

*HR Coating, AR coating and Dual-
Wavelength-ready coating*

Hiro Yamamoto

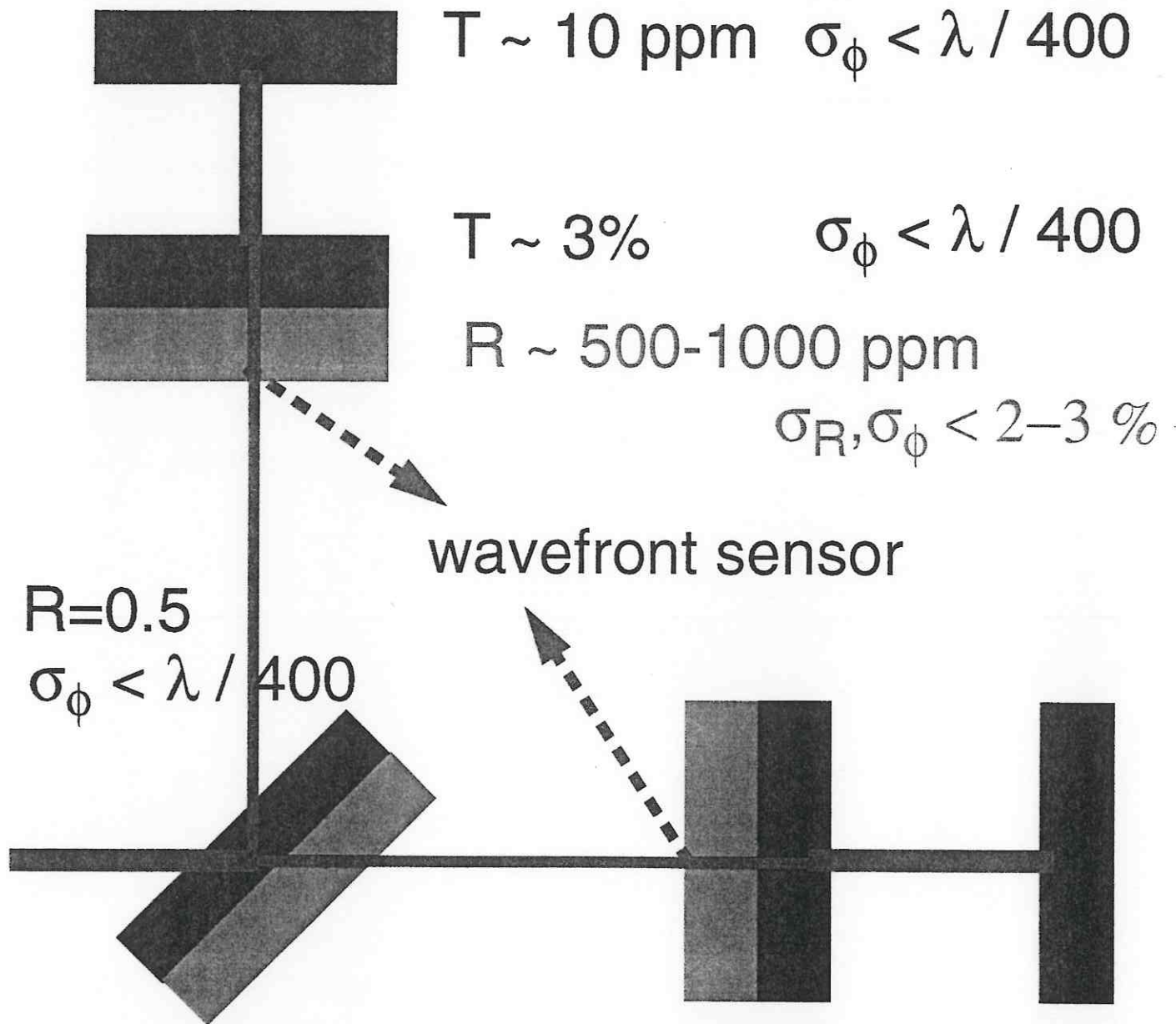
LIGO-G950043

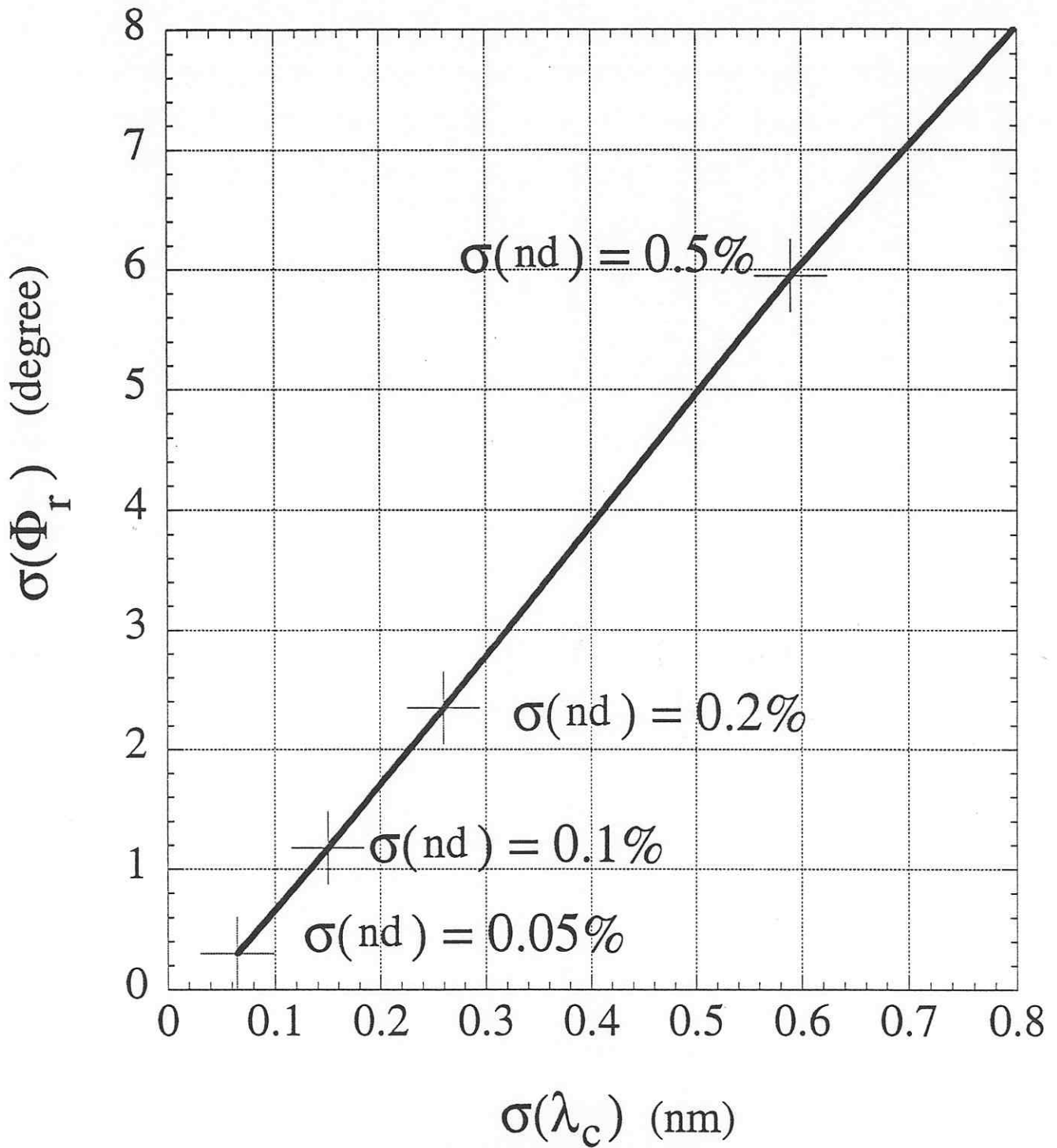
HR coating, AR coating and Dual-Wavelength-ready coating

