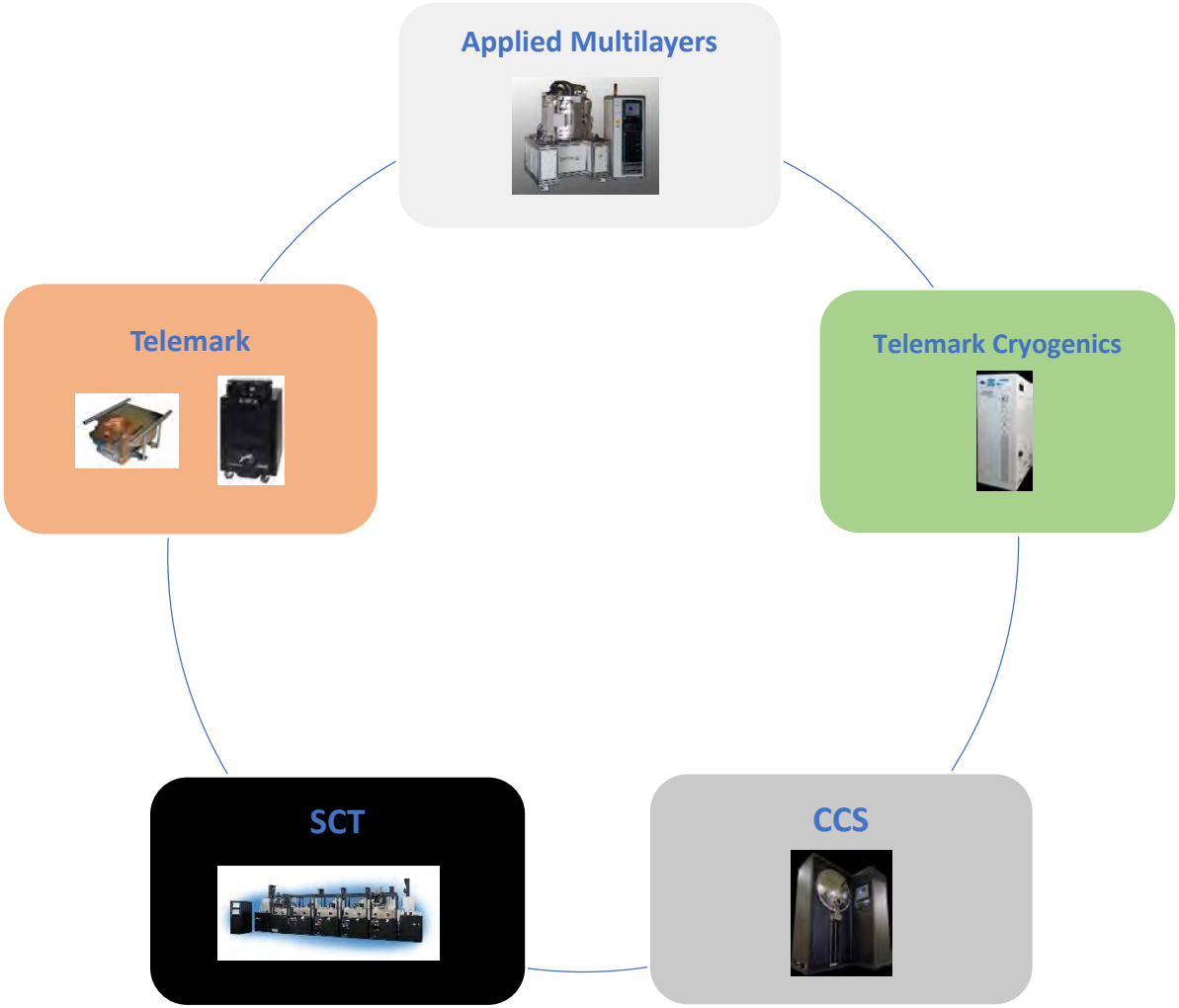
www.applied-multilayers.com

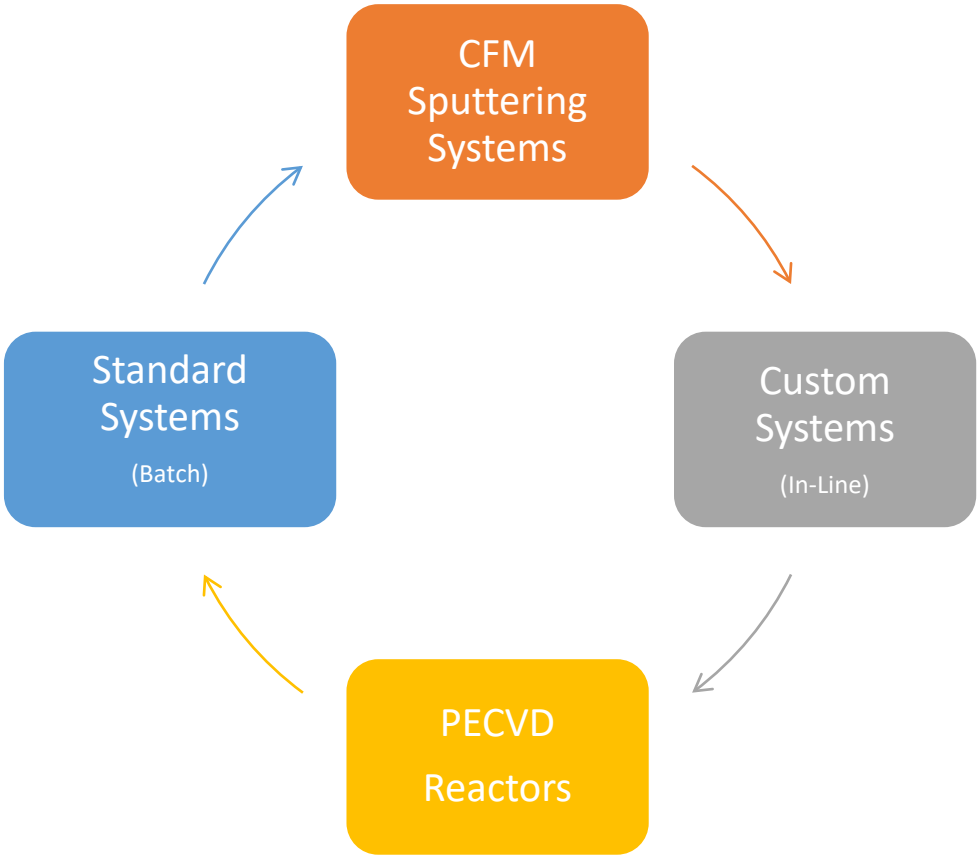
History

- 1985 Closed field magnetron (CFM) sputtering technology developed by Teer Coatings (UK) for tribological and wear resistant PVD coatings
- 1986 Teer Coatings Ltd. files for CFM patents and establishes both coating services and equipment manufacturing specifically for the hard coating and decorative market.
- 2001 AML Ltd. (UK) formed company and licenses CFM sputtering technology from Teer for development of technology into precision optical coating market
- 2003 AML Ltd. markets and delivers systems into the precision optical coating market worldwide
- 2008 AML Ltd. files for multiple patents for CFM technology into optical coating systems
- 2010 AML Ltd. sells company, IP and patents to Applied Multilayers LLC (AML) of Battle Ground, Washington, USA
- 2012 AML purchases IP and patents from Edwards Vacuum Ltd. for the small PlasmaCoat sputtering system
- 2014 Telemark acquires joint ownership of Applied Multilayers LLC

