Light stimulated healing of chronic wounds by use of optical waveguides and light management microstructures

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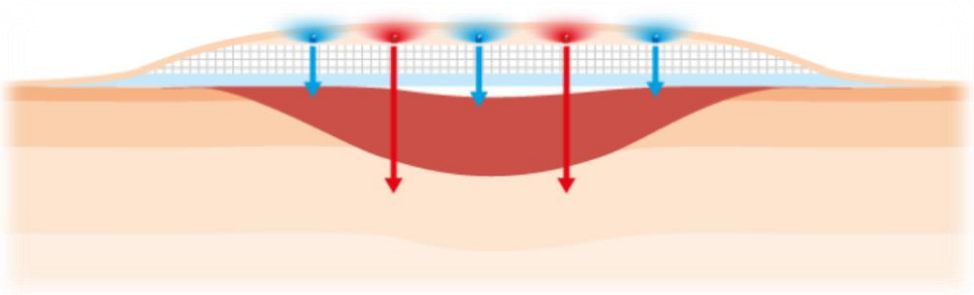
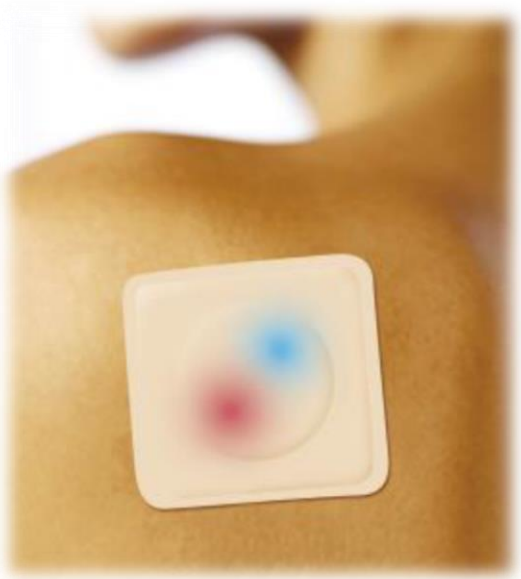




Project Facts

- **Duration: 02/15 – 01/18**
- **Project Costs: 3 Mio €**
- **Co-funded by the European Union as a H2020 Research & Innovation Action**
- www.medilight-project.eu

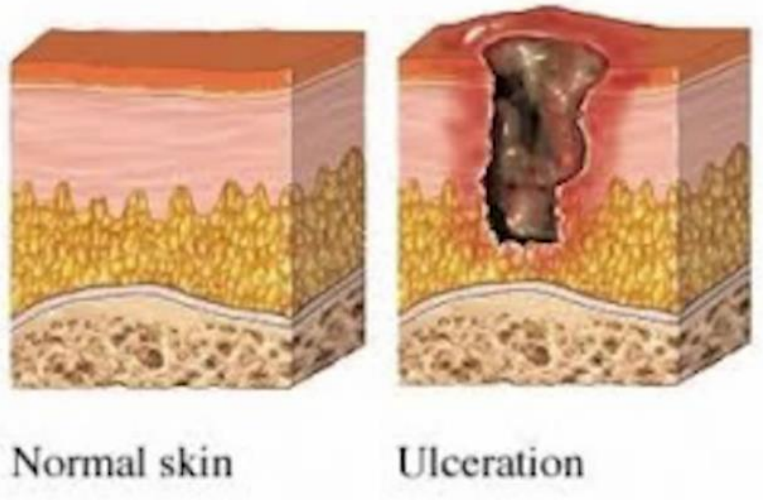
The project MEDILIGHT receives funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 644267.

Health Facts…

- Chronic wounds caused by diabetes
- 170 Mio people worldwide affected
- Costs are 40 billion € per year
- Difficult to treat
- Therapeutic effect of visible light has been proven

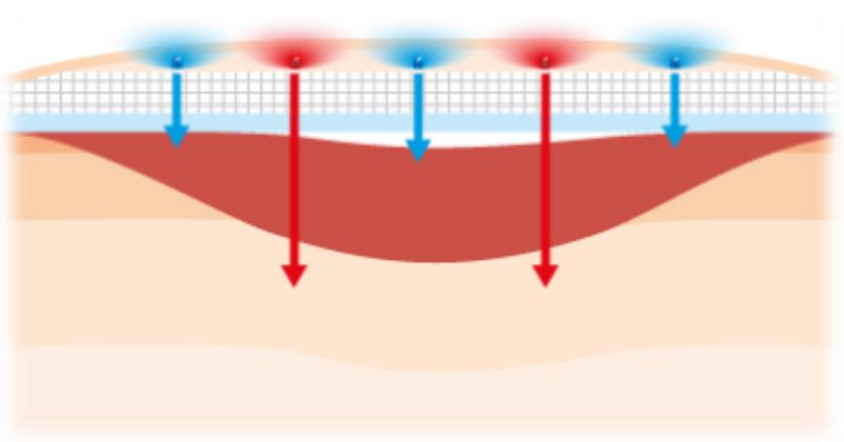
➢ Red light (620-750nm):
growth of keratinocytes and fibroblasts in deeper layers of the skin

