The user need only enter the experimental data and fill in the user defined fields. **FilmEllipse™ Main Window**



In the engineering mode, the engineer specifies the recipe settings. Each recipe contains the layer and material settings, instrument/ellipsometer parameter settings and the required user defined fields such as lot number, wafer number, etc. These recipes may be protected with an optional password and saved for later use.

Instrument Parameter Settings 仪器参数设置

FilmEllipse™ allows the user to enter ellipsometric data ($\tan(\psi)$, $\cos(\Delta)$, ψ , Δ) by itself or in conjunction with spectrophotometric data (*i.e.*, transmittance and/or reflectance). This is particularly valuable to users who also employ spectrophotometers (*e.g.*, Nanospecs) for film thickness measurements. Measured data may be collected at multiple wavelengths and incident angles. **Instrument Parameter Setting Dialog Box**



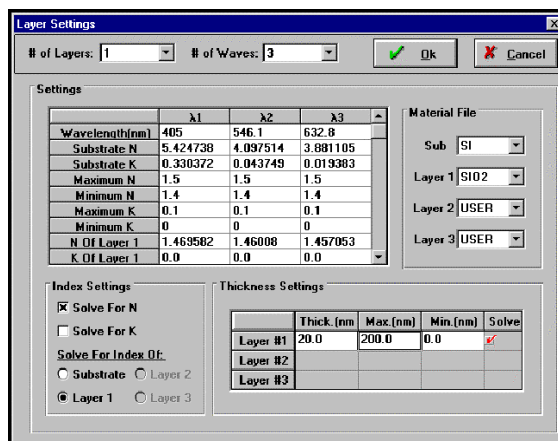
The dialog box titled "Instrument Parameter Settings" contains a table for configuring measurement parameters. It has columns for "Angle", "Weight", and "Type". There are five rows for data entry, each with a "Use" checkbox. Below the table are two radio buttons: "Psi, Delta" (selected) and "Tan(Psi), Cos(Delta)". "Ok" and "Cancel" buttons are on the right.

Use	Angle	Weight	Type
☒	70	1	Psi
☒	70	1	Delta
☐	60	1	Psi
☐	60	1	Delta
☐	0	1	%R
☐	0	1	%T

☒ Psi, Delta
☐ Tan(Psi), Cos(Delta)

Layer Settings 层设置

As many as three layers may can be specified in the film stack. Films may be dielectric, semiconductors, or metallic (absorbing). The optical properties of the various films and substrates are stored as tables of complex refractive index ($n+ik$) versus wavelength. FilmEllipse™ comes with a large database of optical constants (nk) which may be edited. Up to three different wavelengths can be used in a single recipe with multiple angles of incidence. Maximum and minimum bounds may be placed on any unknown thickness or index of refraction. **Design Window**



The dialog box titled "Layer Settings" is used for defining the film stack. It includes fields for "# of Layers" (1) and "# of Waves" (3). It contains a "Settings" table for wavelength, substrate, and layer properties. On the right, "Material File" settings are shown. At the bottom, there are "Index Settings" and "Thickness Settings" sections.

	λ_1	λ_2	λ_3
Wavelength(nm)	405	546.1	632.8
Substrate N	5.424738	4.097514	3.881105
Substrate K	0.330372	0.043749	0.019383
Maximum N	1.5	1.5	1.5
Minimum N	1.4	1.4	1.4
Maximum K	0.1	0.1	0.1
Minimum K	0	0	0
N Of Layer 1	1.469582	1.46008	1.457053
K Of Layer 1	0.0	0.0	0.0

Material File:
 Sub: SI
 Layer 1: SiO2
 Layer 2: USER
 Layer 3: USER

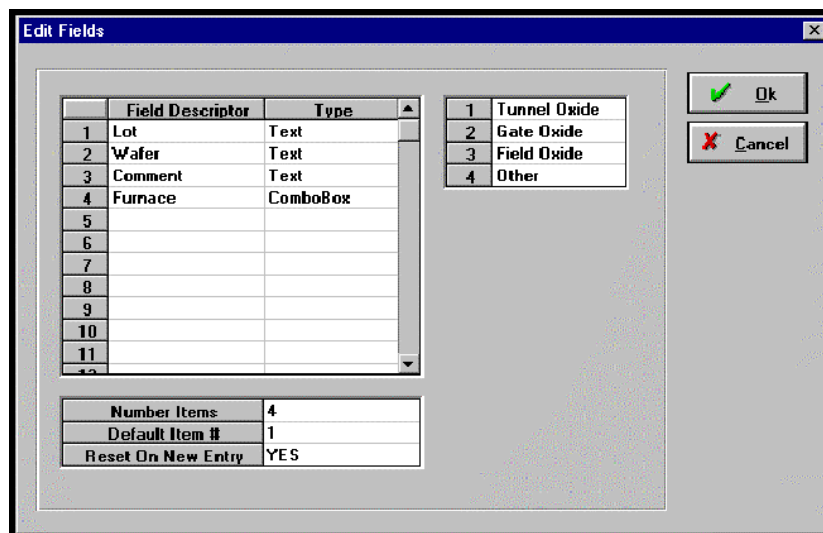
Index Settings:
☒ Solve For N
☐ Solve For K
☐ Solve For Index Of...
☐ Substrate ☐ Layer 2 ☒ Layer 1 ☐ Layer 3

Thickness Settings:

	Thick.(nm)	Max.(nm)	Min.(nm)	Solve
Layer #1	20.0	200.0	0.0	☒
Layer #2				☐
Layer #3				☐

Database 数据库

One of the most attractive features of FilmEllipse™ is the flexibility it gives the user in customizing FilmEllipse™ for entry and storage of user defined fields. The engineer can specify up to 100 fields. The allowed field types include ComboBoxes, Yes/No, Text, Integer, Long, Single, Double, and Dates. In this way, process dependent data can be stored along with the solutions in tab delimited files. The data files FilmEllipse™ generates can be readily imported into Microsoft Excel or Microsoft Access. **FilmEllipse™ Custom Database Window**



Minimum System Requirements 最低系统要求

Microsoft Windows 98, Me, 2000, NT, or XP. Minimum hardware needed: 486-based PC, 16 MB RAM, Math coprocessor, VGA card, mouse, and 20 MB of hard disk space. Faster Pentium systems are, however, recommended.

Applications 应用

FilmTek™ metrology systems can measure a broad array of single and multi-layer films including metallic, semiconductor, amorphous, crystalline, and dielectric materials on virtually any substrate. FilmTek™ can simultaneously determine:

FilmTek™测量系统能测量宽范围的单层/多层薄膜, 包括任何衬底上金属(性)的, 半导体, 非结晶, 结晶, 电介质材料. FilmTek™能同时测定:

- Multiple layer thicknesses (from $<1\text{\AA}$ to 250 microns) 1Å 到 250 微米多层厚度测量
- Indices of refraction [$n(\lambda)$] (both TE and TM components of index)
- 折射指数 $n(\lambda)$ 测量
- Extinction (absorption) coefficients [$k(\lambda)$] 消光(吸收)系数测量
- Birefringence ()双折射
- Energy band gap [E_g] 能量带隙测量
- Surface roughness and damage 表面粗糙度和损伤测量
- Porosity, composition, and crystallinity (EMA model)有孔性,成分, 晶态(电磁加速模型)
- Film properties versus temperature 薄膜温度特性
- Wafer curvature and film stress 硅片曲率和薄膜应力

Optoelectronics Application Reports 光电子学应用报告

- Characterizing Oxide Films for Waveguide Applications 表现波导应用氧化物薄膜特性
- FilmTek™ 4000 Repeatability 可重复性
- Characterizing Film Properties versus Temperature 表现薄膜温度特性
- Measuring Color Coordinates: Colored Resists 测量彩色座标系:
- Characterizing OLED Display Materials 表现 OLED 有机发光二级管显示材料特性
- Characterizing Birefringent Materials: PET 表现双折射材料特性

Semiconductor Application Reports 半导体应用报告

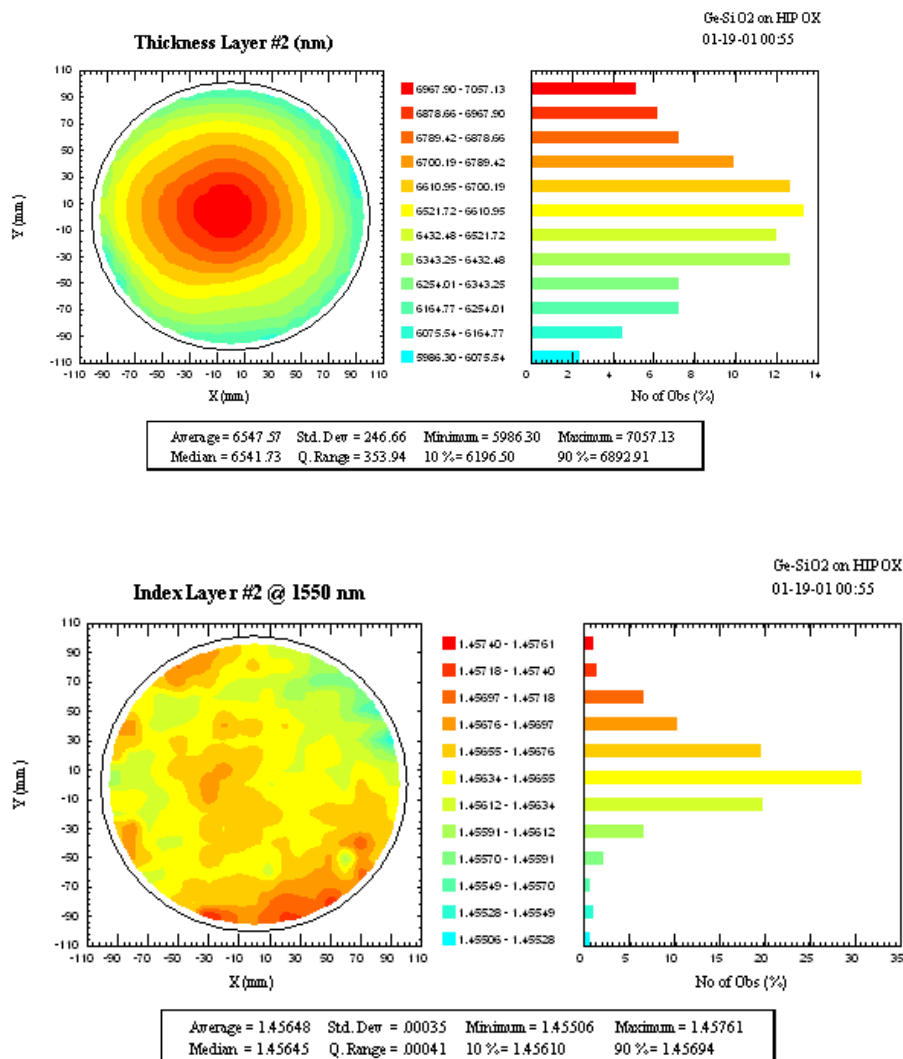
- Measuring Surface Roughness 测量表面粗糙度
- Characterizing Very Thin ONO Films 表现很薄薄膜特性
- Characterizing Advanced Low-k Materials 表现先进低 K 材料特性
- Characterizing High-k Materials 表现高 K 材料特性
- Characterizing SiGe 表现锗化硅特性
- Measuring Silicon on Insulator (SOI) Films 测量绝缘体上硅薄膜
- Characterizing Amorphous Silicon and Polysilicon 表现非晶硅和多晶硅特性
- Characterizing Silicon on Sapphire (SOS) 表现蓝宝石上硅薄膜特性
- Characterizing Photomasks 表现光掩膜特性