Family


Applied Multilayers
Telemark
Telemark Cryogenics
SCT
CCS

Products


CFM
Sputtering
Systems
Custom
Systems
(In-Line)
PECVD
Reactors
Standard
Systems
(Batch)

Patents

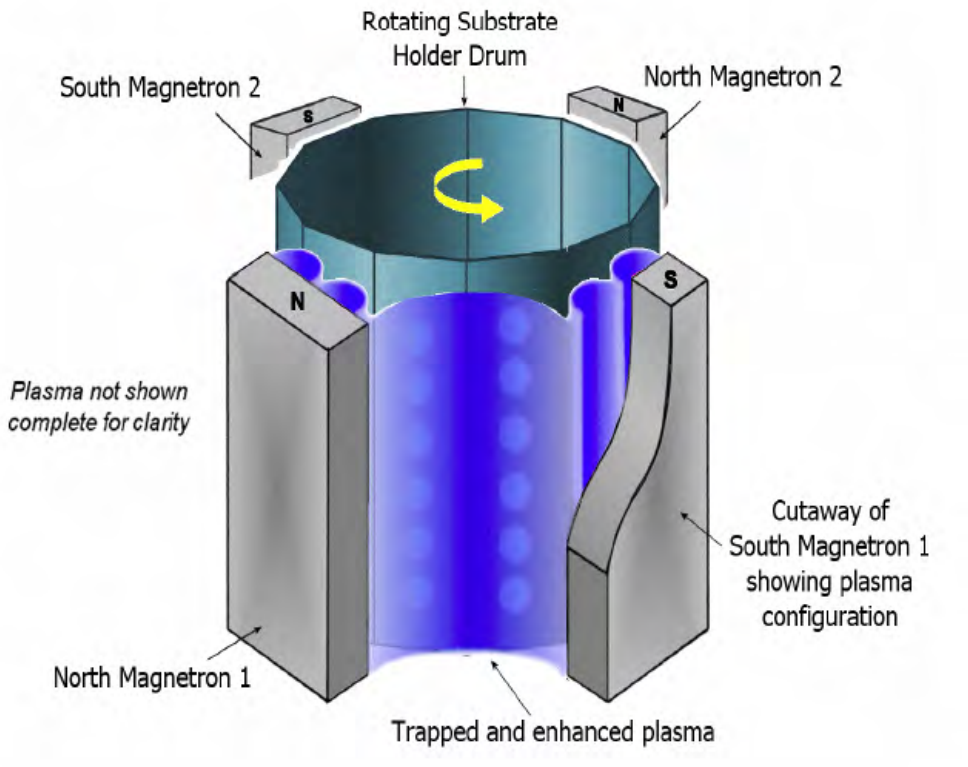
Patents Granted

US 9530629	Method for Depositing Multilayer Coatings
US 8206562	Application of a Material Layer to Display Devices
US 9562283	Coating of Optical Substrates using CFM
US 5427671	Ion Vapor Deposition Apparatus and Method
US 5660693	Ion Vapor Deposition Apparatus and Method
US 6090247	Apparatus for Coating Substrates
US 6090248	Apparatus for Coating Substrates
US 6159351	Magnetic Array for Magnetrons
US 6143143	Masking Means and Cleaning Techniques for Surfaces

Patent Pending

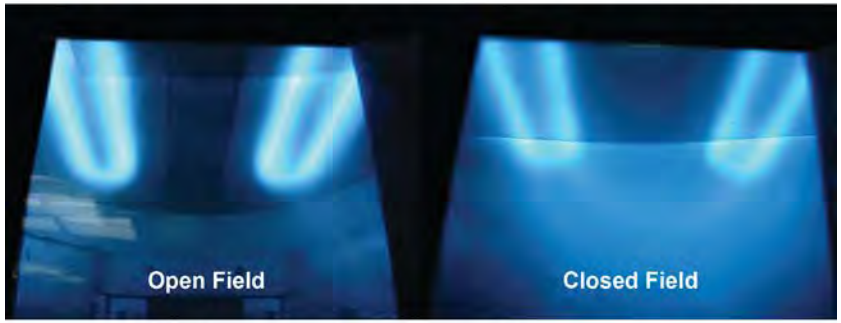
US 12/224 354	Method/Apparatus for Forming a Coated Optical Lens

Technology



Closed Field Magnetron (CFM)

