C. FEATURES OF SPA-4000

1. Key Features
2. Specification
3. Thermo-Optic Coefficient Analysis SPEC
4. Thermo-Optic Coefficient Analysis GRAPH
5. Configuration

C. 1. Key Features

- Propagation Loss measurement of high quality film with low propagation waveguide loss (**0.05dB/cm SiO2 dual layer at 1550nm**)
- No information requirement of lower layer for dual layer film
- Index profile for the film with graded index
- Liquid measurement
- Reverse calculation to verify the reliability of the results graphically
- Easy-to-use Software based on MS Windows

C. 2. Specification

Measurements	Specifications	
Refractive Index	Index measuring range	~ 2.45 (depend on Prism type)
	Index accuracy	0.001
	Index resolution	±0.0005
Thickness	Thickness measuring range	0.4? ~ 20?
	Thickness accuracy	±0.5%
	Thickness resolution	±0.01?
Bulk (index only)	Index accuracy	0.001
	Index resolution	±0.0005
Thick film (thickness only)	Thickness measuring range	2? ~150?
Liquid (index only)	Index measuring range	1.0 to 2.4
	Index accuracy	± 0.001
Loss Measurement Measuring limitation below 0.05dB/cm		

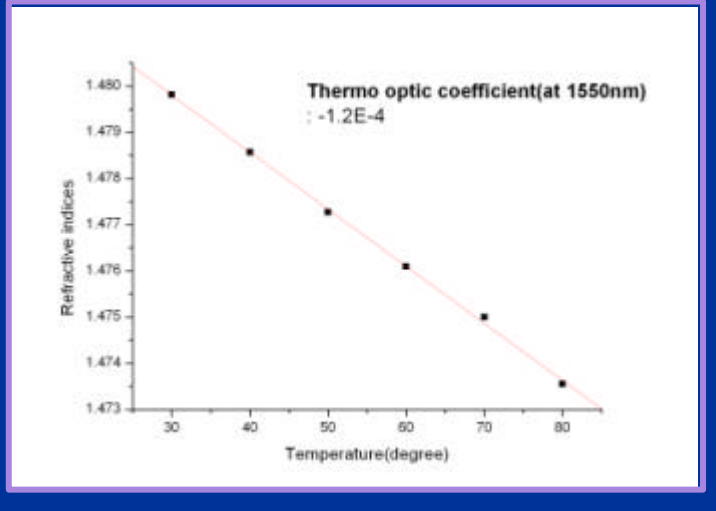
C. 3. Thermo-Optic Coefficient Analysis SPEC

Measurement	Specifications	
Thermo - Optic Coefficient	Sample temperature accuracy*	± 1? (30? ~ 100?) ± 2? (100? ~ 150?)
	Prism temperature accuracy	± 0.5? (30? ~ 100?) ± 1? (100? ~ 150?)
	Temperature rising time	~ 5min/10? (in case 30? , depend on room temperature) ~ 3min/10? (40? ~ 80?), ~ 4min/10? (80 ? ~ 120?), ~ 5min/10? (120? ~ 150?)
	Temperature Stability time	~5min (30? ~100?) ~ 7 min (100? ~ 150?)
	Measurement sample size	Min 25? × 25? , Max 50? × 50? substrate thickness : below 1?

- very easy sample setup
- * It used Si wafer (Temperature accuracy depend on wafer(=substrate) type)

C. 4. Thermo-Optic Coefficient Analysis GRAPH

- Sample Material : PMMA
- Sample Size : 40mm X 40mm
- Substrate : Silicon wafer (Thickness 0.5mm)
- Index of Refraction : 1.48 (at 1550nm room temperature)
- Measuring Temperature range : 30? ~ 80?



Temperature(?)	Wave length	refractive index	Linear Fit* (dn/dT)
30	1550nm	1.4798	$1.2X10^{-4}$/?
40		1.4786	
50		1.4773	
60		1.4761	
70		1.475	
80		1.4736	

- *It used fitting program – Origin

C. 5. Configuration

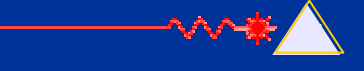
SPA-series	include 632.8nm He - Ne Laser
	include GGG(n=1.965) prism & Holder (index : < 1.8)
	include controller and Desktop PC with MS Windows
	include Analysis software
	include Si - photodiode Detector
Options	Laser Diode Module (405 ~1550nm); user choice
	TM Mode option for each wavelength (Birefringence)
	Ge - Detector for Infrared Laser
	Rutile (n=2.865) prism for high index refraction (index:1.8~2.45)
	Thick - film measurement system(VAMFO)
	Thermo Optic Coefficient measurement system (dn/dt)
	Liquid measurement system
	Propagation LOSS measurement system

