Transmission curves of plexiglass (PMMA) and optical grease

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This note documents transmission measurements of material samples frequently used in the PH/DT scintillator lab. The measurements were performed by C. David on the Perkin-Elmer (visible light) spectrometer available in the DT TFG workshop.

The measured samples were:

- Poly(methyl methacrylate) (PMMA), standard material from CERN stores, also known as Plexiglas, Perspex, Lucite, acrylic glass, etc. The sample was a PMMA sheet of 2 mm thickness. The same base material is used for the fabrication of light guides. Its refractive index is $n_{PMMA} = 1.489$.

- Optical grease of type 'Dow Corning Q2-3067 OPT COUPLANT 453G'. This is the standard grease used for the coupling of light guides to photodetectors (PMTs). Its refractive index is $n_{OG} = 1.466$ (at $\lambda = 589$ nm). For the transmission measurement, the optical grease was applied as thin film between two glass sheets, which were pressed together to be in mechanical contact.

The measured transmission is influenced by two components:

1. Bulk absorption, inherent to the optical transparency of the material

   $$T_b = T_0 \exp(-\alpha \cdot d) = T_0 \exp(-d/\lambda_a)$$

   $\alpha(\lambda)$ is the wavelength dependent absorption parameter (unit [m^{-1}]) and $\lambda_a = 1/\alpha$ is the absorption length [m]. d is the thickness of the material sample [m].

2. The Fresnel losses due to reflections at the optical boundaries, e.g. air/plexiglass and plexiglass/air. For normal incidence, the reflection losses per interface are

   $$R_F = (n-1)^2/(n+1)^2$$

   with $n = n_2/n_1$, the ratio of the refractive indices of the sample and the surrounding medium. In the case of a plexiglass sample measured in air, $n_1 = 1$ and therefore $n = n_2 = 1.489$. The Fresnel losses per interface are therefore 3.86%.

Figure 1 shows the transmission curve of the 2 mm thick plexiglass sheet in air. At wavelengths above 400 nm, the transmission is only constrained by the Fresnel losses which amount to two times 3.86%, i.e. approx. 8%. Below 400 nm, the bulk absorption of plexiglass becomes dominant. The sample doesn’t transmit any light below 360 nm.

Figure 2 shows the transmission curves of two thin glass plates (in mechanical contact) without optical grease (red line) and with optical grease in between (green line). At wavelengths above 400 nm, the transmission is only constrained by the Fresnel losses which amount for ordinary glass (n=1.52) to about 2 or 4 times 4.2%, i.e. approx 8.5% or 17%. Below 350 nm, the bulk absorption of the glass becomes visible. The sample with the thin optical grease film shows a higher transmission than the sample without grease. This is due the almost matched refractive indices of grease and glass, which reduce the Fresnel losses at the inner interface to almost zero. The measurements show that for wavelengths where the glass shows non-zero transparency (λ > 300 nm), the thin layer of optical grease has no noticeable impact on the transmission curve.

