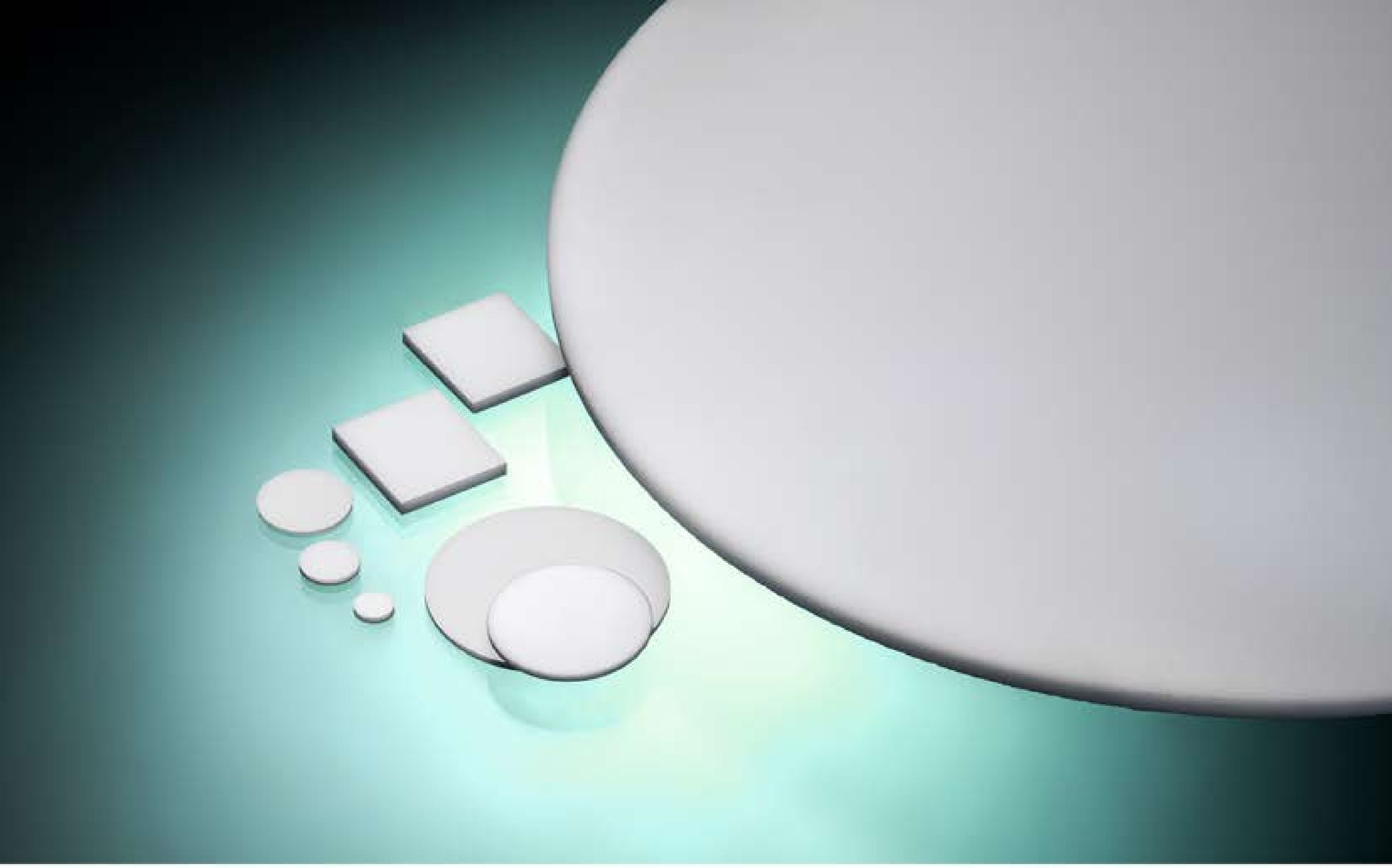


diffusil®

Technical Data Sheet - Optical Diffusers

Firebird Optics

www.firebirdoptics.com

Contents

Introduction

diffusil® diffusers are made of a special opaque synthetic fused silica glass.

They are designed to create an almost perfect Lambertian light output over a wide wavelength range, regardless if they are used in transmission or reflection mode. diffusil® diffusers are the ideal light scattering material for light sources and optical sensors working in the range of 190 - 3200 nm. The diffusers are available in standard and customized geometries and shapes. Even specific precise diffusion profiles can be offered.

Millions of tiny little gas bubbles inside the ultra-pure synthetic fused silica glass are the secret of the optical behavior of diffusil® Diffusers.

They act as optical scattering elements. The gas bubbles of ca. 4 µm diameter are distributed very uniformly in the glass volume and lead to these extraordinary optical results. Due to this working principle neither surface defects nor surface contaminations affect the scattering profile of diffusil® diffusers.

Basic Substrate

Ultra pure, synthetic silica glass (99.999% SiO_2) is the mechanical base of the diffusil® diffusors and the reason for the high transmission values over a wide wavelength region from UV to NIR. Contrary to other diffusor materials, diffusil® diffusors are able to withstand thermal shocks of several hundred degrees and rough surrounding conditions without harm.

diffusil T

Silica glass of the diffusil T brand is made of synthetically produced raw material by sol-gel processing. diffusil T is characterized by an extremely high chemical purity degree and special optical qualities. The translucent, opaque profile of diffusil T is caused by gas bubbles that are distributed homogeneously within the glass and have an optical scatter effect. The quantity and size of the bubbles can be defined for the production process.