Hiro Yamamoto, May 26, 1995

- HR coating
 - ›› $\sigma_d(\text{layer thickness}) < 0.1 \%$ to meet $\lambda/400$
- AR coating
 - ›› $\sigma_d < 0.1 \%$ to meet $\Delta R/R < 2\%$
- Dual-Wavelength-ready coating
 - ›› For most of the mirrors, the coating can be designed to satisfy requirements for R , ΔR and $\Delta\phi$
 - ›› Effect of electric field on the coating surface should be examined
- To be done
 - ›› Mode cleaner
 - ›› Accumulation of phase shift fluctuations
 - ›› Recalculation for updated coating conditions
 - ›› Identification of mirrors to be re-coating for Nd:YAG

HR, AR and DWR coating - overview of requirements -



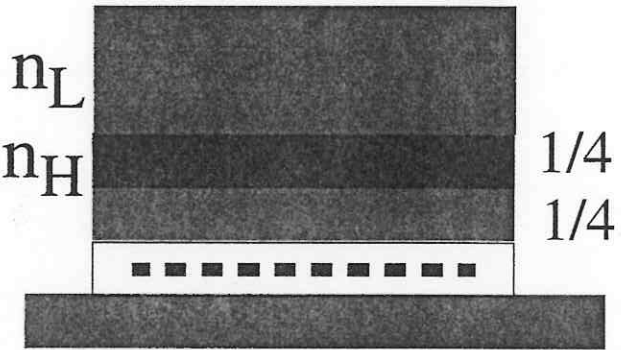
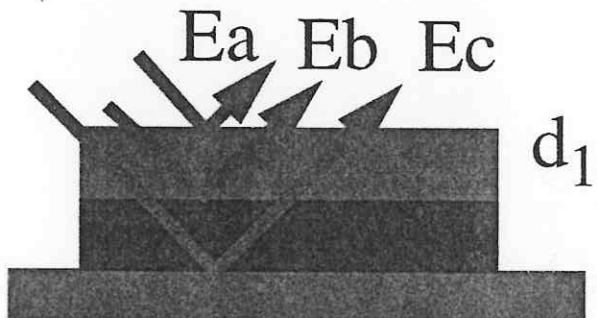
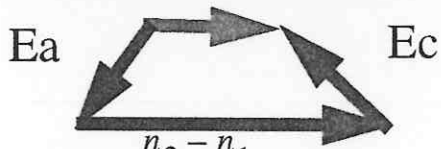


del(nd) (%)	sig(lamC) (nm)	sig(Phi r) (deg)
1.00	1.180	11.80
0.50	0.590	5.950
0.20	0.260	2.350
0.10	0.150	1.180
0.05	0.065	0.305

HR, AR and DWR coating

- HR/AR coating and errors -

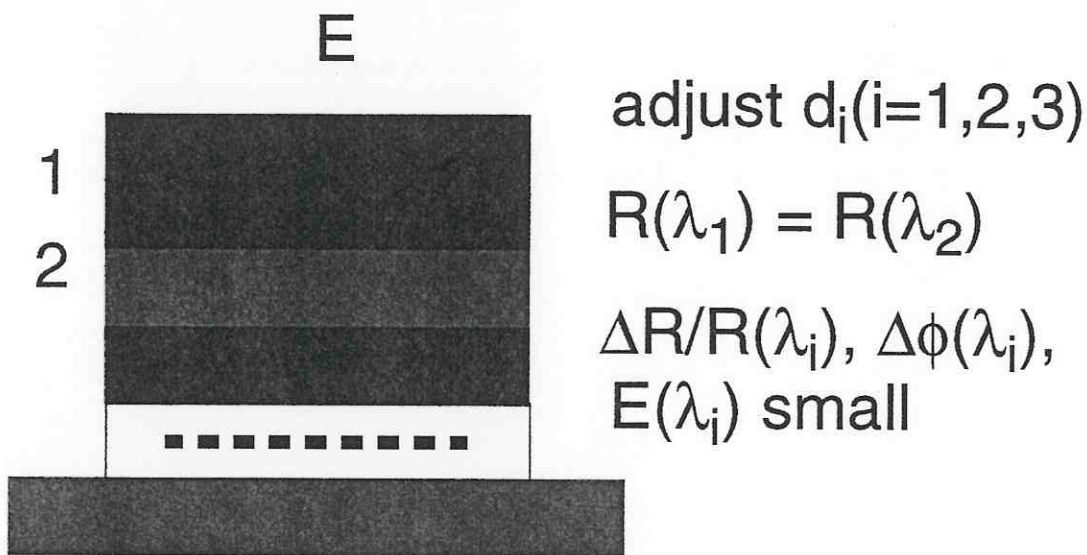
HR and AR coatings

High Reflectance	Anti Reflectance
	
$T = A \cdot \left(\frac{n_L}{n_H} \right)^{n_{Layers}} \ll 1$	 $E_b = \frac{n_2 - n_1}{n_2 + n_1} \exp(i\alpha d_1)$
$R = 1 - T = 1 - \epsilon(1 + a \cdot \delta^2)$ $\epsilon \ll 1, a \sim 100, \delta = \frac{\Delta\lambda}{\lambda} \text{ or } \frac{\Delta d}{d}$	$R = \epsilon + a \cdot \delta^2$ $\epsilon = 10 \text{ ppm}, a \sim 10$
$\Delta\phi \sim \sum \delta d$ <p>physical path length ~ num layers</p>	$\frac{a \cdot \delta^2}{R} \sim 10 \text{ ppm}$ $\delta \sim 0.1\%$

HR, AR and DWR coating - Single vs Double -

- Dual-Wavelength support for HR / AR coating

>>



- HR Coating

>> Single vs Dual

- AR Coating

>> Best (smallest R) vs Optimal (small $\Delta R, \Delta\phi$)

