HCR EXCELLENCE

WACKER ACADEMY®

HTV Silicones Application in LED Lighting

WEDNESDAY, APRIL 17, 2024

Who am I?

TOPSILGLOBAL
Excellence in processing of silicone & TPE

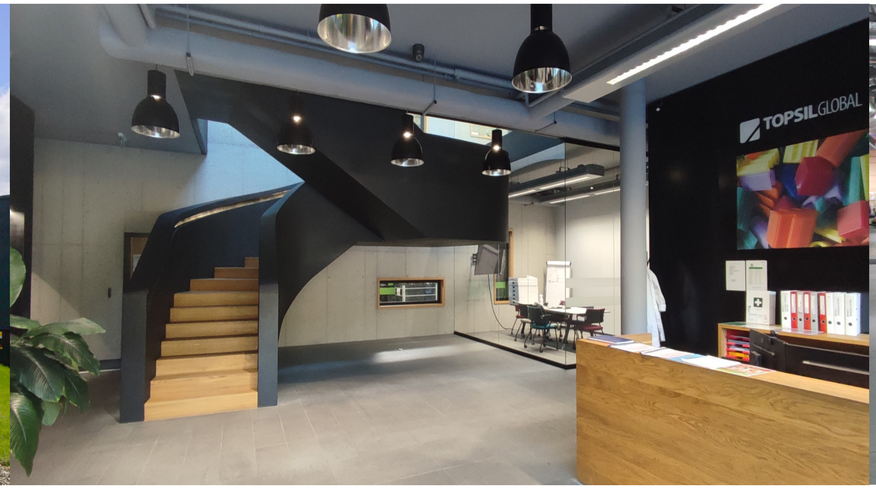
Tomasz Padée M.Sc. Eng.

Warsaw University of Technology,
Faculty of Chemistry (graduated 1976)

1977- 1985	*Institute of Rubber Industry, Poland*
1985- 1988	*First private business in rubber processing*
1988	*Foundation of Topsil*
1988- present	*CEO of Topsil Global Company*

Company overview

TOPSILGLOBAL
Excellence in processing of silicone & TPE



Founded in 1988 ***TopsilGlobal*** *is a private,* ***family-owned*** *company* ***specialising in processing of silicone and thermoplastic elastomers*** *by means of* ***injection moulding*** *and* ***extrusion****. For all these processes we use the tools made in our* ***own tool-making facility****, equipped with* ***state-of-the-art, high-precision machines****.*

Products *manufactured by* ***TopsilGlobal*** *are* ***intended for exceptionally responsible tasks*** *in electrical engineering, home appliances, white goods, baby-care, medical equipment, automotive industry and construction engineering. Currently* ***TopsilGlobal*** *employs ca.* ***250 people****, owns* ***6000 sq. meters of production floor*** *and* ***3500 sq. meters of stock****,* ***social and office space*** *in its two plants in* ***Poland*** *and delivers its products to over* ***fourty countries worldwide****. To our customers with global range we offer also production capacities (LSR injection) in our wholly owned plant in* ***China****,* ***Shanghai*** *region.*

We are proud to count some renowned, ***global brands*** *like* ***Philips****,* ***Bosch*** *or* ***Velux*** *among our Customers.*

TopsilGlobal plants

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TopsilGlobal Slubica (Poland)

Technologies supported:

- ✓ *Silicone injection*
- ✓ *TPE injection*
- ✓ *Silicone extrusion*
- ✓ *TPE extrusion*
- ✓ *Tool-making*

TopsilGlobal Skierniewice (Poland)

Technologies supported:

- ✓ *Silicone injection*
- ✓ *TPE injection*
- ✓ *2K injection (TP+LSR, LSR+LSR)*
- ✓ *Clean room class 10,000 (ISO 7)*

TopsilGlobal Shanghai (China)

Technologies supported:

- ✓ *Silicone injection*
- ✓ *TPE injection*
- ✓ *2K injection*
- ✓ *Clean room class 100,000 (ISO 8)*
- ✓ *Tool-making*

Why with us?

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*In the world of elastomers, we want to be a **guide for our Customers**, leading them from the early concept, through the design phase, to the final product.*

*We strive for perfection to not only meet but **exceed the expectations** of our Customers and ourselves.*

35+
Years of experience

>20 mln €
Revenue

3
Production sites

75+
Production machines

200+
Employees

ISO 7
Cleanroom

500+
Customers

40
Countries of export

Why silicones for optics?

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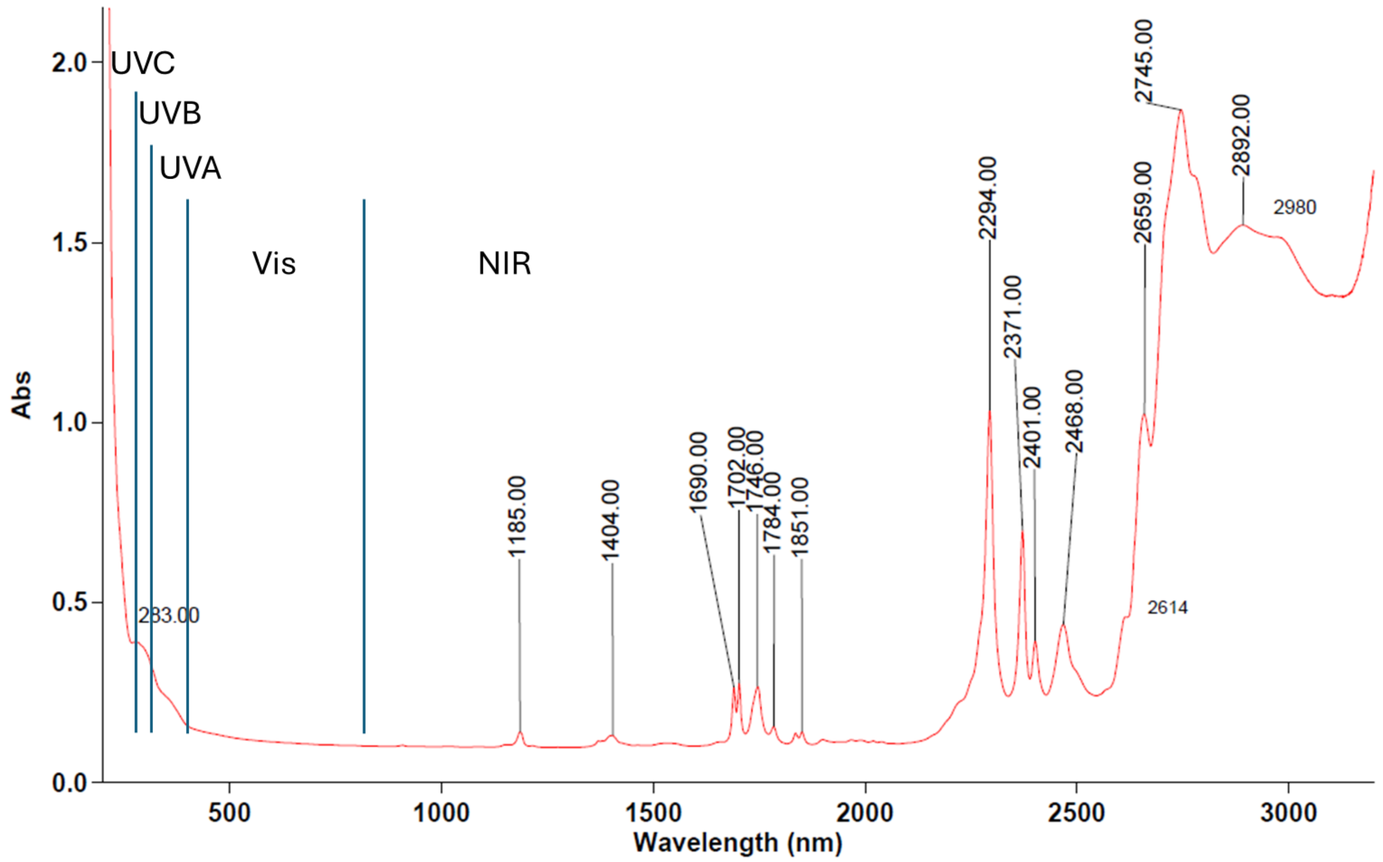
Spectrum UV-Vis-NIR for Elastosil R4305/40