Closed Field Magnetron Sputtering

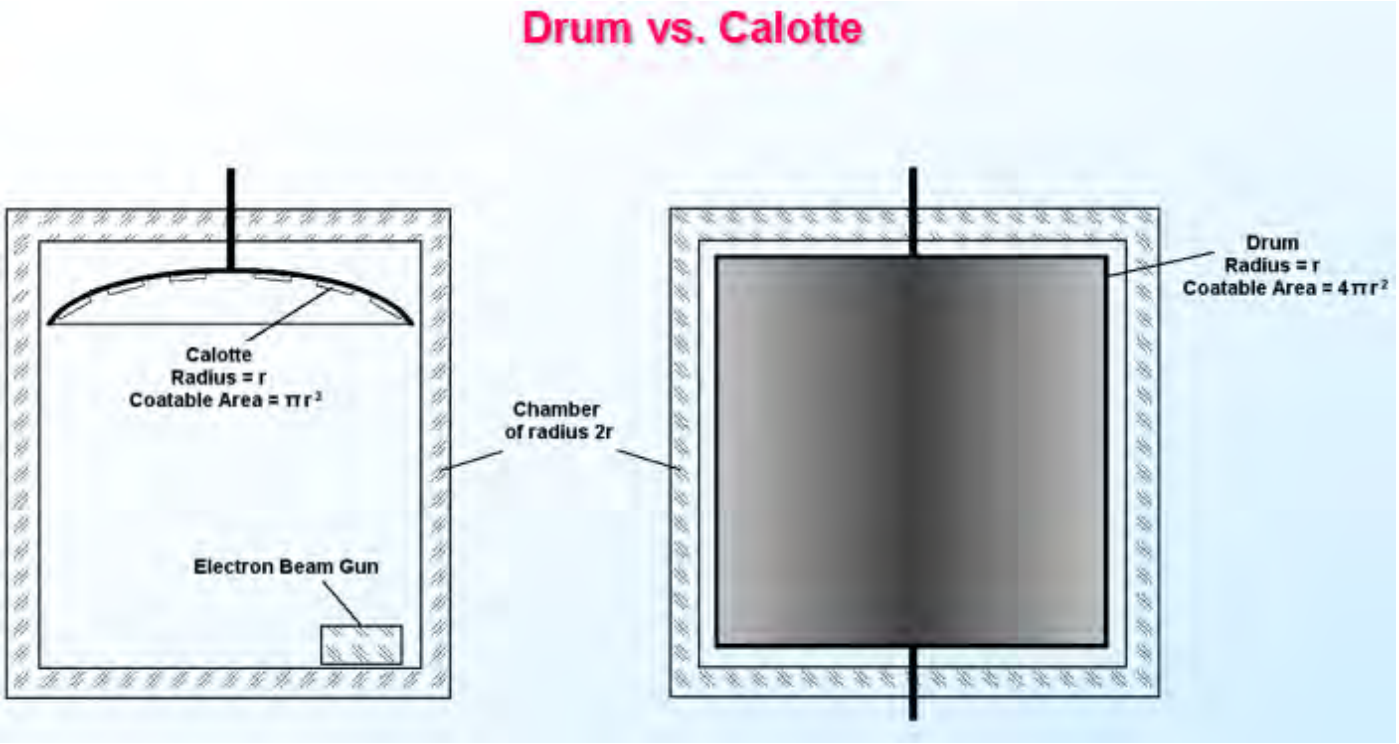


High Ion Current Density and Low Ion Energy

- High Density Films
- Smooth Surface Optical Coatings
- Stress Controlled Films
- Minimal Defect Density/Particles
- Low Temperature Process
- Small and Large Load Capacity
- Scalable Technology

PRECISION OPTICS • OPHTHALMICS • PLASTICS • PHOTOVOLTAICS

Load Capacity



CFM has nearly 3X the Load Capacity vs. Evaporation Systems

Coating System	CFM450/2	CFM650/4	CFM850/6	CFM1050
Drum diameter	250mm	424mm	532mm	700mm
Linear magnetron length	410mm	610mm	1055mm	1255mm
Magnetron width (target size)	133mm	133mm	133mm	133mm
Magnetron positions	2	4	6	6 - 8
Available coating area (±1%)	1875 cm^2	5040 cm^2	11,130 cm^2	17,920cm^2

Systems

CFM450 AR Coating system

- 30 lens capacity (72mm dia)
- Two 400mm linear magnetrons
- 250mm drum diameter
- Diffusion pumped system
- Modem and Internet diagnostics
- In situ hydrophobic process
- AR coating cycle time typically 40 minutes
- Meissner trap option

CFM650 AR Coating system

- 60 lens capacity (72mm dia)
- Up to Four 600mm linear magnetrons
- 400mm drum diameter
- 2000litre/sec Turbomolecular pumped system
- Modem and Internet diagnostics
- In situ hydrophobic process
- AR coating cycle time typically 40 minutes

CFM850 AR Coating system

- 120 lens capacity (72mm dia)
- Up to six 1m linear magnetrons
- 550mm drum diameter
- Two 2000litre/sec Turbomolecular pumps
- Modem and Internet diagnostics
- In situ hydrophobic process
- AR coating cycle time typically 40 minutes
- Meissner trap option

CFM1050 AR Coating system

- 240 lens capacity (72mm dia)
- Up to eight 1.2m linear magnetrons
- 750mm drum diameter
- Four 2000litre/sec Turbomolecular pumps
- Modem and Internet diagnostics
- In situ hydrophobic process
- AR coating cycle time typically 40 minutes
- Meissner trap option

CFM 450 Used to AR coating prescription lenses in Canada

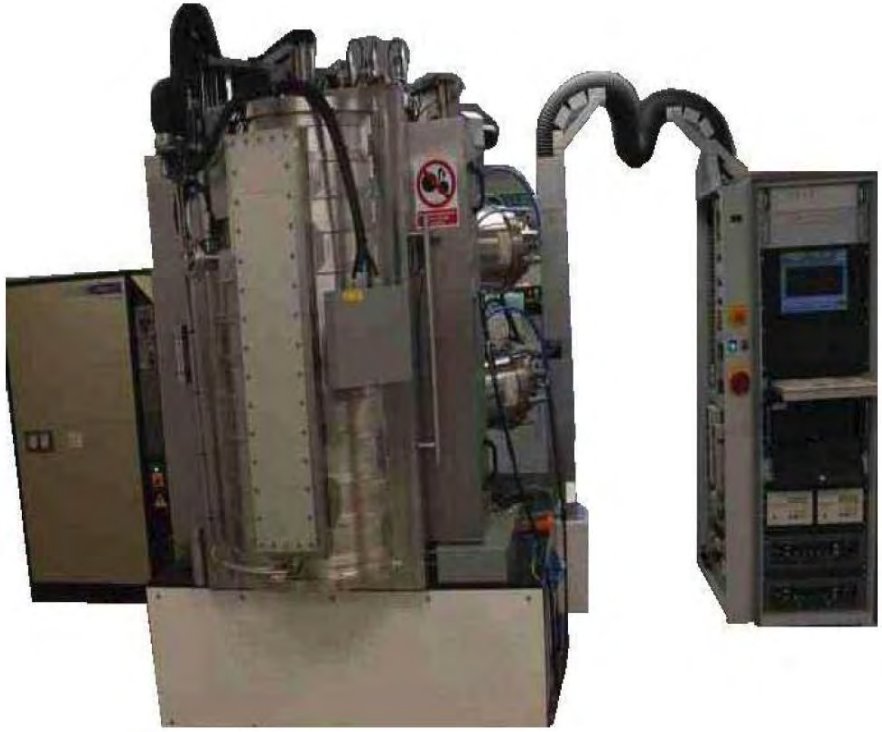
CFM650 used to apply mirror coatings to sunwear lenses in Shenzhen, China

CFM450

Chamber diameter (internal)	450mm
Chamber height (internal)	640mm
Chamber diameter (external)	528mm
Chamber height (external)	685mm.
Drum diameter	250mm
Linear magnetron length	410mm
Magnetron width (target size)	133mm
Magnetron positions:	22
Available coating area (±1%):	1875 cm^2

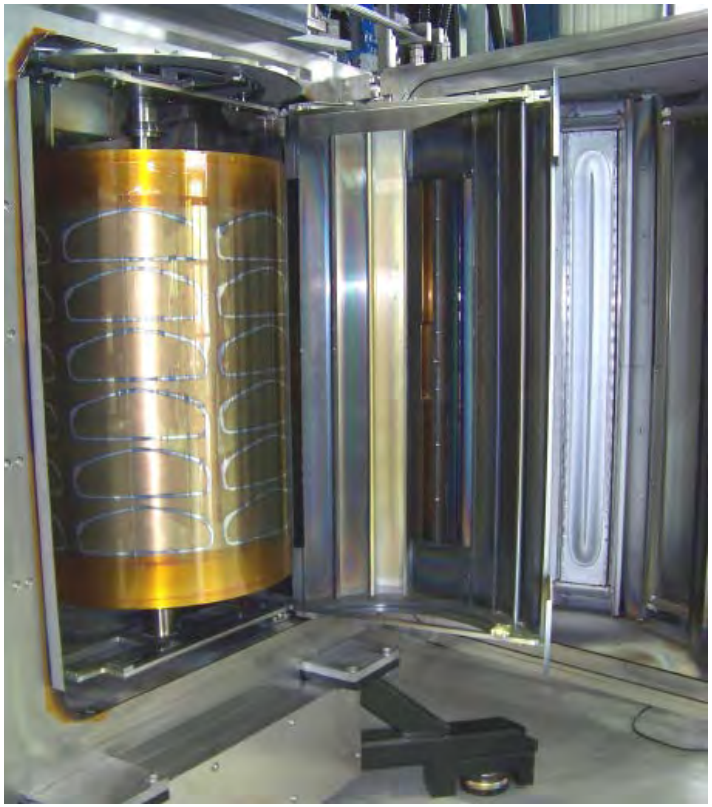
CFM650/4

Chamber diameter (internal)	714mm
Chamber height (internal)	837mm
Chamber diameter (external)	724mm
Chamber height (external)	881mm.
Drum diameter	424mm
Linear magnetron length	610mm
Magnetron width (target size)	133mm
Magnetron positions:	4
Available coating area (±1%):	5040 cm^2