>> Single wavelength with small enough fluctuation

>> Dual wavelength support - 90, 45-S polarization

1. HR Coating

Table 2: End mirror

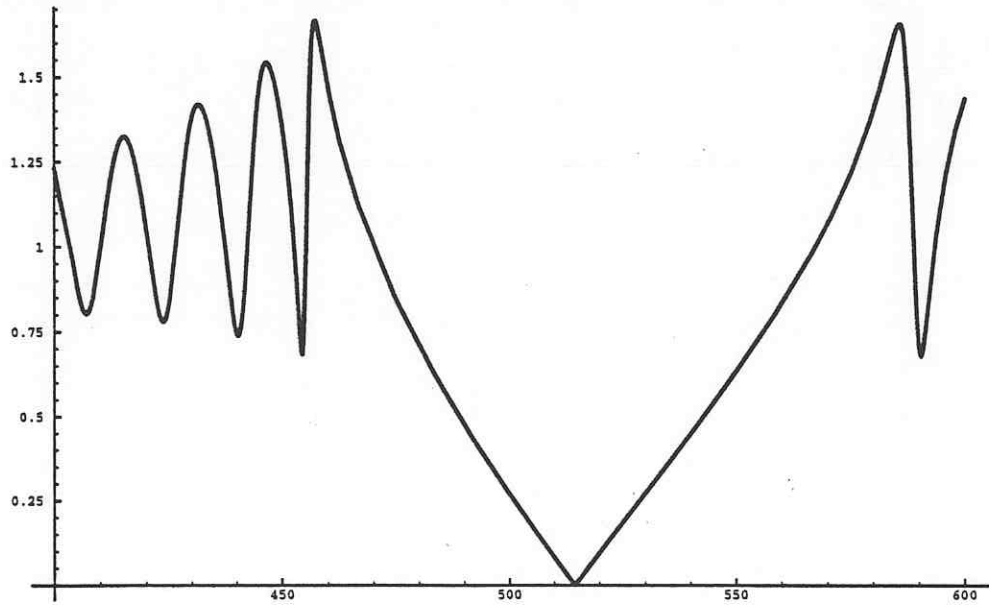
	Ar	Ar	NdYAG
thickness	2-1-1-...-1 (34 layers)		
T	1.16×10^{-5}	1.3×10^{-5}	1.4×10^{-5}
Error	Error of ϕ_r are almost identical		
E	0	0.15	0.16

Table 3: Front mirror

	Ar	Ar	NdYAG
thickness	2.67-0.23-1-... 14 layers	2.62-0.29-1-... 14 layers	
T	2.999%	2.83 %	3.15 %
Error	Error of ϕ_r are almost identical		
E	0.015	0.23	0.18

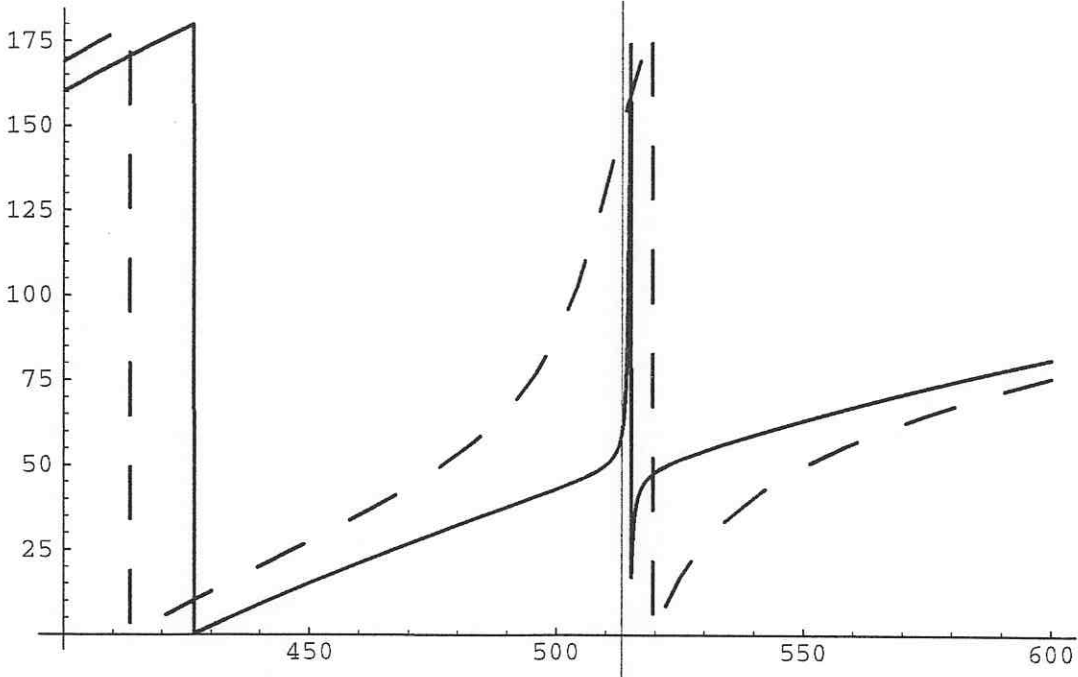
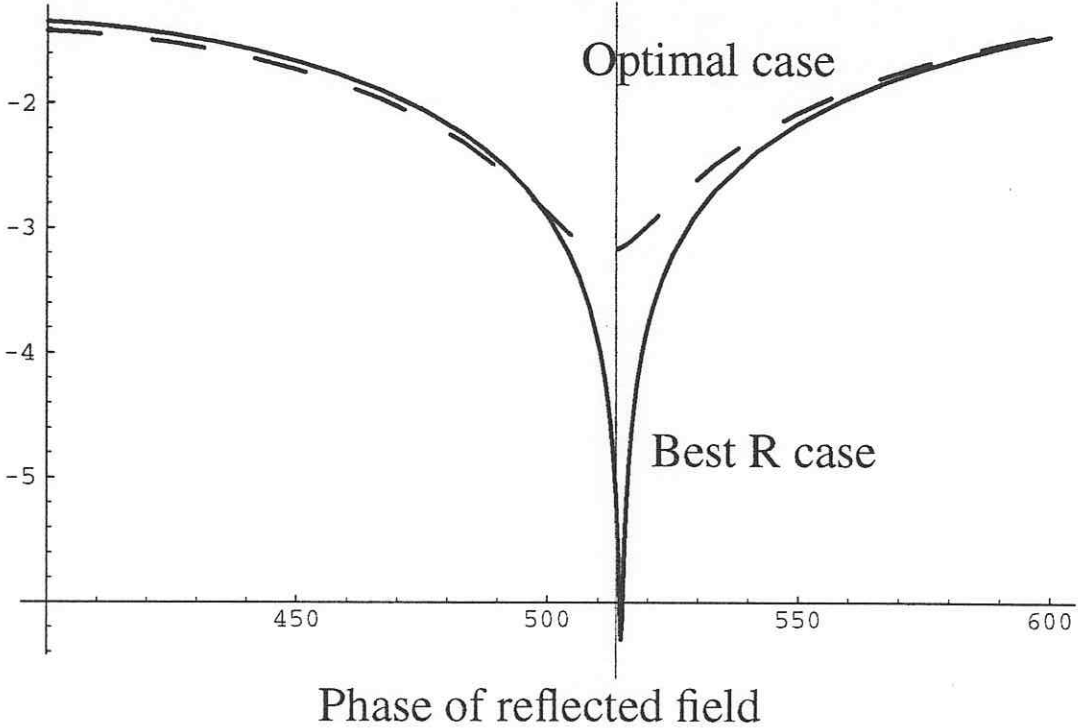
Table 4: Beam splitter - S pol

	Ar	Ar	NdYAG
thickness	2-1.5-0.3-1	2-1.6-0.3-1 (4 layers)	
T	0.5	0.5	0.5
Error	Error of $\Delta R/R$ (10^{-4} for 0.1%) and ϕ_r (0.23 °for 0.1%) are almost identical		
E	0.29	0.33	0.29

