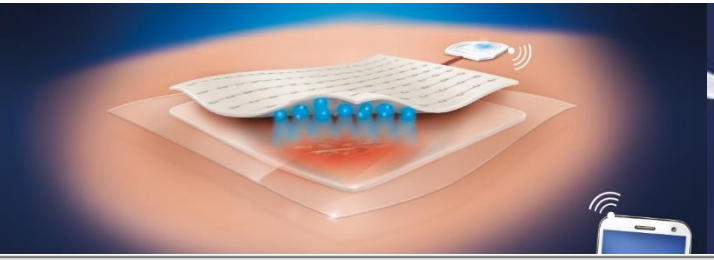
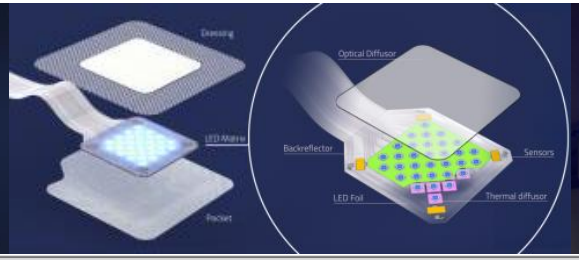
SPIE. PHOTONICS WEST BIOS

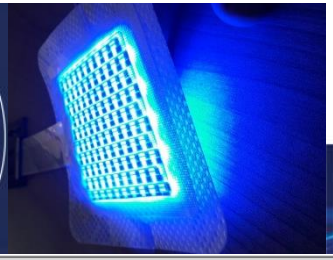
Smart wearable system for light treatment of chronic wounds

R. Ferrini, D. Kallweit, A. Klapczynski, N. Kuch, A. Becker, N. Gretz, K. Michaelides, J. Steinbrunn, M. Bouschbacher, R. Waite, M. Seckel, and D. Manessis

SPIE Photonics West – BIOS, 29.01.2018







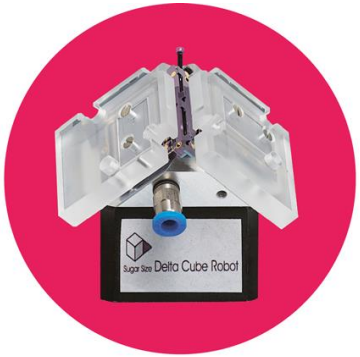
MEDILIGHT

HORIZON 2020

csem

Booth #5658

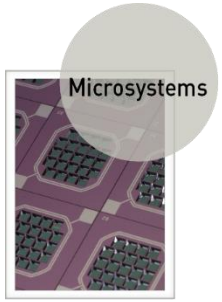
Our mission



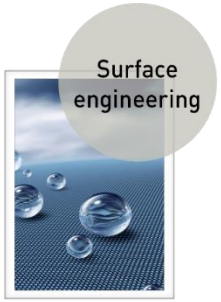
Development and transfer of microtechnologies to the industrial sector – in Switzerland, as a priority – in order to reinforce its competitive advantage.

- Cooperation agreements with established companies
- Encouraging the creation of start-ups

Technology platforms to foster innovation

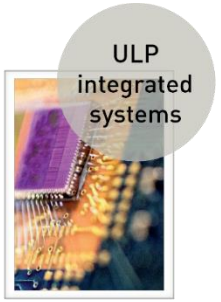


- MEMS
- Functional packaging
- Advanced micro-manufacturing

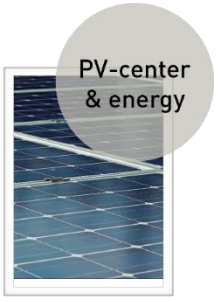


- Printable electronics
- Nano-surface engineering
- Bio-surface engineering

- Automation
- Scientific instrumentation
- Medical technologies



- Vision systems
- System-on-chip
- Wireless



- PV cells & Modules
- Energy systems
- Emerging & thin-film PV

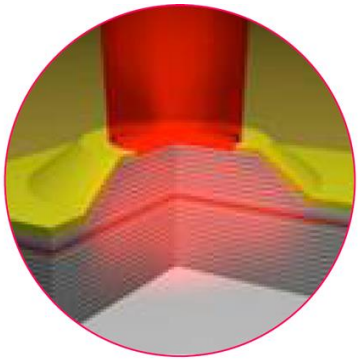
- Industry 4.0
- Advanced manufacturing
- IoT
- e-health
- e-energy

Successes of our startups

- Over 15 years, 43 new ventures (start-ups and spin offs)
- More than 400 jobs created in Switzerland