The typical properties are:

- incident angle independed homogenization of light beams in transmission mode
- incident angle independed homogenization of light beams in reflection mode
- applicable for wavelength from UV to NIR
- applicable up to 1000 °C
- applicable in strong acids and bases
- diffusil® diffusers are available in the most common shape as square or round plane-parallel discs from stock
- surface qualities to be chosen as "honed" or "polished"

Specifications

Minimum size	2 x 2 mm
Maximum size	160 x 200 mm or 160 x 160 mm
Maximum diameter	160 mm
Typical shape	circular discs
Thickness	0.3 - 25.0 mm
Temperature stability	up to 1000 °C

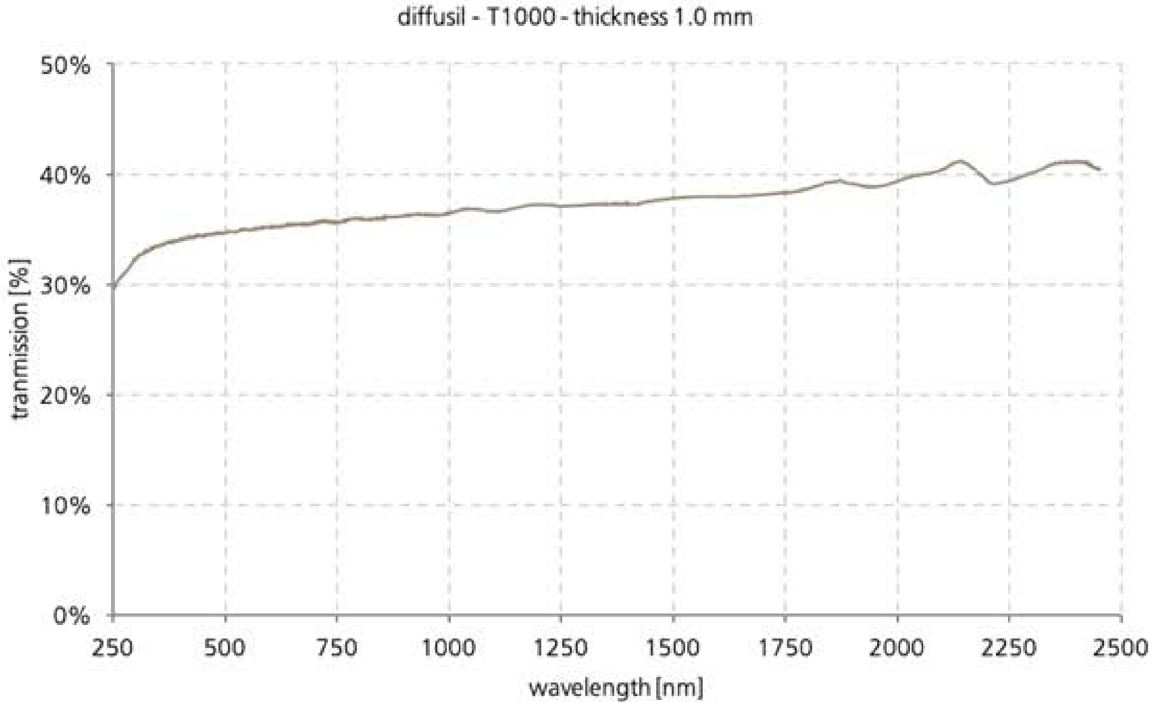
Bubbles / Scatter Center in the Material

Size	ca. 4.0 ± 0.5 µm
Amount of bubbles (doping)	diffusil T300 = ca. 300 million bubbles/cm³ diffusil T500 = ca. 500 million bubbles/cm³ diffusil T1000 = ca. 1 billion bubbles/cm³ diffusil T2000 = ca. 2 billion bubbles/cm³

Optical Material Properties

Spectral Transmission

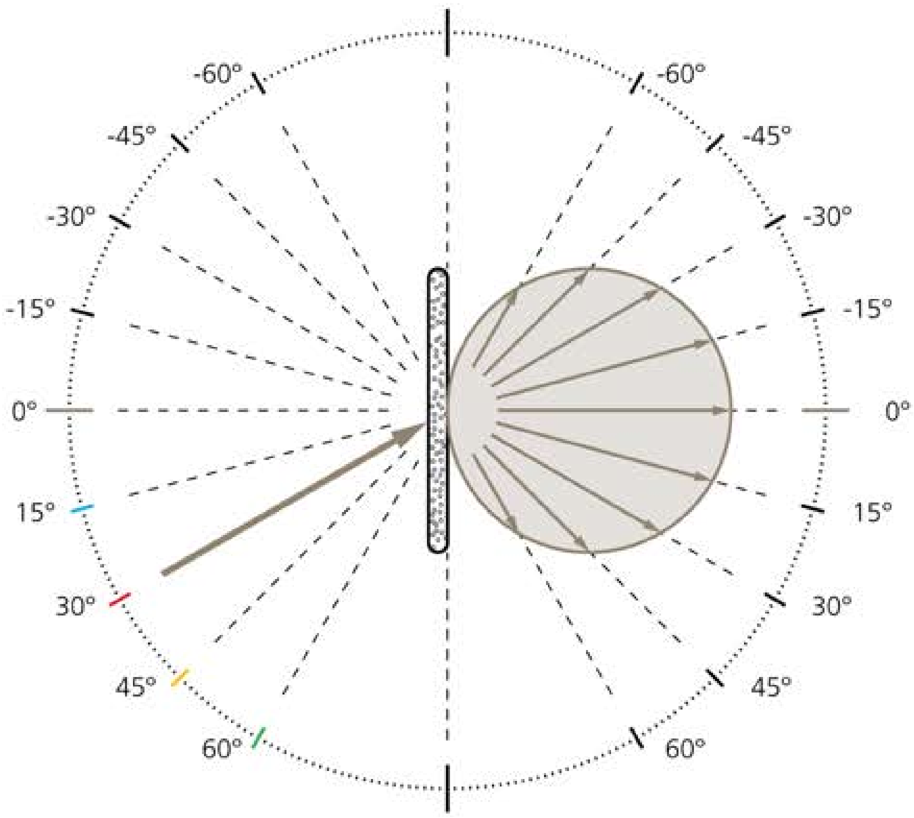
The following figure shows the typical spectral transmission of diffusil® at a thickness of 1 mm and a doping of 1 billion bubbles/cm³ (diffusil T1000).