CFM850/6

Chamber diameter (internal)	760mm
Chamber height (internal)	1381mm
Chamber diameter (external)	780mm
Chamber height (external)	1451mm.
Drum diameter	532mm
Linear magnetron length	1055mm
Magnetron width (target size)	133mm
Magnetron positions:	6
Available coating area (±1%):	11,130 cm^2



CFM 1050/ 8

Chamber d ...nternal)	1640mm
Chamber height (internal)	1620mm
Chamber diameter (external)	1690mm
Chamber height (external)	1670mm.
Drum diameter	700mm
Linear magnetron length	1255mm
Magnetron width (target size)	133mm
Magnetron positions:	8
Available coating area (±1%):	11,130 cm^2

Plasma Express

Multilayer Express AR Coating system

- 6 lens capacity (72mm dia)
- Two 6 inch circular magnetrons
- 200mm drum diameter
- Load Lock for fast cycle time
- Turbomolecular pumped system
- Modem and Internet diagnostics
- In situ hydrophobic process
- AR coating cycle time typically 15 minutes

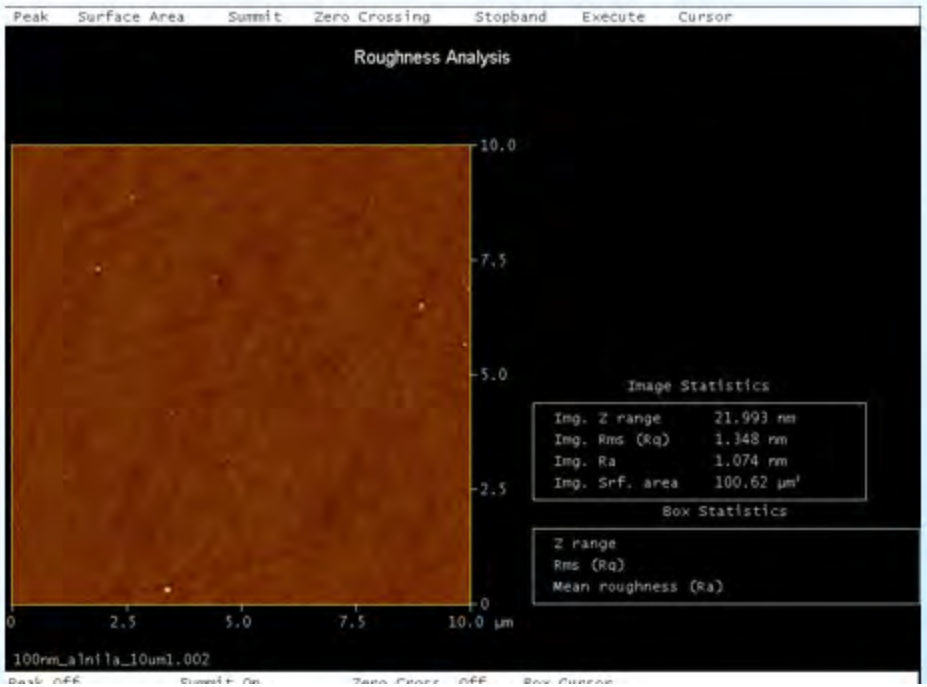
Process Categories	Target Materials	Applications
Thin film photovoltaics	Az0, IZ0, CdTe, CdS	Thin film solar cells on glass or polymer sheets
Precision Optics		
Multilayer visible coatings	SiO2, Nb205, Ti02. Ta205	AR, IR, UV coatings, telecommunications, imaging optics, edge/notch filters
Infra-red coatings	GeC, DLC	Infrared coatings, hard carbon coatings
Transparent conducting oxides	ITO, AZO	Touch panels, EMC coatings, cold mirrors, displays, electrochromics
Metal reflectors	Au, Ag, Al	Lamp reflectors for heat management and greater efficiencies
Ophthalmic Optical Coatings		
Express systems	SiO2, Nb	Eye glasses, colored sun glasses, AR coating on optical fibers
Laboratory and Stock lens systems		

Film Characteristics

100nm thick aluminium alloy films produced with:

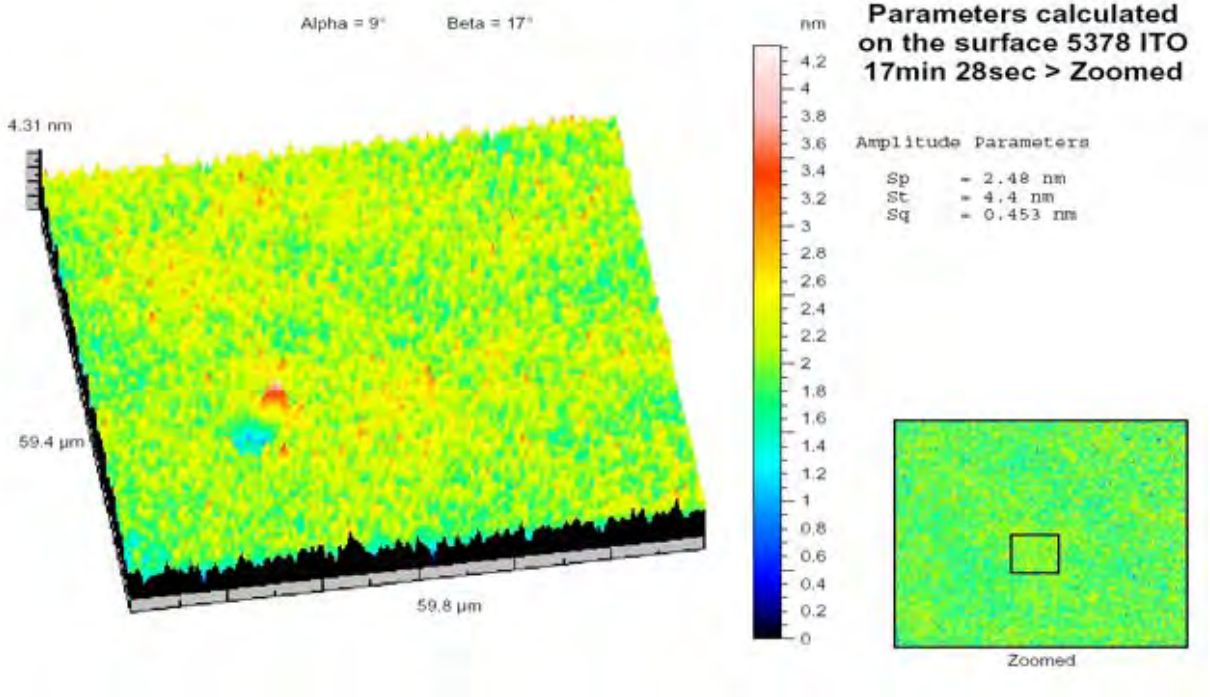
RMS roughness ~ 1.3nm

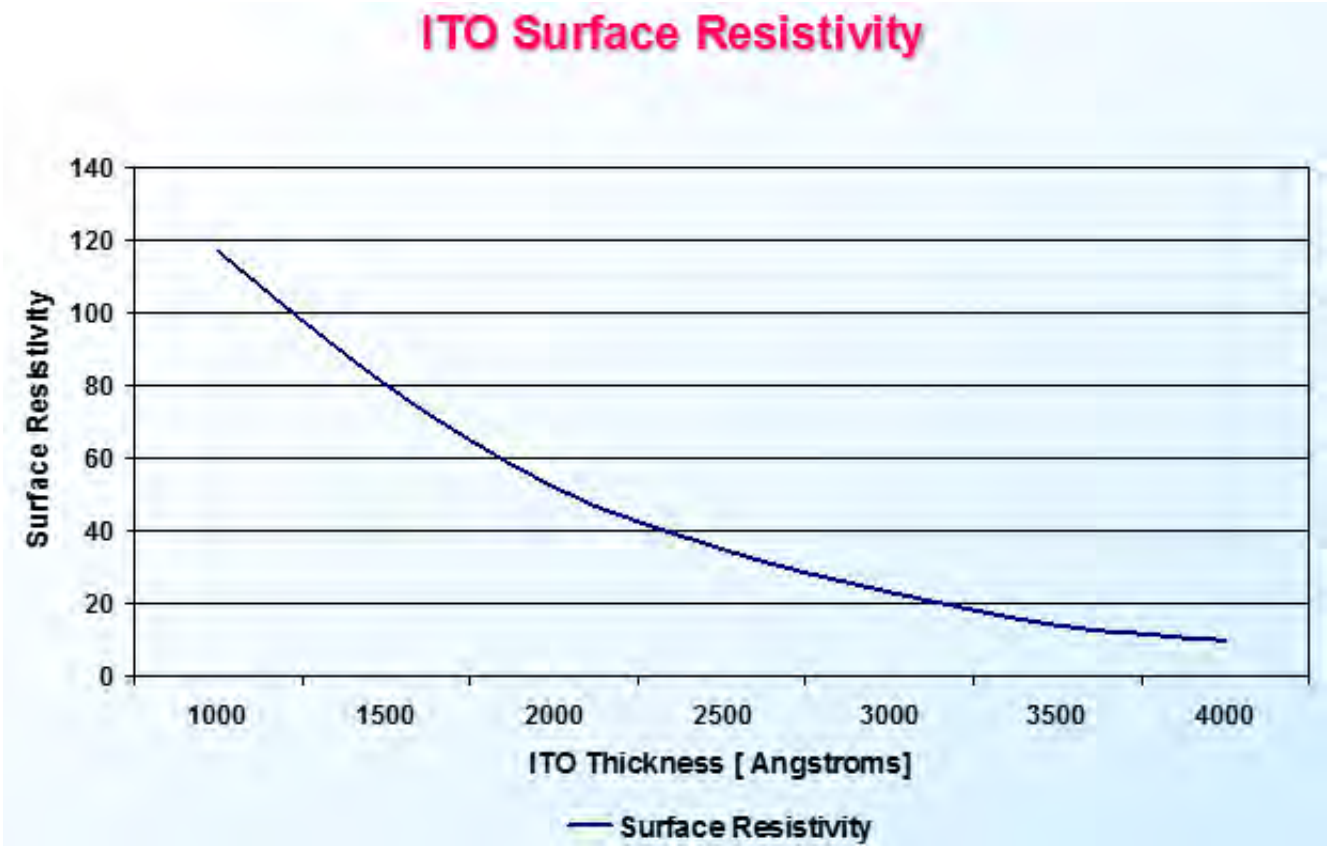
Grain size < 200nm

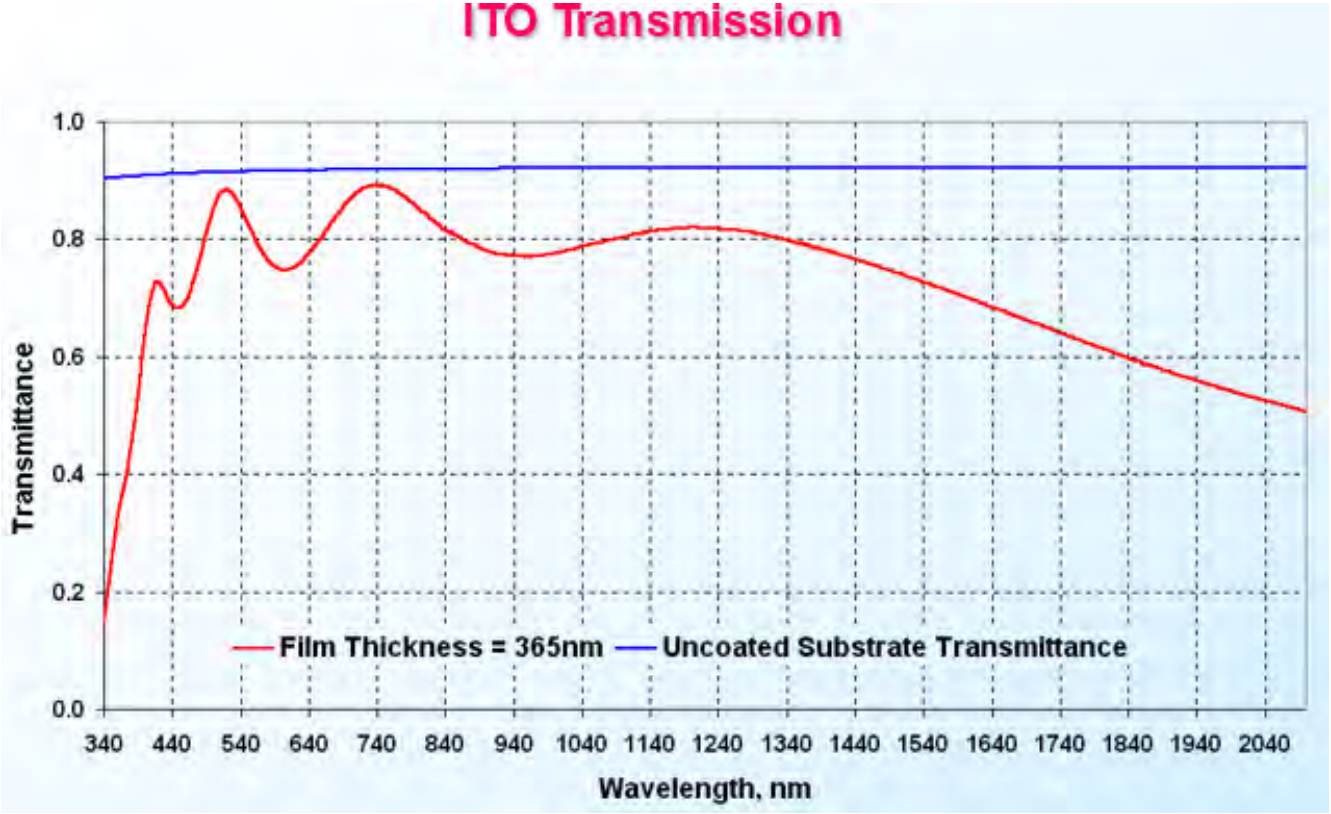


Data provided by Cambridge Display Technology

ITO – 3D Surface Roughness




ITO Surface Resistivity
Surface Resistivity
140
120
100
80
60
40
20
0
1000
1500
2000
2500
3000
3500
4000
ITO Thickness [Angstroms]
Surface Resistivity


ITO Transmission
