



AR-coating with layers

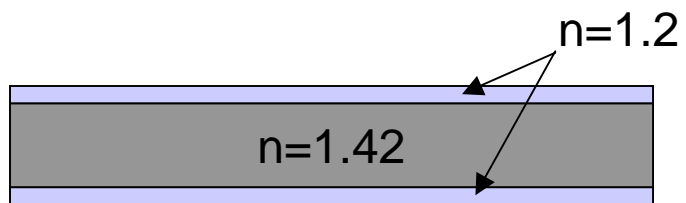
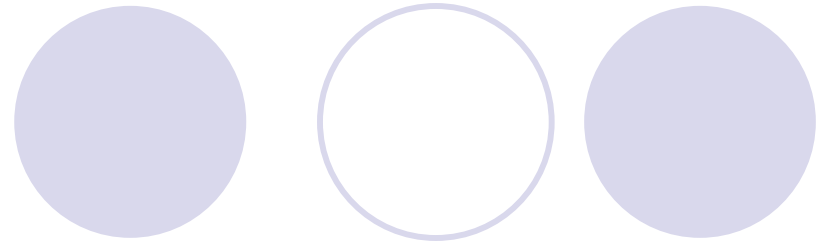
Chao-Lin Kuo

With contribution from J. Lau,

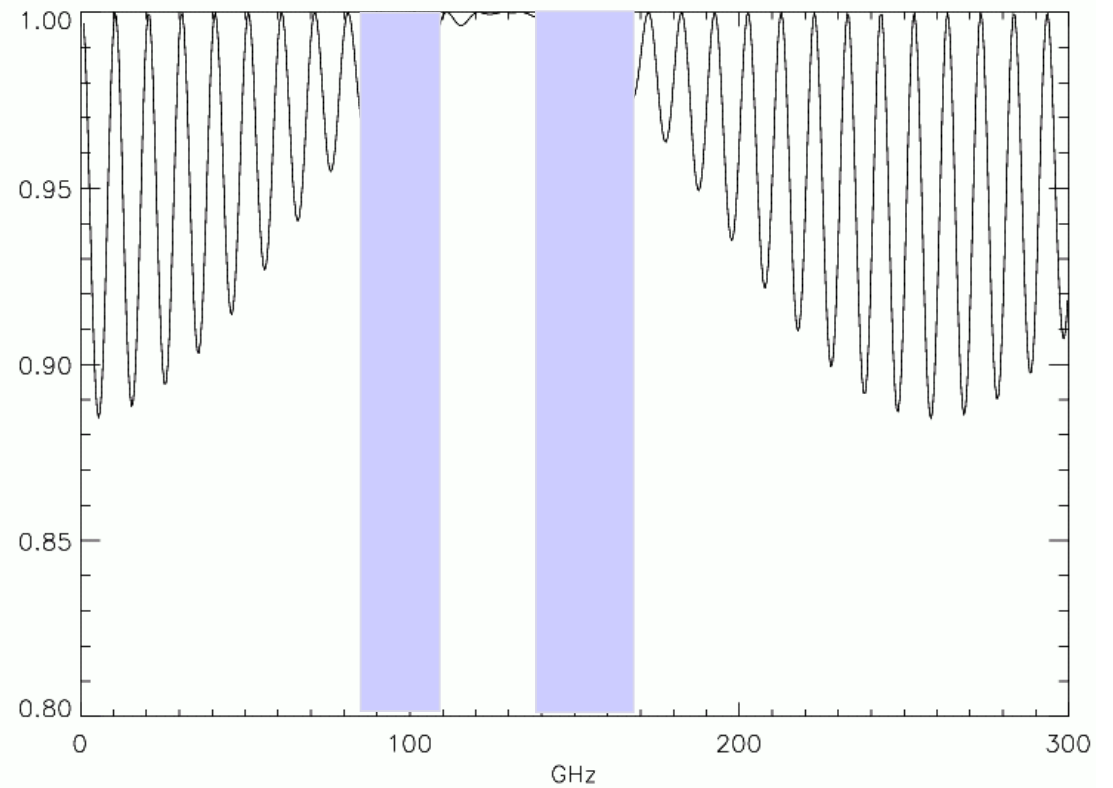
E. Quealy

CMBPOL Technology Workshop
Aug 27, 2008

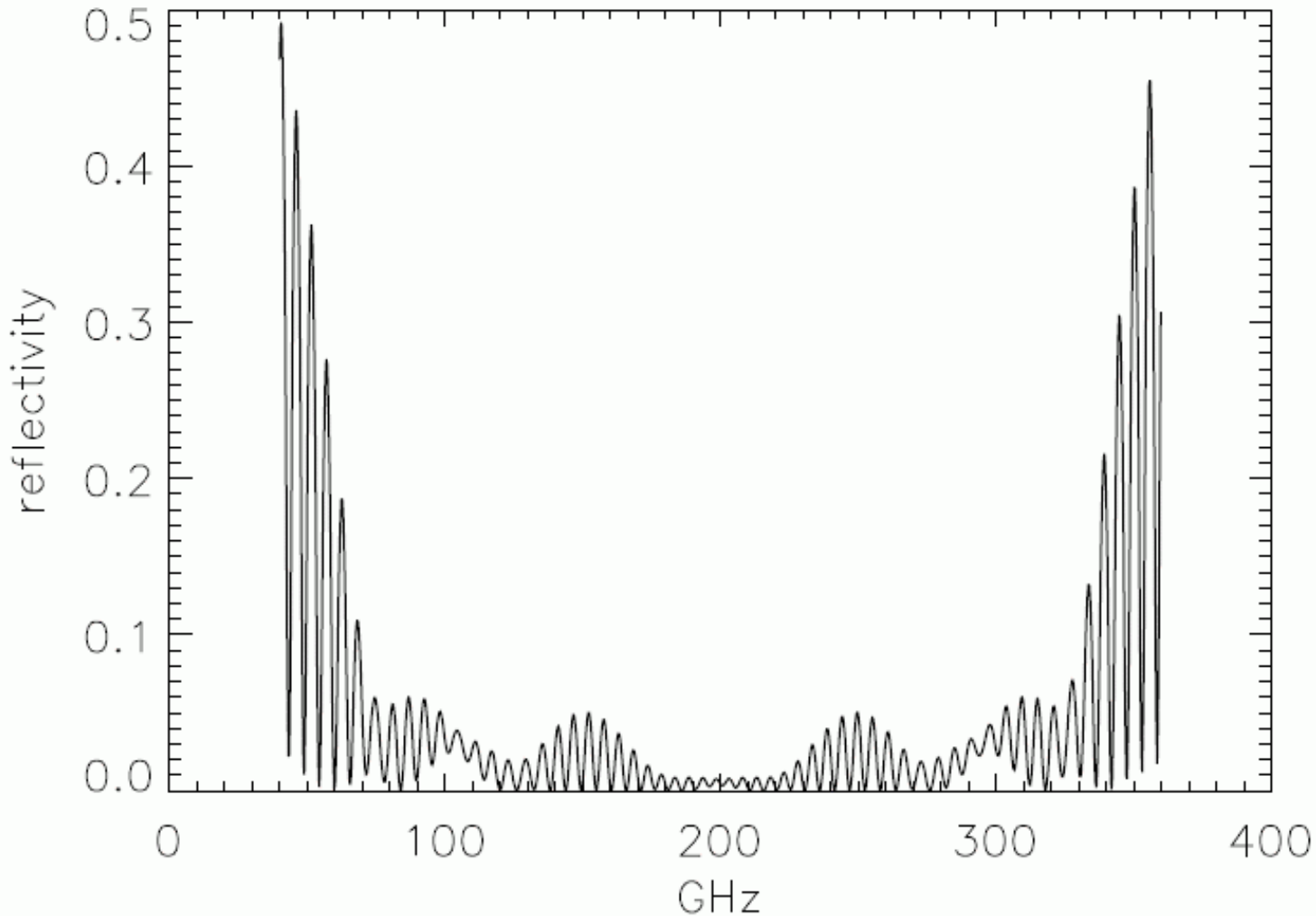
AR coating



Transmittance (modeled)