Binding Energy:

- Si-O : 444kJ/mol
- C – C : 356kJ/mol
- C – O : 339kJ/mol

Rotational Energy:

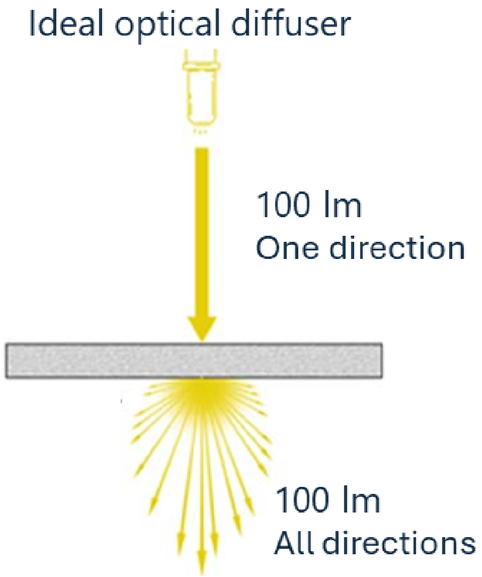
- Si-O : 0,8kJ/mol
- C – C : 15kJ/mol

UVB sunlight Energy:

- 398 kJ/mol

Ideal LED strip

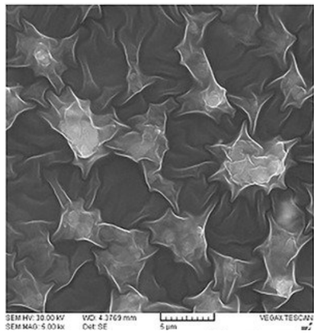
100% light transmittance
100% diffusive



Three ways of light scattering:

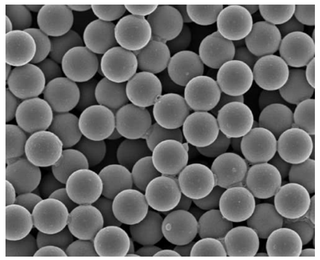
α ≪ 1: Rayleigh scattering (small particle compared to wavelengthof light);

Silicone rubber particle 2um-20um



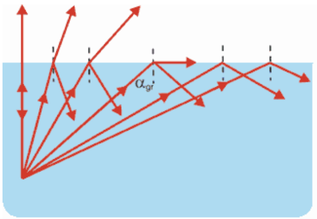
α ≈ 1: Mie scattering (particle about the same size as wavelength of light, valid only for spheres);

e.g. 700nm spheres



α ≫ 1: geometric scattering (particle much larger than wavelength of light);

Diffusive films



Why silicones for optics?

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Properties	Silicone	Glass	PC (Polycarbonate)	PMMA (Polymethyl methacrylate)
State	Thick (solid after setting)	Solid	Solid	Solid
Processing Temperature [°C]	15-25	1500	280-320	250
Molding Temperature [°C]	125-180	600	90-120	60-80
Refractive Index [n]	1.41	1.52	1.58	1.49
Thermo-optic Coefficient [dn/dT]	-3.2 * 10^-4	About 2 * 10^-6	-1.07 * 10^-4	-1.1 * 10^-4
Total Transmittance for the range 400-700 nm (Approx. Path Length of 1 cm White Light)	94	91	89	93
Service Temperature of Material [°C]	150	>200	120	90
Glass Transition Temperature Tg [°C]	-127	About +600	+145	+120
Density [g/cm³]	1.07	2.5	1.2	1.2
Thermal Expansion Coefficient [CTE; ppm/°C]	275	10	65	72
Abbe Number	About 50	20-65	About 30	About 58

Materials used for our tests

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PDMS

Sample type	Average light transmittance coefficient in the visible radiation range
Silicone resin MS-1002 Dow Corning	0.894
Polsil MV AB/S	0.890
Silicone oil of viscosity 20,000 mPa·s	0.872
Polymer MV 0.07 crosslinked with peroxide at 175°C	0.854
Elastosil R4305/40	0.834
Elastosil R4305/80	0.749
Polymer MV 0.07 crosslinked with peroxide at 135°C	0.709
Polymer MV 0.07 crosslinked in the presence of platinum catalyst	0.693

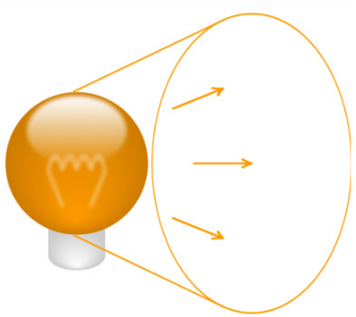
Additives used in HCR compounds

Additive	Symbol	Description	Supplier	Price EUR/kg
Glass microspheres	HVD-0034	Glass beads S-22 V-25	3M	~12.21
Al2O3	HVD-0083	High Purity Alumina AA-05 [Sumitomo]	Sumitomo chemical	135
TiO2	HVD-0045	TITANIUM DIOXIDE PIGMENT Tytanpol® R-003 (25 kg)	Zakłady Chemiczne "Police" S.A.	~4.02

Test method

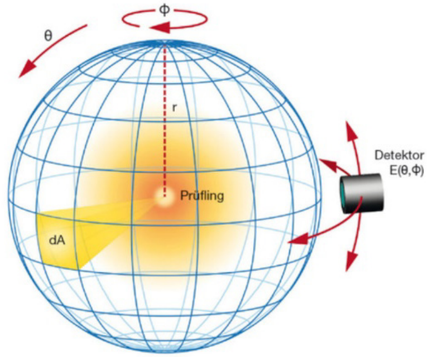
During the test, two parameters were measured:
- Transmittance coefficient
- Luminous intensity distribution (light intensity distribution)

Goniophotometer is a device used to measure the **light intensity** at various angles.