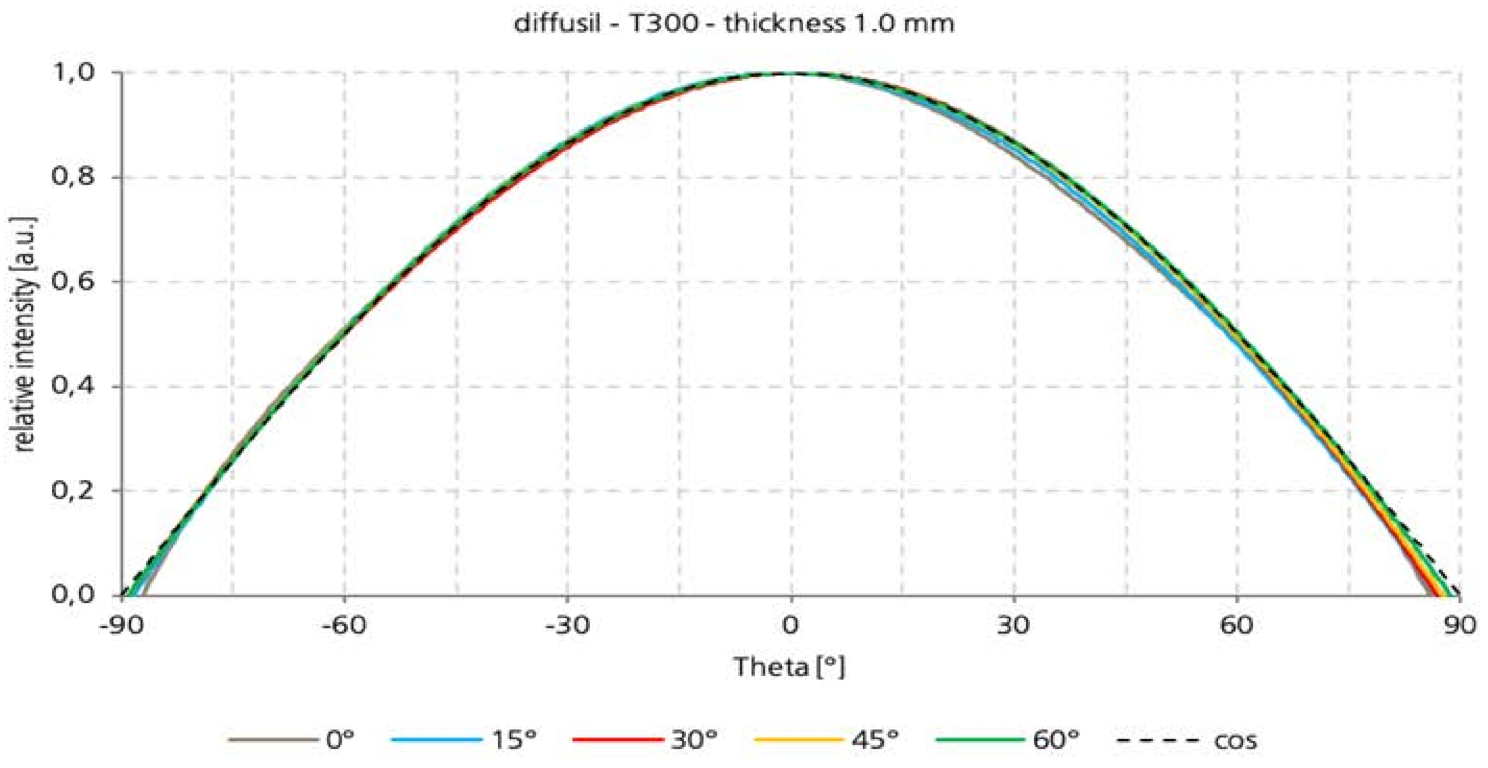


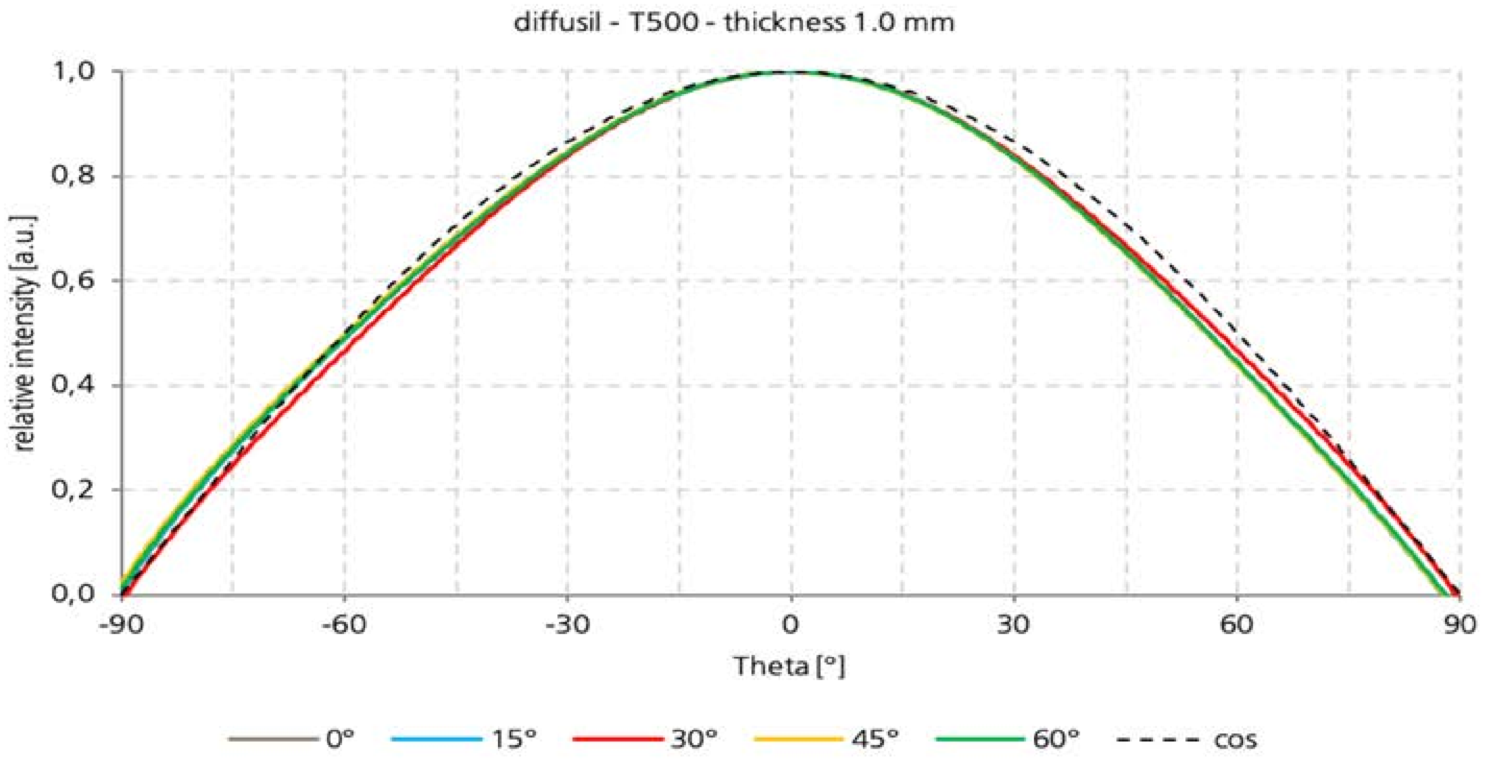
		typical mean diffuse transmission [%]			
wavelenght range [nm]		T2000	T1000	T500	T300
250 - 2.450		---	37.3 %	43.1 %	---
250 - 360	UV	---	32.2 %	37.1 %	---
360 - 830	VIS	---	35.1 %	40.4 %	---
830 - 1.100	NIR1	---	36.4 %	42.0 %	---
1.100 - 2.450	NIR2	---	38.7 %	44.7 %	---