D. PRINCIPLE

1. Principle of Prism Coupling method

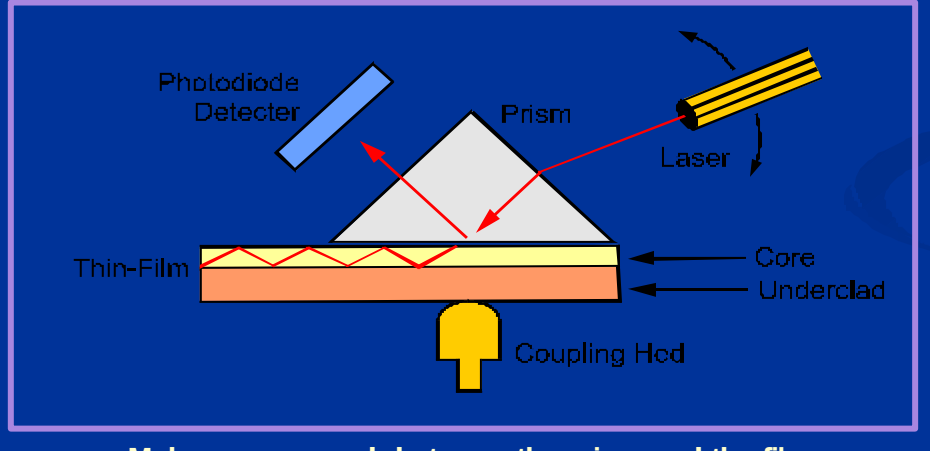
2. Principle of Loss Measurement

3. Principle of Liquid Measurement



D. 1. Principle of Prism Coupling Method

- Incidence Laser light
  - totally reflected at the base of the prism
- Proper orientation of the direction of the incidence beam
  - Coupled through their evanescent fields in the gap.
  - Permits excitation of anyone of the film waveguide modes.
- Measurement for both Refractive Index and Thickness of the film.



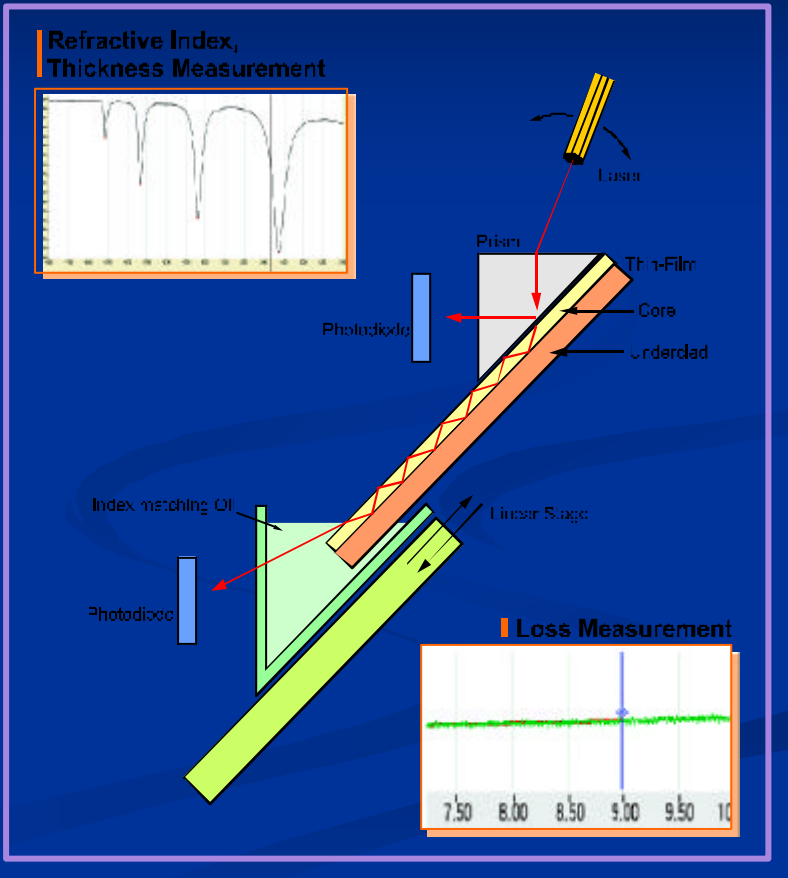
Make a narrow gab between the prism and the film
using coupling (push) head