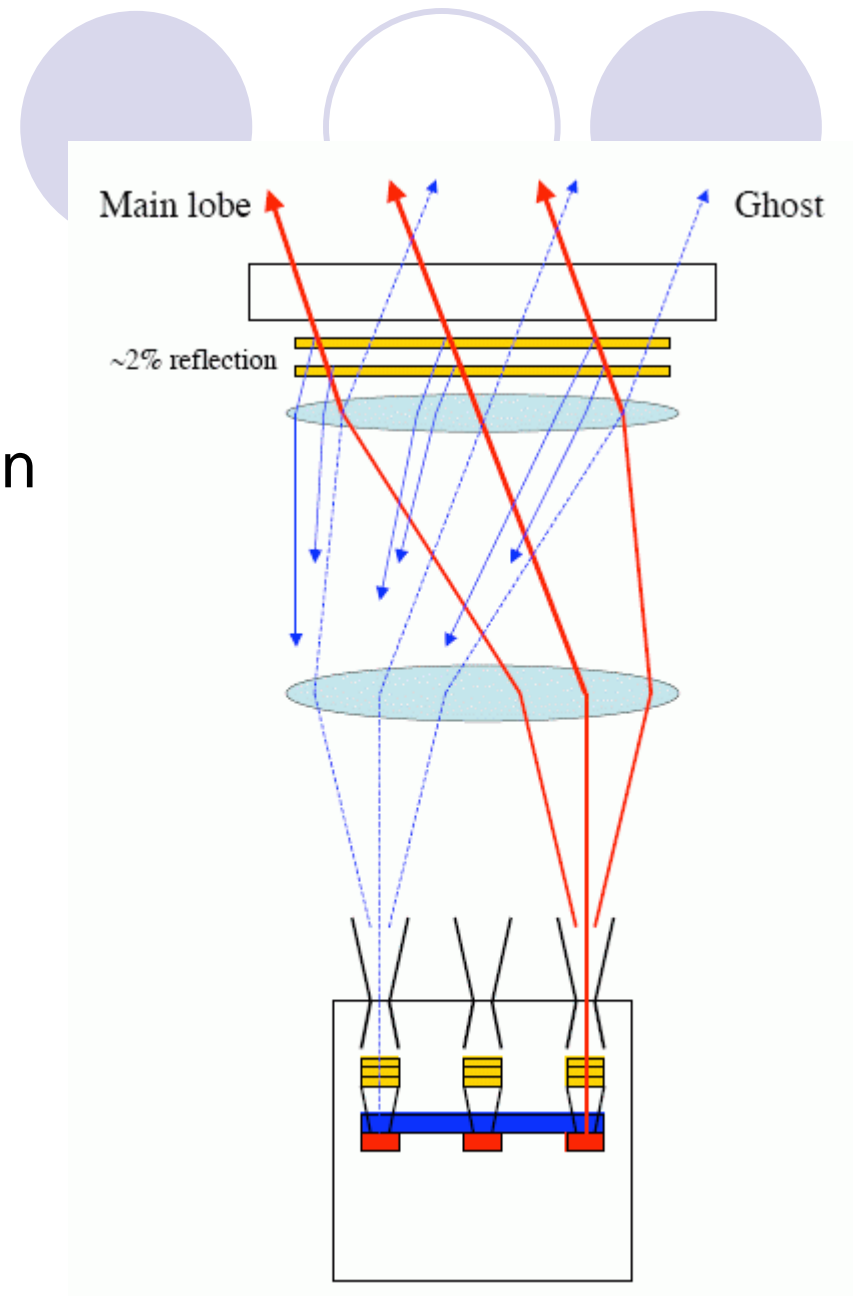
5-layer double-side AR coating for Si (modeled)



Reflection

- Ghost images (systematic uncertainties)
- Reflections reduce sensitivity in the Poisson-noise regime
- Reduction of O.E./sensitivity
- Reflections will also reduce sensitivity *in the Bose-noise regime:*

$$\frac{(S/N)_{new}}{(S/N)} = \frac{\frac{\int \eta_\nu Q_\nu d\nu}{\sqrt{\int \eta_\nu^2 Q_\nu^2 d\nu}}}{\frac{\int Q_\nu d\nu}{\sqrt{\int Q_\nu^2 d\nu}}} \leq 1$$