➢ Blue light (450-495nm):
antibacterial effects at the skin surface



http://americanfoot.com

MEDILIGHT



Medilight Device

consists of two parts:

A) electronic module
B) wound dressing (**disposable**)

A: Electronic Module

- Light sources
- Beam shaping optics
- Controller & Data Acquisition
- Data transmission unit
- Rechargeable battery

B: Wound Dressing

- Flexible large area optical waveguide
- Light management structures:
  - diffraction gratings (incoupling blue and red)
  - diffusor (homogenization, outcoupling)
- Integrated sensors
  - temperature
  - blood oxygenation

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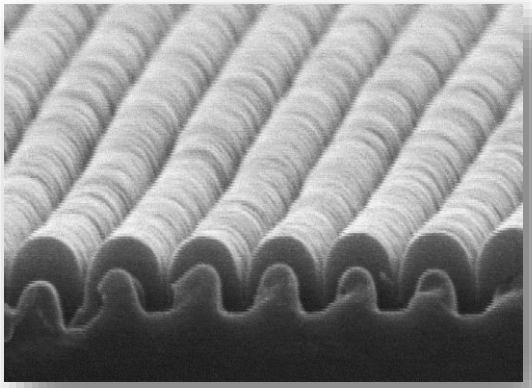
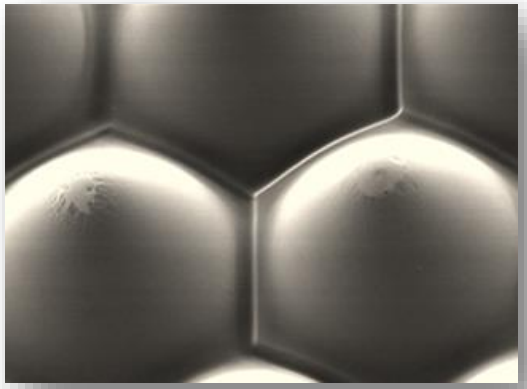
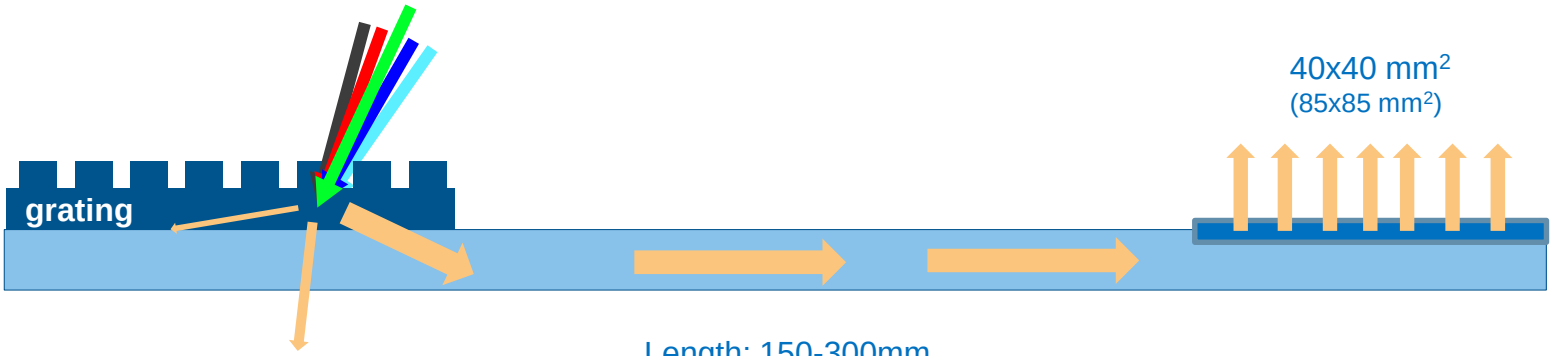
Waveguide Design



Diffraction grating (light incoupling)



Diffusing microstructure
(light outcoupling and homogenization)

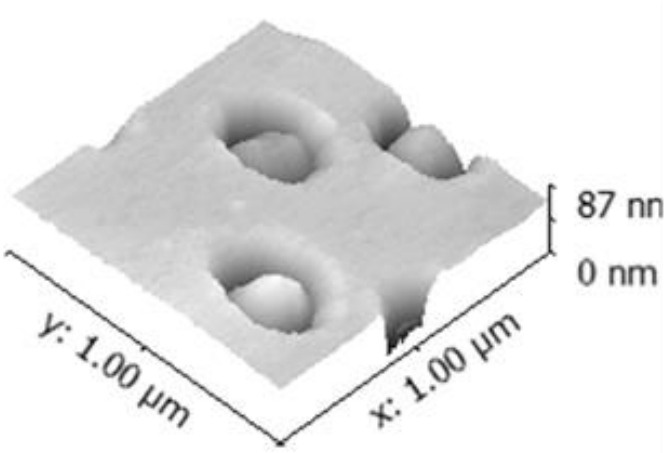


Length: 150-300mm

Selection of Waveguide Material

The following properties are desired:

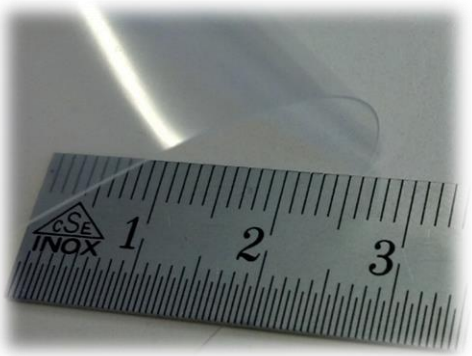
- high optical clearness
- low scattering
- good surface quality
- highly flexible / bendable
- not sensitive to humidity (swelling, etc.)
- easy to be embossed / injection molded

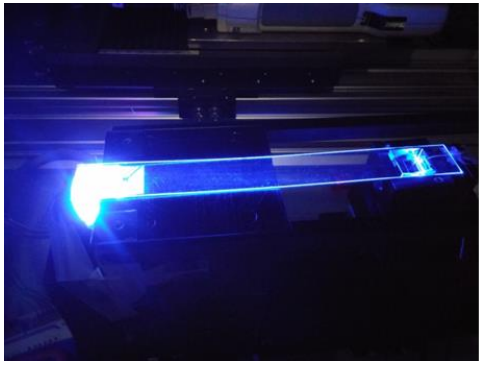


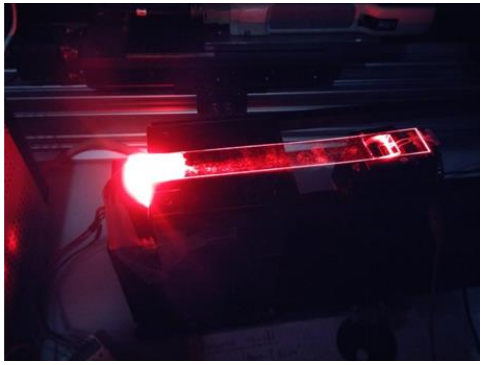
Surface of a measured PMMA sample

- Different materials were tested:
  PET, PMMA, PC, COP (different types of each)

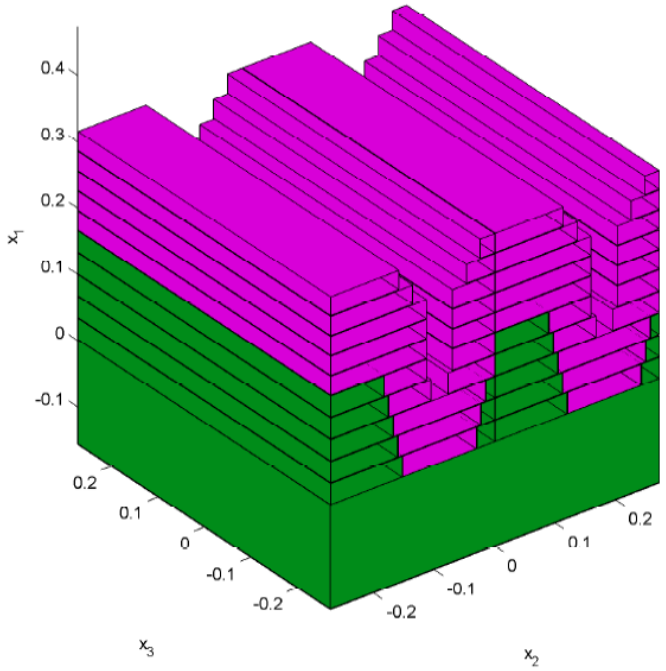
- **Cycloc olefin polymer (COP) has been selected**