D. 2. Principle of Loss Measurement

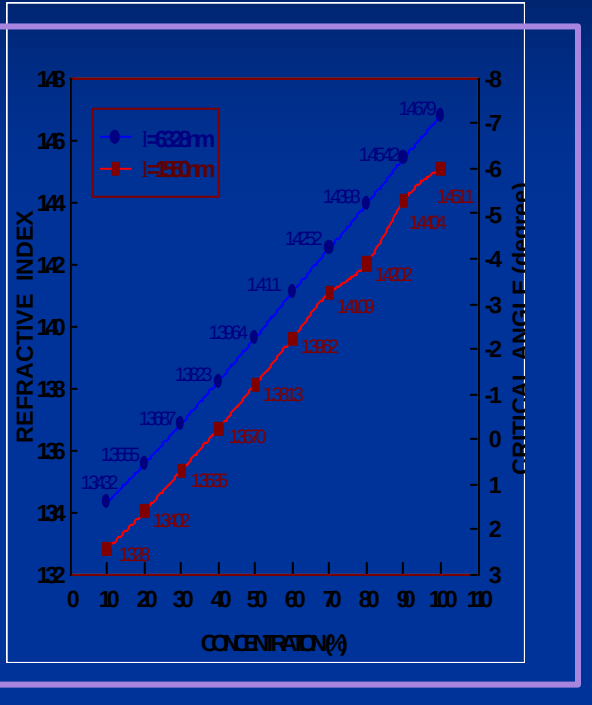
Index Matching Oil Method

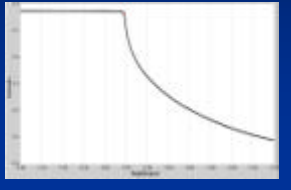
- Waveguide light undergoes numerous total internal refractions inside the film.
- Immerse the film into the liquid oil, with the index of refraction slightly higher than that of the film.
- The light emerge out from the film at the intersection between the liquid surface and the film surface.
- Detecting the outgoing light through the liquid oil.
- Recording the intensity of the guided light as a function of propagation distance.

❖ **Highly precise measurement down to 0.05dB/cm** (SiO2 dual layer at 1550nm)



D. 3. Principle of Liquid Measurement





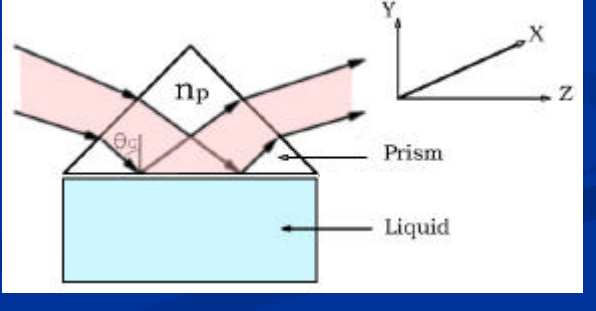
Snell's law

$$n = n_p \sin\theta_c$$

$$q_c = q_p - \sin^{-1}[\sin\frac{q_{input}}{n_p}]$$

Index range : 1.0 ~ 2.4

(It depend on prism type)



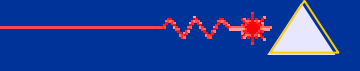
Measuring Methods	Specifications		Remark
Liquid Measurement	index accuracy	0.001	GGG
	index resolution	±0.0005	

E. CORE COMPETITIVENESS

1. SAIRON(SPA- 4000)
2. Advantages of Index Matching Oil Method
3. Thermo Optic coefficient measurement
4. Dual Layer Calculation
5. Reverse Calculation