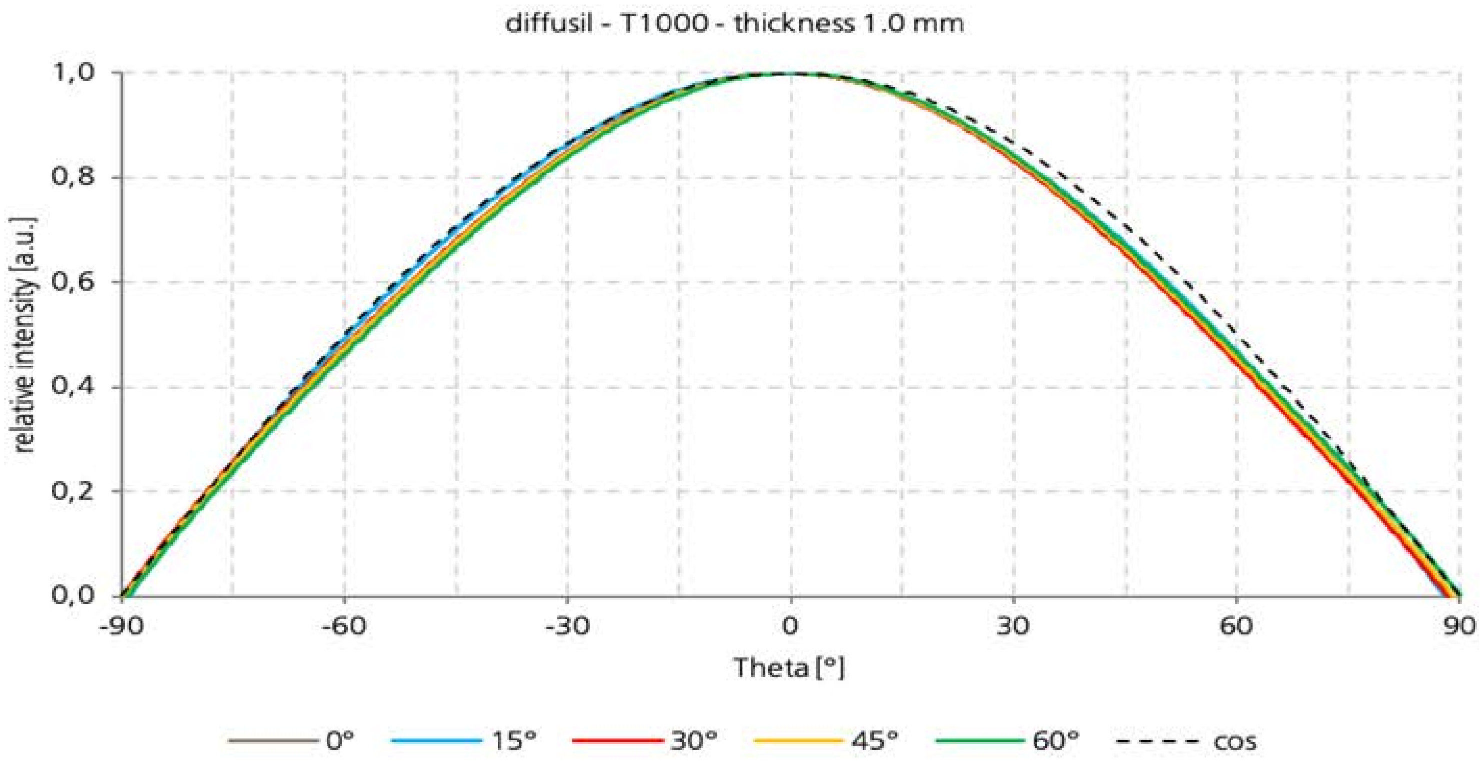
Scattering Behaviour

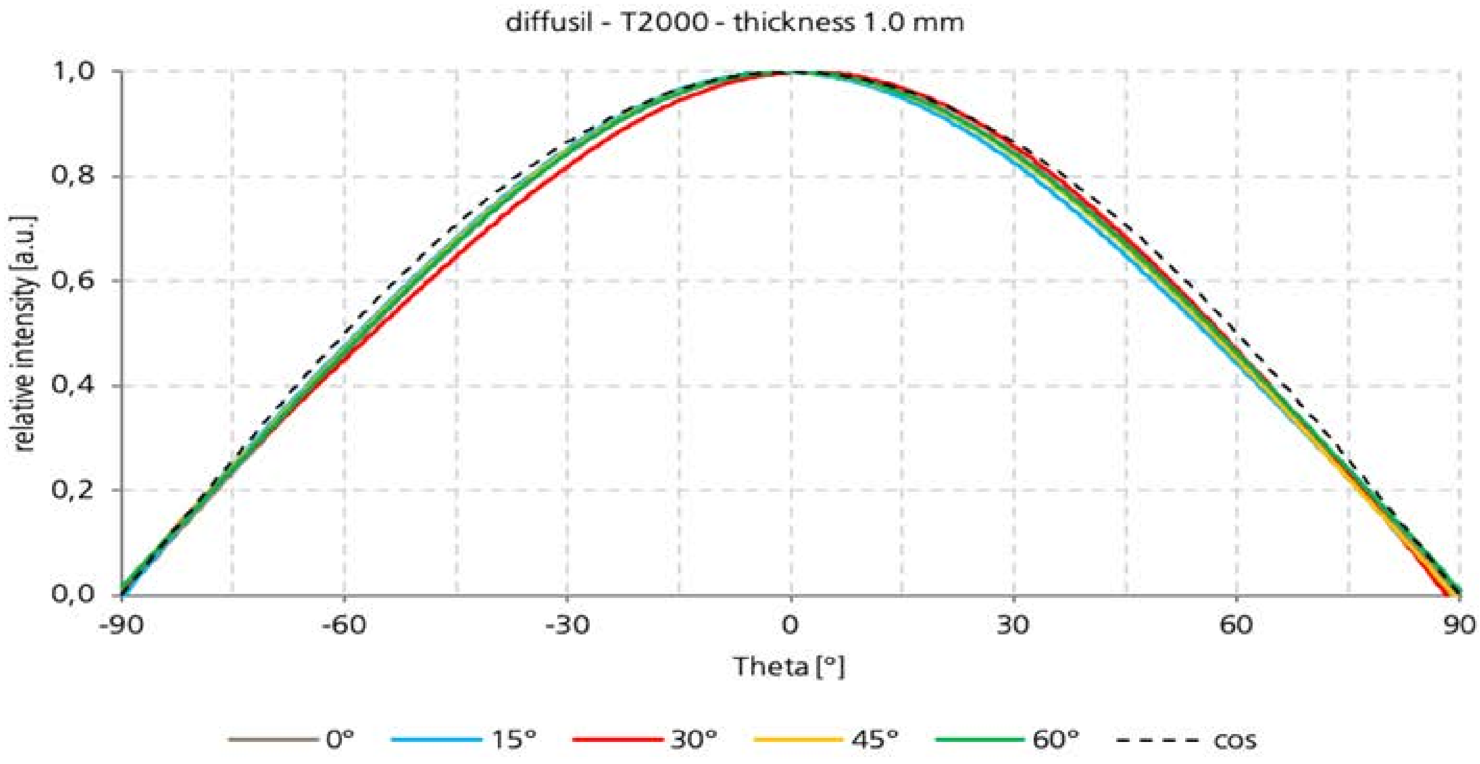
Size and number of the encapsulated gas bubbles are responsible for different scattering behavior of the diffusers. In order to meet the requirements of most scattering light applications, these parameters can be adapted. The following figures show the scattering characteristics in transmission of the different dopings and the different incident angles, based on the following angle definition:

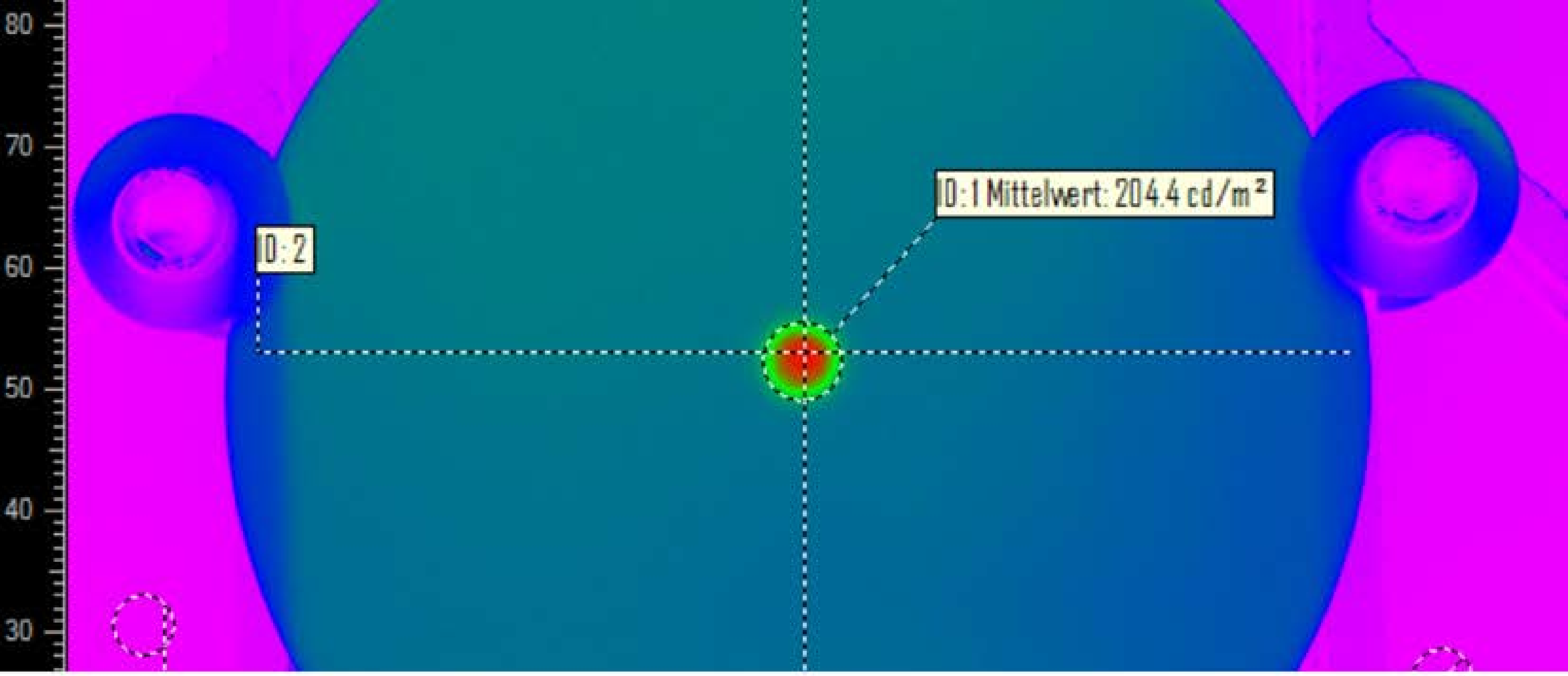



diffusil - T300 - thickness 1.0 mm
1,0
0,8
0,6
0,4
0,2
0,0
relative intensity [a.u.]
-90
-60
-30
0
30
60
90
Theta [°]
0°
15°
30°
45°
60°
cos


diffusil - T500 - thickness 1.0 mm
1,0
0,8
0,6
0,4
0,2
0,0
relative intensity [a.u.]
-90
-60
-30
0
30
60
90
Theta [°]
0°
15°
30°
45°
60°
cos

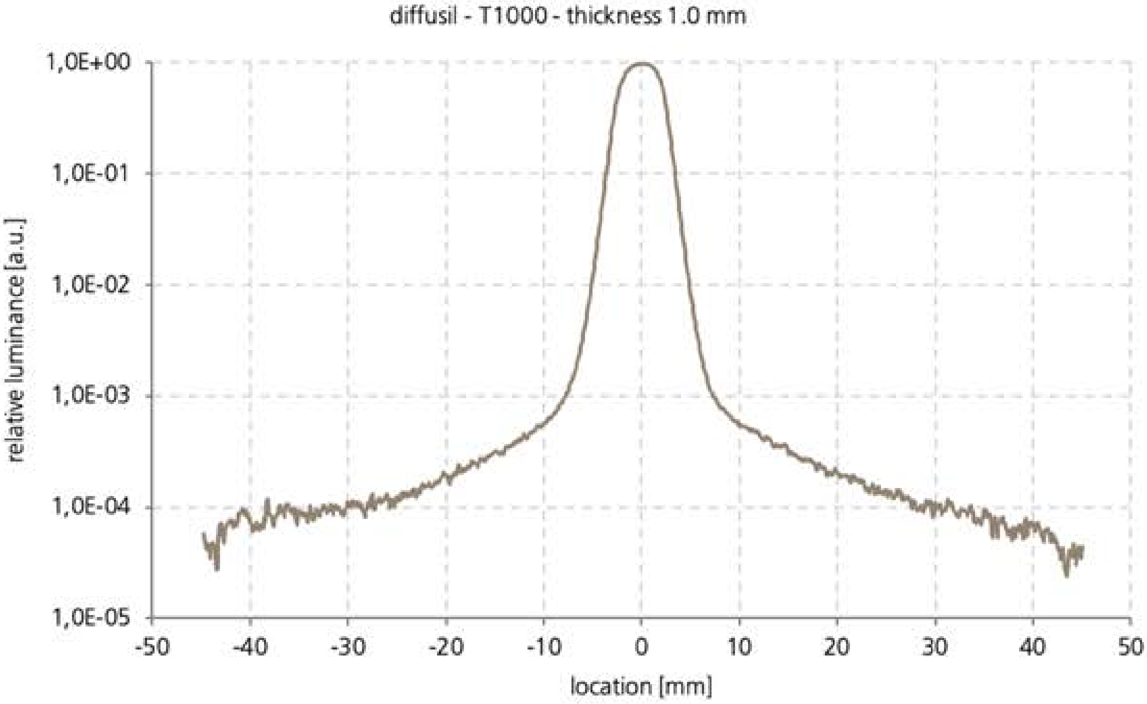

diffusil - T1000 - thickness 1.0 mm
relative intensity [a.u.]
1,0
0,8
0,6
0,4
0,2
0,0
-90
-60
-30
0
30
60
90
Theta [°]
0°
15°
30°
45°
60°
cos