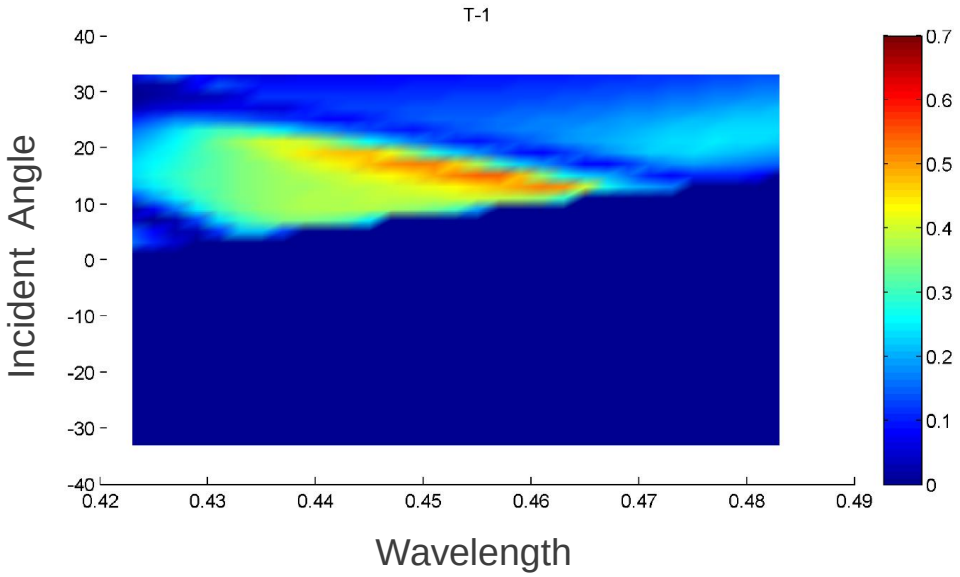






Incoupling Grating (Blue) – Design by RCWA



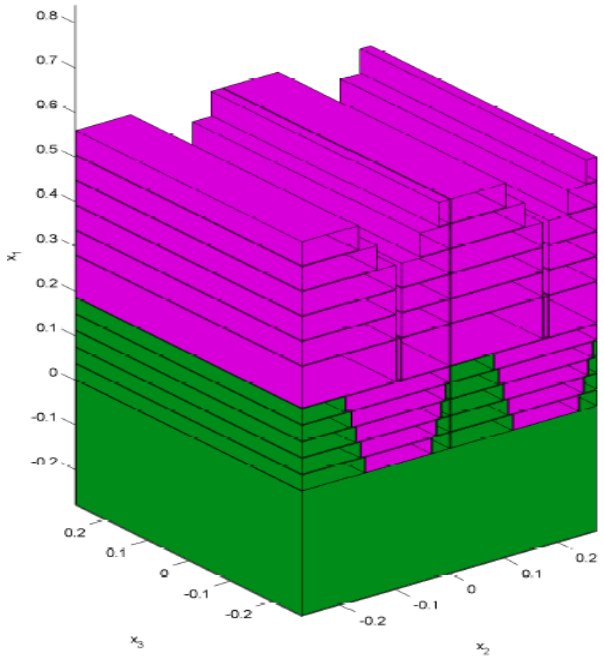


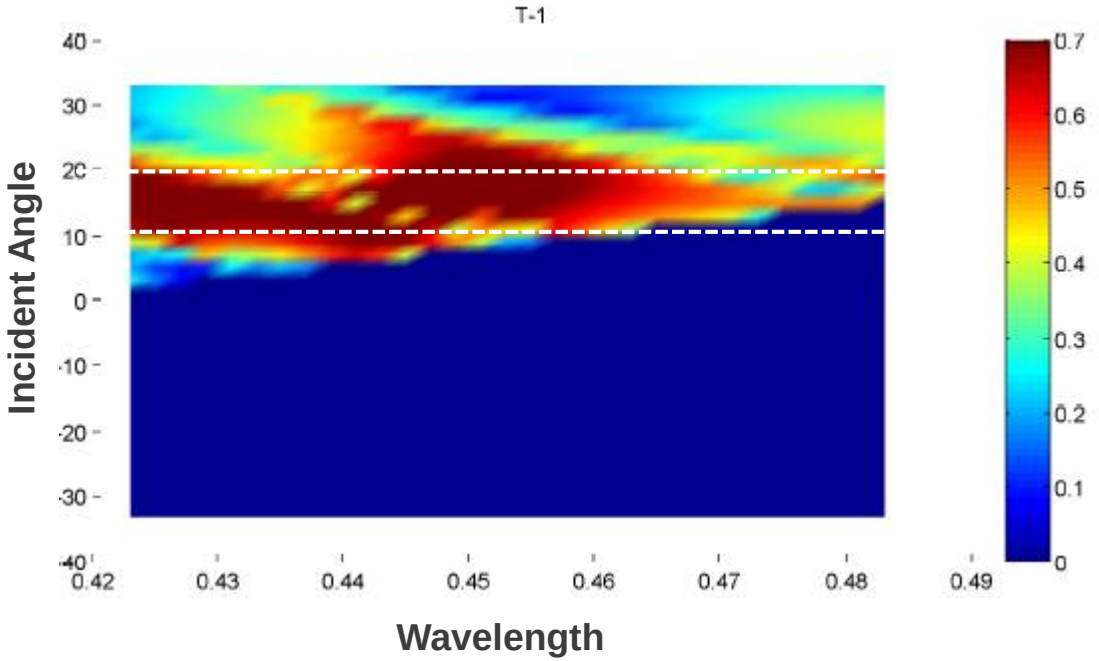
- **Theoretical maximum diffraction efficiency in T-1 is 50%** (at 440-465nm)
- **25% diffraction efficiency were measured** (fabricated profile deviated from simulation model)