Potential dielectric materials for layer AR coating

Table 2. Dielectric properties of the materials for AR coating.¹

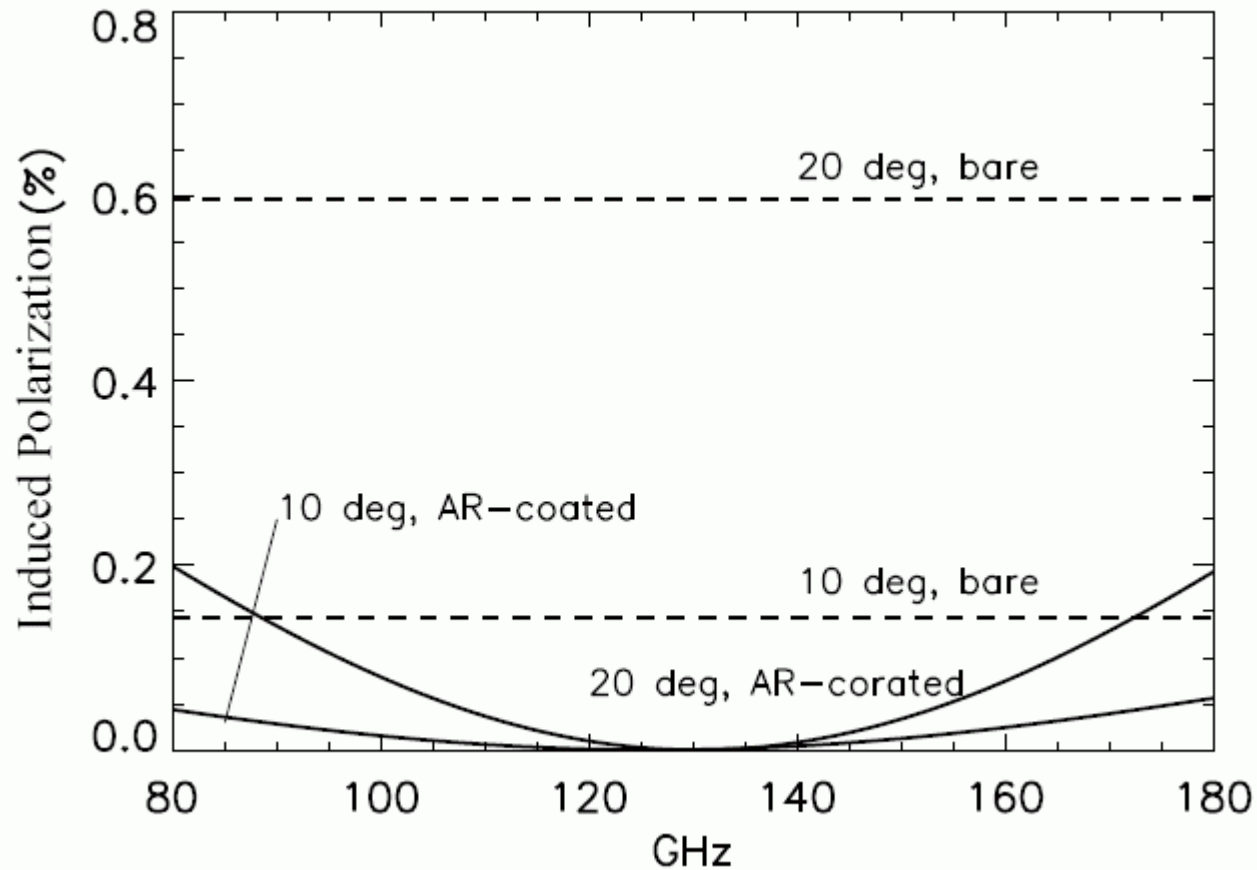
Material	Index n	$\tan \delta^2$
Silicon	3.42	2.2×10^{-4}
Sapphire	3.07/3.40	$2.3/1.2 \times 10^{-4}$
TMM 10i	3.13	
TMM 10	3.03	
TMM 6	2.55	
TMM 4	2.12	
TMM 3	1.81	
Quartz (Herasil)	1.87	0.001
Cirlex	1.84	0.008
Stycast 1266	1.68	0.023
HDPE	1.54	3×10^{-4}
PTFE	1.44	3×10^{-4}
Expanded PTFE ³	1.2	

¹ Data from [22, 23, 24]

² At or around 150 GHz.