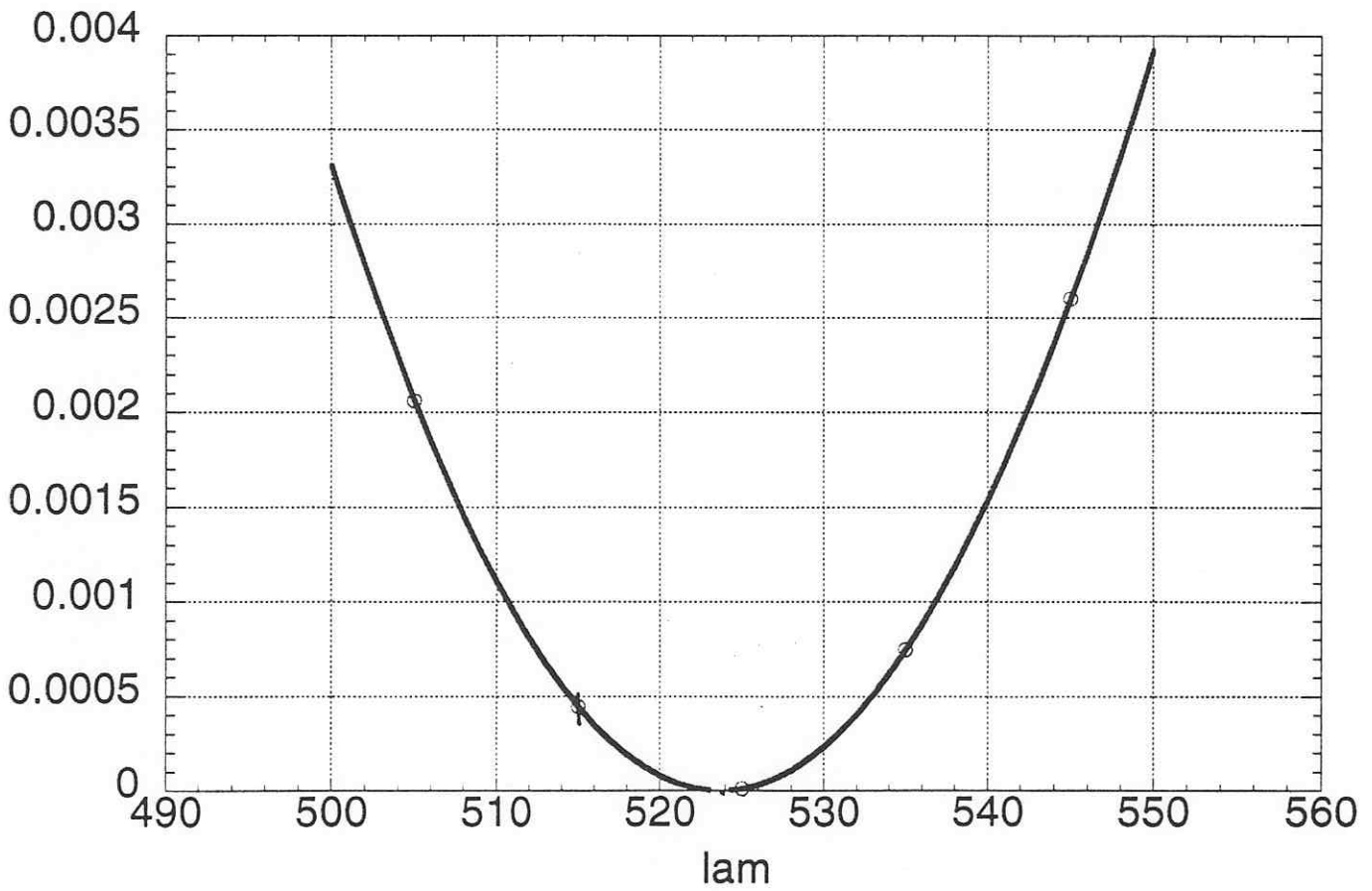
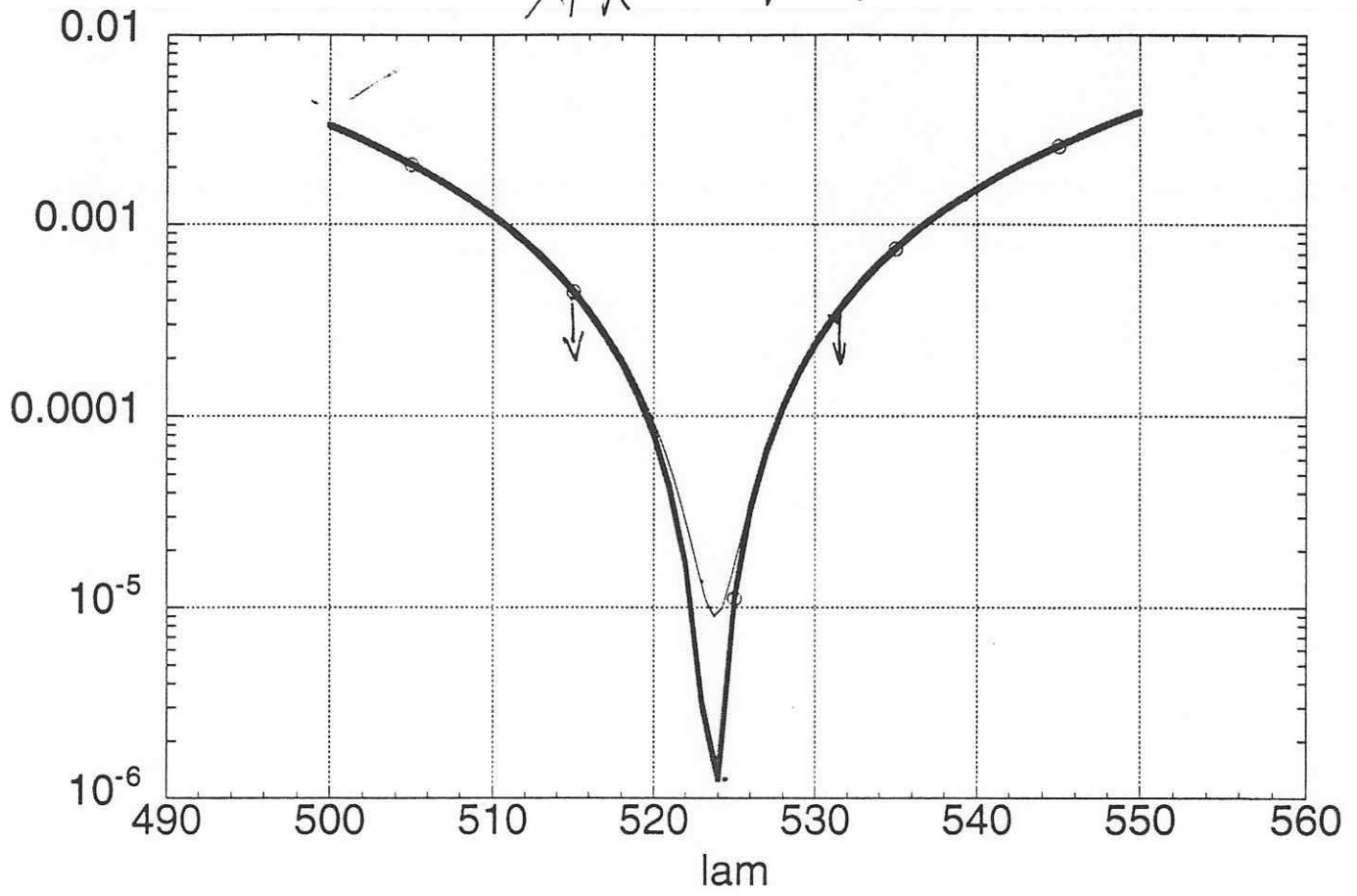


