Tech Tip 18

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Understanding Optical Properties for Epoxy Applications

What > Optical Properties of Epoxy Adhesives

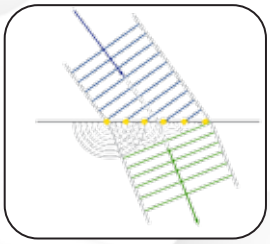
Why > Index of Refraction & Spectral Transmission play a critical role in optoelectronic applications involving epoxies

Introduction

Optical or unfilled epoxy adhesives are commonly used for adhering various substrates, encapsulating components and providing protective coatings in several optical applications. They are found in optoelectronic devices for telecommunications, avionics, satellites as well as scientific and medical instrumentation. Epoxy adhesives can provide optical transparency and opacity. Optical epoxies provide structural integrity, while resisting many types of environmental tests including: sterilization, elevated temperature and humidity.

Two of the most important parameters to be considered in selecting an optical epoxy are refractive index (Nd) and spectral transmission.

Index of Refraction (Nd)



Index of Refraction (sometimes referred to as Refractive Index) is the measurement of the speed of light within a certain substance. The value itself is expressed as the ratio of the speed of light in a vacuum relative to the speed of light in the specific medium.

A common example of refractive index is a straw in a half-filled glass of water. The straw appears to be bent or crooked, due to the differing indicies of refraction of air versus water.

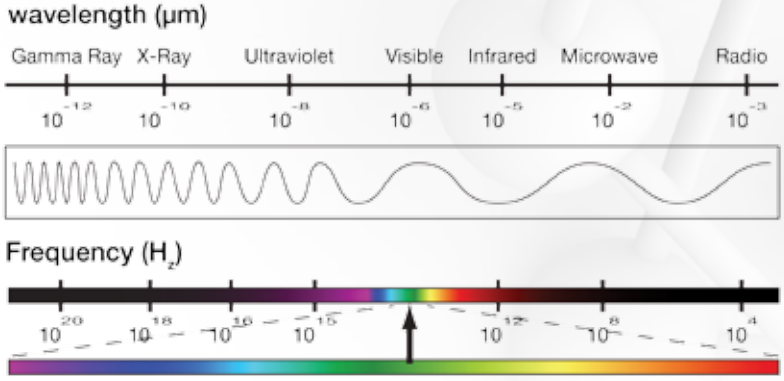
NOTE: Most epoxies have a refractive index ranging from 1.50 to 1.57.

Spectral Transmission

Spectral Transmission (%T) is an important property when selecting epoxy adhesives for two reasons. First, in electro-optical circuits, light signals may be required to pass through the epoxy glue joint interface. Secondly, spectral transmission of a substrate needs to be fully understood in order to select the best UV curing epoxy adhesive. Not only does it determine process methods and capabilities prior to curing, but also spectral transmission generally will not be realized <400nm, after cure.

In order to select the best optical grade adhesive, users need to specify the %T versus wavelength targets. As an example, it is common for a given epoxy to have a characteristic of being infrared transparent, but visible light opaque. It is important to remember that epoxies will not provide significant optical transmission <400nm, since these are the absorption bands needed to cross-link the epoxy.

The Electro Magnetic Spectrum



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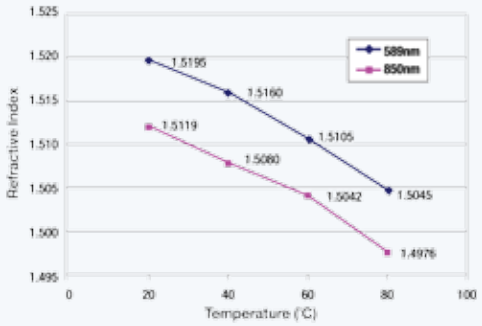
Measurement of Optical Properties by Epoxy Technology

Index of Refraction

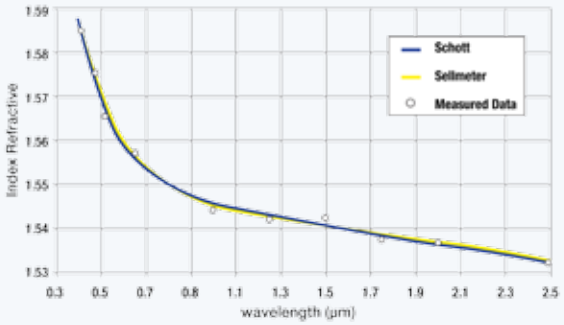
Index of refraction is measured using a refractometer, capable of room temperature measurements of liquid samples, at a fixed wavelength only called the Sodium D line, or 589.3nm. As a general rule, Nd values increase by 0.03 upon curing. For example, a data sheet listed value at 1.56 (wet) becomes 1.59 in its cured state, at 589nm. If the application of the optical epoxy is for fiber optic telecomm, using NIR wavelengths of 1330nm or 1550nm, the Nd value will decrease with increased wavelength, in a manner shown in the curve below.

Refractive Index vs Temperature for EPO-TEK® OG142-87



Tip: As with increasing wavelength, an increase in temperature will cause a decrease in Nd value.

Refractive Index vs Wavelength for EPO-TEK 301-2FL

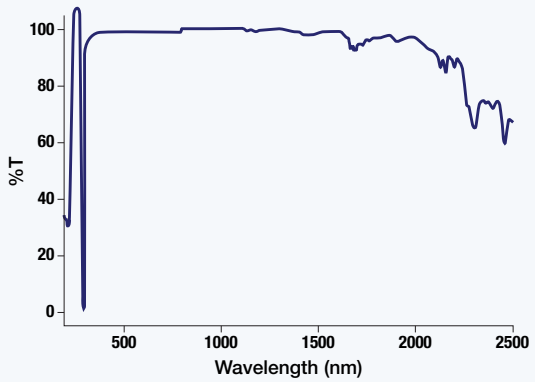


Tip: As a general trend, Nd decreases with an increase in wavelength.

Spectral Transmission

Spectral transmission values are determined using a UV-VIS Spectrophotometer that measures transmission intensity as a function of the light source wavelength. The epoxy adhesive is applied as a coating onto a glass slide and cured according to the data sheet. Specimen thickness is generally determined by the product's overall viscosity, surface tension and wetting forces and is recorded on the resulting %T spectrum curve. The cured product is then subjected to a light source (laser) over 300nm – 2500nm, providing a curve that shows how much the material absorbs or transmits the light at distinct wavelengths. A reference sample of glass is also measured in order to subtract out the baseline curve resulting from the glass slide.

Spectral Transmission Curve for EPO-TEK 301-2



Conclusions

Index of refraction and spectral transmission play a critical role in the increasing demands of optoelectronic or photonic applications of today and the future.

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