Polarizer/Depolarizer options for the high performance Lambda family

PRODUCT NOTE

UV/Vis and UV/Vis/NIR Spectroscopy

Key Features

- Common beam depolarizer corrects for instrument polarization bias
- Polarizer/depolarizer drive allows analysis of oriented samples using polarized light
- Reflectance and transmittance studies cater for a wide range of materials
- Large sample compartment accommodates polarizer-depolarizer and reflectance accessories

Polarizer/Depolarizer Options for the LAMBDA 650, 750, 850, 950 and 1050 UV/Vis

Nature of polarized light

Natural light is a transverse electromagnetic wave with electric (E) and magnetic (H) fields perpendicular to each other (Fig. 1). The two fields are also perpendicular to the wave's direction of travel (k). In unpolarized light the electric field vectors vibrate in all directions of the EH plane equally (Fig. 2). Note that all the electric field vectors are of the same length.

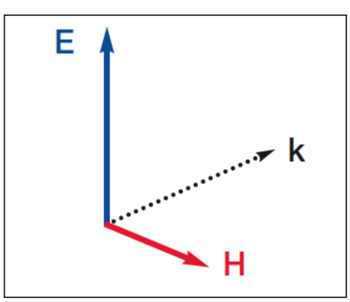

Figure 1. The field vectors of light.

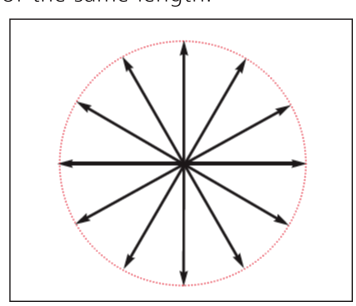

Figure 2. Electric field vectors of un-polarized light.

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When the distribution of the electric field strength becomes non-uniform, the light is defined as polarized. A partially polarized state, with asymmetric electric vectors, is shown in Fig. 3. The most extreme case occurs if the light consists of only one direction of polarization (Fig. 4).

Polarizing materials

Many polarizing materials produce their polarized light by a process of double refraction called birefringence. A birefringent material divides an entering beam of monochromatic radiation into two beams having opposite and orthogonal polarizations. Polaroid film sheets produce polarized light from a specialized form of birefringence called dichroism, which is the selective absorption of one plane of polarization in preference to the other orthogonal polarization as light is transmitted through them. Dichroic polarizers are made of birefringent materials, often oriented plastics, in which one of the two orthogonal polarizations is subject to strong absorption, while the other is not. The preferential absorption of one polarization is achieved by incorporating pigment molecules into the polymeric substrate of the polarizer material. These molecules selectively attach themselves to the aligned polymer molecules, resulting in very high absorption in one plane and very weak absorption in the other.

Polarized light within a spectrophotometer

Radiation emitted by a spectrophotometer's light source is by nature un-polarized. However, this light will become partially polarized by the spectrophotometer's optical components before it interacts with the sample. The primary causes of the polarization are:

- The diffraction grating
- The polarization contribution of mirror reflections
- The diffraction grating slits

In opposition to these factors, if the light is scattered by dust particles or irregularities on optical surfaces it will become randomly polarized (which means a depolarization of the already polarized light).

Polarization effects on samples

When samples such as liquids or amorphous solids do not themselves polarize light, the inherent polarization bias of the spectrophotometer does not affect the data. However, if the sample polarizes light, numerous errors can occur. The nature and magnitude of the errors will be unique to the optical design of the spectrophotometer and the polarization characteristics of the sample. An example of a common error is the variation of transmission values when a polarizing sample is rotated about the beam axis. Typical measurements which may be affected include the measurement of single crystals, liquid crystals or stretched polymers. Use of a depolarizer is recommended for all types of transmission and reflectance measurements involving an angle of incidence typically greater than 10° from normal.

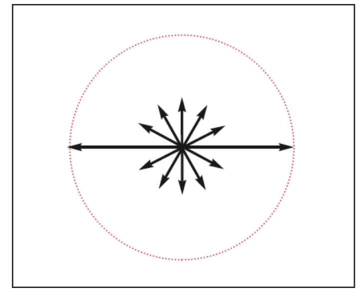

Figure 3. Electric field vectors in partially polarized light.

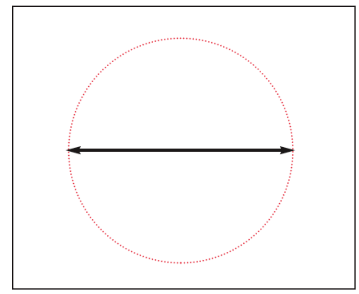

Figure 4. Electric field vectors in totally polarized light.

Depolarization of radiation

The most practical way to control the effects of instrument polarization is to depolarize the instrument beam. Here an optical device, called a depolarizer is mounted in the spectrophotometer's light beam and generates depolarized radiation by scrambling. The depolarizers used in the LAMBDA™ 650/750/850/950/1050 range are of the Hanle type which consists of two wedges of different materials fastened together. The first wedge is made of double refracting natural quartz and the second, which corrects the direction of the beam, is manufactured from Suprasil quartz.