Measurement

Angle (deg)	T-1
11	24.6%
12	25.0%
13	**25.3%**
14	24.8%
15	24.5%

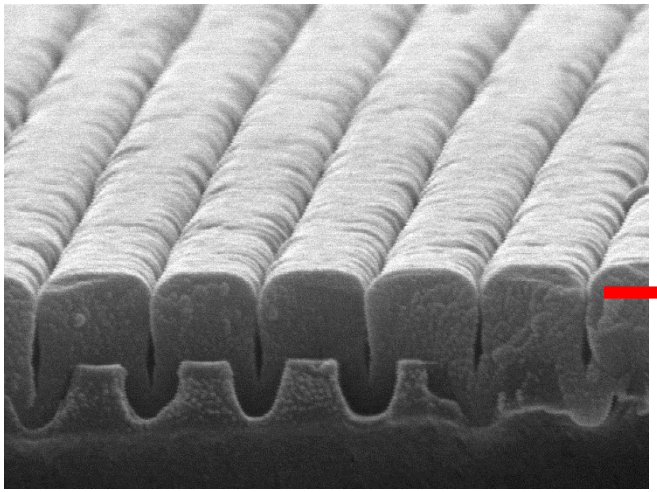
New Design with Increased ZnS Coating





- ✓ Theoretical **maximum** was increased **up to 70% at 10-20°**
- ✓ **Angle dependence is reduced**
  (higher aceptance angle)

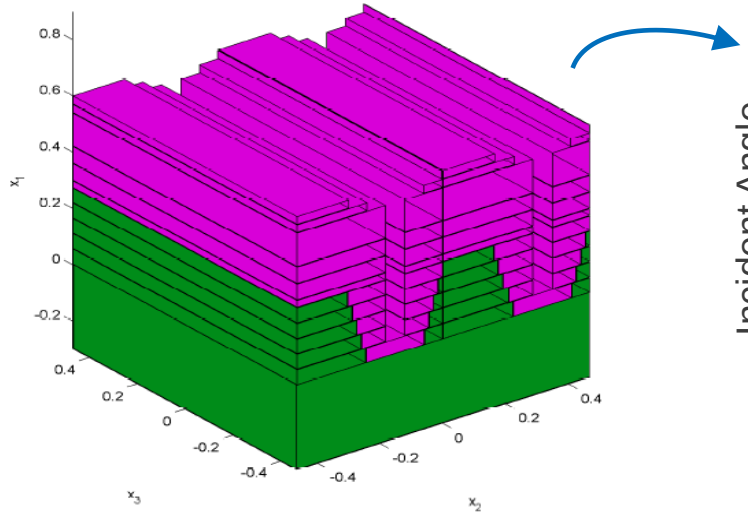
Fabricated Grating (for Red)

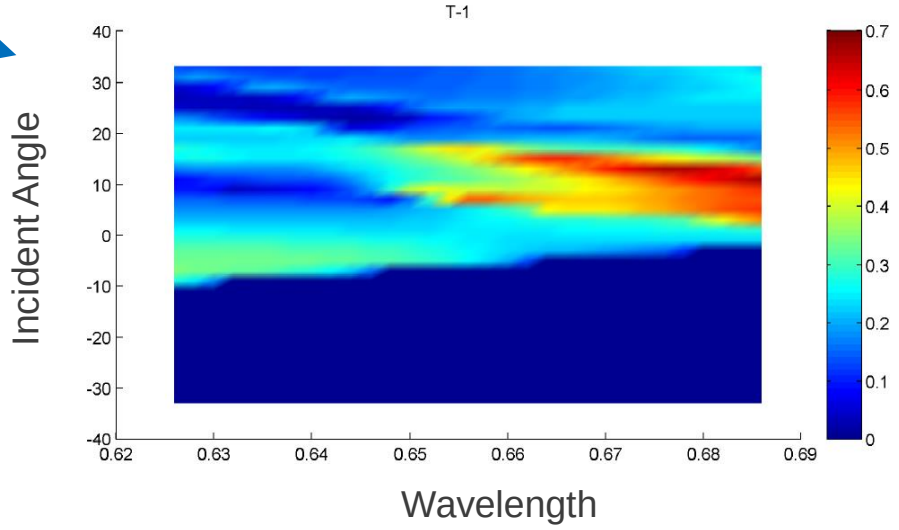


Measurement

Angle (deg)	T1
-5	0.0%
0	0.6%
3	7.7%
7	20.1%
8	36.6%
9	**60.9%**
10	**61.0%**
11	53.3%
12	45.4%
13	38.2%
14	35.3%
15	30.4%