E. 1. SAIRON(SPA- 4000)

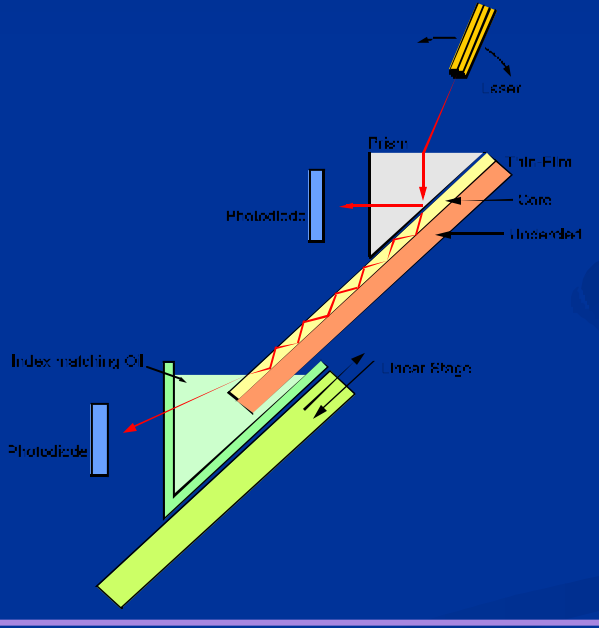
	SPA-4000
Loss measurement method	Index matching liquid
	limit to 0.05dB/cm
	Applicable for high quality film
Scan type	Rotation of the Laser beam (No Effect from vibration of film)
Reverse Calculation	Verify the reliability of the results with reverse calculation graph
PC Interface	RS-232 type
software	Easy to use User-Friendly graphical interface
Dual -layer	1 upper layer mode is enough for calculation
	No requirement information on lower layer



E. 2. Advantages of Index Matching Oil Method

SPA-4000

A. Index Matching Oil Loss measurement
- below 0.05dB/cm for high quality thin-film



E. 3. Thermo Optic coefficient measurement

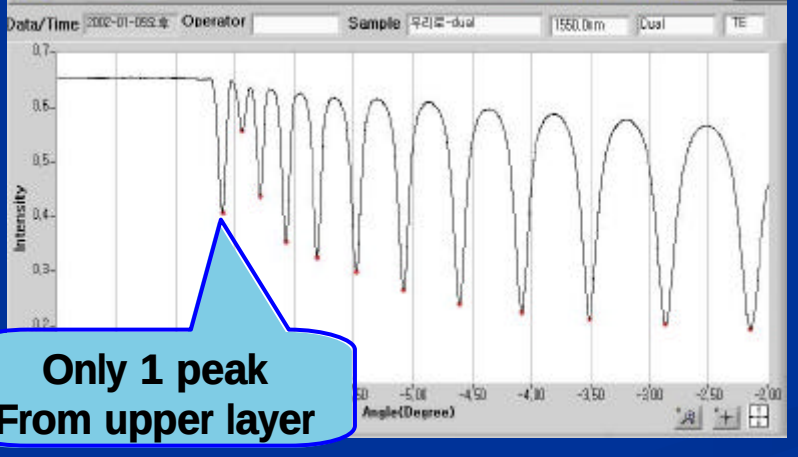
	SPA-4000
Software	Calculation software for Thermo optic coefficient. Built in designed Thermo optic coefficient measuring module.
Prism temperature accuracy	± 0.5? (~ 100?) ± 1? (~ 150?)
Sample temperature accuracy	± 1? (~ 100?) ± 2? (~ 150?)
Stabilization Time	~ 5min/10? (30? ~100?) ~ 7 min/10? (100? ~ 150?) (Stabilization time depend on Sample condition)
Temperature measuring range	30 ? ~ 150 ?

E. 4. Dual Layer Calculation

? Dual Layer Calculation

SPA-4000

- Be calculated only 1 peak case from upper layer
- No requirement information on lower layer



It is useful in the case that the difference of refractive index between upper and lower layer is small

