TECHNICAL NOTE - 005-M

Group Index

What is it? Why is it important? How is it determined?

WHAT IS GROUP INDEX?

Group refractive index, commonly referred to as "Group Index," is a dimensionless number that defines how a broadband light source, such as the superluminescent light emitting diode (SLED) used by the Optical Thickness Gauge, travels through a particular material. Specifically, it is the ratio of the velocity of light in a vacuum to the group velocity of the entire bandwidth of the light source in the material of interest. Therefore, each material will have unique Group Index values at different wavelengths.

Group Index is similar to the more commonly known index of refraction, or refractive index. However, these terms are not the same and their values cannot be used interchangeably.

WHY IS GROUP INDEX IMPORTANT?

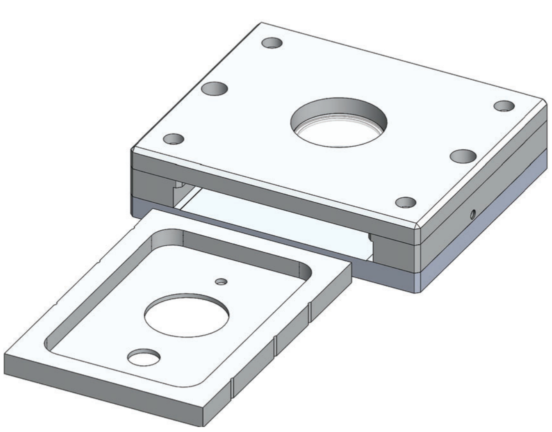
The Optical Thickness Gauge products from Bristol Instruments take advantage of the unique properties of light to measure the physical thickness of a variety of materials. This is done using optical interferometry to first determine, what is known as, "optical thickness." This measurement is then automatically converted to physical thickness using the appropriate Group Index value.

$$\textit{Physical Thickness} = \frac{\textit{Optical Thickness}}{\textit{Group Index}}$$

Therefore, it is necessary to know the Group Index value for the material under test at the light source's wavelength in order to convert the data provided by the Optical Thickness Gauge to the desired physical thickness values.

HOW IS GROUP INDEX DETERMINED

Group Index values for materials such as glasses, liquid optically clear adhesives (LOCA), and plastics usually can be obtained from the manufacturer. If the Group Index value for the material to be tested is not available, it can be measured using the Optical Thickness Gauge and a special measurement cell available from Bristol Instruments.



This Group Index Cell consists of a fixture that holds a pair of air-spaced flat optical plates and a sliding tray that is used to hold a material sample and position it between the two optical plates. The sample must be able to fit in the cell and can consist of only one material.

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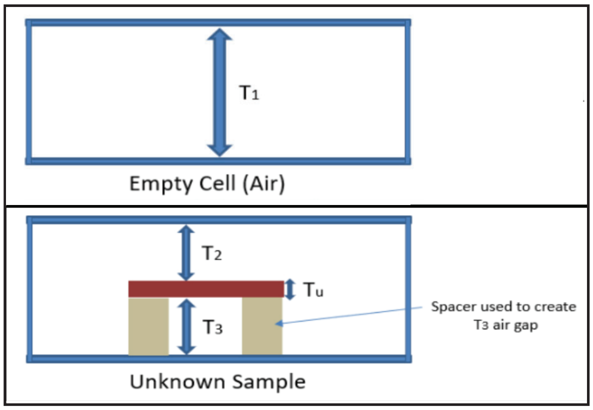
The process of measuring the Group Index of a material is as follows.



1. With an empty Group Index Cell, the Optical Thickness Gauge is used to measure the optical path length (T_1) of the air gap between the two optical plates.

2. The unknown sample is placed on the sliding tray and inserted between the two optical plates. The Optical Thickness Gauge is used to measure three values.

   - The optical path length (T_2) of the air gap between the bottom surface of the top plate and the top surface of the unknown sample.

   - The optical thickness (T_u) of the unknown sample.

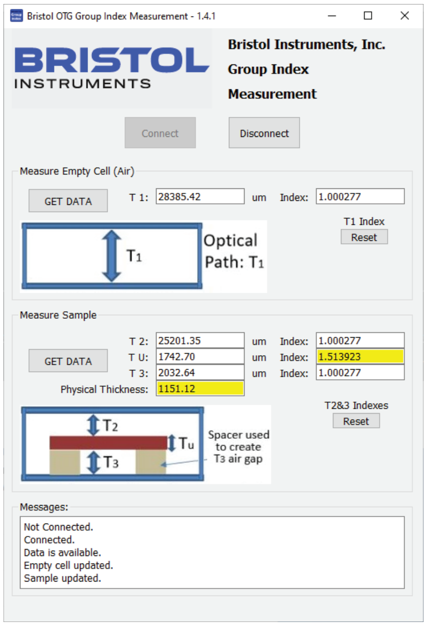
   - The optical path length (T_3) of the air gap between the bottom surface of the unknown sample and the top surface of the bottom plate.

3. The measured values T_1, T_2, T_3, and T_u are then used in the following formula to calculate the Group Index (n_g) of the unknown sample.

$$n_g = \frac{(T_u)(n_{air})}{(T_1 - T_2 - T_3)}$$

In addition, the physical thickness ($T_{physical}$) of the unknown sample can be measured simultaneously using this formula.

$$T_{physical} = \frac{T_u}{n_g}$$



To simplify this process, the Group Index Cell includes a convenient software application to do the calculations. This Group Index Measurement Application works together with the *Opti-Cal* software of the Optical Thickness Gauge requiring only two mouse clicks to collect and analyze the data. A screen shot of this application is shown on the left.

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