Transmittance
1.0
0.8
0.6
0.4
0.2
0.0
340
440
540
640
740
840
940
1040
1140
1240
1340
1440
1540
1640
1740
1840
1940
2040
Wavelength, nm
Film Thickness = 365nm
Uncoated Substrate Transmittance

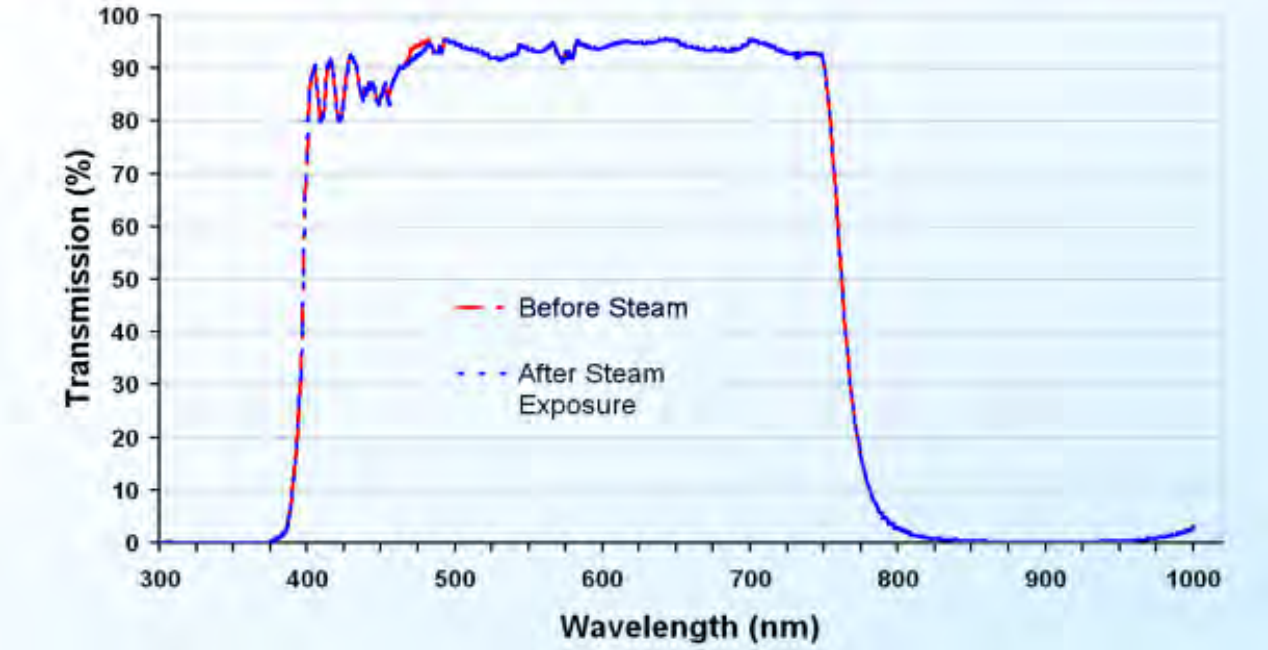
Metal Oxides Stress Levels

Dielectrics	Silica	- 150MPa
	Niobia	- 27MPa
TCO	ITO	- 50MPa

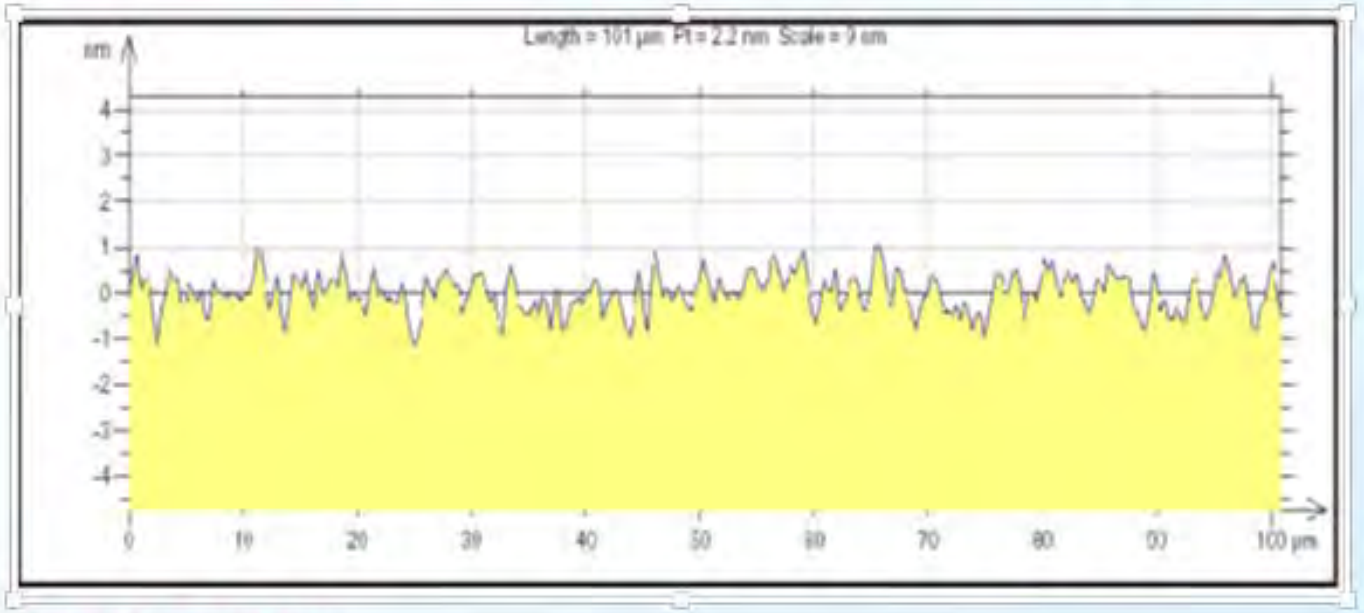
Method – Deflection of thin coated substrate