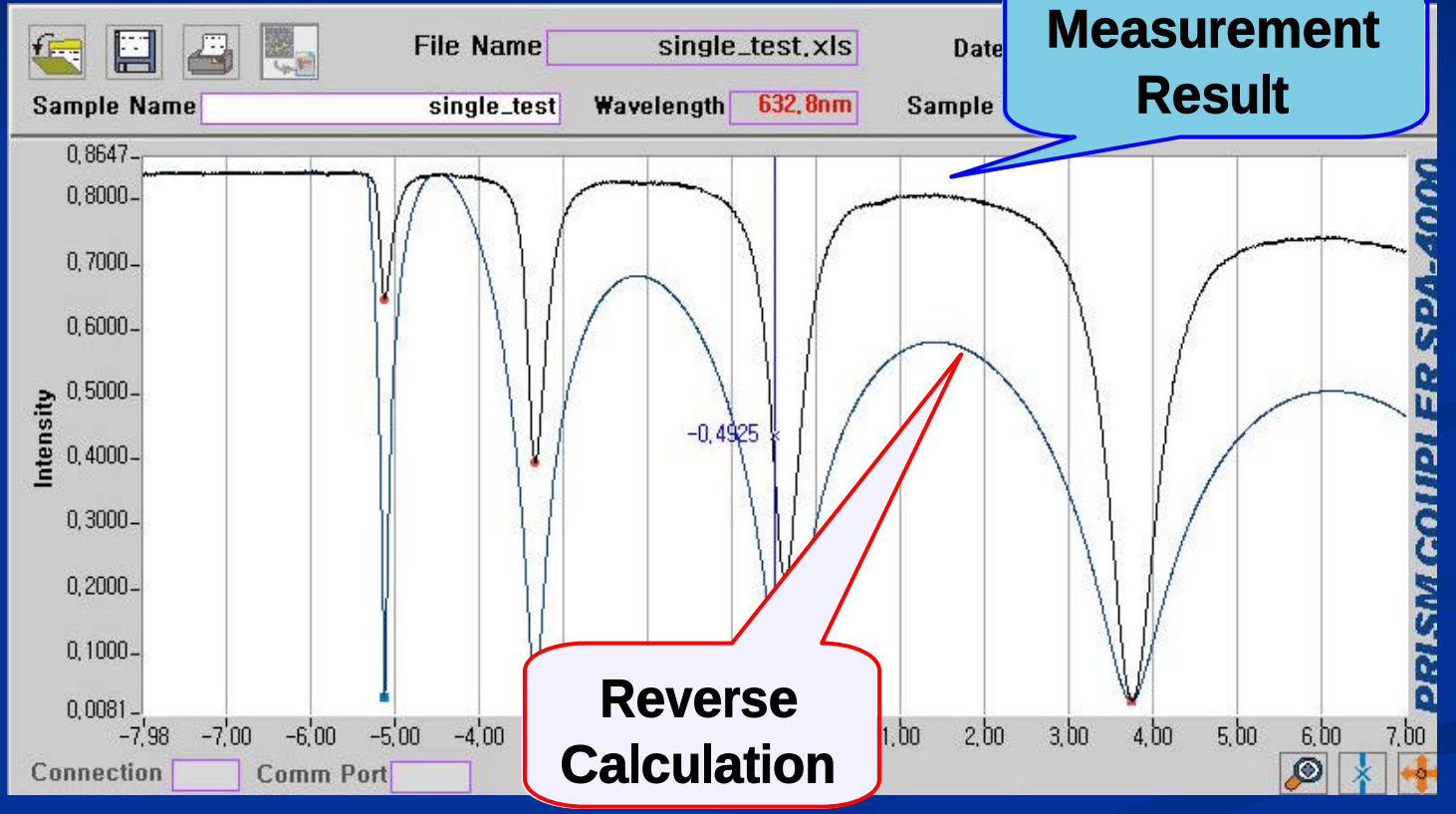
? Sample Info : dual film

upper layer ~ 6 ? , n=1.447 SiO2

low layer ~18 ? , n=1.443 SiO2

wavelength measured : 1550nm

E. 5. Reverse Calculation



F. APPLICATION & EXPORT PERFORMANCE

1. Application Fields
2. Export Performance

F. 1. Application Fields (1)

Film Types		Substrate Types
Silicon Nitride		Silicon
Silicon Dioxide	Silicon Oxynitride	GaAs
Low-k films	Polymers	Quartz
Polyimides	ITO	Glass
Zinc Sulfide	Titanium Dioxide	Sapphire
Sapphire	Epi Garnet	GGG
Photoresists	Holographic Gels	Lithium Niobate

F. 1. Application Fields (2)

Optical components for optical communication systems

polymeric optical waveguide components

- -Optical Switches
- -Variable Optical Attenuators(VOA) for WDM(Wavelength Division Multiplexing)
- -Low optical propagation loss

Controllability of refractive index and birefringence

Plastic Optical Fiber (POF)

Plastic Optical Fiber Amplifier(POFA) for Optical Communication

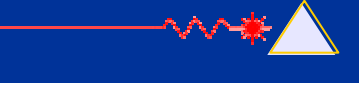
- -High Temperature Polymers for Waveguides

Properties of polymer

- -Investigation of chromic properties of polymer
- -Information display and processing
- -Storage Materials

Nano devices : MEMs, Micro-electronics

Temperature dependence



F. 2. Export Performance