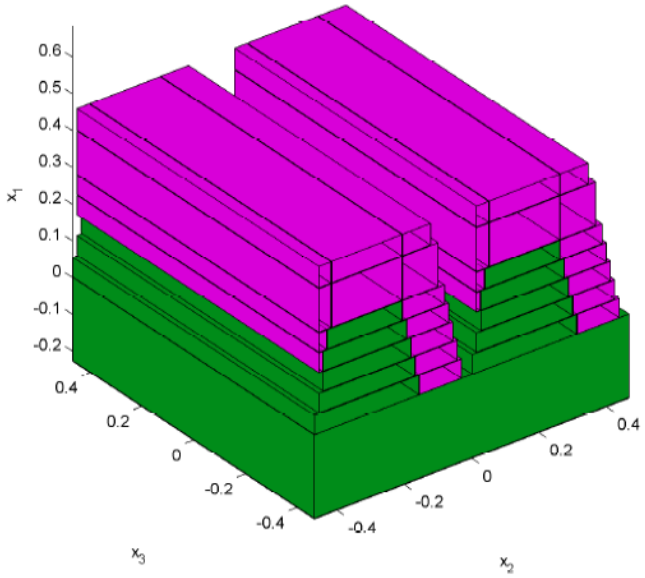
61% efficiency measured

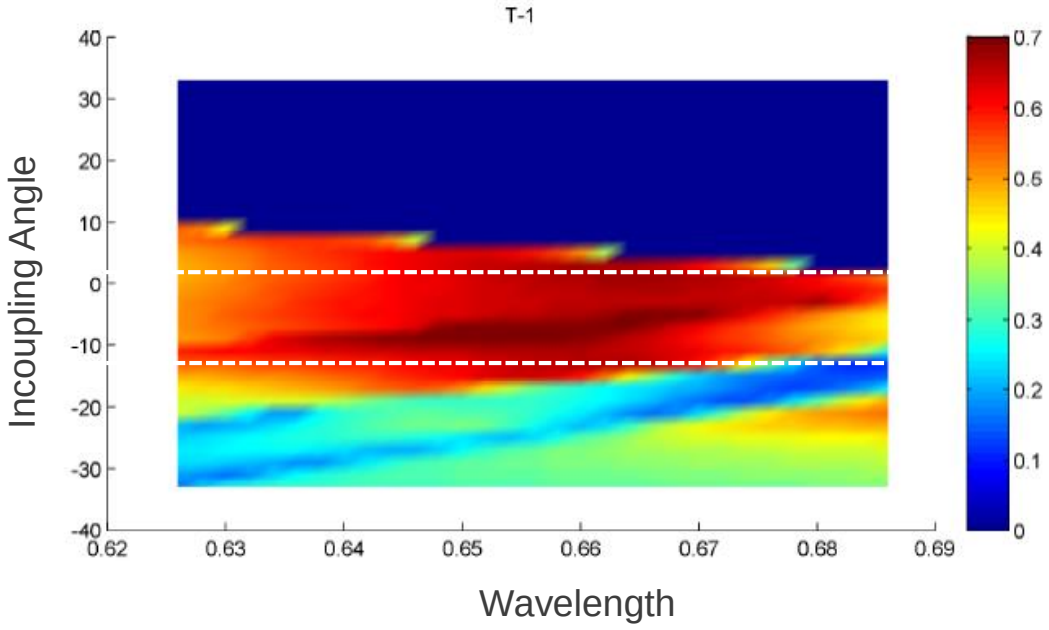




Further Improvement: Angular Evaporation of ZnS

- Provides a maximum efficiency of T-1 diffraction order at **normal incidence** (α_{in} = 0°) with a **high angular tolerance**