³ Zitex, or Porex Mupor.

Polarization effects



Experiences from various groups

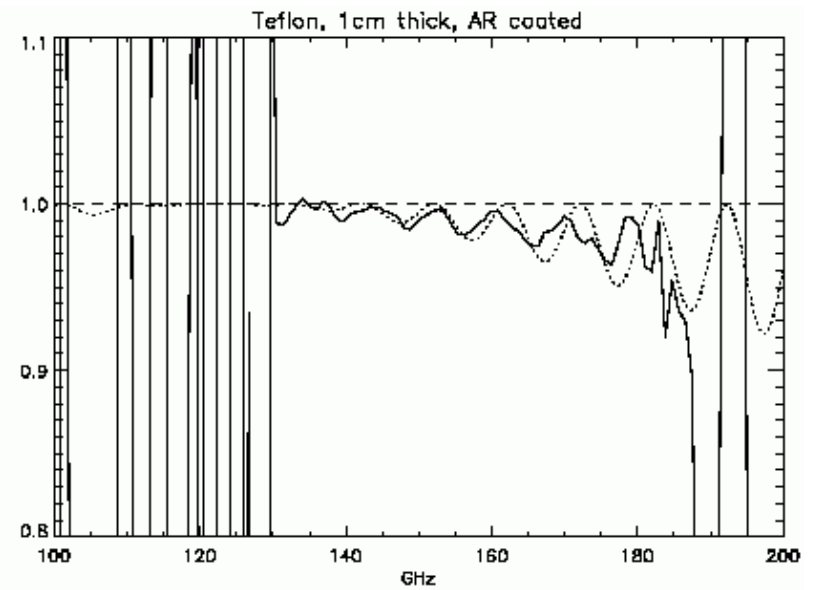
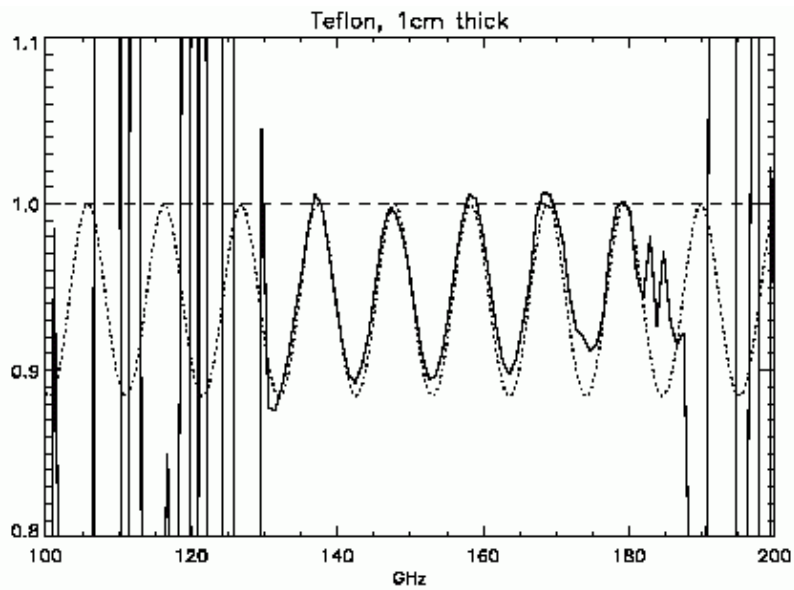
Group	substrate	AR layer	bonding	comment
BICEP/ QUAD/..	PTFE, HDPE	Expanded PTFE	Thermal bonding w/ LDPE	Curved surfaces (etched PTFE)
ACT	Silicon	Kapton/ Cirlex	Stycast 1266+ adhesion promoter	Curved surfaces
UC Berkeley	Silicon	TMM	glue (epoxy?)	Multiple layers (flat sample)
Manchester	Silicon/germa nium/sapphire	PE(?) + rutile Particles		