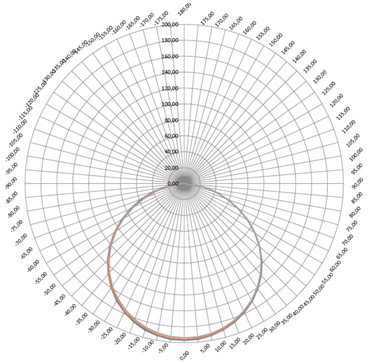


Luminous intensity I_V
(candela, cd=lm/sr)

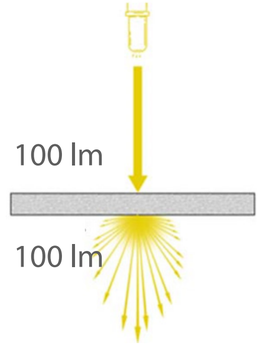
Luminous intensity definition



Measurement method of light intensity distribution

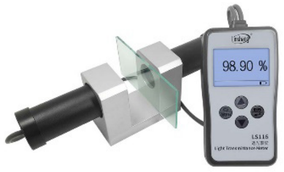


Measurement of the luminous intensity of an LED strip without a silicone coating



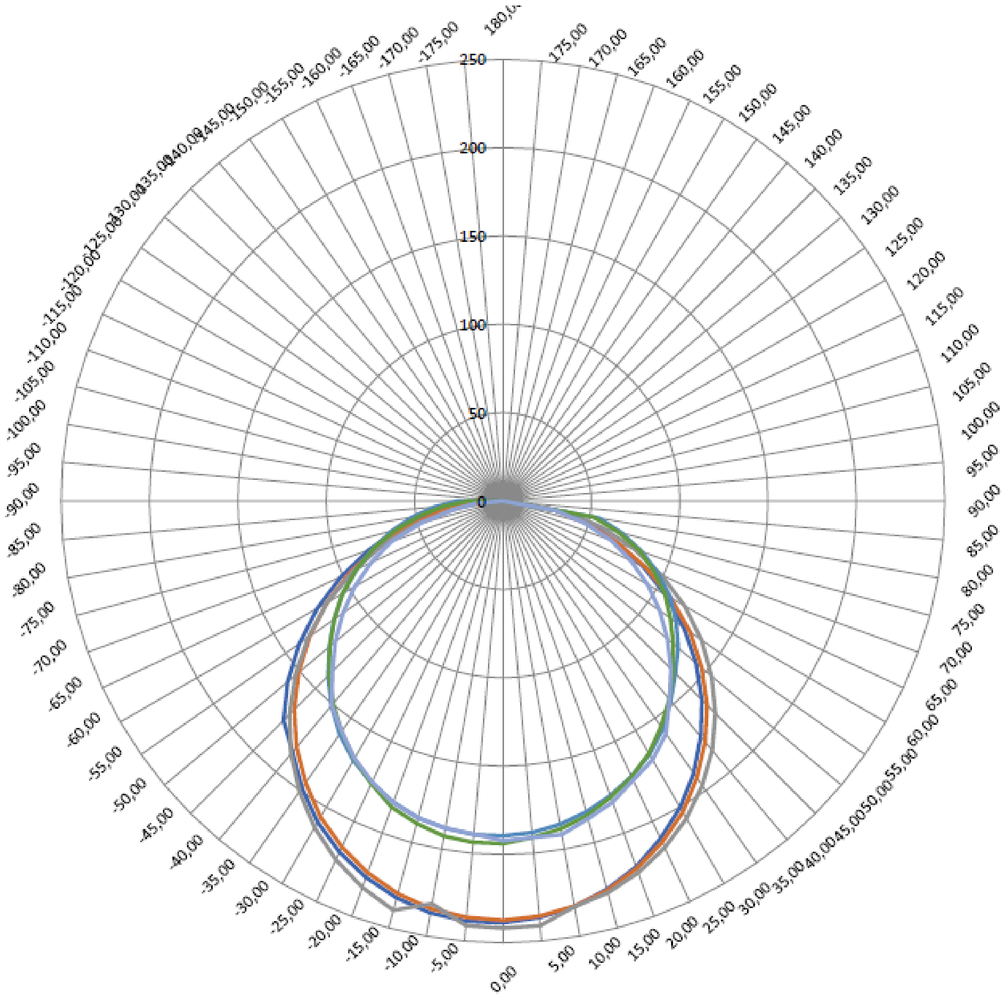
Ideal optical diffuser

Light transmittance meter is a device used to measure **light transmittance** through optical materials.



Impact of silicone coating

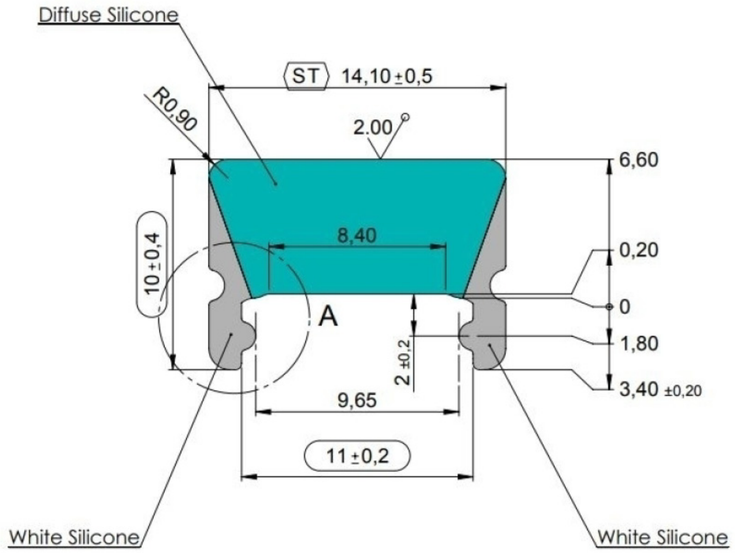
Covering the strip with a silicone layer causes a 20% loss of light flux and does not affect the character of the light distribution. The light flux of the LED strip covered with silicone is about 20% less than that of the strip without a coating.