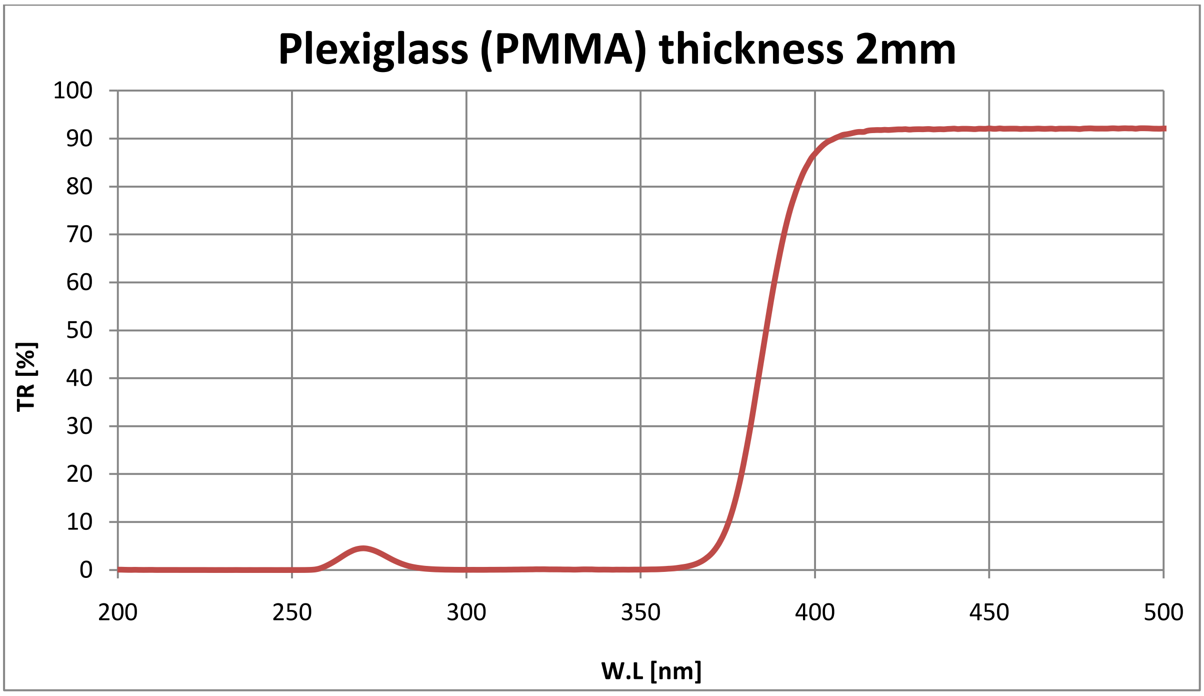

Figure 1: Transmission curve of a 2 mm thick plexiglass sheet in air. At wavelengths above 400 nm, the transmission is constrained by the Fresnel losses which amount to two times 3.86%, i.e. approx. 8%. Below 400 nm, the bulk absorption of plexiglass becomes dominant. The sample doesn't transmit any light below 360 nm.

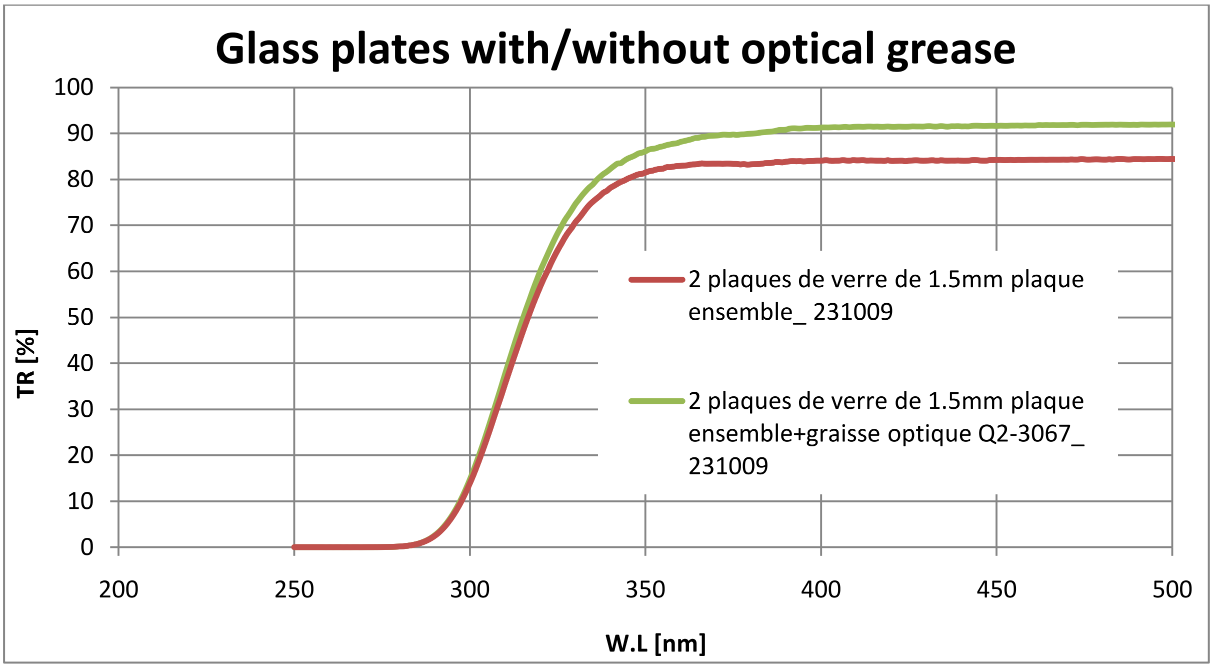

Figure 2: Transmission curves of two thin glass plates without optical grease (red line) and with optical grease in between (green line). At wavelengths above 400 nm, the transmission is constrained by the Fresnel losses which amount for ordinary glass (n=1.52) to about 2 or 4 times 4.2%, i.e. approx 8.5% or 17%.