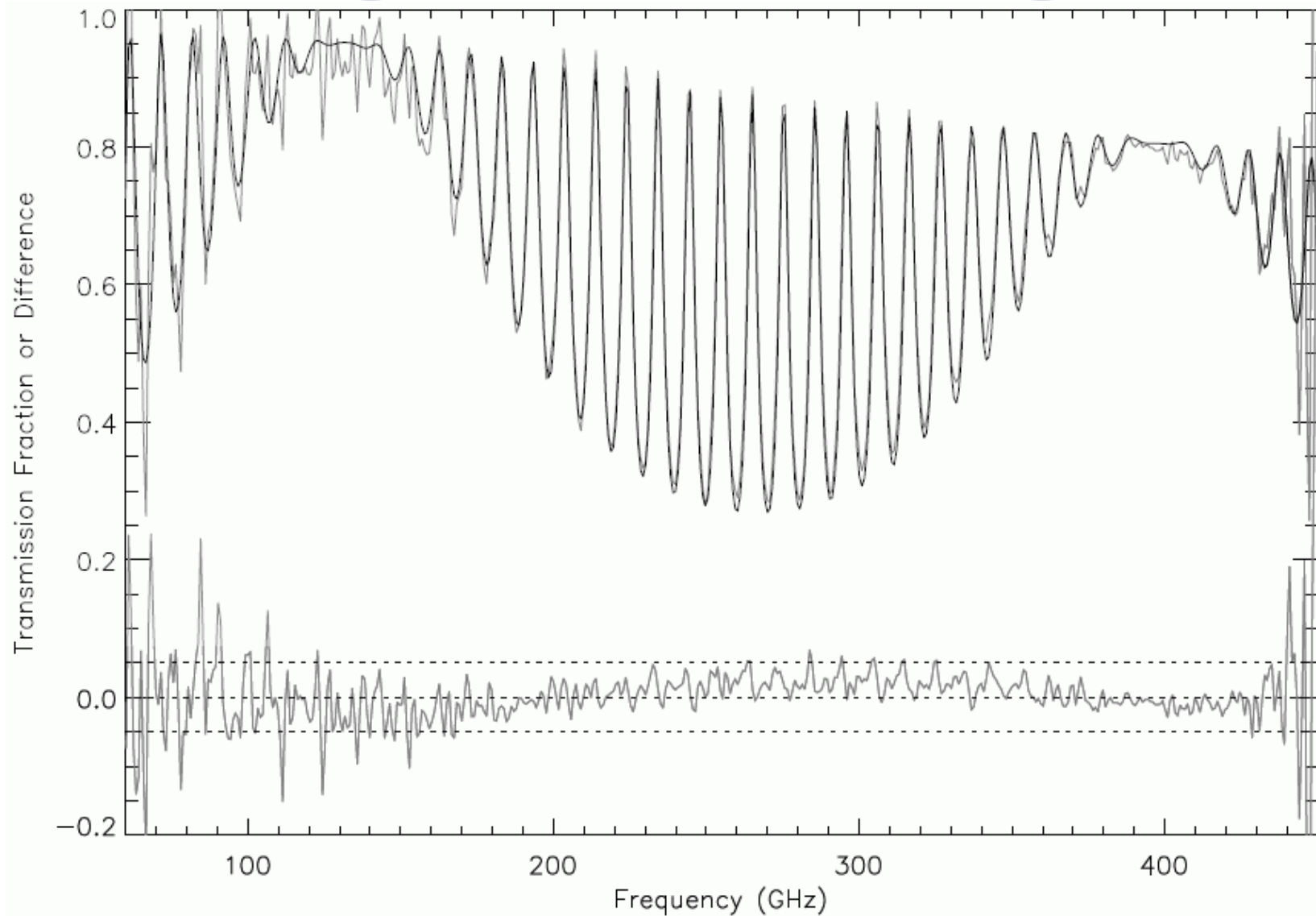
Testing

- FTS
- Difficulty: verify the performance of AR for a curved surface cryogenically