Characterizing Oxide Films for Waveguide Applications (表现波导应用氧化物薄膜特性)

FilmTek™ Advantages 优势

- FilmTek™ 4000 measures thickness and index of refraction independently with SCI's patented Differential Power Spectral Density (DPSD) technology.
- 基于 SCI 专利的示差功率谱密度技术 FilmTek™ 4000 测量厚度和折射指数
- Accurate and simultaneous determination of film thickness and index of refraction as a function of wavelength [$n(\lambda)$] (both TE and TM components of index).
- Measure optical properties from 190nm-1700nm.
- FilmTek™ 4000 has the highest resolution and repeatability in the industry, with a thickness resolution of 2Å and index resolution of 2×10^{-5} .
- 厚度分辨率 2Å, 折射指数分辨率 2×10^{-5} .

6.5μm Ge-SiO₂/15μm SiO₂/Silicon Substrate (6.5μm 锗-二氧化硅/15μm 二氧化硅/硅衬底)

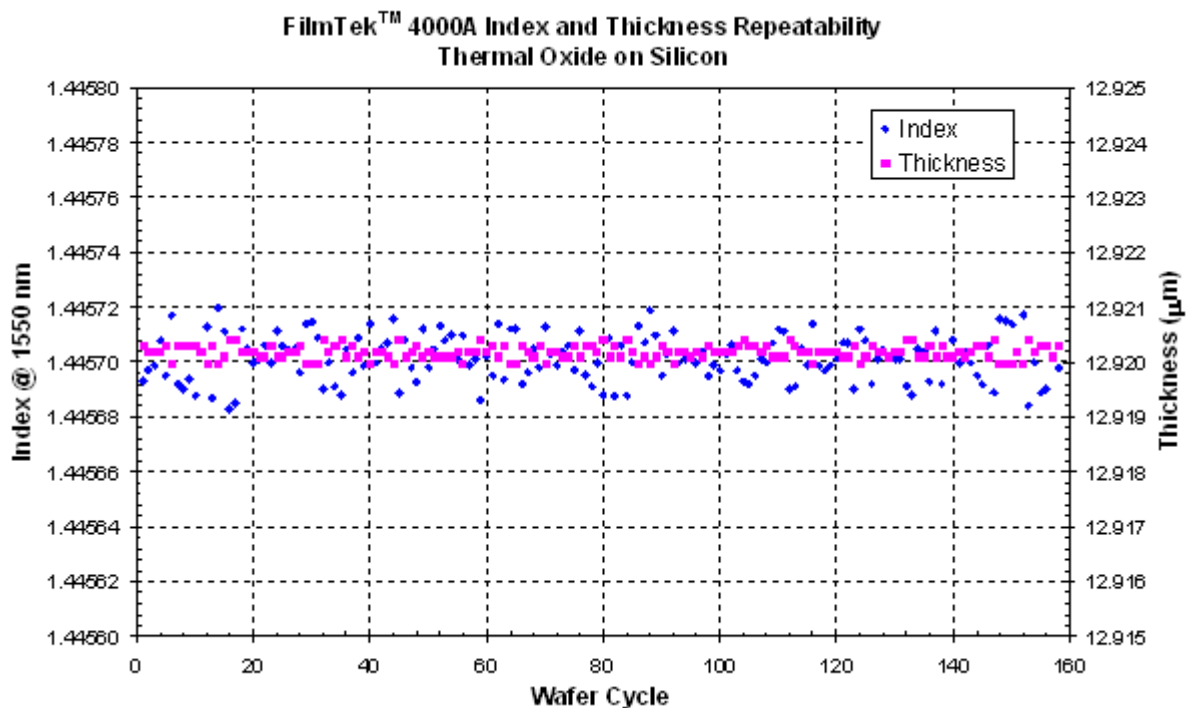


FilmTek™ 4000 Repeatability(可重复性)

FilmTek™ Advantages 优势

- FilmTek™ 4000 measures thickness and index of refraction independently with SCI's patented Differential Power Spectral Density (DPSD) technology.
- 基于 SCI 专利的示差功率谱密度技术 FilmTek™ 4000 测量厚度和折射指数
- Accurate and simultaneous determination of film thickness and index of refraction as a function of wavelength [$n(\lambda)$] (both TE and TM components of index).
- Best index and thickness repeatability in the industry.
- 工业中最好的折射指数和可重复性测试

FilmTek™ 4000A Index and Thickness Repeatability: 160 Wafer Load/Unload Cycles 折射指数和可重复性测试 :160 晶片加载/卸载循环

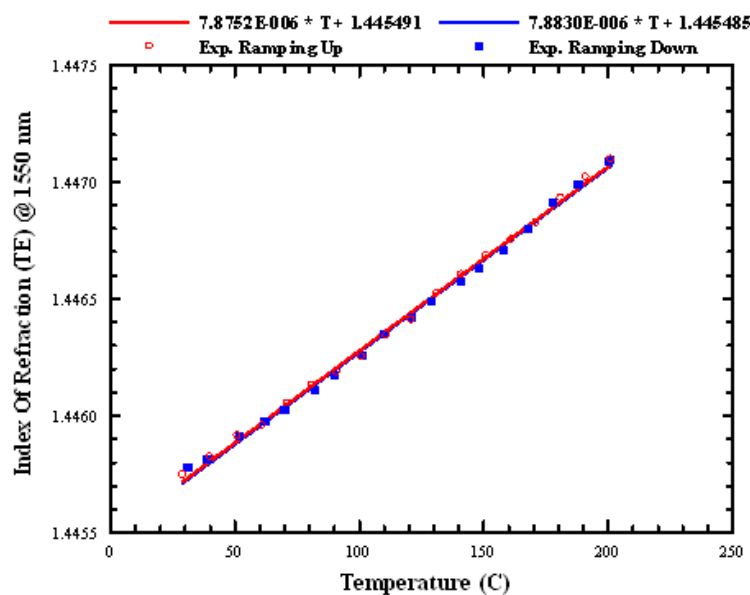


Characterizing Film Properties versus Temperature (表现薄膜温度特性)

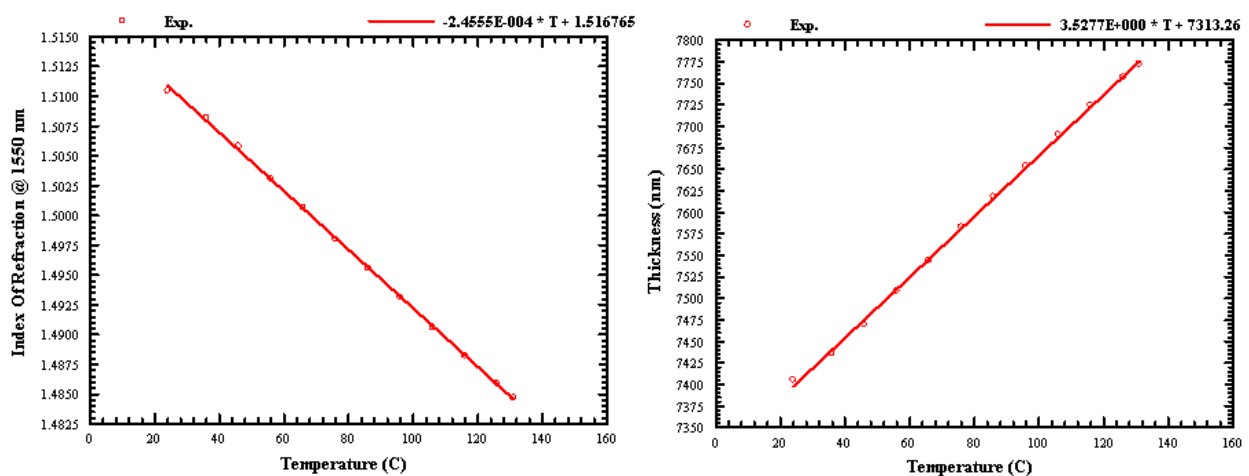
FilmTek™ Advantages 优势

- The high index and thickness resolution of the FilmTek™ 4000 allows film properties to be accurately characterized as a function of temperature.
- Measure dn/dT and thermal expansion coefficients for new materials.
- Thermal characterization of films provides a quick measure of environmental stability for process research and development.