Error ±5%

UV/IR Blocker Spectral Transmission Before & After Steam Exposure



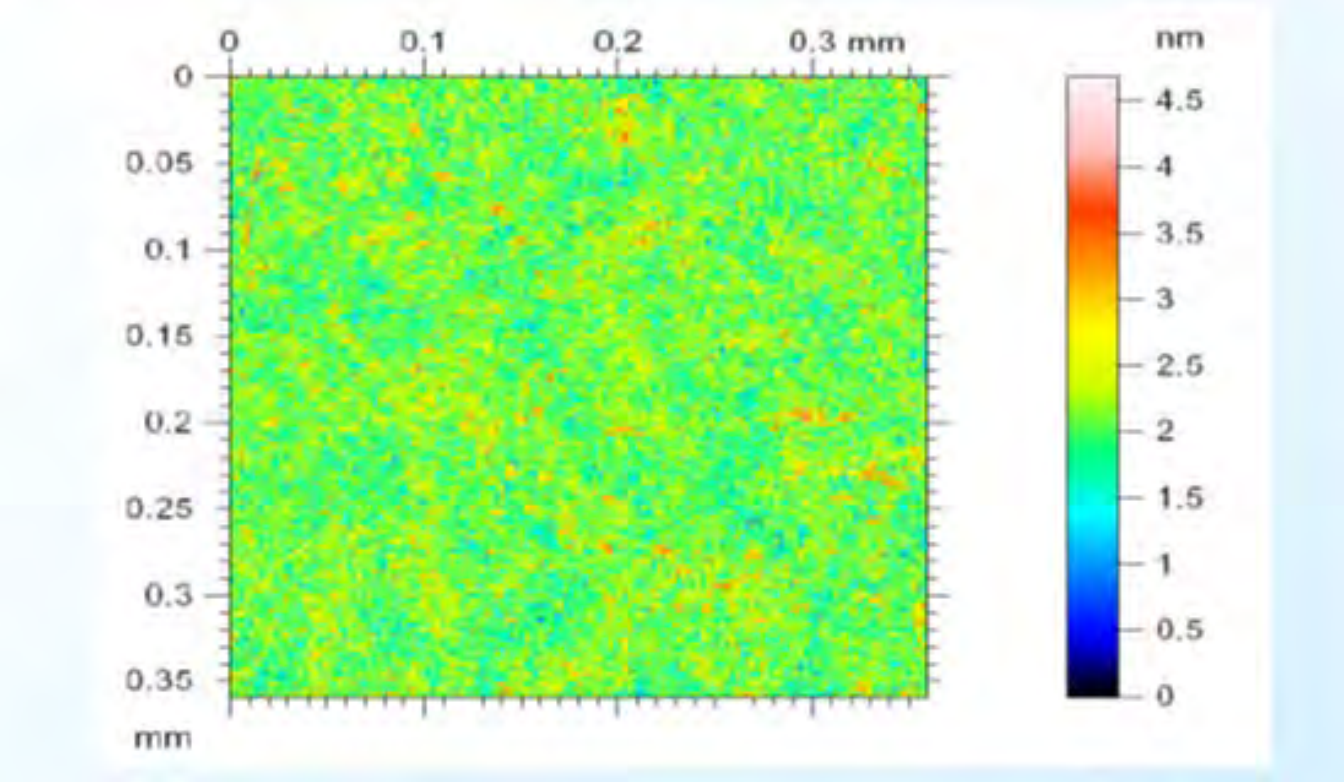
Surface Roughness Parameters – 1um Thick Nb2O5