BICEP coating on PTFE filters



Coating for ACT lenses



UC Berkeley

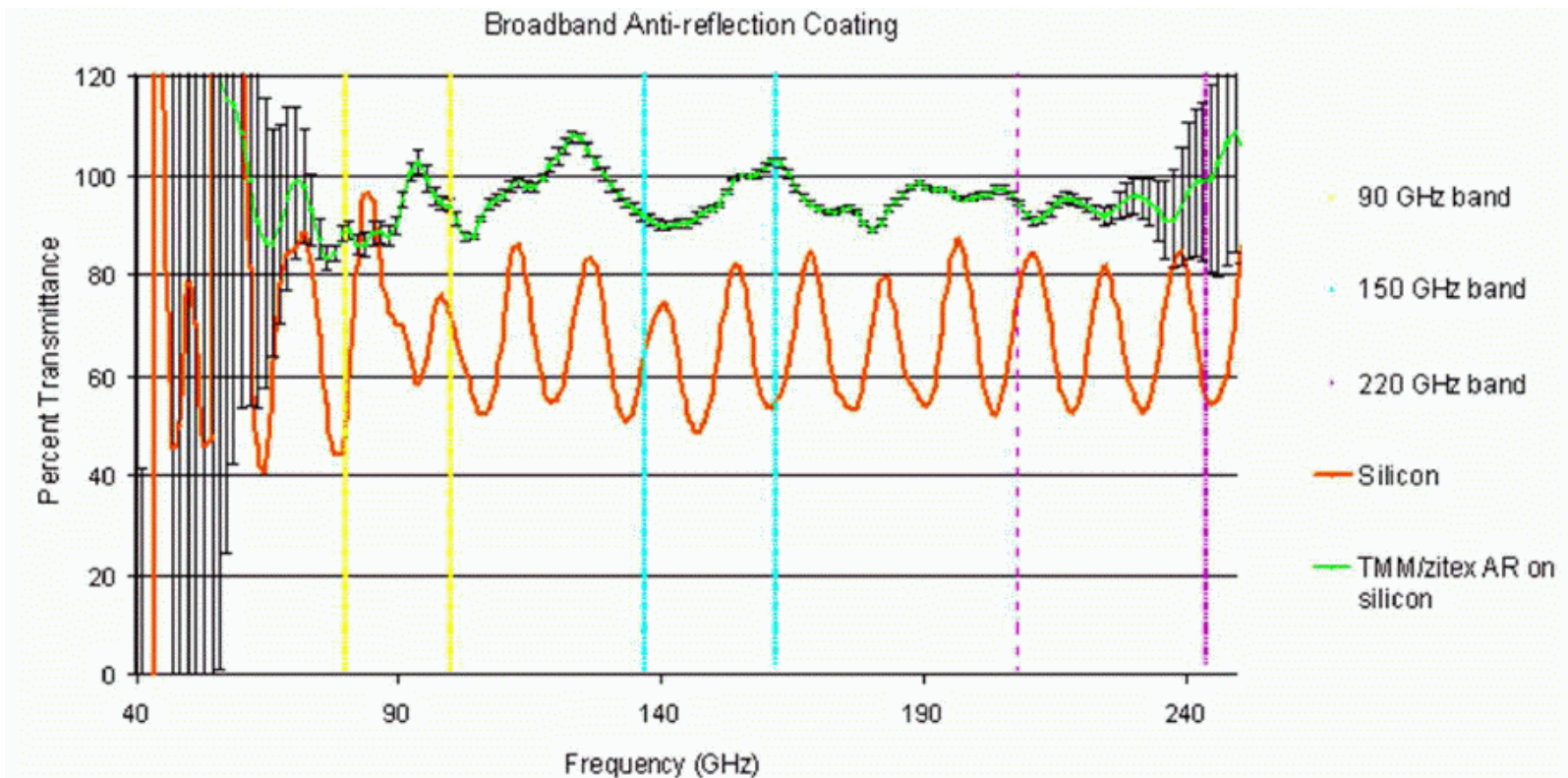


Figure 6. The transmittance spectra for a reference silicon sample and a AR-coated sample. The normalization of the measurement is affected by the optics, but the 4-layer coating significantly reduces the reflection fringes over the entire frequency range (E. Quealy).



Comments – for CMBPOL

- Cheap once a recipe is found:
 - Recipe= layer materials + a cold surviving bonding method
- Many layers (>5) per surface required for wide-band silicon coating (~40-350GHz)