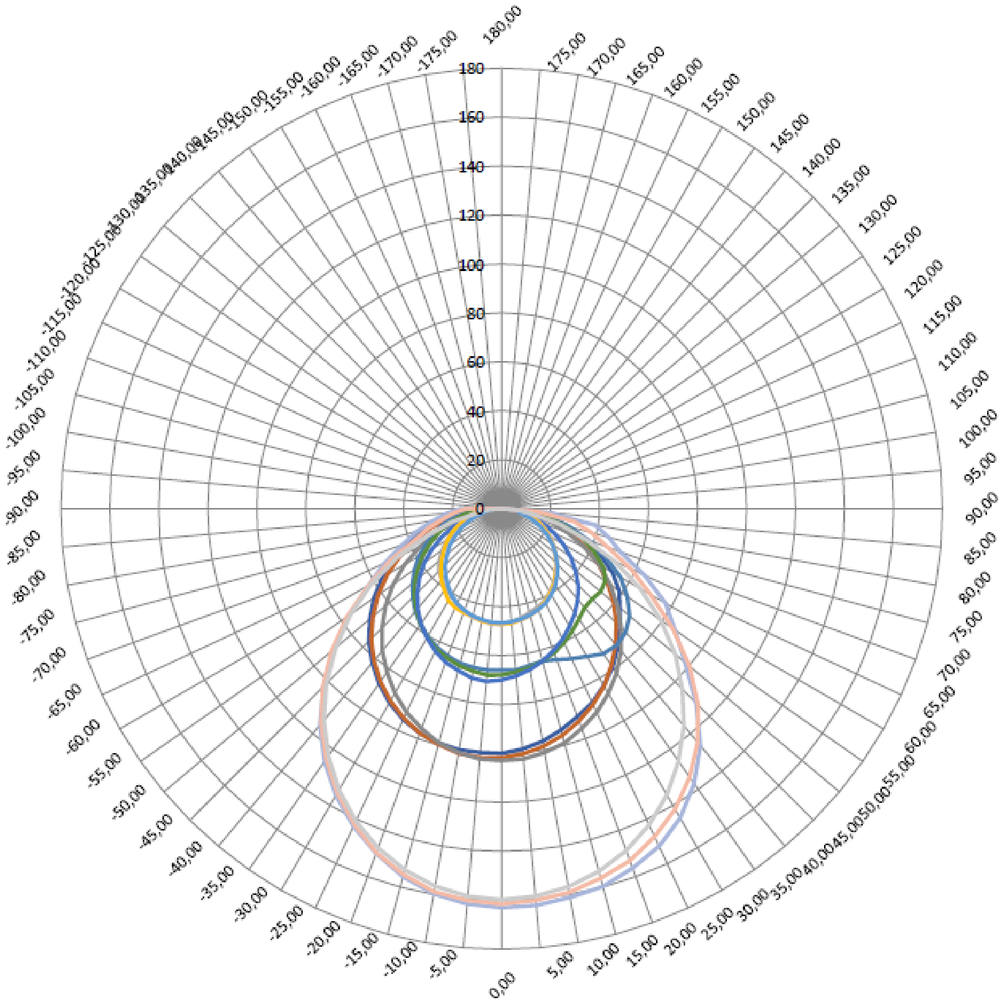
Measurement of the luminance of an LED strip with a silicone coating (2mm thickness of Elastosil R4305/60)

Additive TiO2

The LED strip from the previous measurement was then equipped with various types of silicone profiles containing TiO2 at concentrations of 1, 5, and 10%. In all measurements conducted, a sharp decline in luminance in any direction was observed compared to the luminance measurements of the LED strip without a cover.

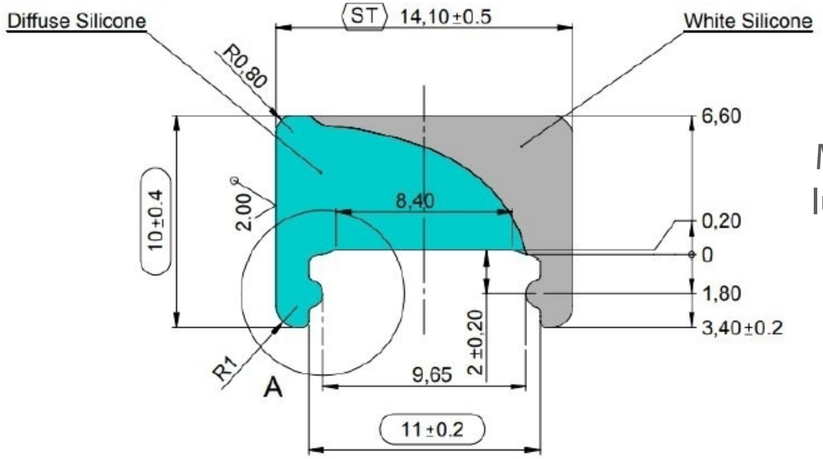


Measurement of the luminance of an LED strip placed in silicone profile with TiO2

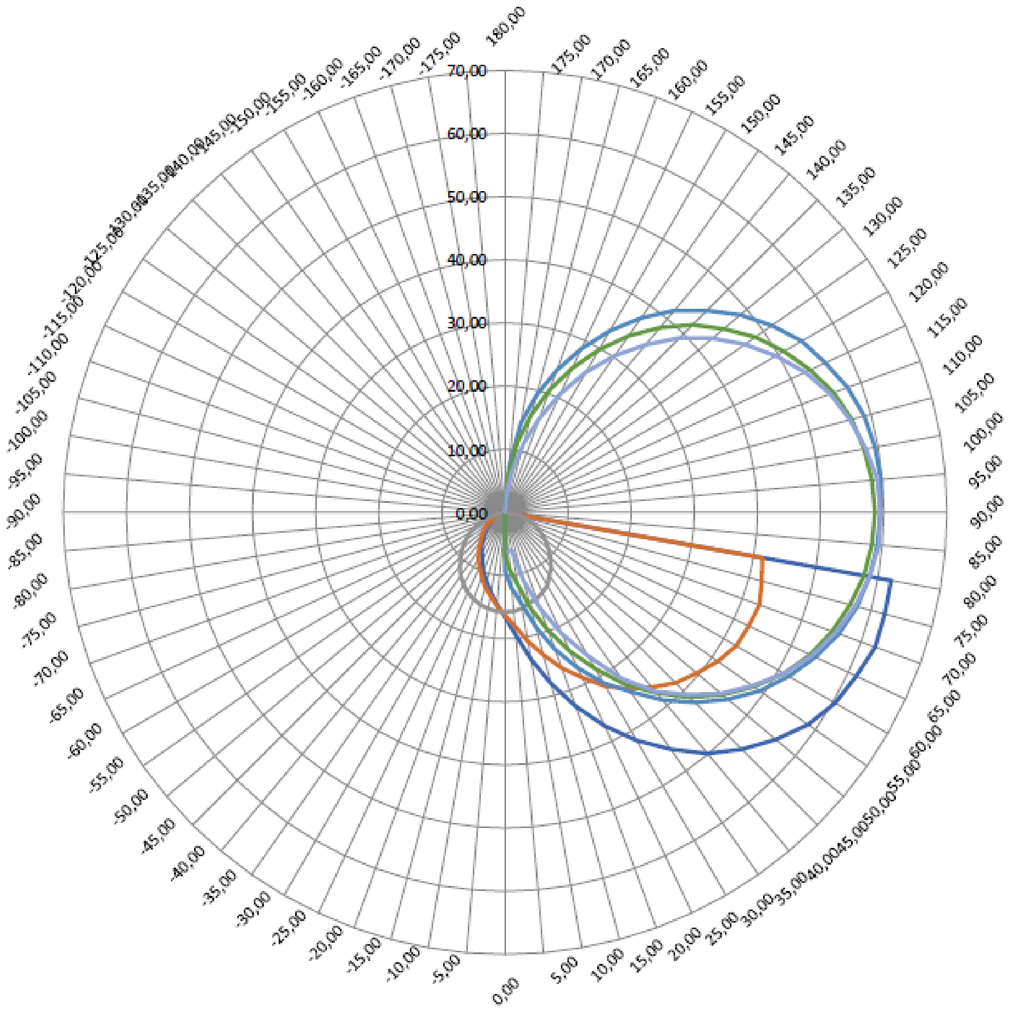


Additive Al2O3

The maximum luminance occurs at an angle of 70-90 degrees from the direction of maximum lminance of the bare strip. This is due to the structure of the silicone profile and the chemical composition of its layers. The measured maximum luminance value is 62.4 cd, which is nearly 68% less than that of the 'bare' strip. The decrease in emitted light flux also amounts to about 70%.