2. AR Coating

Reflectance and phase of 2 layer coating
 $\text{Log}_{10}[R]$

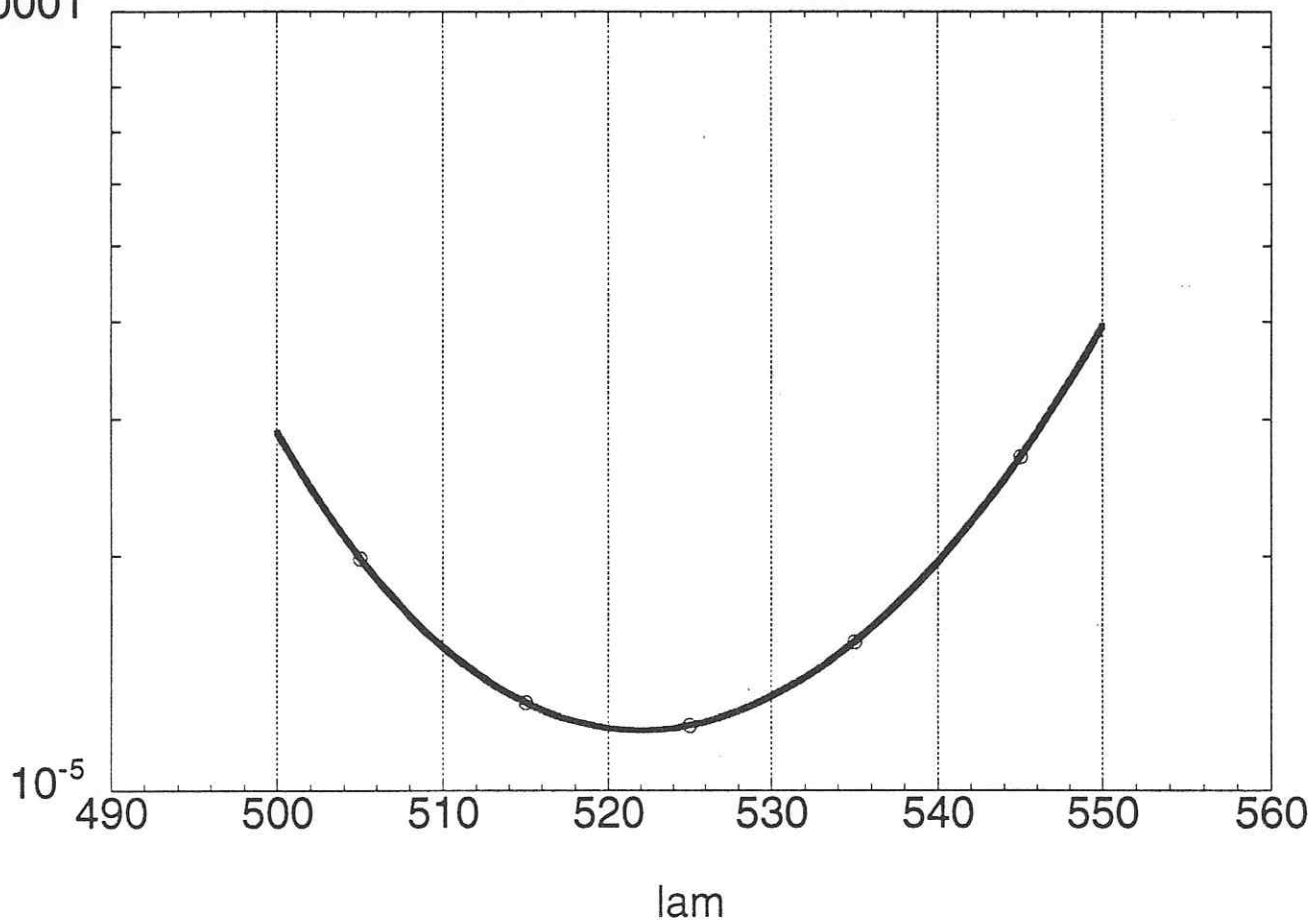


AR Ref'