Measured Index of Refraction versus Temperature of SiO₂ on Silicon 硅上二氧化硅薄膜折射系数温度特性测量



Characterization of a Tunable Polymer Waveguide Material versus Temperature 可调聚合体波导材料温度特性测量



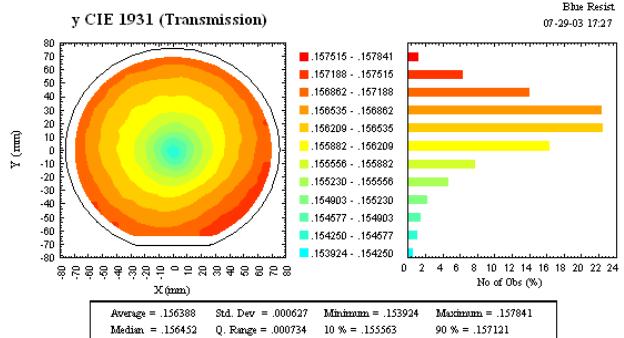
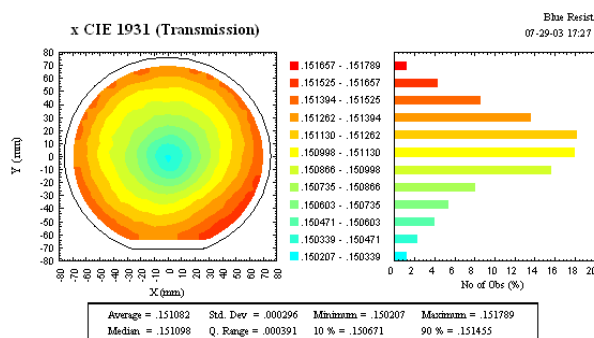
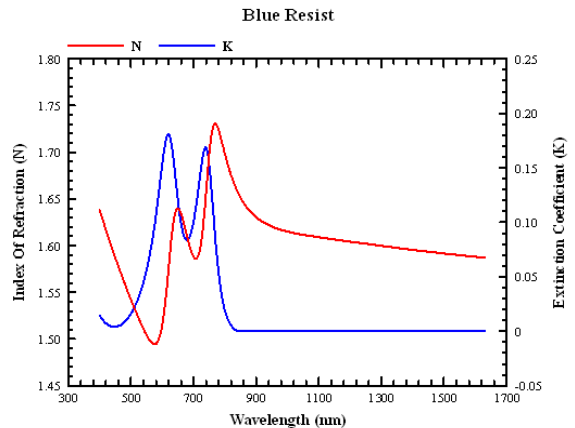
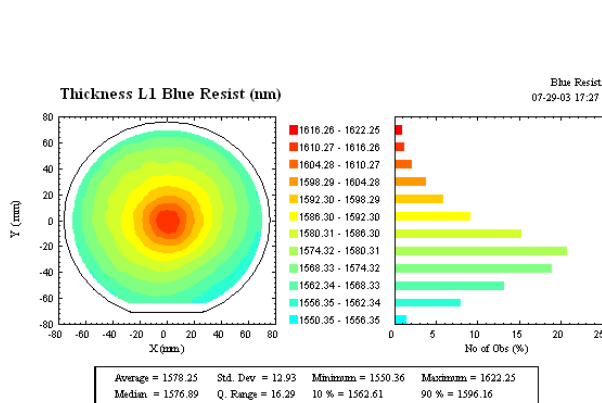
Measuring Color Coordinates: Colored Resists

(测量彩色坐标系)

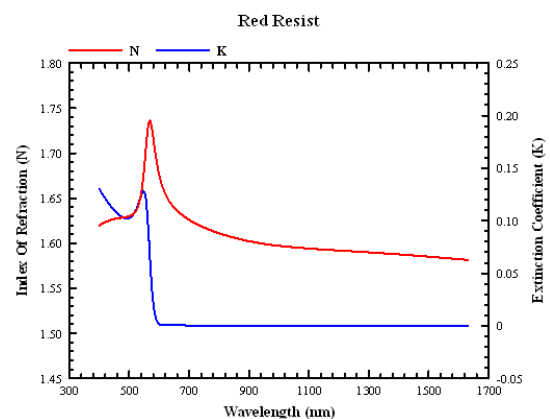
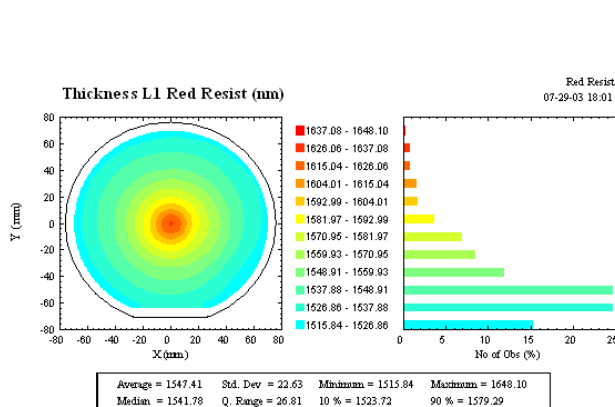
FilmTek™ Advantages 优势

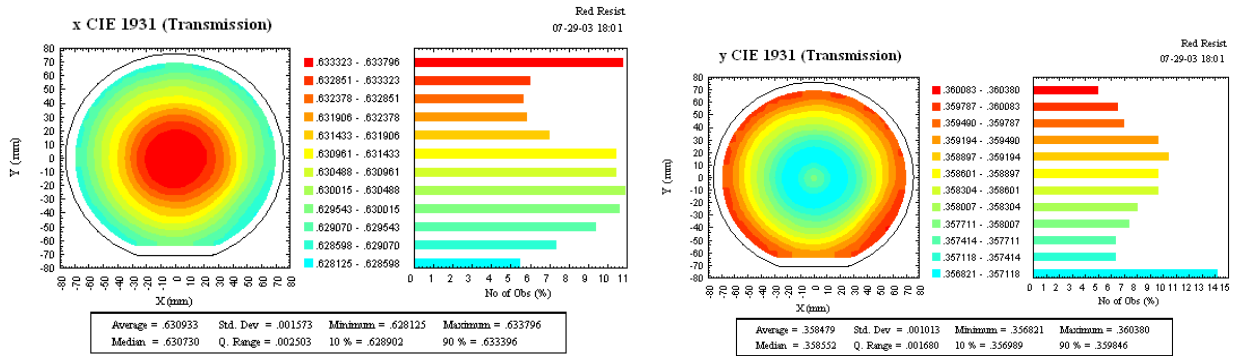
- FilmTek™ simultaneously measures thickness, optical constants, and CIE color coordinates. 同时测量厚度, 光学常数, 相干红外能量彩色坐标系
- Superior film characterization enables accurate and repeatable process monitoring.

Measuring Colored Resists on Silicon > Blue Resist

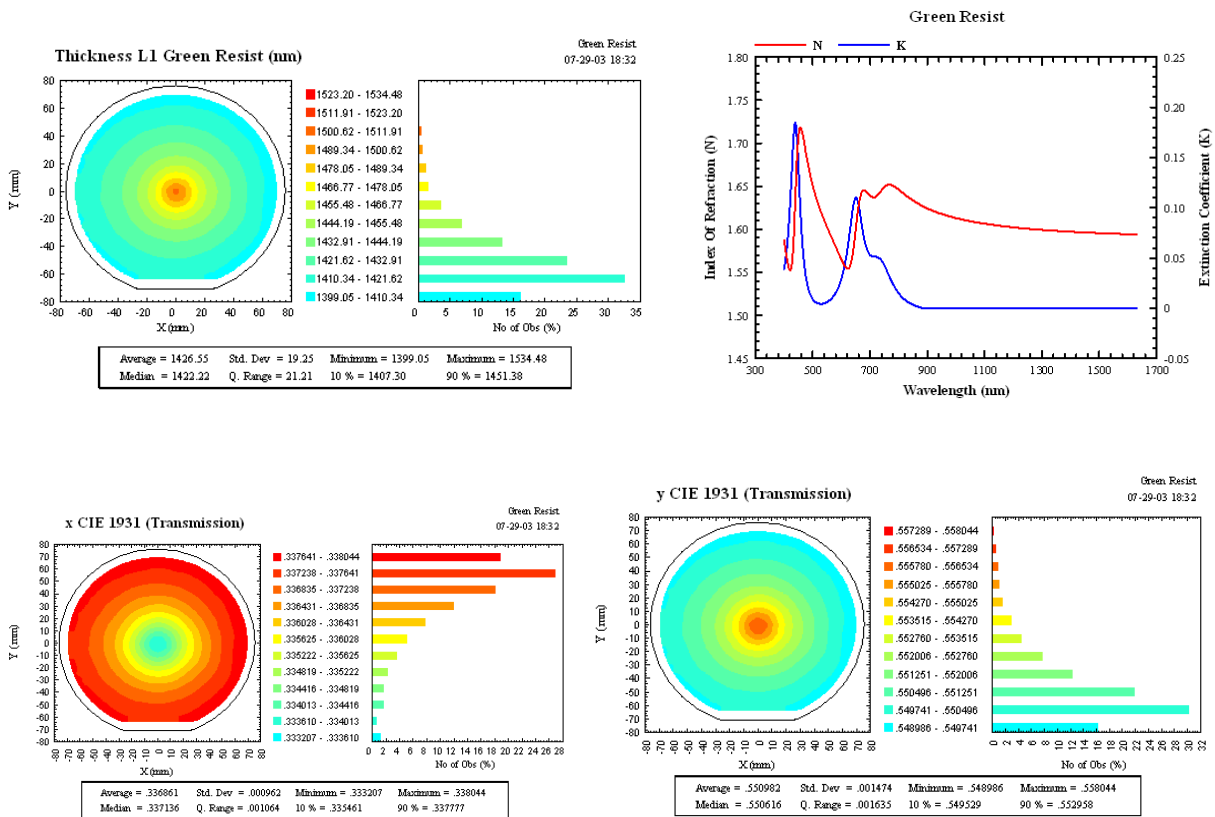


Measuring Colored Resists on Silicon > Red Resist

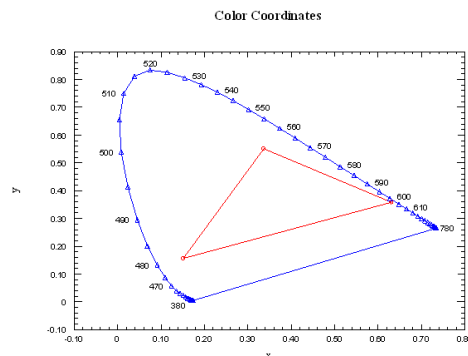




Measuring Colored Resists on Silicon > Green Resist



Measuring Colored Resists on Silicon > CIE Color Coordinates

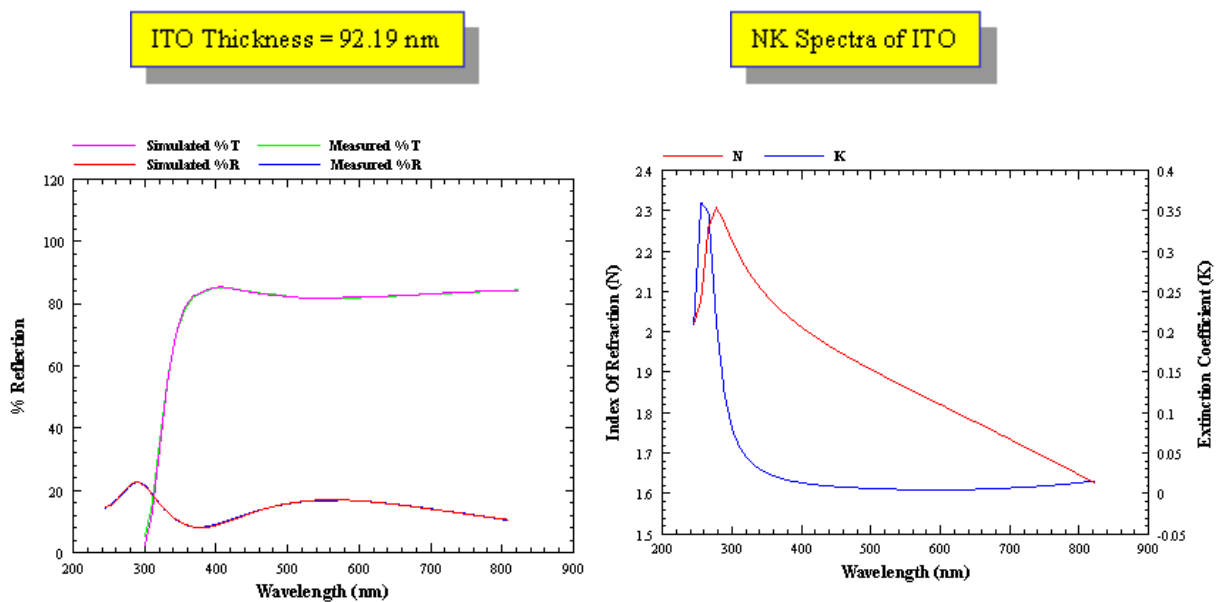


Characterizing OLED Display Materials (表现 OLED 有机发光二级管显示材料特性)