Measurement of the luminance of an LED strip placed in 2K silicone profile (reflective layer containing 20% TiO2, while the diffusive layer contained 0.3% Al2O3)



Additive Glass Microspheres

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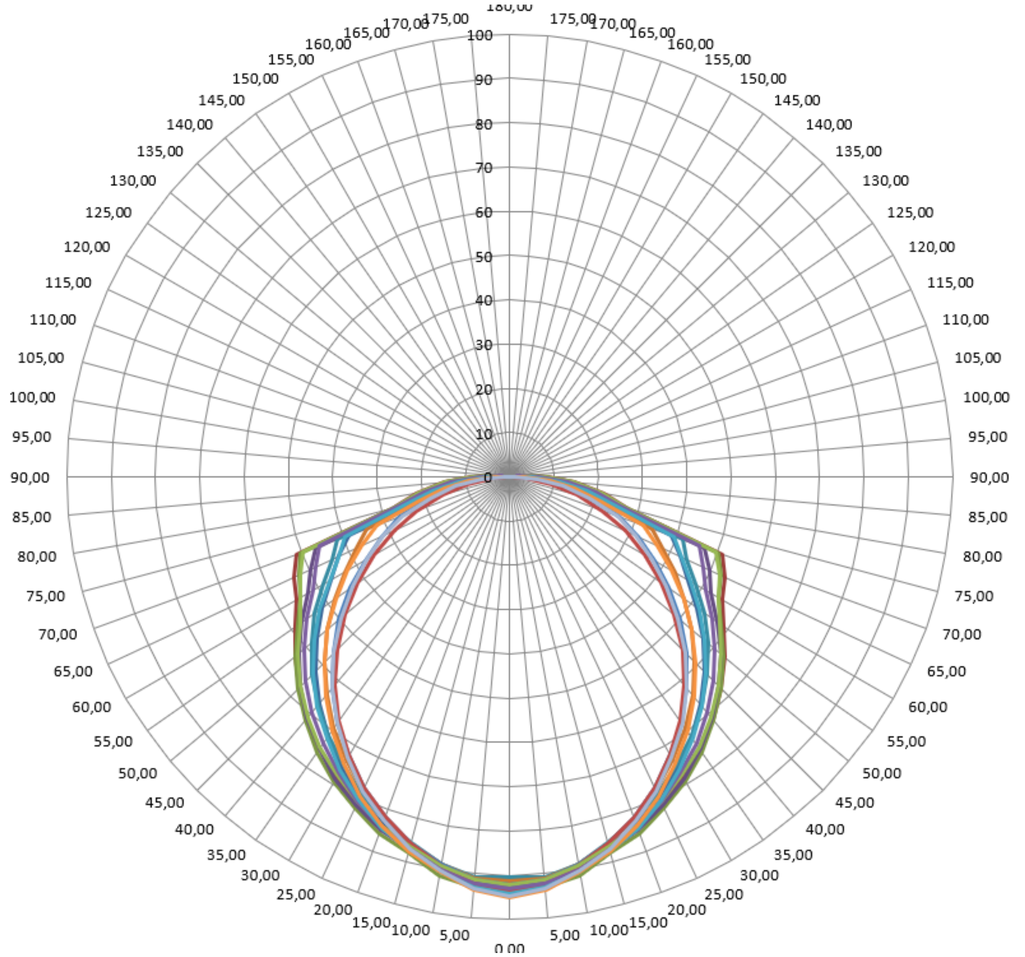
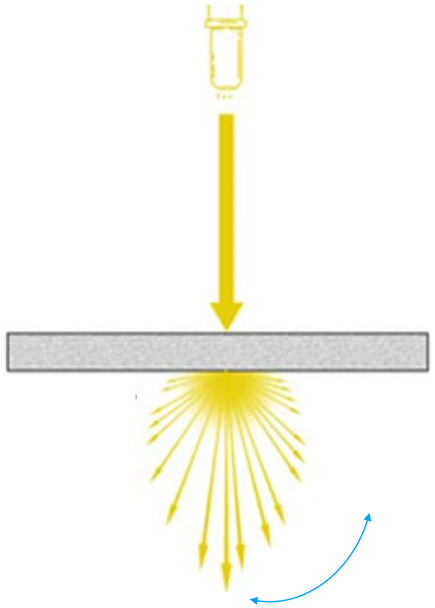
Elastosil R 4305/40 silicone compound (containing 10 percent glass microspheres) has a **density of 0.8 g/cm³.** Please note the different character of the light flux when using this additive.



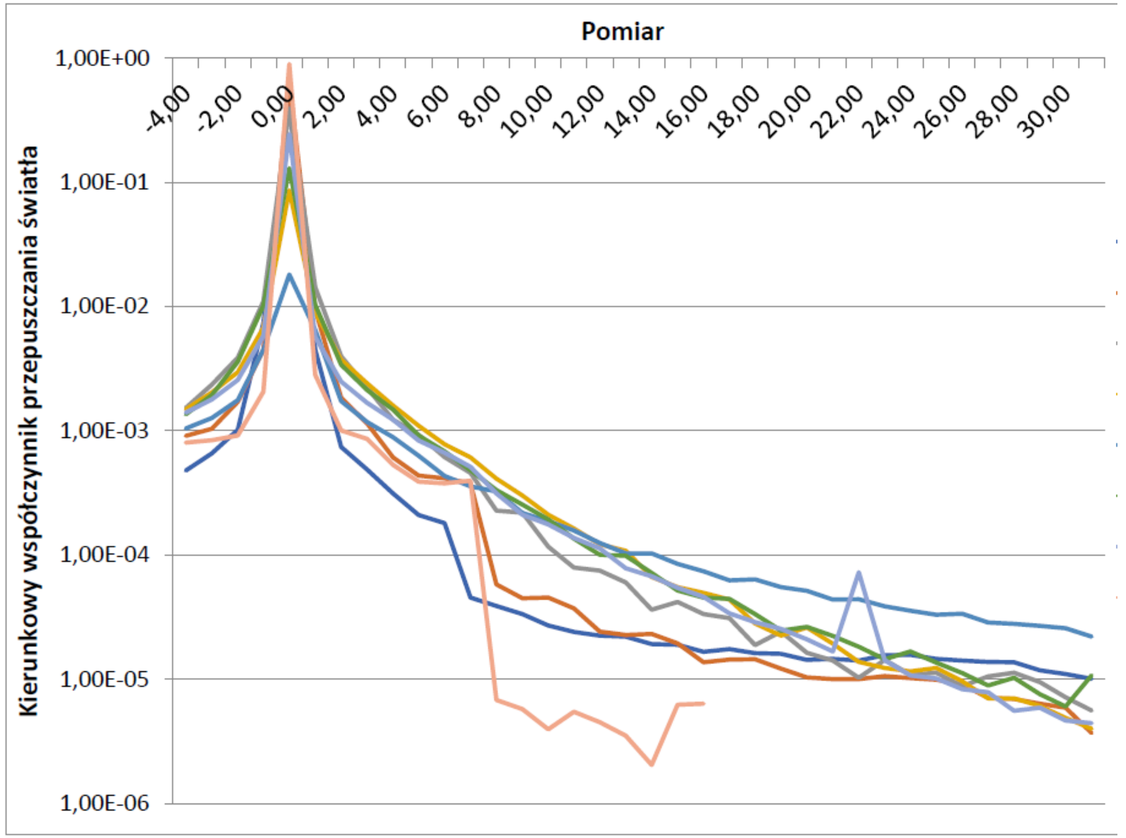
Measurement of the luminance of an LED strip placed in 2K silicone profile (reflective layer containing 20% TiO2, while the diffusive layer contained 10% glass microspheres)