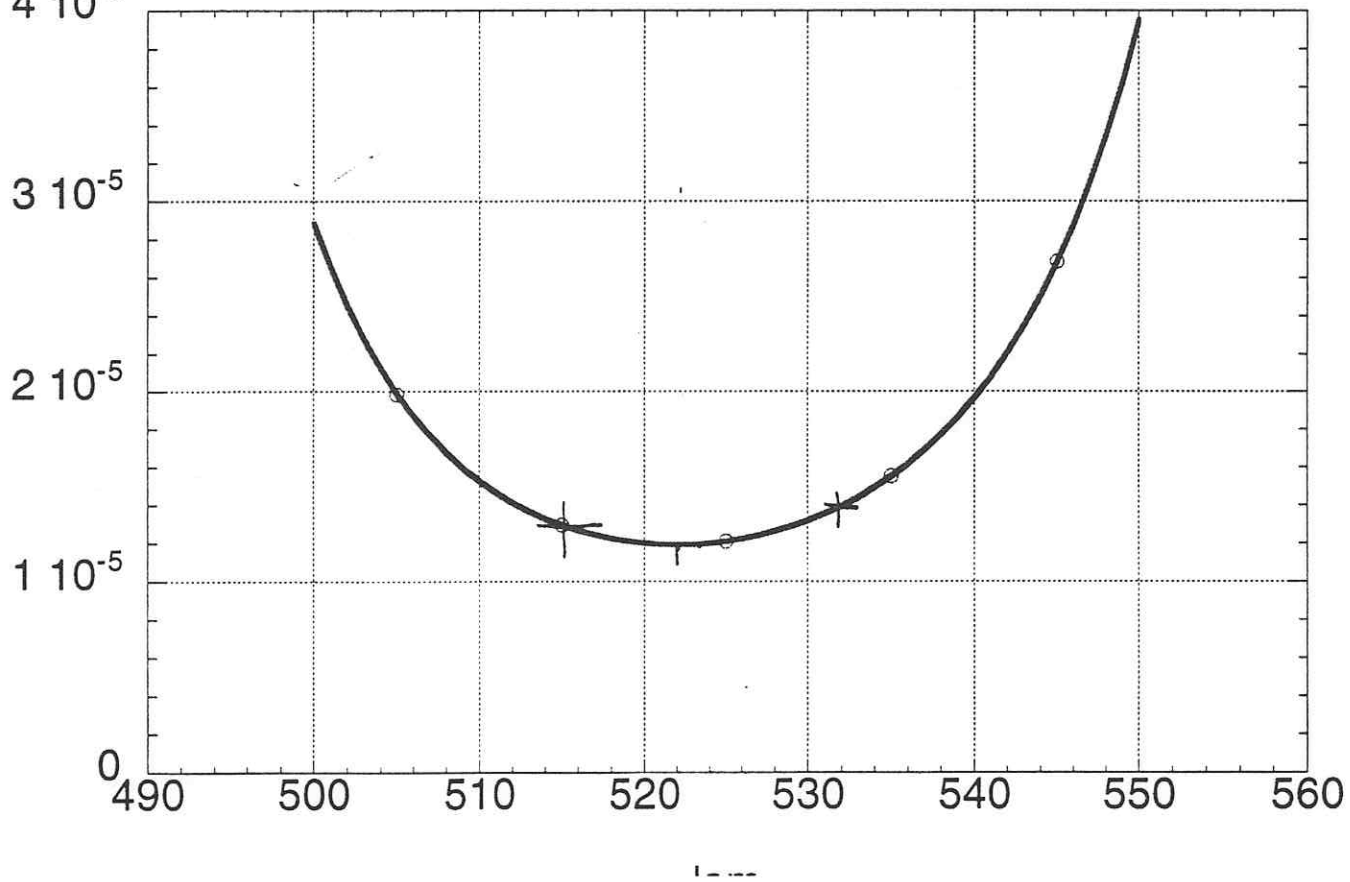


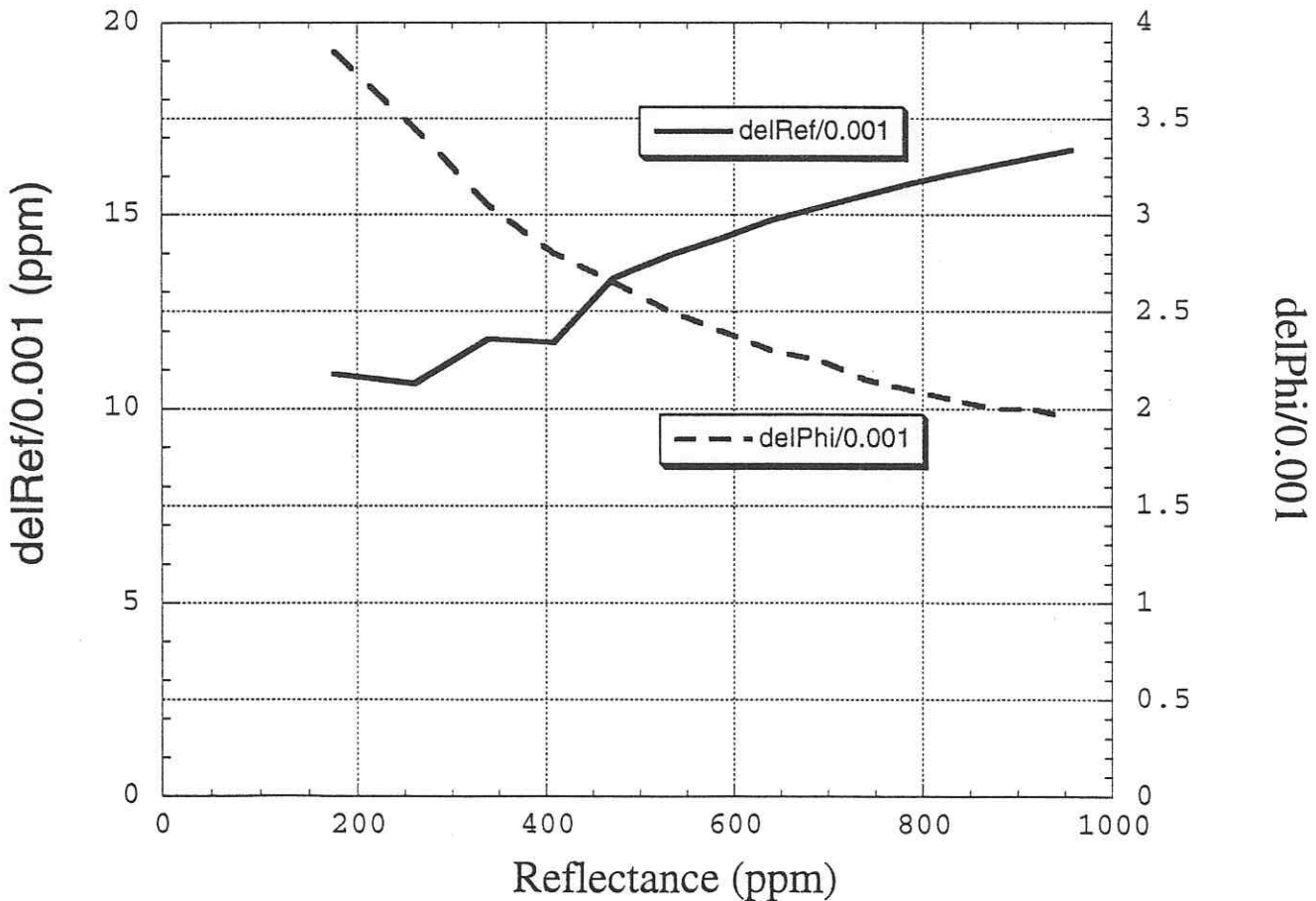
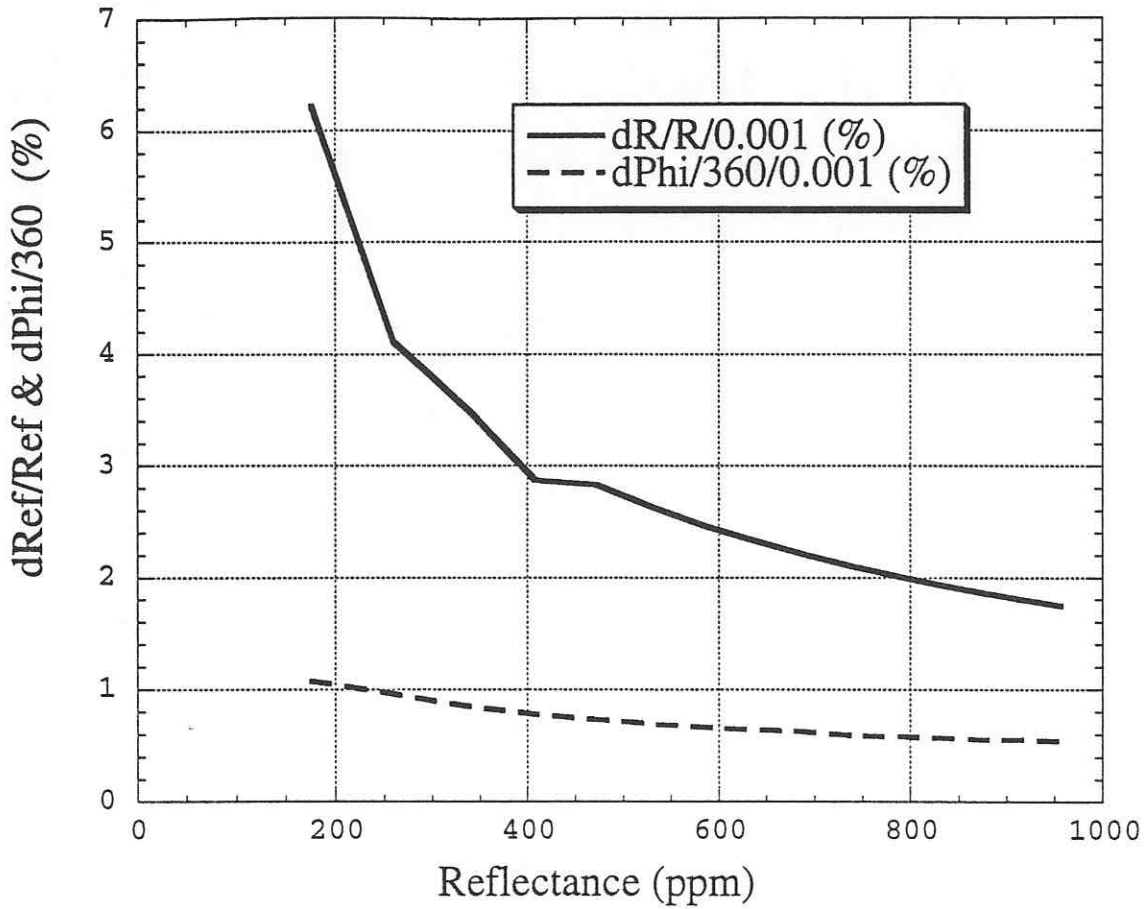
HR Trans