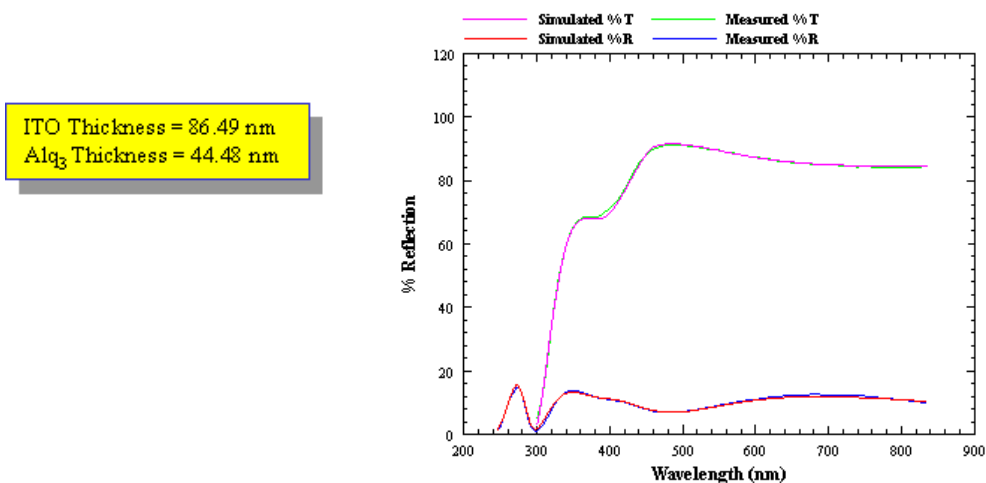
FilmTek™ Advantages 优势

- FilmTek™ 3000 measures spectroscopic reflection and transmission.
- FilmTek™ 3000 光谱反射和透射测量
- Accurate and simultaneous determination of film thickness and index of refraction as a function of wavelength [$n(\lambda)$].
- Simultaneous measurement of multiple OLED layer thicknesses.
- Advanced process control achieved with FilmTek's™ high resolution measurement of optical constants and thickness.

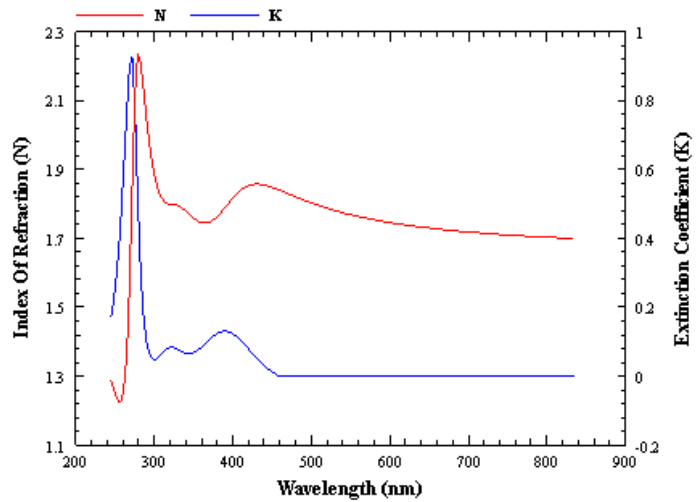
ITO/Glass



Alq₃/ITO/Glass

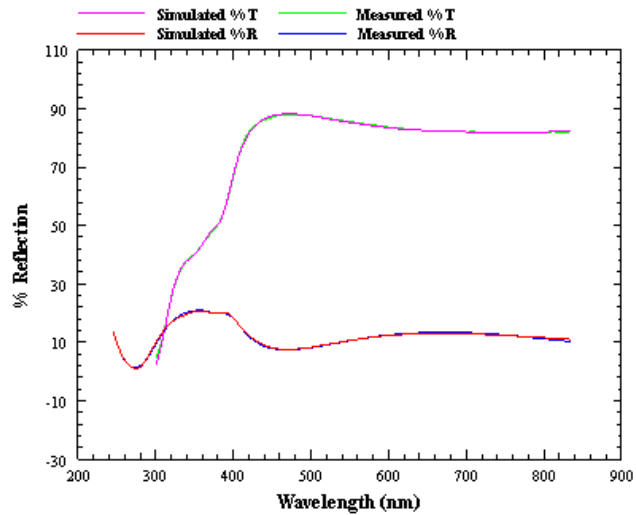


NK Spectra of Alq_3

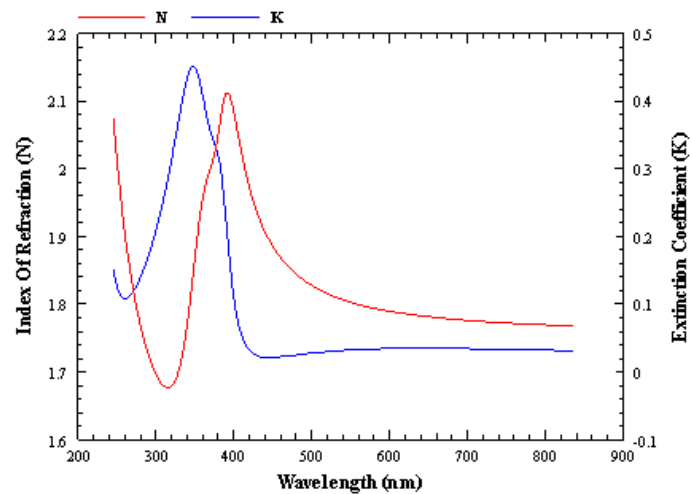


NPB/ITO/Glass

ITO Thickness = 89.90 nm
NPB Thickness = 35.67 nm



NK Spectra of NPB



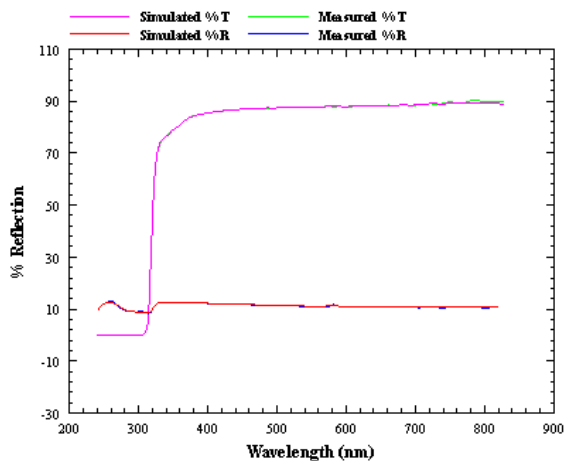
Characterizing Birefringent Materials: PET (表现双折射材料特性)

FilmTek™ Advantages 优势

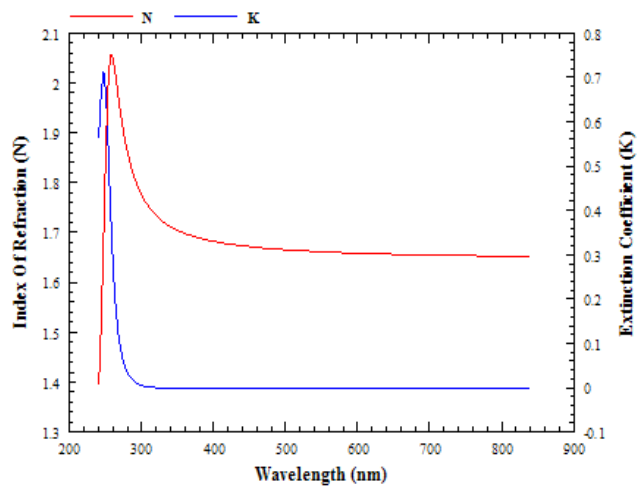
- FilmTek™ 3000P combines spectroscopic reflection, transmission, and polarimetry measurements for the accurate and simultaneous determination of optical constants and birefringence ($n_e - n_o$). 光谱反射, 透射, 偏振测定测量
- Simultaneous measurement of multi-layer films on birefringent substrates.
- Advanced process control achieved with FilmTek's™ high resolution measurement of optical constants, birefringence, and thickness.