Directional light transmission coefficient

Specific raw material with specific vulcanization temperature can already cause initial diffucion without any additives (light blue line)



0-30 °



Initial diffusion without additives

Conclusions

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Here are the main advantages of placing LED strips in silicone profiles:

1.Significant reduction in the brightness of the emitted light.

2.Reduction of the phenomenon known as hostile glare.

3.Silicone profiles with scattering additives homogenize the light.

4.Hermetic sealing of the LED strip protects it from adverse environmental influences.

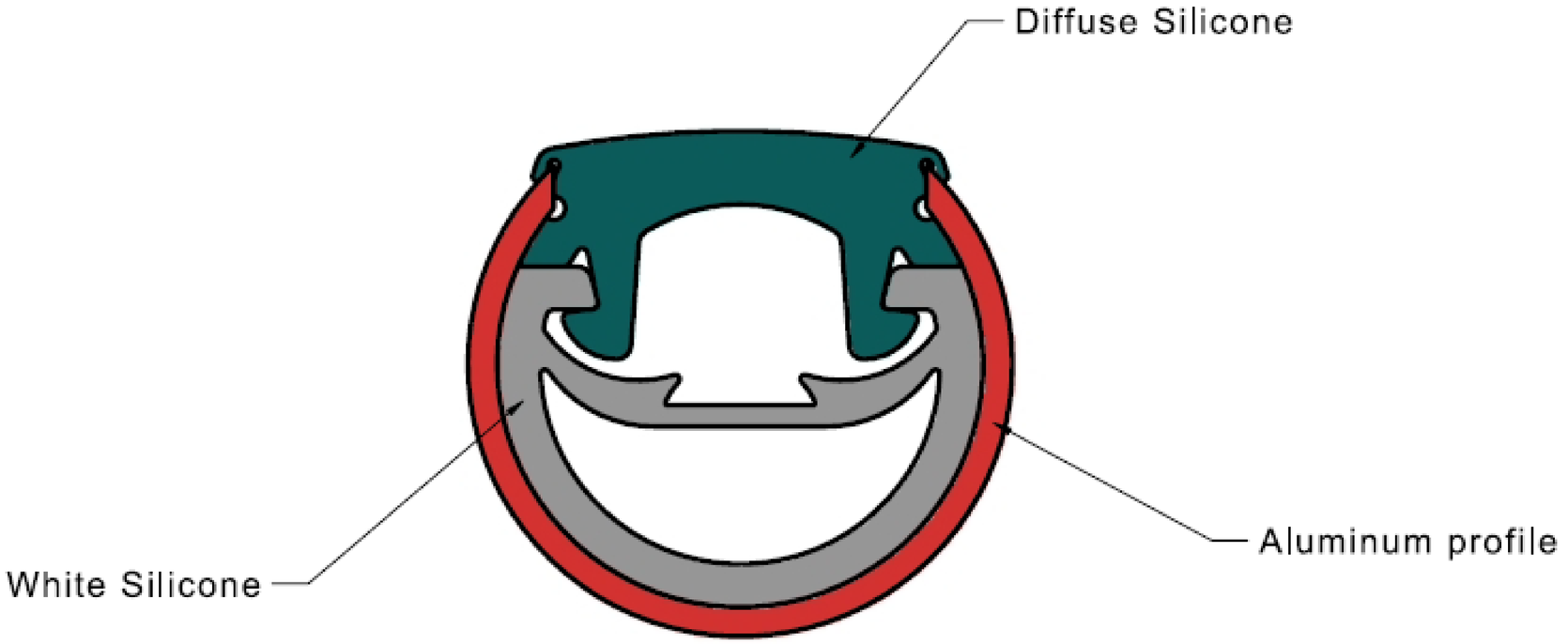
… and few disadvantages:

1. Using a silicone layer leads to a reduction in the light flux from the light source by up to 70 percent.

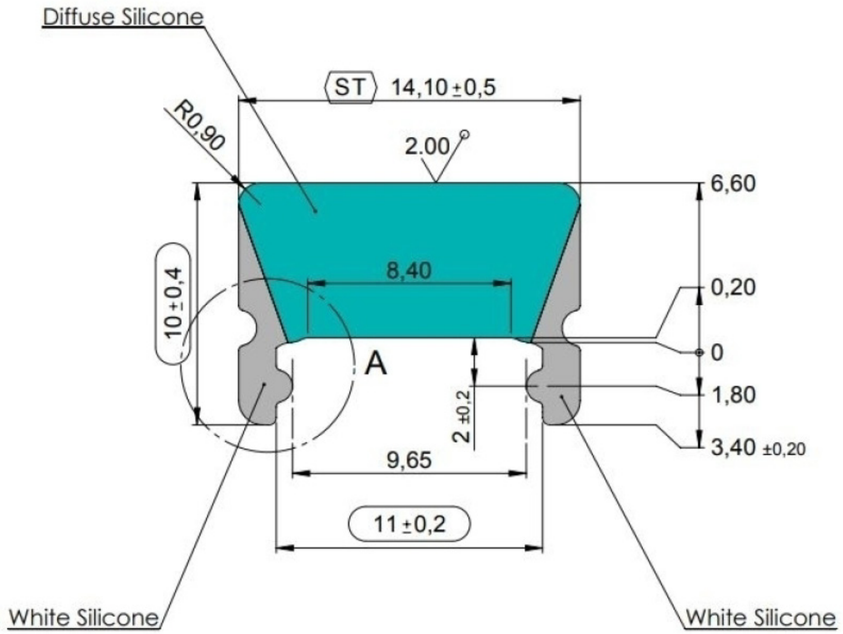
2. Due to its electrostatic properties, silicone easily attracts dust