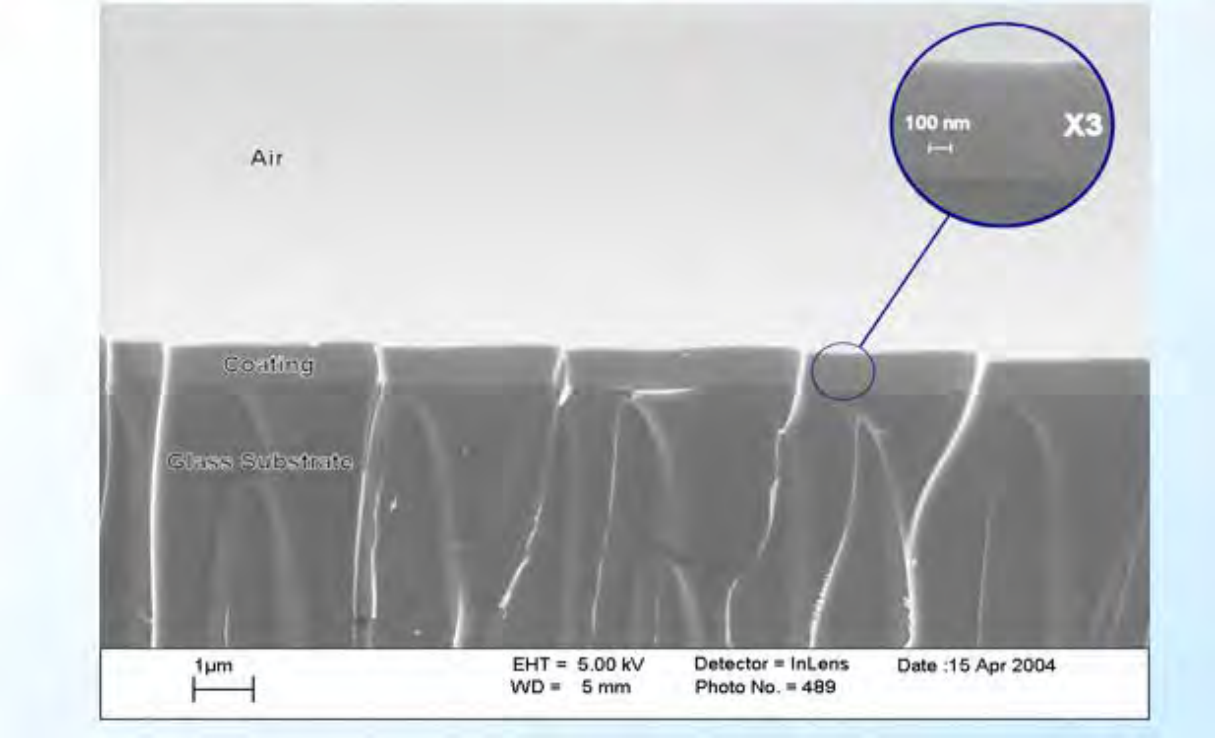
Amplitude Parameters

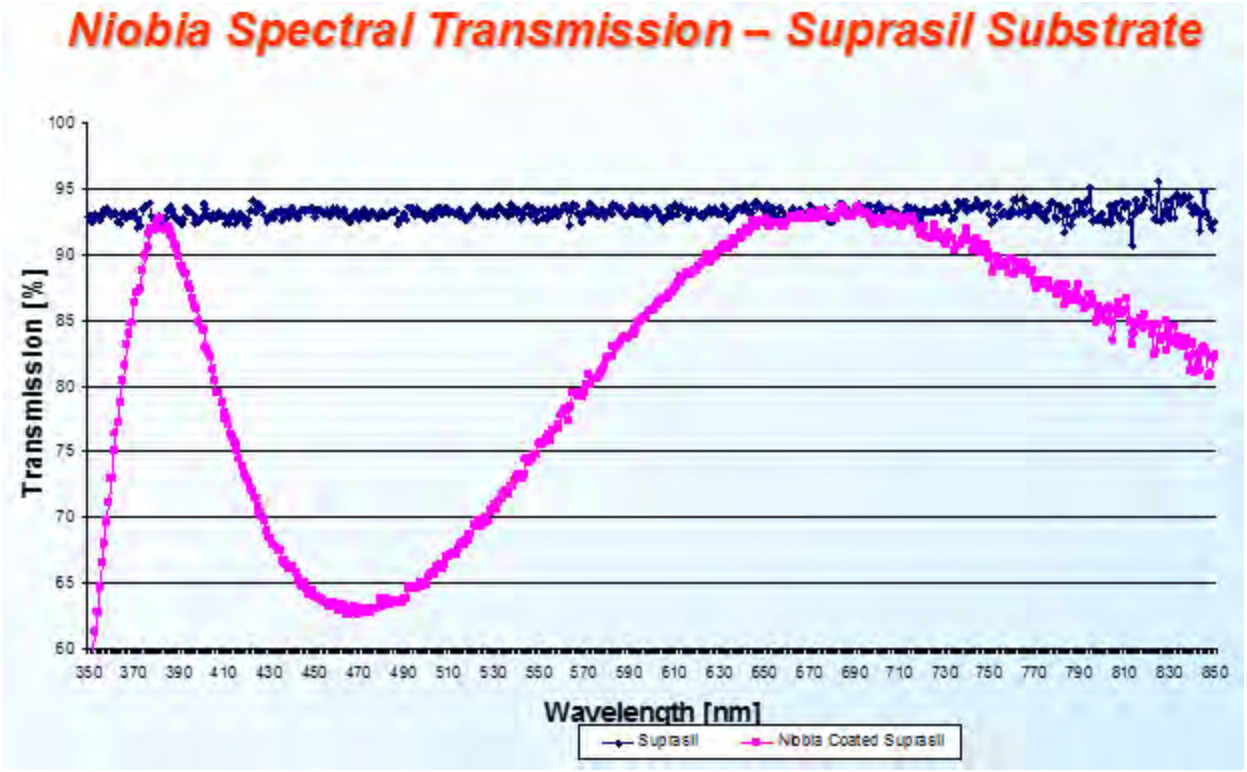
St = 5.69 nm
Sq = 0.452 nm

Quantitative Metrology Analysis – 1um Nb2O5 Film



Cross Sectional Electron Micrograph – 1um Thick Nb2O5




Niobia Spectral Transmission – Suprasil Substrate
Transmission [%]
100
95
90
85
80
75
70
65
60
350 370 390 410 430 450 470 490 510 530 550 570 590 610 630 650 670 690 710 730 750 770 790 810 830 850
Wavelength [nm]
Suprasil
Niobia Coated Suprasil

CFM Summary

- CFM optimizes deposition energy and produces low stress, high ion current density with low ion energy, ultra-smooth and spectrally stable coatings
- Process is room temperature - ideal for use on polymer substrates
- High deposition rates as CFM is reactive sputtering
- Simplified deposition control system – Time & Power
- Does not require an expensive auxiliary plasma source or separation of reaction and deposition zones
- Typical 3X load capacity over evaporator systems
- CFM technology is readily scaleable in drum diameter and magnetron cathode length
- CFM process can be implemented in batch, in-line or roll-to-roll formats
- Only two moving parts in chamber - Substrate Drum & Shutter
- Excellent economy of source materials

PECVD Reactors

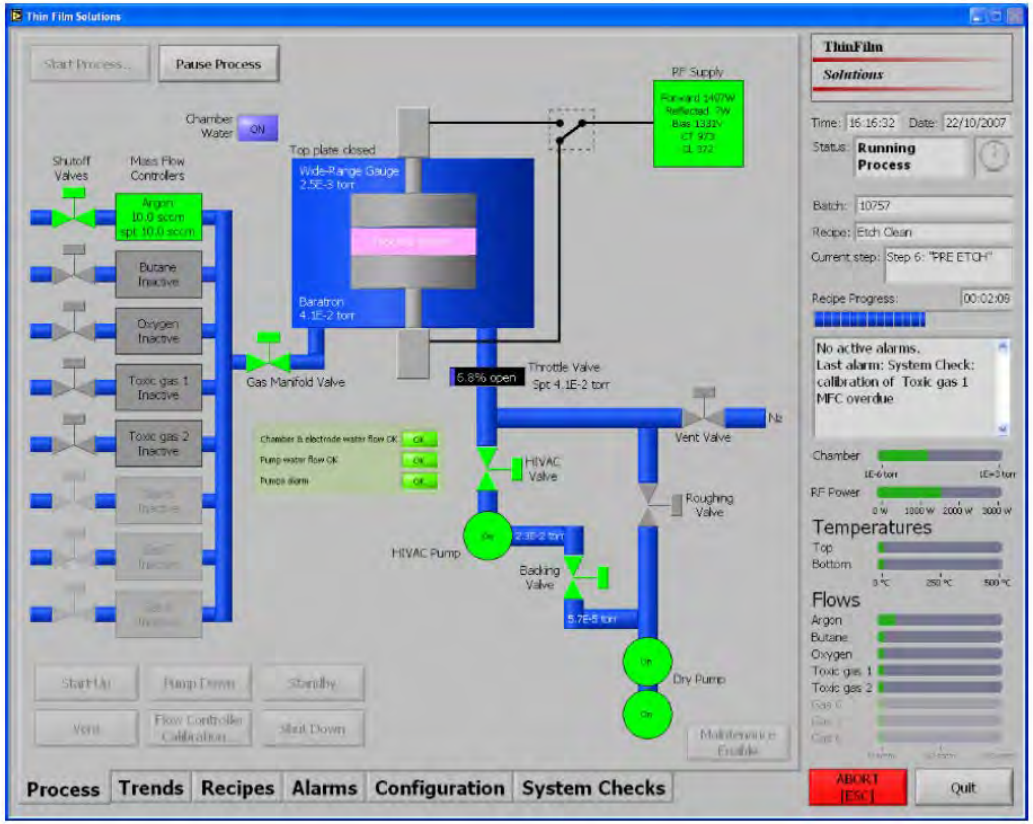
PECVD Applications: Diamond-like Carbon (DLC)
Boron Phosphide (BP)

- An extremely rugged and abrasion resistant AR coating for use on large area, outer surfaces of Ge optical components (domes)

- Environmental Specifications

Passes MIL-C-675 tests for

- ✓ Adhesion
- ✓ Abrasion
- ✓ Humidity
- ✓ Salt Spray
- ✓ Salt Solubility



Sample Reactor Screen