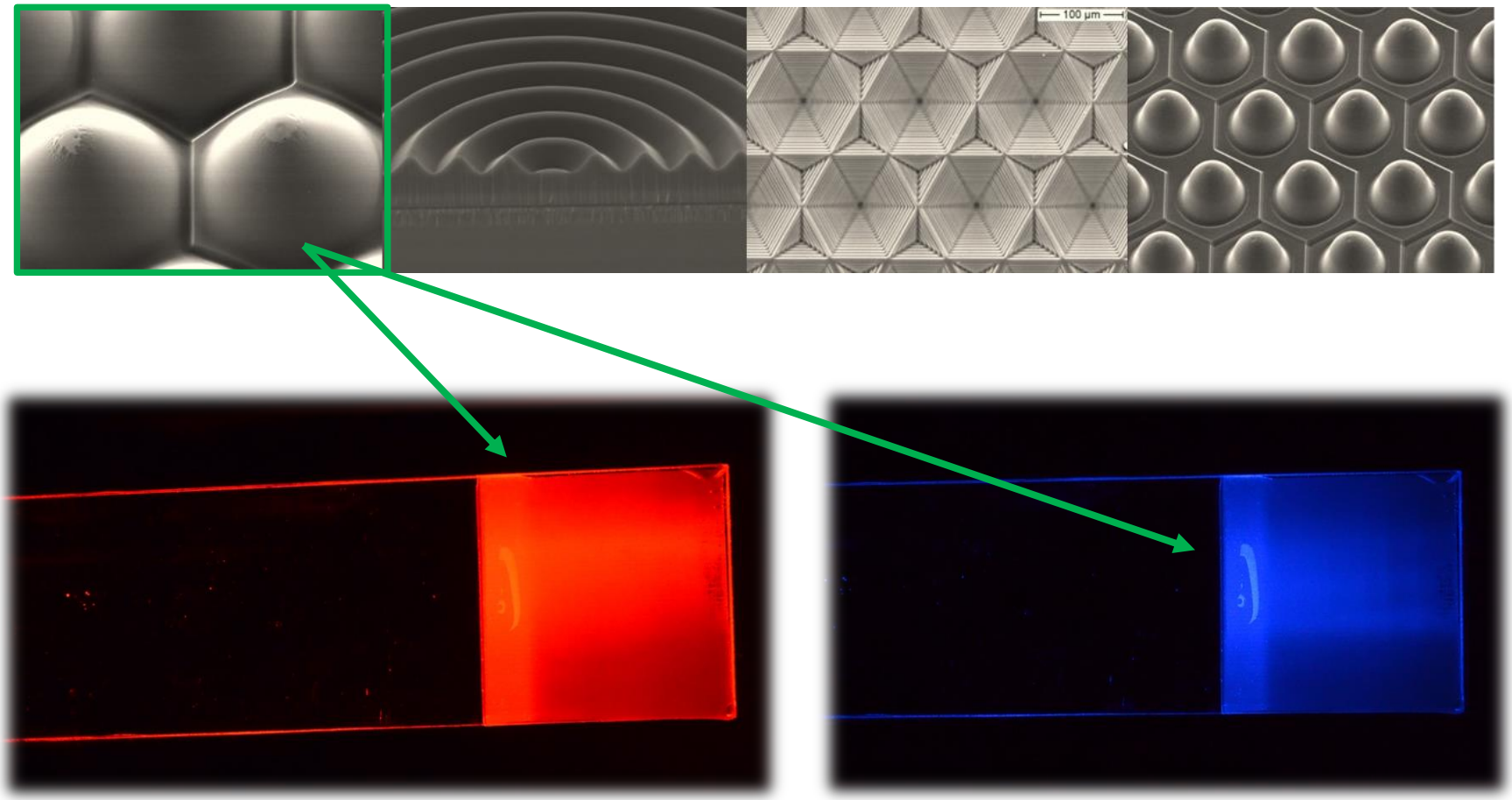




Fabrication is ongoing and the compliance with the calculations still needs to be evaluated

Homogenizing Diffusor

Different diffusor designs were developed and tested:



Challenges & Outlook

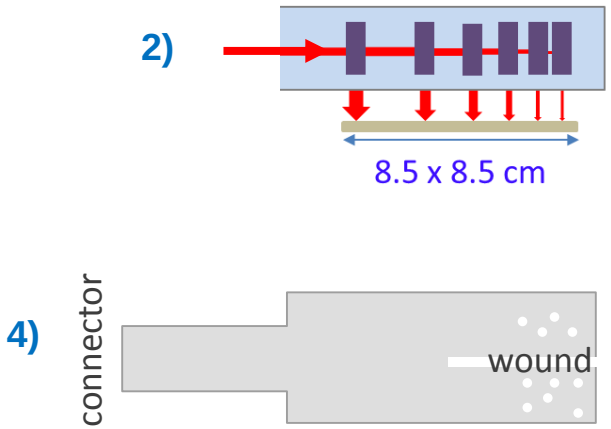
1. **Waveguide efficiency**: Currently we reach 15-20%. To be improved.

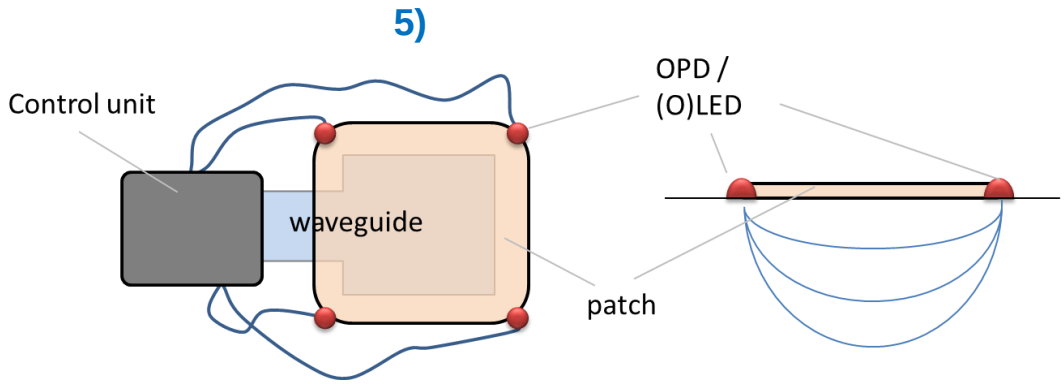
2. **Homogenous illumination** of the wound area
   - ➢ Suitable patterning of the diffusor matching the used light sources and the waveguide geometry