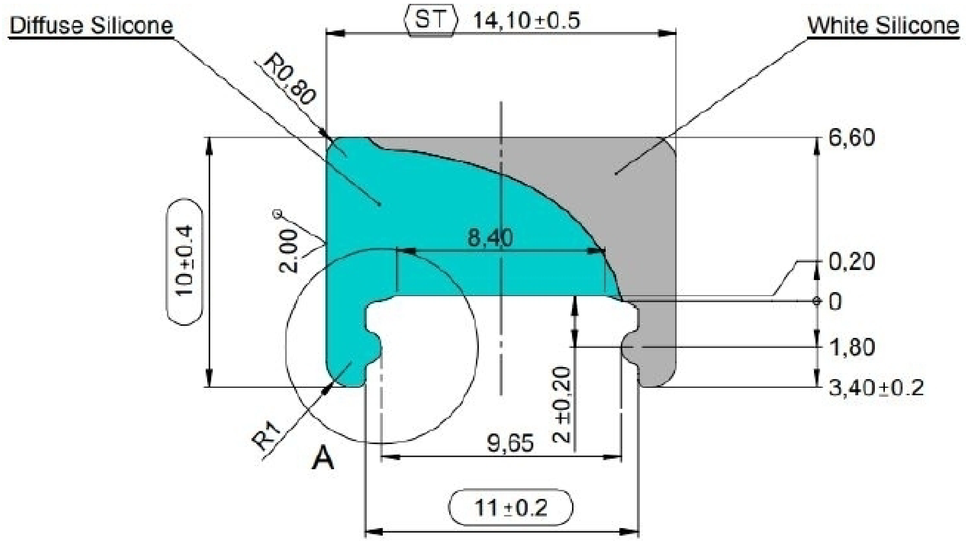
3. Due to the loosely packed molecular structure of silicone, it easily absorbs organic contaminants, which can lead to change the color of the light.