PET Film

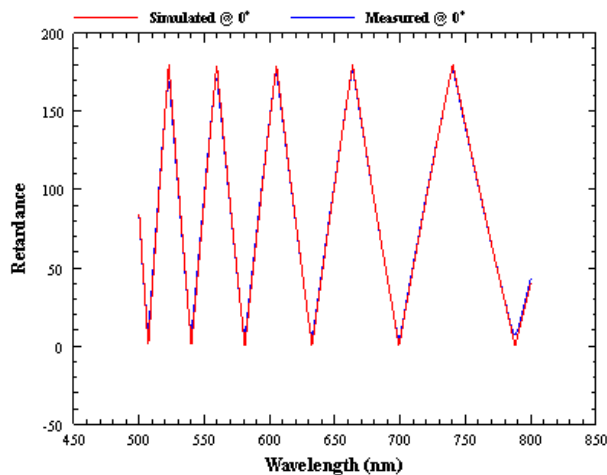
Reflection/Transmission Spectra of PET



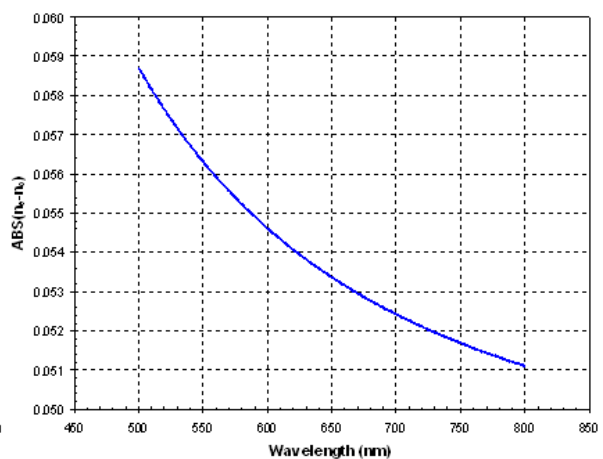
NK Spectra of PET



Retardance of PET



Birefringence of PET

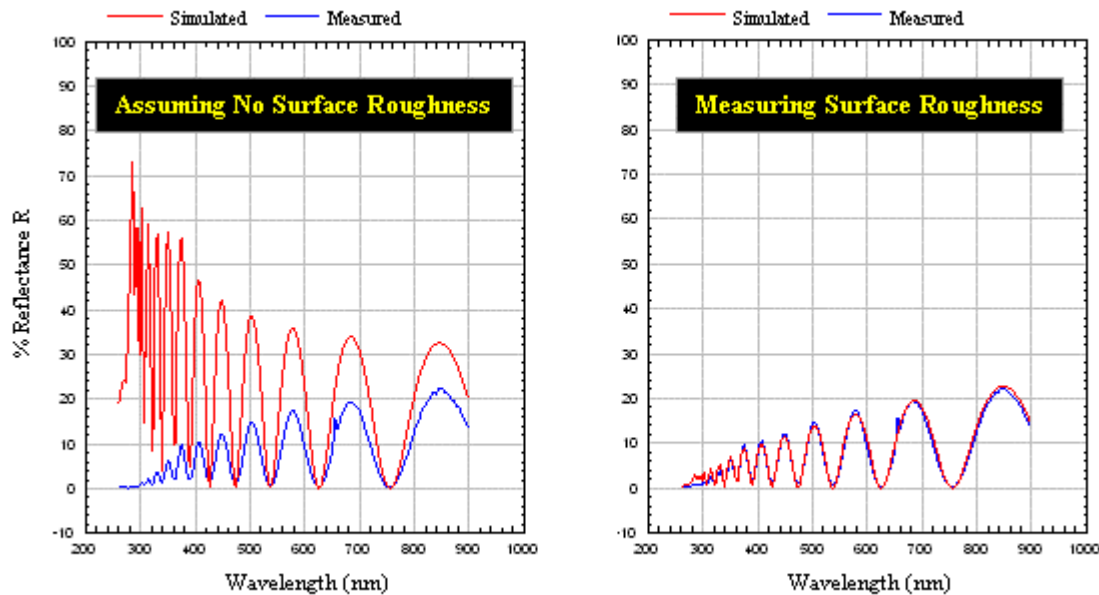


Measuring Surface Roughness(测量表面粗糙度)

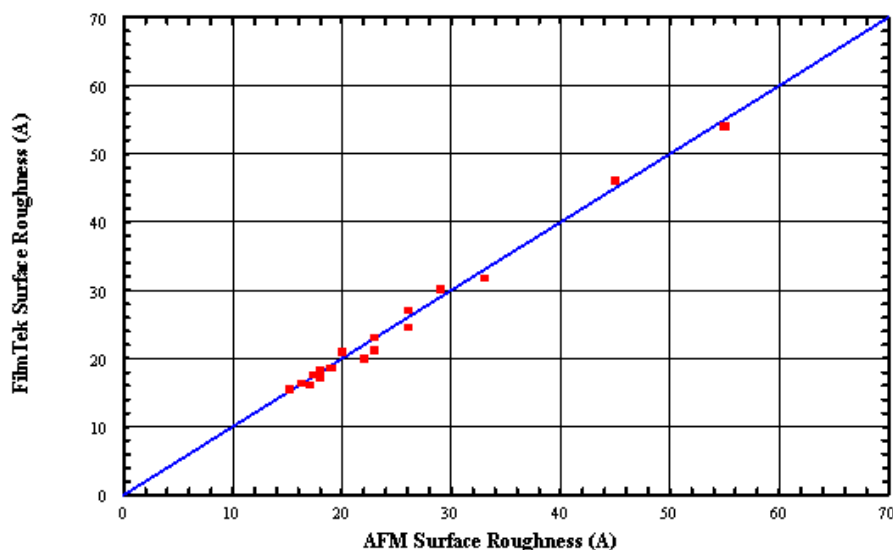
FilmTek™ Advantages 优势

- Fast, non-contact surface roughness measurement. 快速的,非接触表面粗糙度测量
- FilmTek™ simultaneously measures surface roughness, thickness, and optical constants (nk spectra).

SrS Film with 40nm RMS Surface Roughness 40nm 均方根表面粗糙度

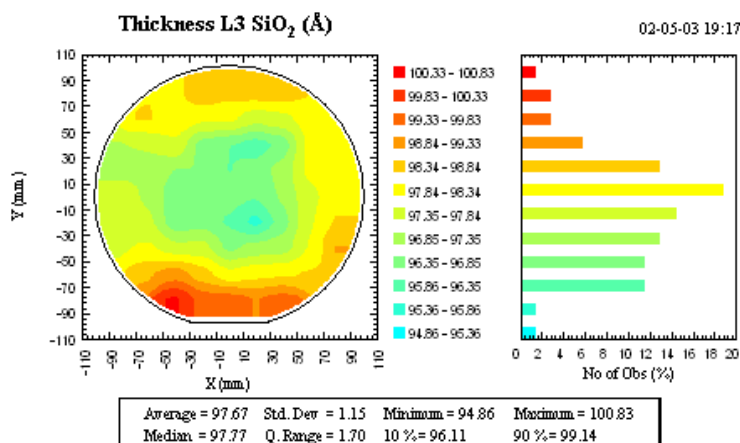
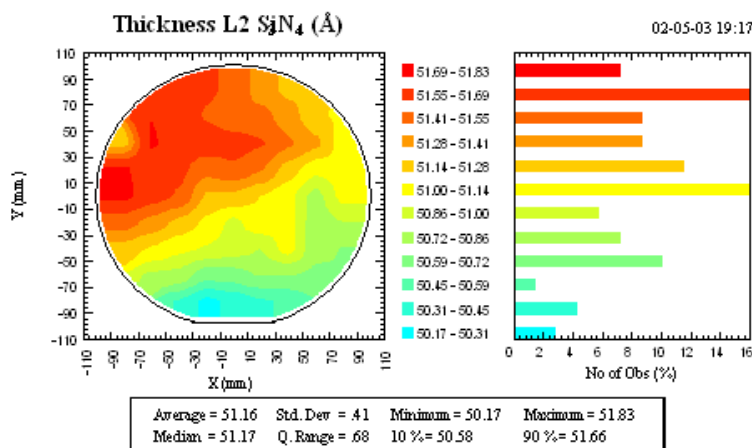
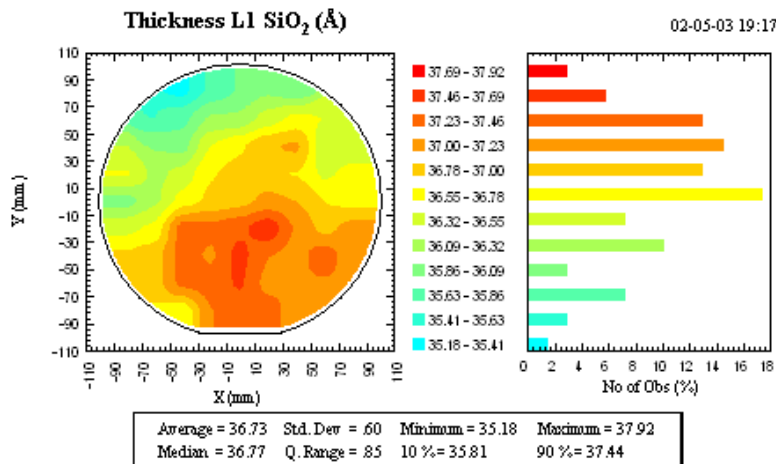


FilmTek™ Surface Roughness Correlation with Atomic Force Microscopy (AFM) FilmTek™-原子力显微镜表面粗糙度测试比较



Characterizing Very Thin ONO Films(表现很薄 ONO 薄膜特性)

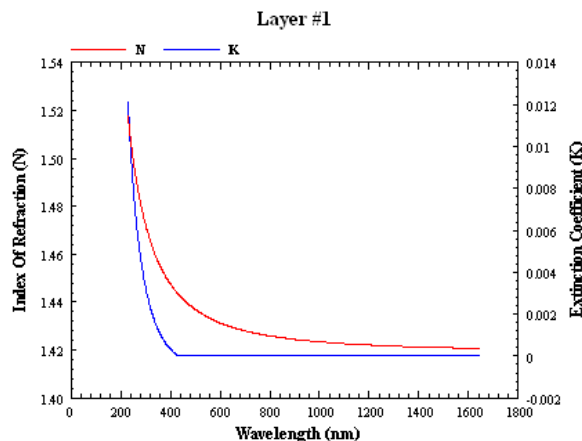
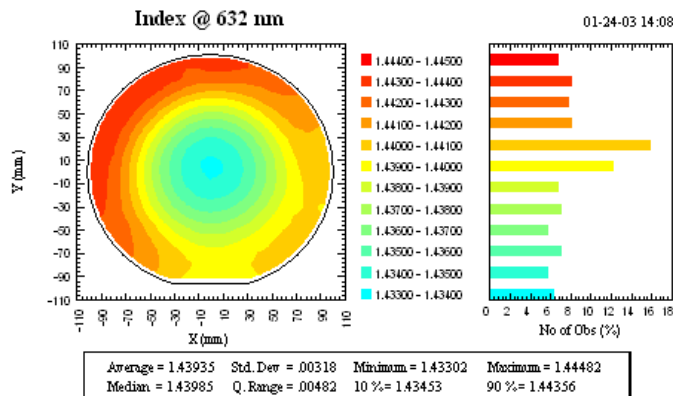
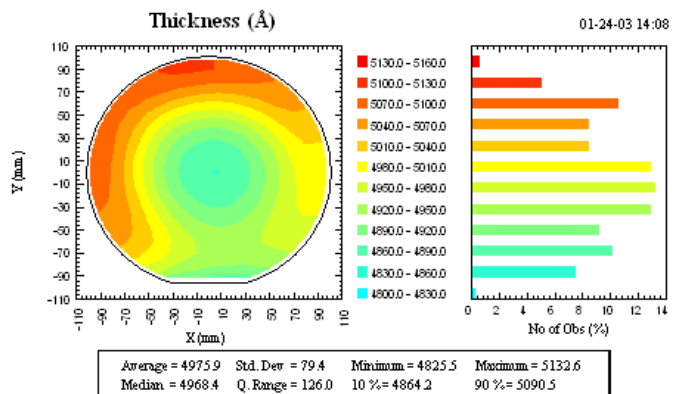
- Simultaneous measurement of all three oxide/nitride/oxide (ONO) layers.
- 同时测量三层薄膜(氧化物/氮化物/氧化物)
- FilmTek 4000EM-DUV combines spectroscopic ellipsometry with deep UV reflectometry using SCI's patented Multi-Angle Differential Polarimetry (MADP) technology to discriminate between the top and buried oxide layers.
- FilmTek 4000EM-DUV 基于 SCI 专利的示差功率谱密度技术并结合紫外反射计和光谱椭圆偏光计鉴别顶层和隐藏层氧化物.