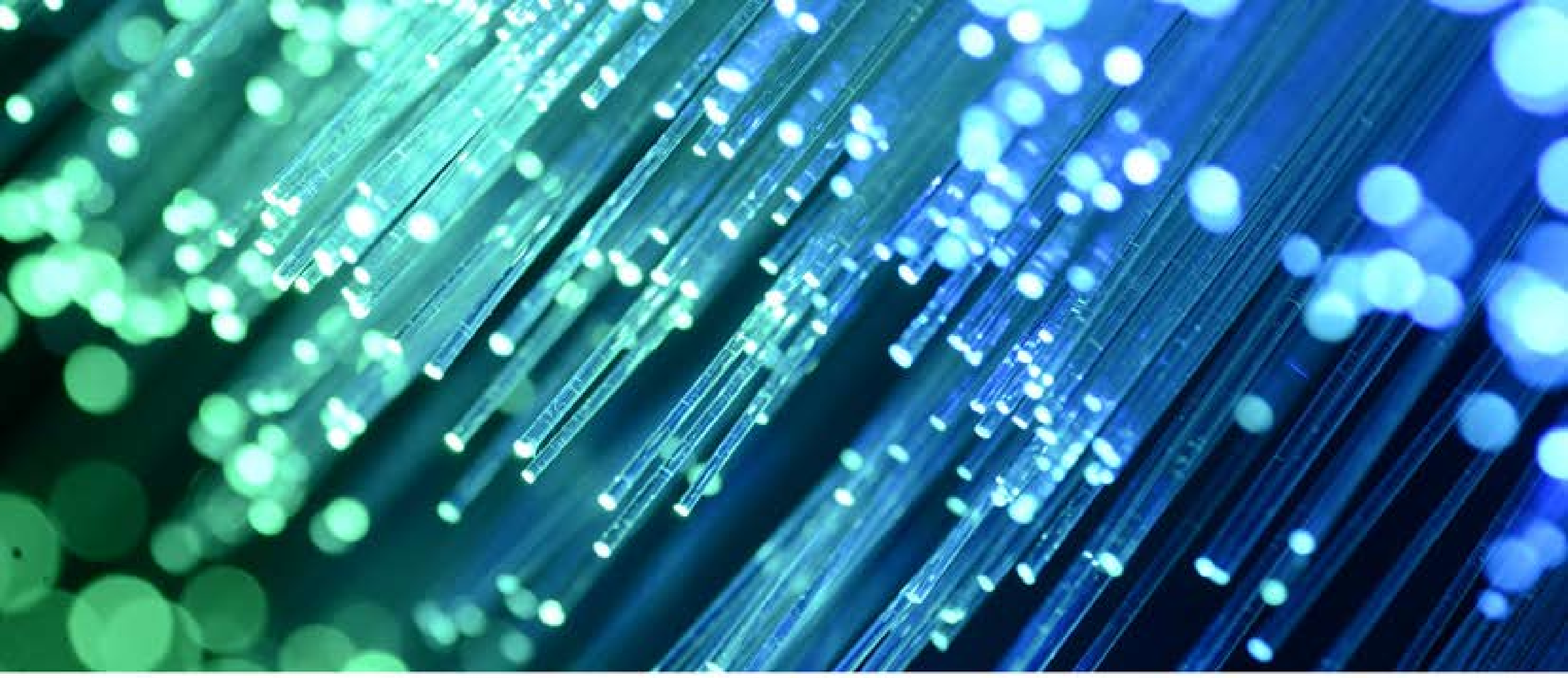

diffusil - T2000 - thickness 1.0 mm
relative intensity [a.u.]
1,0
0,8
0,6
0,4
0,2
0,0
-90
-60
-30
0
30
60
90
Theta [°]
0°
15°
30°
45°
60°
cos



Luminance

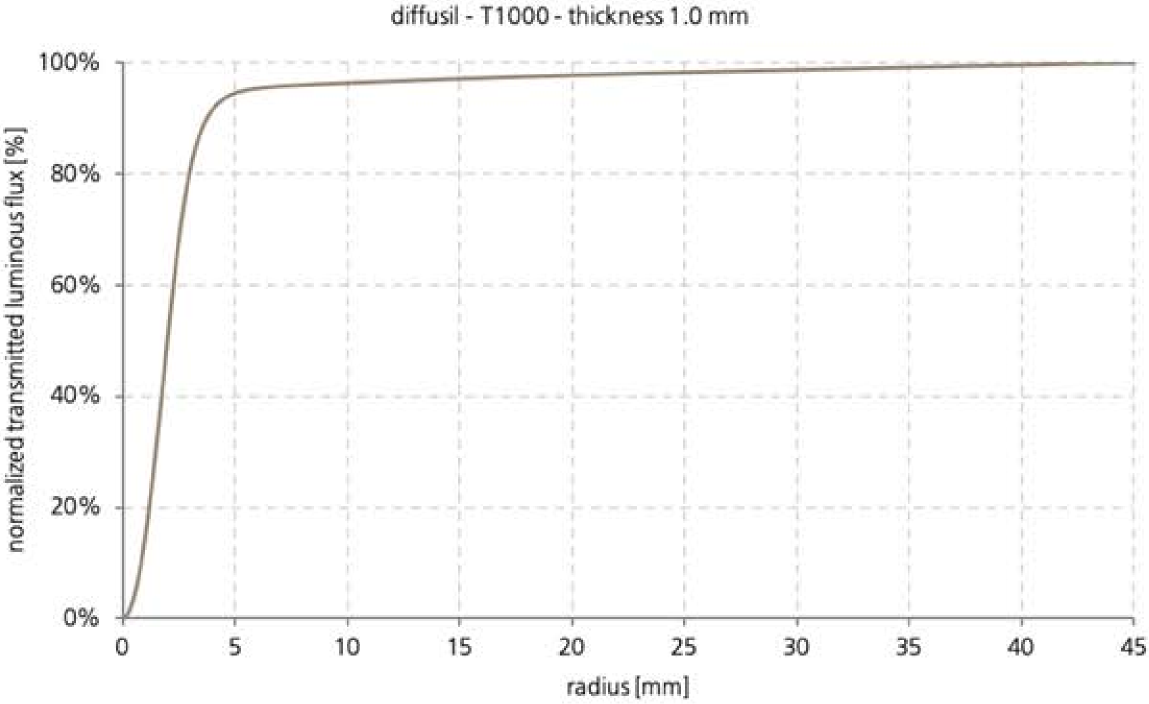
When irradiating a sample with a thickness of 1 mm with a collimated beam of 5 mm diameter, the following luminance distribution is shown due to the volume scattering. This distribution refers to the light exit surface of the material with a vertical view on the exit surface.