Silicone profiles for LED strips

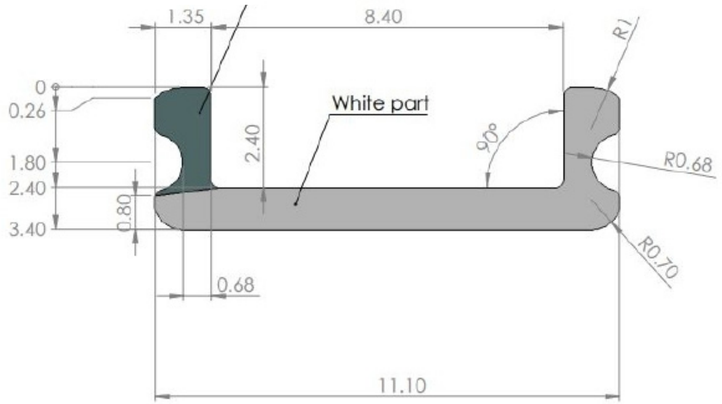


Silicone profiles for LED strips

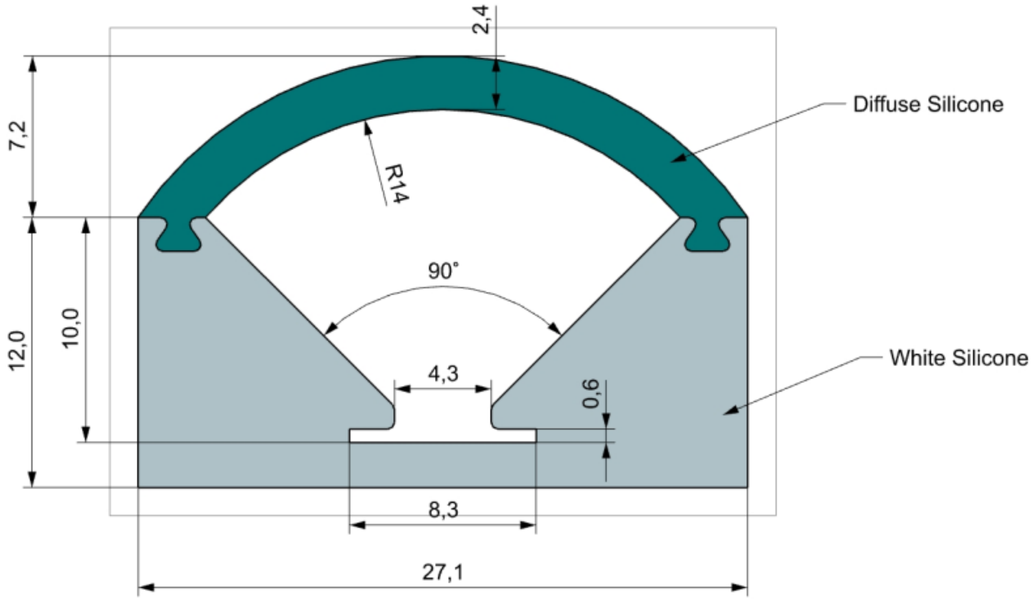


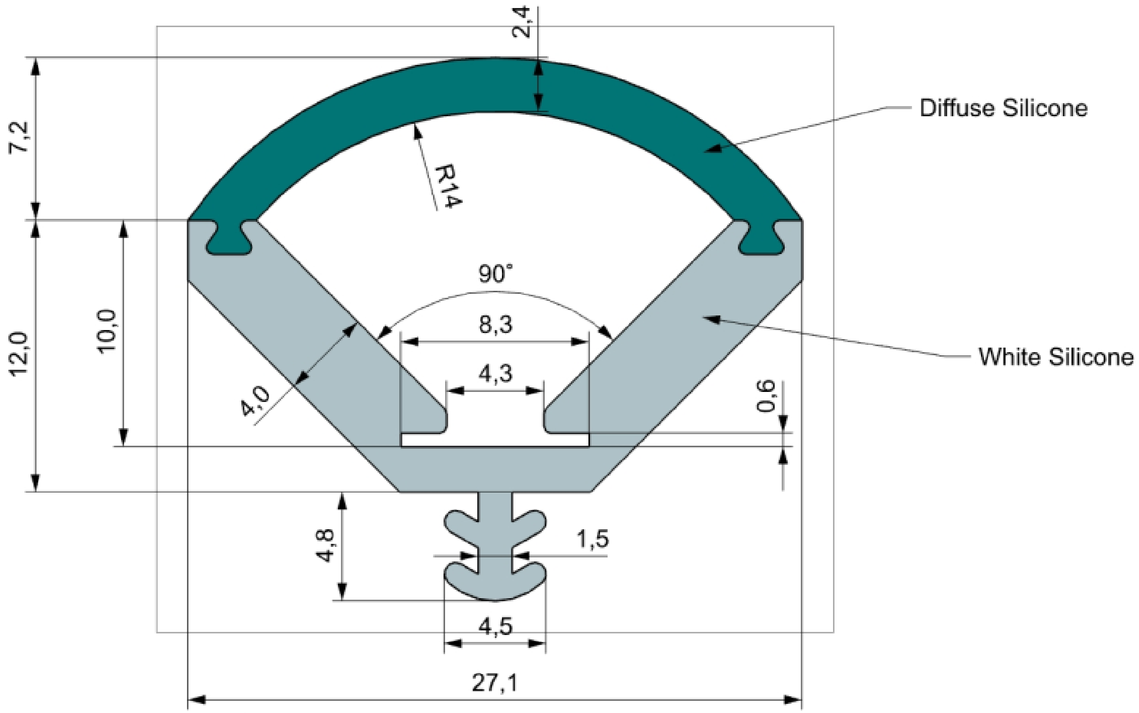


Diffusive part



Silicone profiles for LED strips

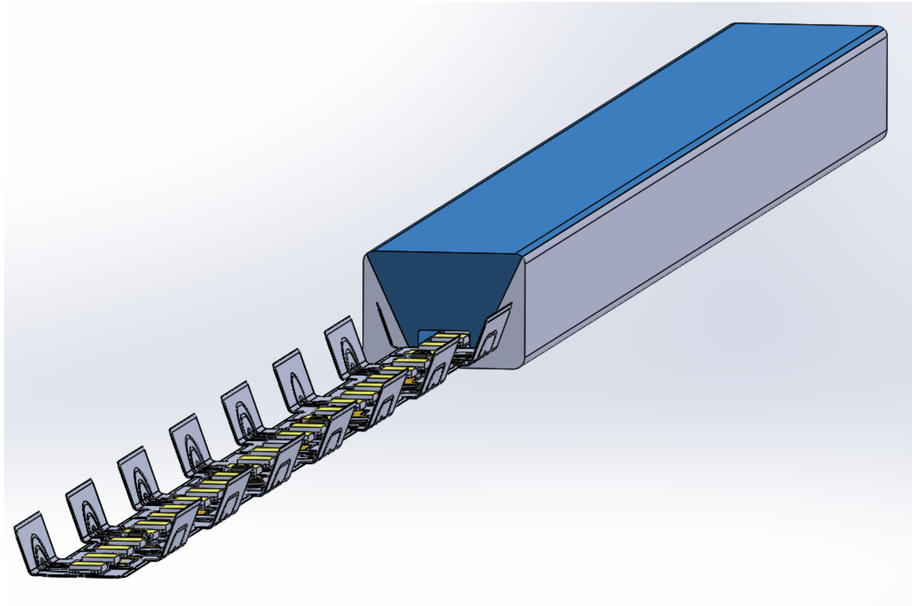


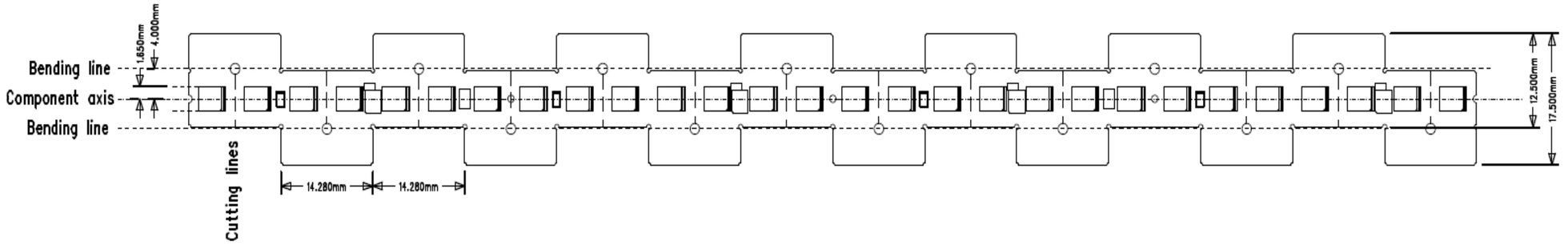


Design of a new profile

New profile 2K project with LED strip

(FPCB- flexible printed circuit board)





Design of a new profile

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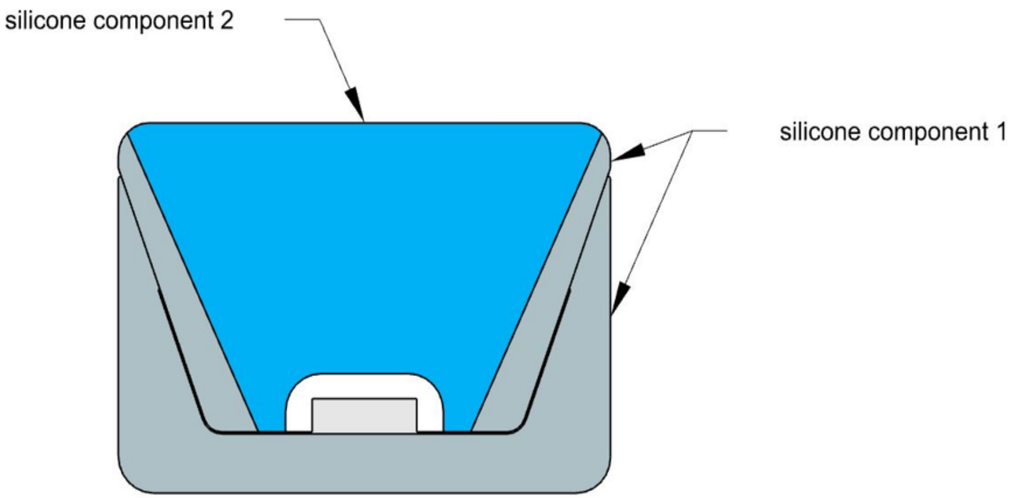
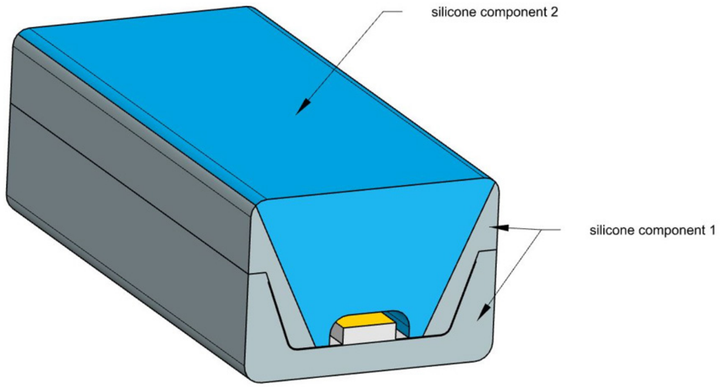
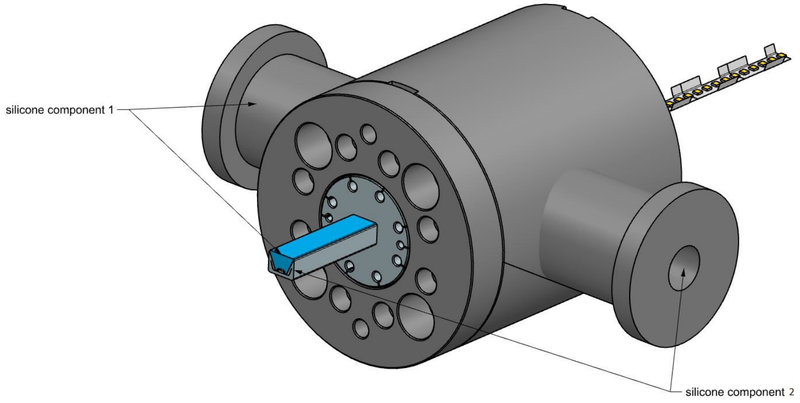
Three steps process:

- 2K profile extrusion
- 1K profile extrusion
- LED strip gluing to both extruded parts



One step process (?):





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Thank you very much

for your attention

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