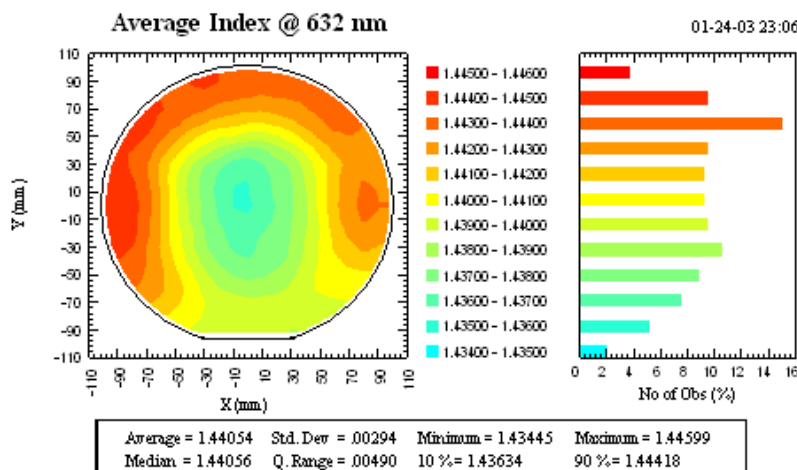
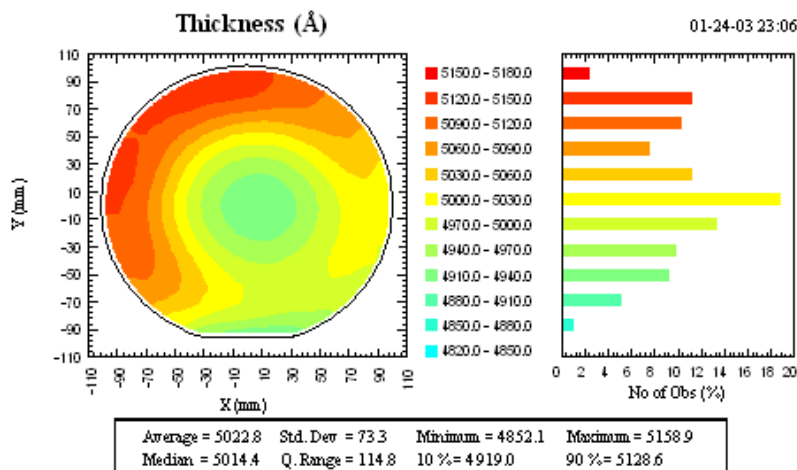
Characterizing Advanced Low-k Materials (表现先进低 K 材料特性)

- Advanced process control achieved with FilmTek's™ high resolution measurement of optical constants and thickness using SCI's patented Differential Power Spectral Density (DPSD) technology.
- Measure graded low-k films (e.g., after plasma damage) with SCI's advanced modeling algorithms.
- Superior film characterization enables accurate and repeatable CMP and trench depth process monitoring of multi-layer low-k film stacks on copper.

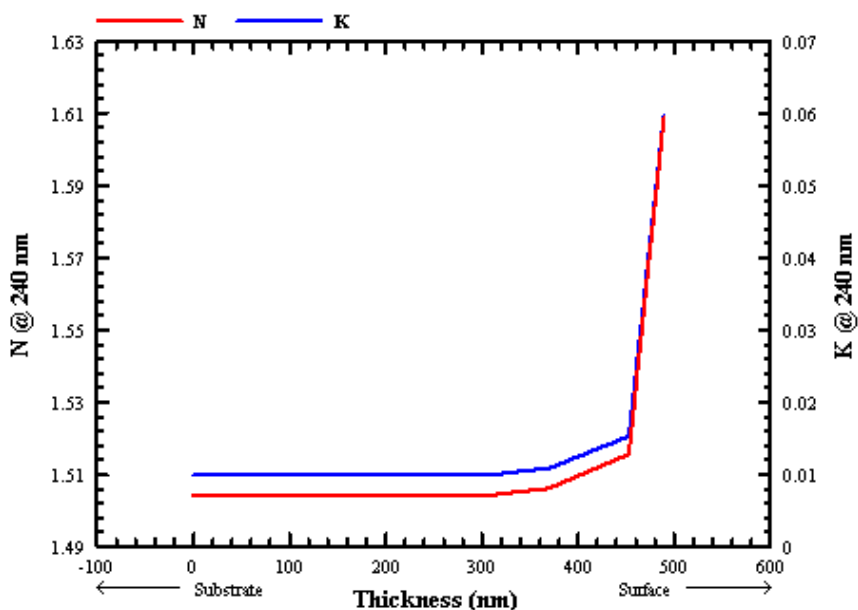
Low-k (As Deposited)



Low-k (Plasma Damaged)



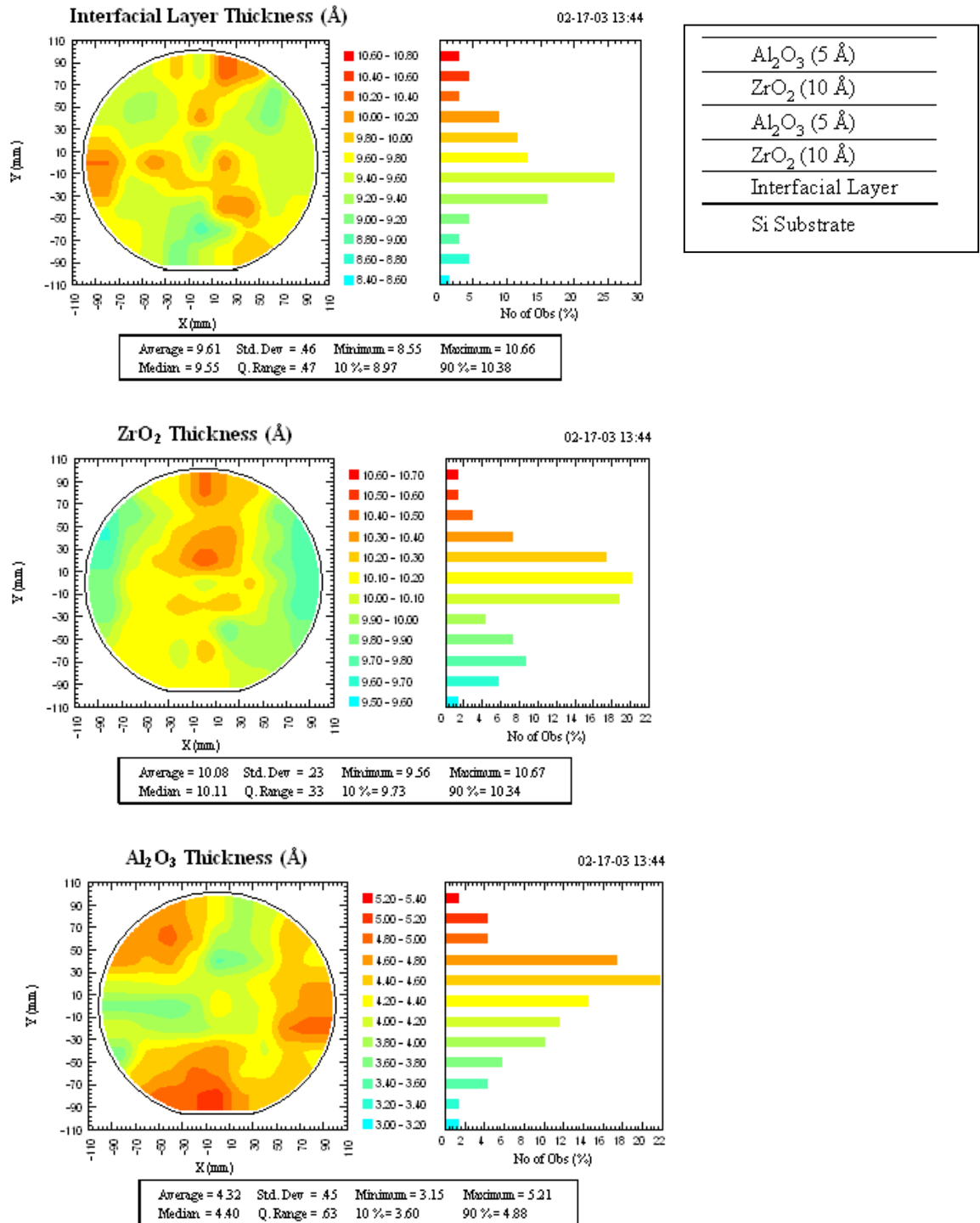
Low-k Plasma Damaged



Characterizing High-k Materials(表现高 K 材料特性)

FilmTek™ Advantages 优势

- Measure multi-layer advanced high-k film stacks with SCI's unique Multi-Angle Differential Polarimetry (MADP) technology.
- Simultaneous determination of the interfacial layer thickness.