0.0001

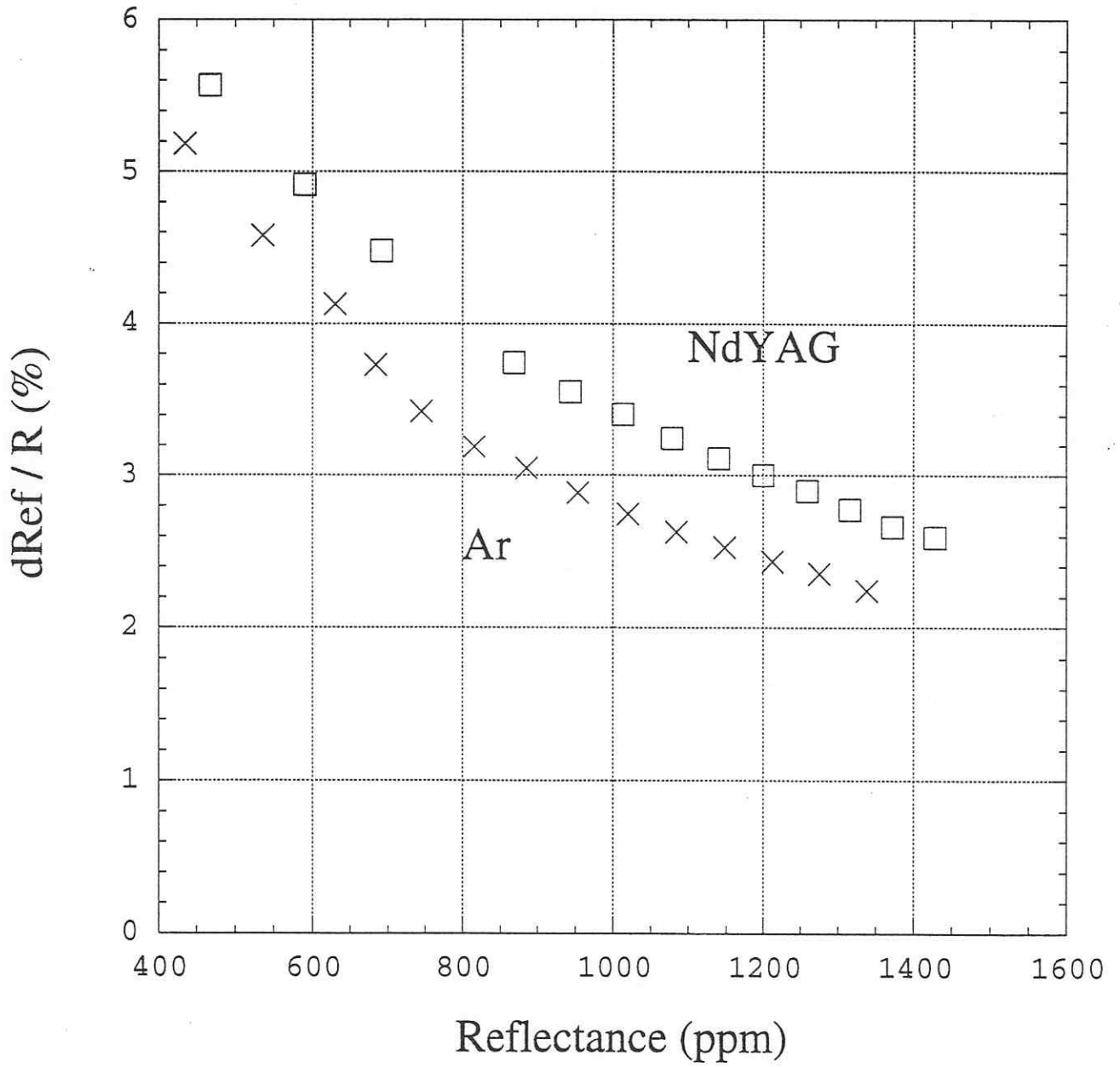


4×10^{-5}



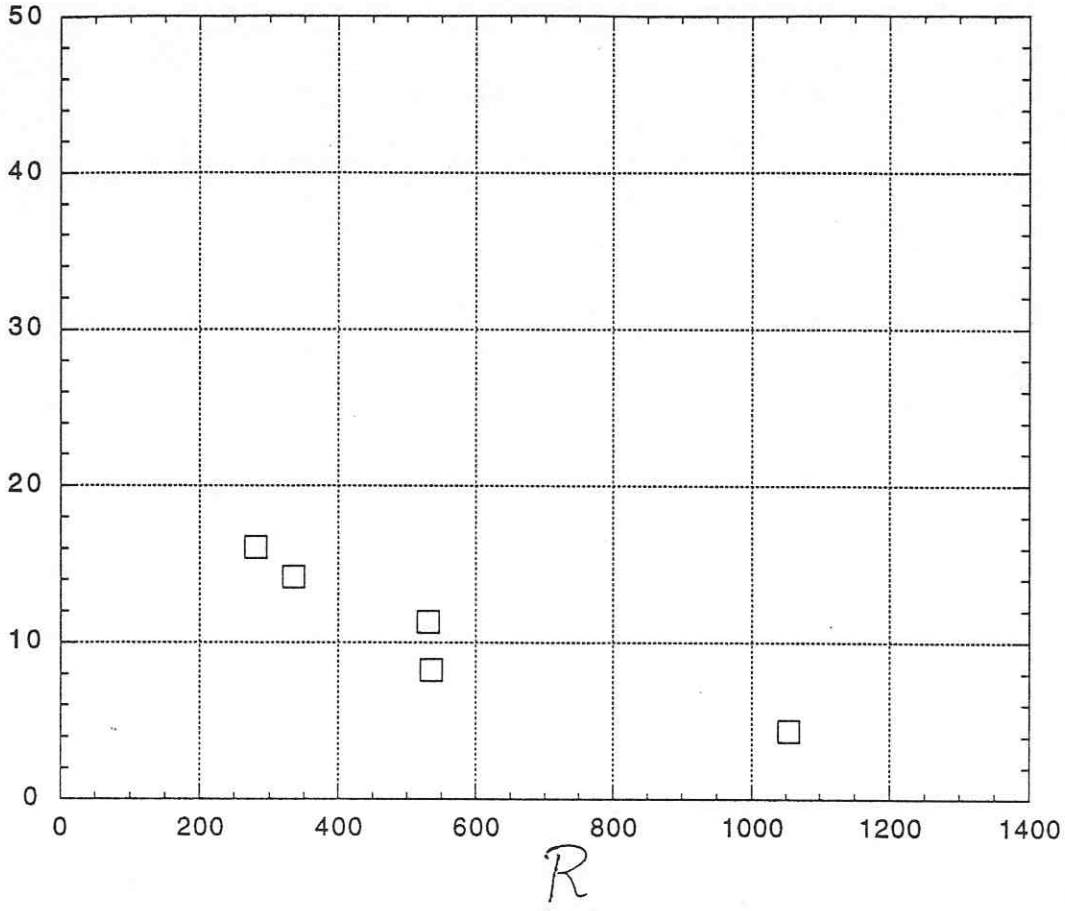


Result of tuning for dual-purpose

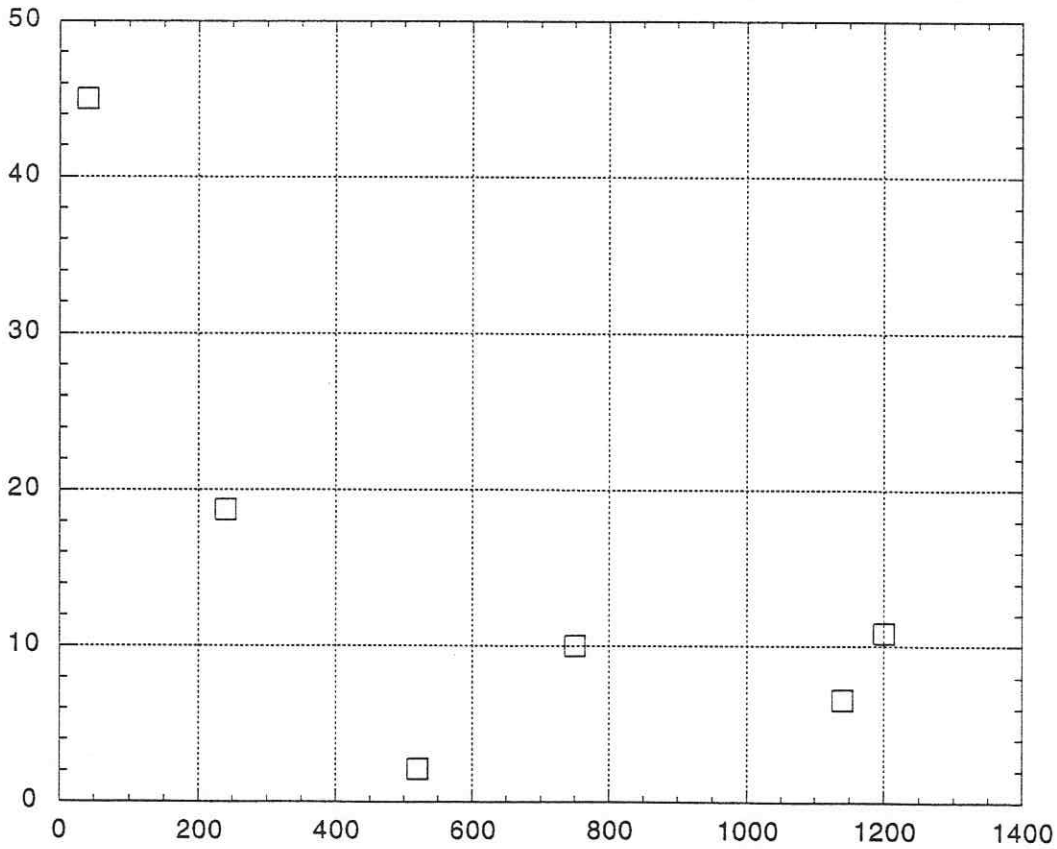


AK 2

3 layer



4 layer



$\Delta R/R$ (%)

Not optimized
to reduce error

Dual purpose coating
S-pol
45-0

AVS Fifo

Help | File | View | Edit

Status (press to disable)

Top Level Stack

- Fifo
- combine scalars
- combine scalars
- abstract scalar
- abstract scalar
- abstract scalar
- AVSGraph
- AVSGraph

Ref1 0.0000
 Ref2 0.0000
 Loss 0.0001
 ModFreq 12.0000

CarrierOffset 0
 Length 10000
 dLength120W 0
 MirOscAmp 0-100
 ExtModInd 0.1
 defModPhase 0

StartFreq
 StopFreq 70000
 numPoints 240

AVS Network Editor AVS Module Library

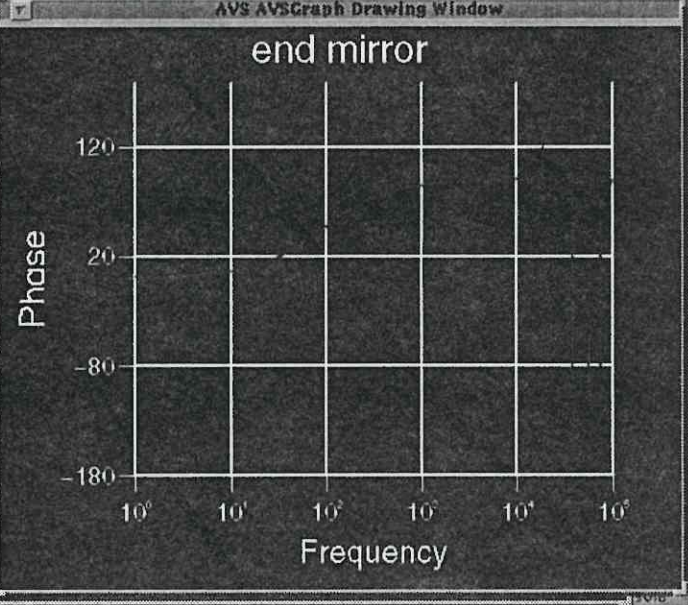
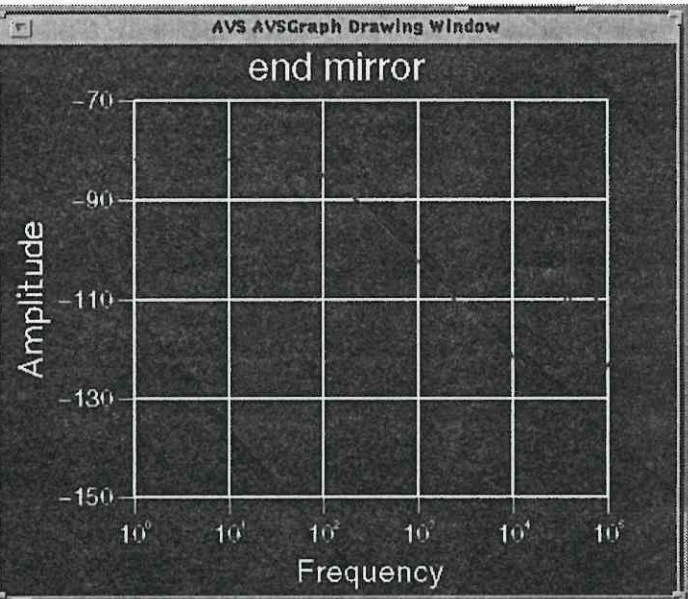
Help | Close

Data input Filter

- Network Tools
- Module Tools
- Editing Tools
- Layout Editor

Load Network
 Write Network
 Clear Network
 Print Network
 Double Plot Executive
 Save Parameters
 Restore Parameters

Fifo



AVS coating

Help Data Viewers Exit

Status (press to disable)

Top Level Stack

- coating
- extract scalar
- AVSGraph
- combine scalars
- AVSGraph
- extract scalar
- combine scalars

num layers 54

cap thickness 2

num steps 1000

lambda 1900

781.825

AVS Network Editor

File Edit Help

AVS Module Library

Network Tools

- Module Tools
- Editing Tools
- Layout Editor
- Build Network
- Write Networks
- Clear Network
- Print Network
- Disable View Executive
- Save Parameters
- Restore Parameters

AVS Module Library

Data Input

- calc temp coeffs
- character styles
- clip genes
- coating
- color range
- create genes
- data dictionary
- dialog box

Filters

- namefile
- netfiles
- average
- blend col
- clamp
- colorize
- selectrow
- combine

coating

extract scalar

combine scalars

AVSGraph