Luminance and Luminous Flux

Radial-integral view provides information on the radius in which luminous flux component of the total transmission is transmitted.



Further Material Properties

Chemical Material Properties

Typical impurity in ppm/weight

Al	Ca	Cu	Fe	K	Li	Mg	Na	Ti	Zr
< 0.08	< 0.03	< 0.01	< 0.02	< 0.04	< 0.01	< 0.01	< 0.02	< 0.01	< 0.05

Acid resistance:	class 1; according to DIN 12 116
Alkali resistance:	class 1; according to DIN 52 322

Mechanical Material Properties

Density	ca. 2.15 - 2.19 g/cm³	(depending on the chosen opacity)
Porosity	ca. 0.01 - 5.0%	(depending on the chosen opacity)
Elasticity modulus	ca. 50 - 54 kN/mm²	(depending on the chosen opacity)
Bending stress	ca. 80 - 84 N/mm²	(depending on the chosen opacity)

Thermotechnical Material Properties

Thermal coefficient of expansion	ca. 0.00 - 0.40 · 10^{-6} · K^{-1} (20 °C – 500 °C)
Thermal conductivity	ca. 1.24 W/m · K (@ 20 °C) ca. 1.35 W/m · K (@ 100 °C) ca. 1.47 W/m · K (@ 200 °C) ca. 1.70 W/m · K (@ 400 °C) ca. 1.85 W/m · K (@ 600 °C)
Softening temperature	ca. 1,600 °C
Max. working temperature, shortterm	ca. 1,200 °C
Max. working temperature, continuous	ca. 1,000 °C

Electrical Material Properties

Dielectric strength	ca. 3.70 (20 °C 1 x 10^6 Hz) ca. 3.77 (23 °C 9 x 10^8 Hz) ca. 3.81 (23 °C 3 x 10^{10} Hz)
Electrical resistivity	ca. 1 x 10^{18} Ω · cm (@ 20 °C) ca. 1 x 10^{10} Ω · cm (@ 400 °C) ca. 6.3 x 10^6 Ω · cm (@ 800 °C)

Cleaning Instructions

Silica glass is sensitive to all alkali metal and alkaline earth metal compounds. Finger prints (bits of alkali) should always be removed from silica glass before heating to over 900 °C. Please always use powder-free rubber or latex gloves or suitable gripping tools (tweezers or similar) to handle diffusil products

Dust deposits:

5 min ultrasonic bath in distilled water, T < 100 °C, then blow dry with oil-free compressed air or nitrogen. Alternatively, dry 10 min at T 70 °C - 300 °C in a dust-free drying cabinet.

Finger prints / residue of glue:

Wipe with ethanol or acetone and lint-free cloth, then 5 min ultrasonic bath with distilled water, T < 100 °C, then blow dry with oil-free compressed air or nitrogen Alternatively, dry in a dust-free drying cabinet at T 70 °C - 300 °C for 10 min.

Other organic / inorganic impurity:

Clean in acids (e.g. hydrochloric acid, acetic acid, nitric acid, etc.) until impurities are visually removed, then neutralize briefly in suitable base solution or rinse with sufficient distilled water, then 5 min ultrasonic bath with distilled water, T < 100 °C, then blow dry with oil-free compressed air or nitrogen.

Alternatively, dry in a dust-free drying cabinet for 10 min at T 70 °C - 300 °C

Other persistant impurity / deposit:

In case the above mentioned cleaning procedure should not be sufficient for a complete removal of the impurity, the following procedure is recommended:

- clean in 10% aqueous ammonium bi-fluoride (NH_4HF_2) solution
- immerse silica glass parts about 1 – 5 minutes in the above mentioned solution until impurities are visually removed, then
- neutralize briefly in suitable base solution or rinse with sufficient distilled water, then
- 5 min ultrasonic bath in distilled water, T < 100 °C, then
- blow dry with oil-free compressed air or nitrogen. Alternatively, dry 10 min at T 70 °C - 300 °C in a dust-free drying cabinet

Caution: In this procedure the upper layer of silica glass is dissolved and with it the respective contamination. This may cause a change of the surface characteristics or the optical characteristics of the silica glass product. Generally, please note the respective safety data sheets and safety instructions of the used chemicals for all the cleaning procedures described above.