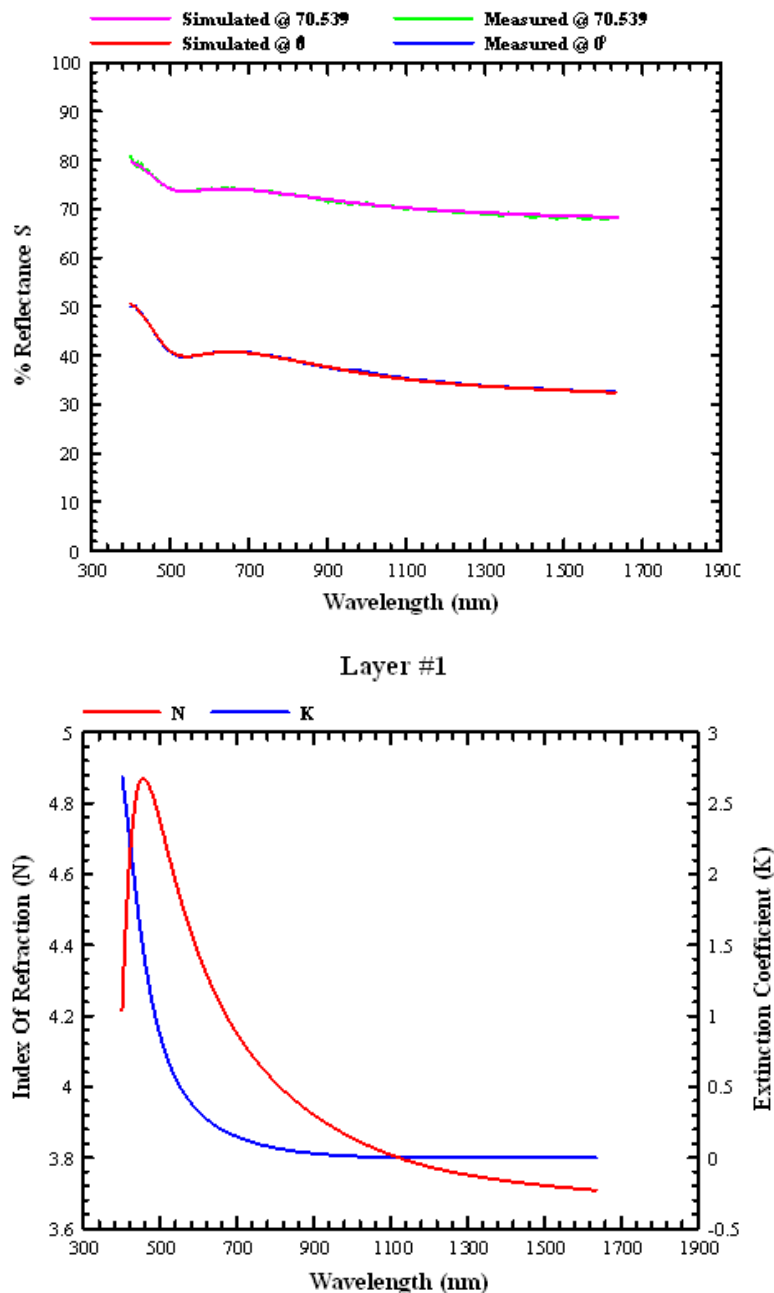


Characterizing SiGe(表现锗化硅特性)

FilmTek™ Advantages 优势

- Simultaneous determination of SiGe thickness and germanium concentration.
- 同时决定锗化硅厚度和锗浓度
- Fast, accurate, and repeatable measurement of thin and thick SiGe films.

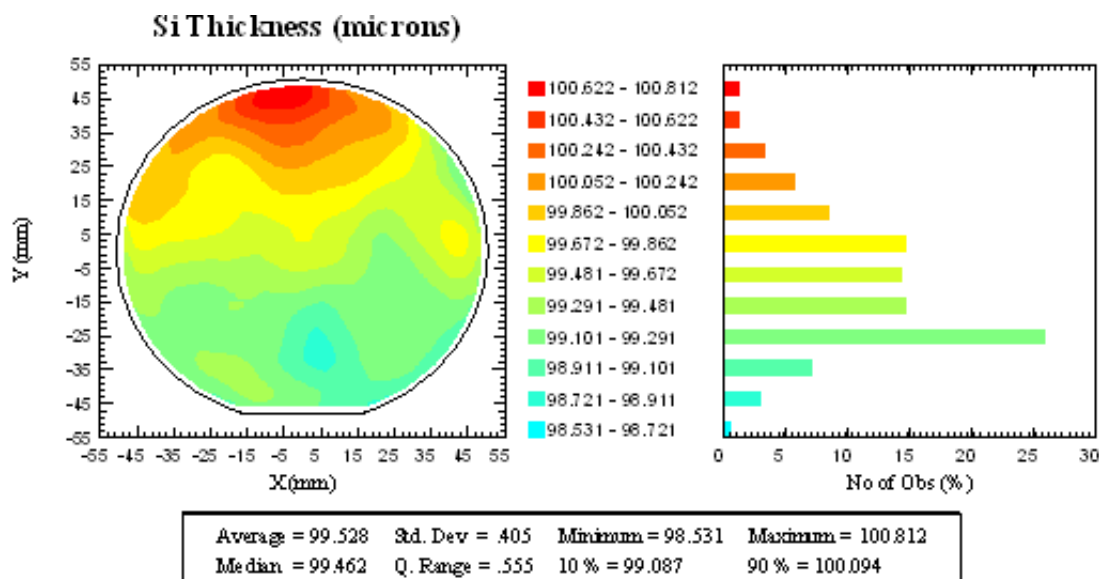
SiGe Thickness = 442.5 Å
% Ge = 35%



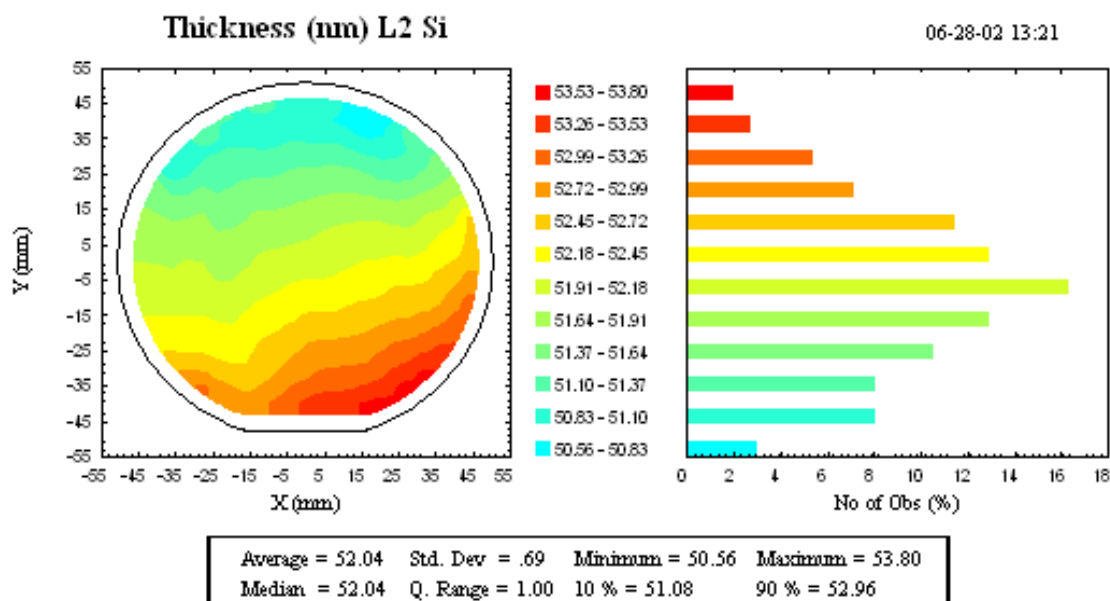
Measuring Silicon-on-Insulator (SOI) Films (测量绝缘体上硅薄膜) FilmTek™ Advantages 优势

- Simultaneous determination of silicon and buried oxide thickness.
- Fast, accurate, and repeatable measurement of thin and thick SOI films.

Thick SOI (100 microns)



Thin SOI (50 nm)



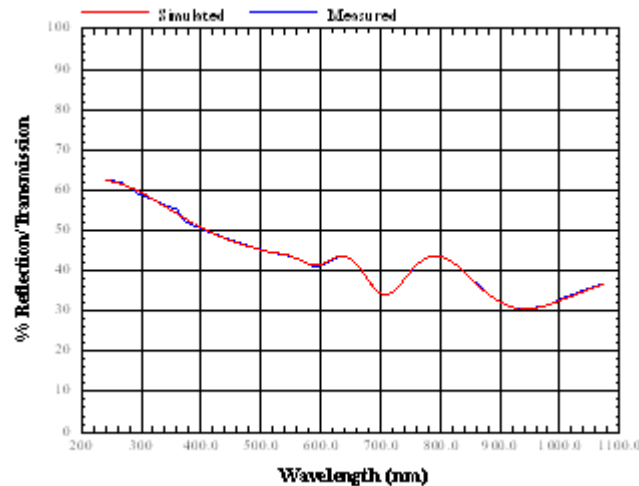
Characterizing Amorphous Silicon and Polysilicon (表现非晶硅和多晶硅特性)

FilmTek™ Advantages 优势

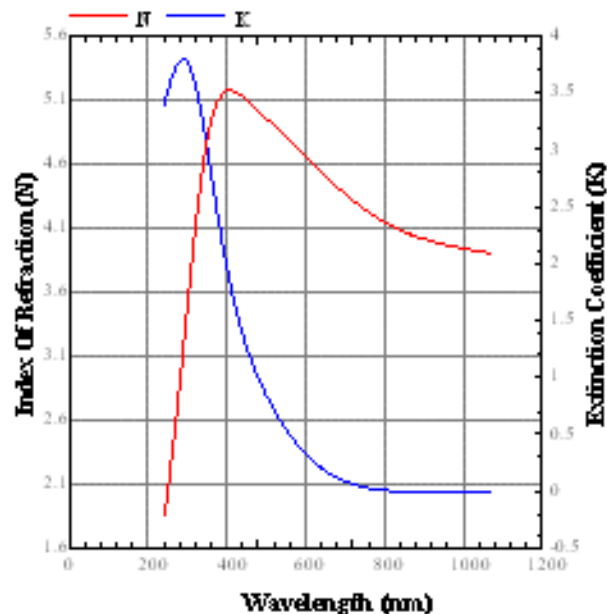
- Simultaneous measurement of a-Si thickness, oxide thickness, and a-Si crystallinity.
- Advanced process control achieved with FilmTek's™ high resolution measurement of optical constants and thickness.

