Optical Material Qualification

OM-1

Show that for the Hilger-Chance refractometer the relationship between the refractive index n_1 of the sample and the refractive index n of the V-block is given by

$$n_1 = \left(n^2 - \text{Sin}[\theta]\ \left(n^2 - \text{Sin}[\theta]^2\right)^{1/2}\right)^{1/2}.$$

OM-2

Show that for the Pulfrich refractometer

$$n_1 = \text{Sin}[A]\ \sqrt{n^2 - \text{Sin}[I_2']^2}\ \text{-Cos[A]}\ \text{Sin}[I_2']$$

where n_1 is the refractive index of the sample, n is the refractive index of the instrument prism, A is the prism angle, and I_2' is the angle at which the limiting ray emerges from the second face of the instrument prism.

OM-3

Apart from taking precautions against thermal and like errors, if the prism angle and angle of deviation between incident and emerging rays of a prism spectrometer are measured to an accuracy of 1 arc-second, the refractive index n can be measured to an accuracy on the order of 1 part in the 5th decimal place.

(A) Determine if this statement is correct. What is the optimum range of prism angle?
(B) Which angle measurement is more critical, the prism angle or angle of deviation?

How does the answer depend upon prism angle? For all calculations assume the refractive index is approximately 1.5.

OM-4

The Abbe refractometer is used to measure the thickness and refractive index of a thin film coated on a substrate having a higher refractive index than the film. When the thin film is contacted to the measuring prism and light is transmitted up through the measuring prism, the light reflected off the two surfaces of the thin film is observed. Interference fringes are seen. The first two dark interference fringes are designated n_1 and n_2 respectively, where n_1 is the one with apparently higher index of refraction. Show that n_f, the index of the film, and d, the film thickness, are given by

$$n_f = \sqrt{\frac{\left(4\ n_1^2 - n_2^2\right)}{3}}, \quad \text{and} \quad d = \frac{\lambda}{2}\sqrt{\frac{3}{\left(n_1^2 - n_2^2\right)}}.$$

OM-5

If the index matching oil film in an Abbe refractometer has a 1 minute wedge, what is the effect upon the index measurement if the oil has an index of 1.62, the prism has an index of 1.65, and the sample being measured has an index of 1.5?

OM-6

An Abbe refractometer having a reference prism of refractive index 1.6 is used to measure the refractive index of a solid sample. During the measurement the maximum angle the light is from the normal in the reference prism is 76°.

a) Sketch the Abbe refractometer.

b) What is the refractive index of the solid sample being measured?

c) What is the minimum refractive index of the index matching fluid that can be used for this test.

OM-7

Give two factors which limit the maximum refractive index that can be measured using the Abbe refractometer.

OM-8

What influence will scratches on the reference prism of an Abbe refractometer have on the accuracy of the refractive index measurement? Other than re-polishing the surface, what can be done to minimize the effects of the scratches?

OM-9

An Abbe refractometer is used to measure the refractive index of a transparent solid sample. The reference prism in the instrument has a refractive index of 1.62. The index matching fluid has a refractive index of 1.58.

a) What is the maximum refractive index that can be measured?

b) If the refractive index of the sample being measured is 1.55, what is the maximum angle the light makes with respect to the normal of the reference prism inside the prism?

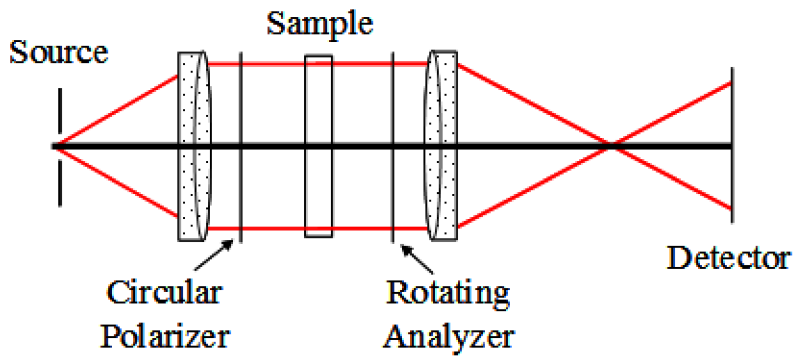
c) What is the major advantage of the Abbe refractometer to a spectrometer for measuring refractive index?

OM-10

Ellipsometry is used to measure the state of polarization of light reflected off a sample. What are the two properties of the state of polarization being measured?

OM-11

A source of wavelength 500 nm is used in the setup shown below to measure the birefringence of the sample.



In units of nm, what is the smallest amount of birefringence present in the sample if the irradiance at a detector point varies from I_{min} to I_{max} as the analyzer is rotated 360°, where I_{min} and I_{max} are

- **a)**

  $I_{min} = 1$ and $I_{max} = 1$;

- **b)**

  $I_{min} = 0$ and $I_{max} = 1$;

- **c)**

  What is the second smallest amount of birefringence such that $I_{min} = 1$ and $I_{max} = 1$?