Depolarization options

Two options are available:

Common beam depolarization

Here the depolarizer is located inside the spectrophotometer just before the chopper assembly in which the beam is split into sample and reference beam. The major advantage of this approach is that only a single depolarizer is needed. A small amount of polarization may be added after the depolarizer by the mirror reflections associated with chopper and transfer optics which direct the beam back into the sample compartments. The efficiency of the depolarization is greater than 92%, which is perfectly acceptable for most analyses.

Polarizer/depolarizer drive accessory

For more demanding analyses, a depolarization efficiency of greater than 98% can be achieved by polarizing the beam just before the sample. Here the polarizer/depolarizer drive accessory is used (Fig. 5). This mounts directly in the standard sample compartment of the LAMBDA™ 650/750/850/950/1050 and can be configured with separate polarizers or depolarizers for sample and reference beams. The accessory is fully automated and is recognized by the software when installed.

Polarization measurements

Another important application of the polarizer/depolarizer drive is to analyze samples using a specific polarization of incident radiation. This is achieved by inserting a polarizer into the polarizer/depolarizer drive in the sample compartment directly before the sample, in combination with common beam depolarization. For reflectance measurements, if the polarizer is orientated so that the E field vector is parallel to the plane of incidence of the sample, the P vibrations are measured. Rotation of the polarizer through 90° then allows the S vibrations perpendicular to the plane of incidence to be measured.

As the sample compartment is large enough to accommodate the polarizer drive in combination with a reflectance accessory, both transmission and reflectance measurements can be made. For materials like stretched polymers and material under magnetic or electrical fields, the orientation of chromophores or the conformation of molecules can be deduced. For single crystals, information about crystal symmetry can be collected.

Figure 5. LAMBDA Polarizer/Depolarizer Drive Accessory (B050-5530).

Applications

Characterization of an antireflection coating on glass

An anti-reflection coating on glass was measured using an absolute reflectance accessory at 45°. Optical interference coatings respond differently to S and P polarized light and must be analyzed under different polarization conditions to fully characterize performance. Fig. 6 shows spectra from P (red), random (blue) and S (green) polarizations. In each case the common beam depolarizer was used to remove the instrument polarization and a film polarizer and a depolarizer were used in the drive unit.

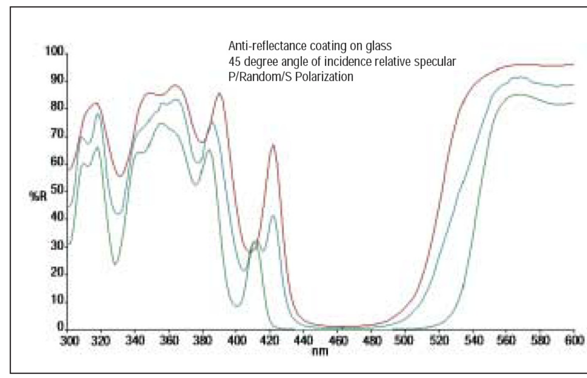

Figure 6. Polarization spectra of an anti-reflection coating on glass.

Characterization of an anti-reflection coating on a laser window

An anti-reflection coating applied to a window used in a ND-YAG laser was characterized using a LAMBDA™ 950 and 45° relative reflectance accessory with a NIST SRM 2003 reference mirror. The performance depends on the polarization of the incident light. Measurements were made using a common beam depolarizer in combination with a Glan-Thompson polarizer in the polarizer drive. Spectra are shown from P (pink) and S (red) polarizations (Fig. 7). The specification of the mirror is <0.5% reflectance at 1064 nm, the laser wavelength, using P-polarized radiation.

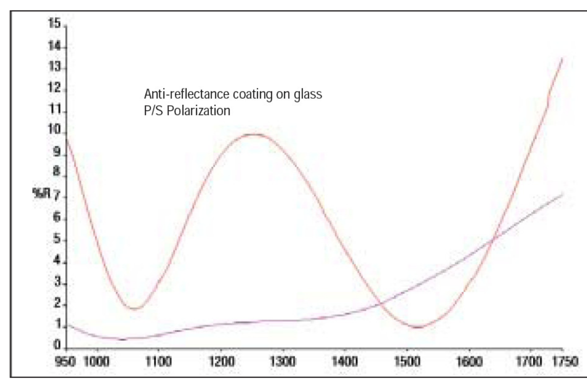

Figure 7. Polarization spectra of an anti-reflection coating on glass.

Specifications for the LAMBDA™ 650/750/850/950/1050 depolarizer and polarizer accessories

Depolarizer/Polarizer	Film Polarizer	Glan-Thompson	Glan-Taylor	Depolarizer	CB-Depolarizer
Wavelength Range	400 to 700 nm	300 to 2600 nm	210 to 1100 nm	185 to 2600 nm	185 to 2600 nm
Efficiency	–	–	–	> 98%	> 92%
Part Number	B220-5022	B050-5284	N101-0520	B220-5021	B050-1282

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