Amorphous Silicon/Oxide/Silicon

a-Si Thickness = 2506.0 Å
Oxide Thickness = 46.0 Å
Crystallinity = 0.5%



NK Spectra of a-Si



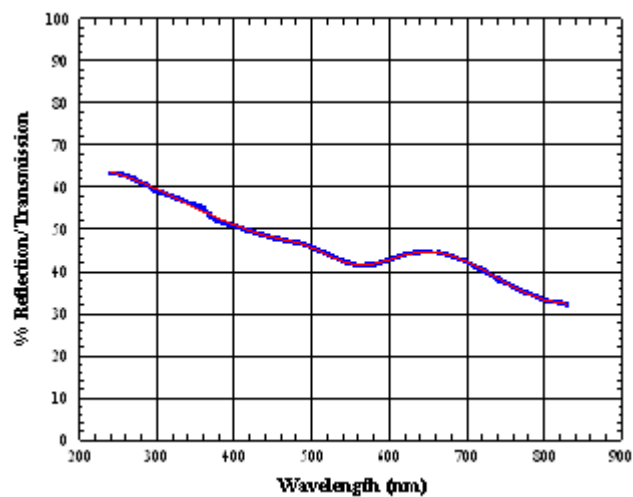
Study of Amorphous Silicon Crystallization Due to Heat Treatment

Sample Number	Hold Time at 550 C (hours)	Thickness (Å) (Main Layer)	% a-Si (Main Layer)	Top a-Si Thickness (Å)
1	0	4191	100	4191
2	6	4004	82.67	51
3	7	4003	61.33	37
4	8	4069	26.70	23
5	10	4102	10.66	14

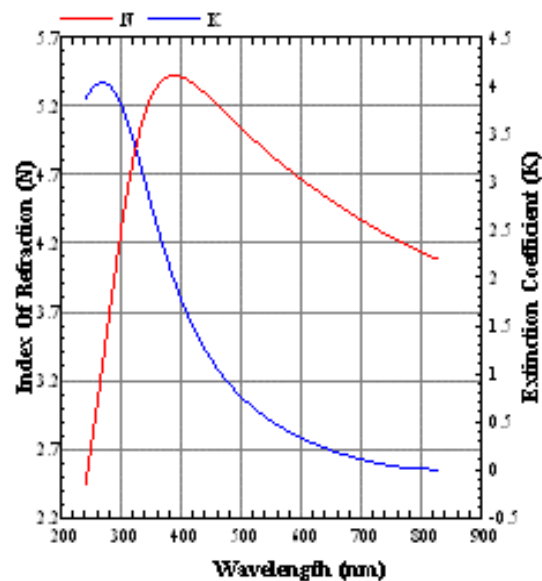
Note: a-Si films deposited on 1000 Å of thermal oxide

Polysilicon/Oxide/Silicon

Poly-Si Thickness = 1114.9 Å
Oxide Thickness = 19.8 Å



NK Spectra of Polysilicon

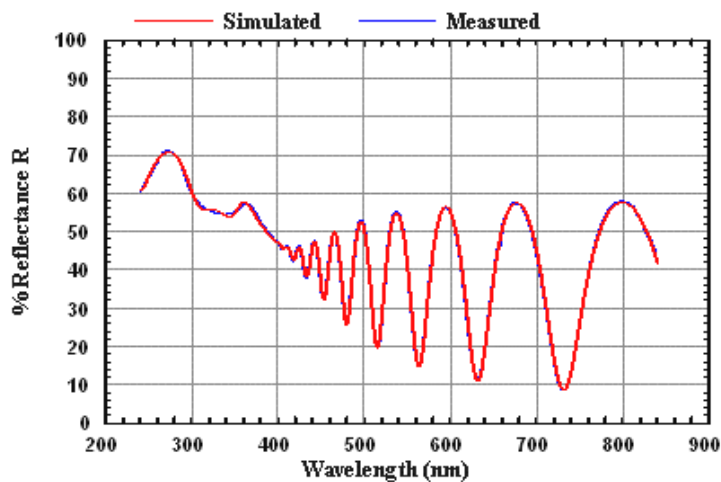


Characterizing Silicon on Sapphire(表现蓝宝石上硅特性)

FilmTek™ Advantages

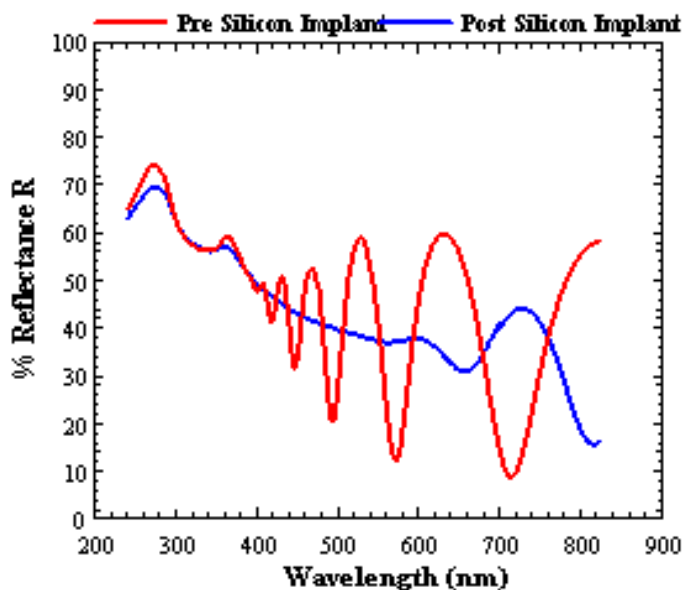
- Simultaneous measurement of silicon thickness and surface roughness.
- 同时测量硅厚度和表面粗糙度
- Measure the profile of silicon implant damage using FilmTek's™ advanced modeling algorithms. 利用 FilmTek's™先进建模算法测量硅植入损伤轮廓
- Superior film characterization enables accurate and repeatable process monitoring.
- 优异薄膜特性表现力使精确和可重复的操作[加工]过程监视成为可能

Heteroepitaxial Silicon on Sapphire 蓝宝石上异质硅



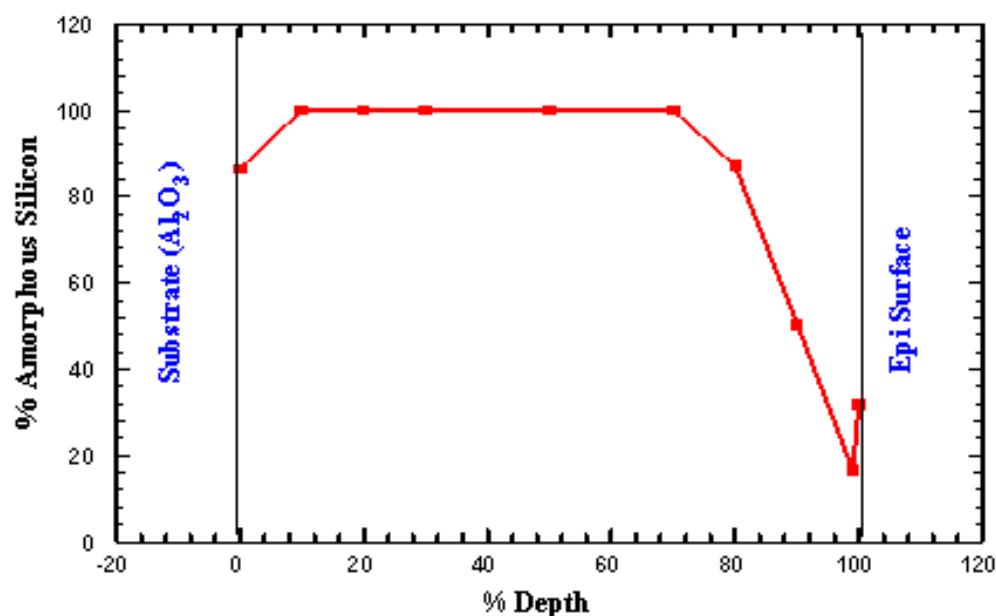
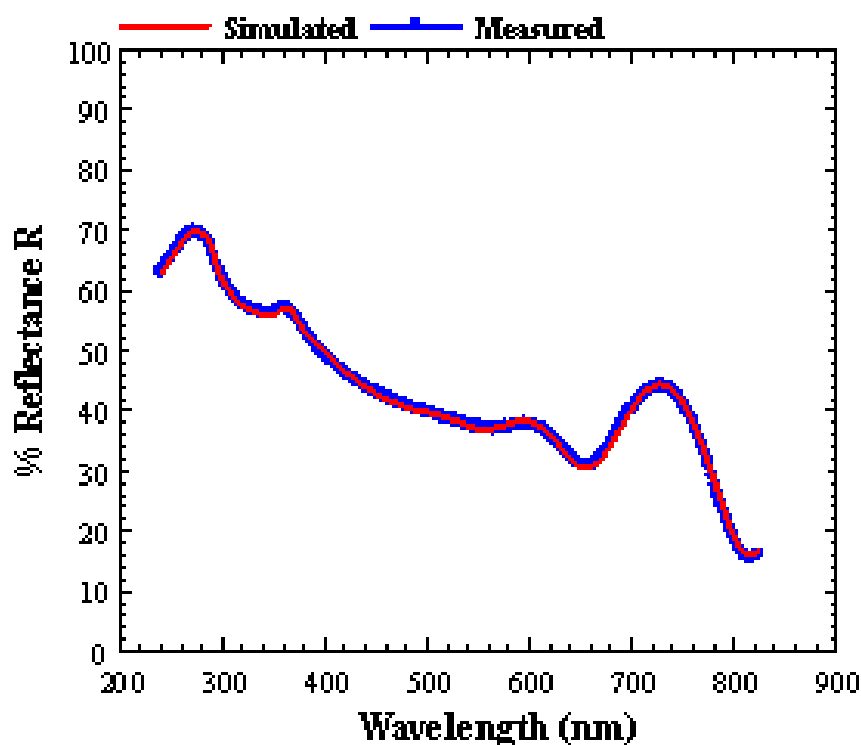
Silicon Thickness = 4987.0 Å
RMS Surface Roughness = 28.0 Å

Profile of Implant Damage: Silicon Epi on Sapphire 植入损伤轮廓: 蓝宝石上硅 Epi



280 nm Silicon Epi on Sapphire
Pre and Post Si Implant

280 nm Silicon Epi on Sapphire
Post Si Implant



Characterizing Photomasks(表现光掩模特性)

FilmTek™ Advantages 优势

- FilmTek™ 3000 measures reflection and transmission. 反射和透射测量
- Simultaneously characterize the photoresist, chrome oxide, and chrome layer thickness.
- 同时表现光刻胶, 氧化铬, 铬层厚度的特性

Photoresist/Cr₂O₅/Cr/Quartz Substrate 光刻胶/五氧化二铬/铬/石英衬底