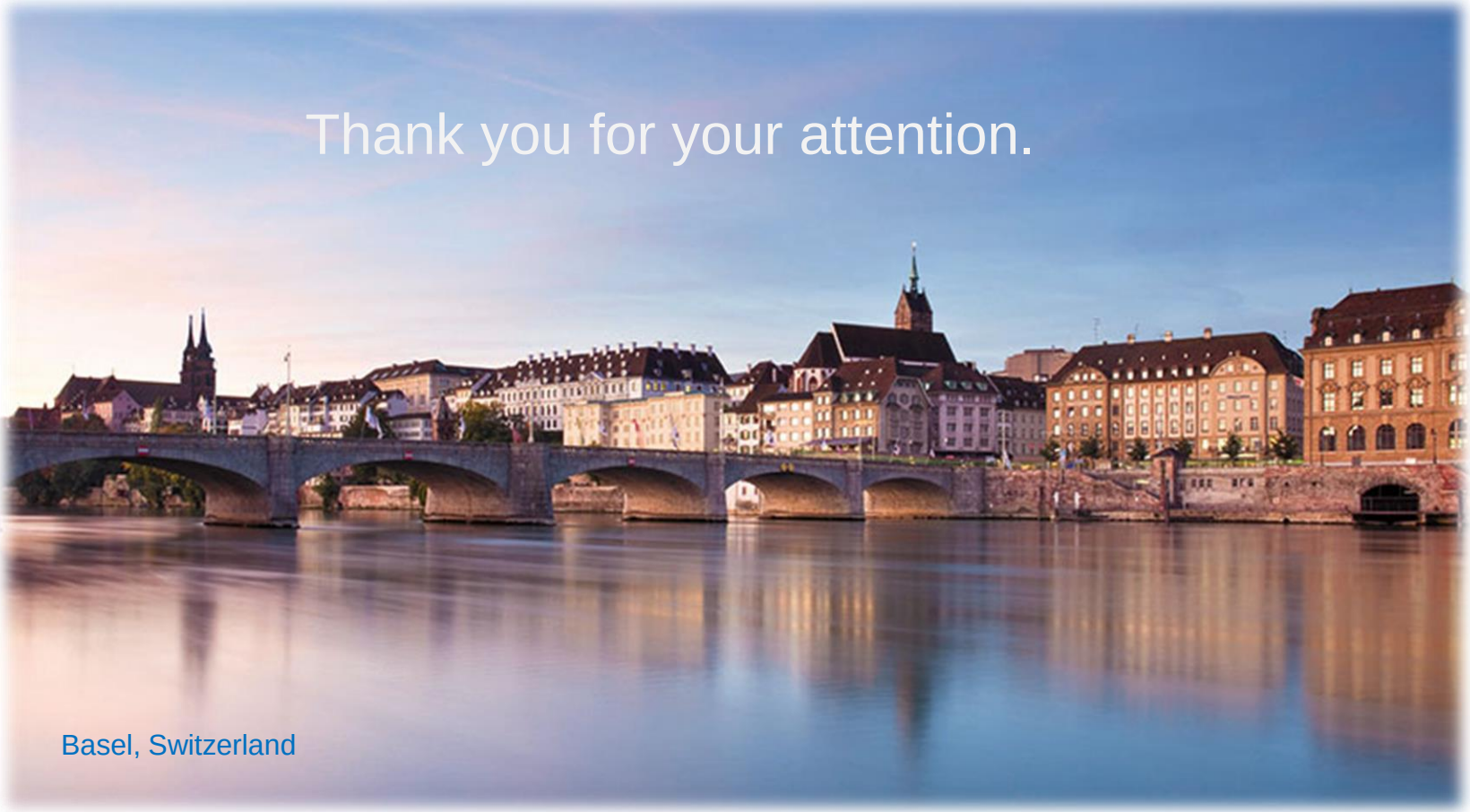
3. **Waveguide cladding**: nanoporous layer under development

4. **Waveguide shape:** wholes, «fingers» allowing the wound to breath

5. **Integration of sensors** (temperature, blood oxygenation)






Thank you for your attention.
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