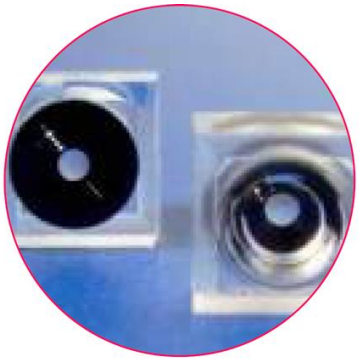
Pulseon, Limmex, Neurobat

commercial, reliable connected devices



II-VI Laser Enterprise (Oclaro / Bookham)

mass production of +50 mio laser diodes / year



Heptagon member of the ams group

Over 2 billion units shipped

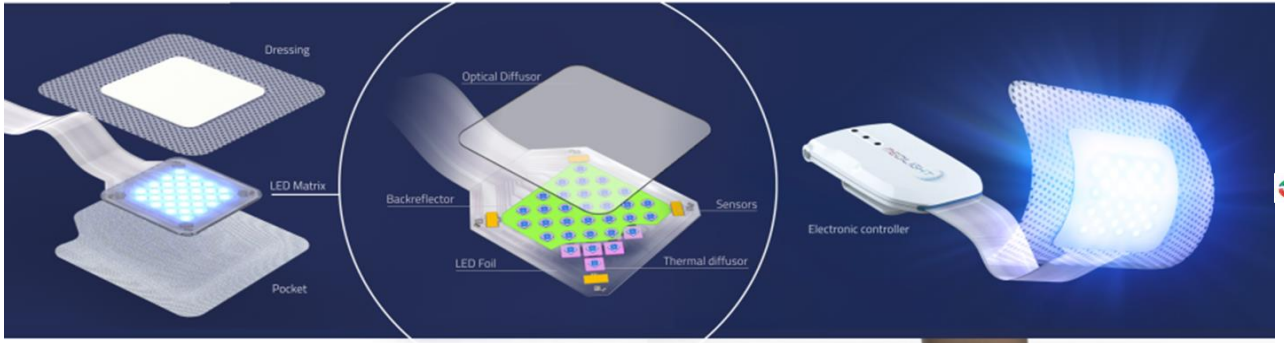
Outline

- The MEDILIGHT project
- Health facts & Motivation
- The MEDILIGHT system
- In-vitro testing
- Conclusions

MEDILIGHT

MEDILIGHT

Miniaturized smart system for light stimulation and monitoring of wound healing



Project Facts

- **Duration: 02/15 – 07/18**
- **Project Costs: 3 Mio €**
- **www.medilight-project.eu**

Health facts & Motivation

- **Acute wounds**: healing time = 20 days
- **Chronic wounds**: healing time = 200 days
  - Significant reduction of quality of life
  - Infections, amputations and even death

- ***In the world***
  - Societal cost = 40 B€ per year
  - Advanced wound care market = 10 B€

- ***In Europe***
  - Societal cost = 10 B€ per year
  - Advanced wound care market = 780 M€

- **SOA:** Therapeutic effects of visible light proven

- **BSOA:** Smart wearable device based on blue light

Diabetic Foot Ulcer

Pressure Ulcer

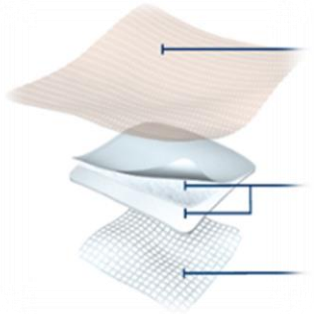
Venous Leg Ulcer

The system

- ✓ Treats chronic wounds with blue light

  Antibacterial & Proliferative

- ✓ Management of patient's exudates
- ✓ Breathability



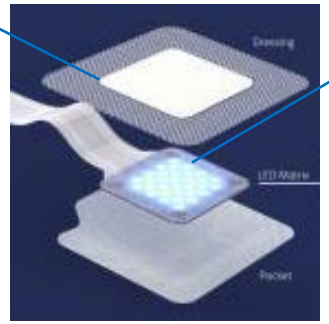
Waterproof backing
- *Breathable*

Highly absorbing layers
- *Exudates management*

Soft adherent layer
- *Atraumatic withdrawal*

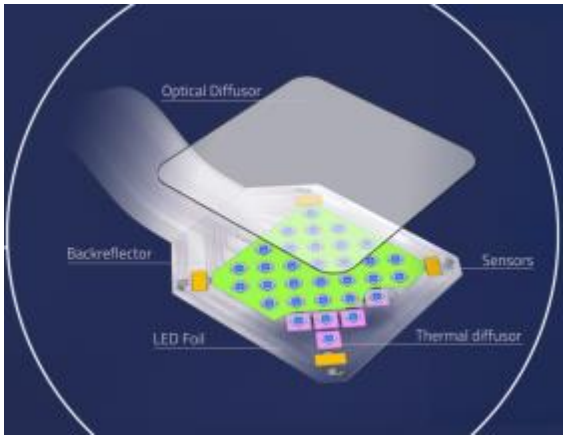
Chemical free

URGO know-how



Patented

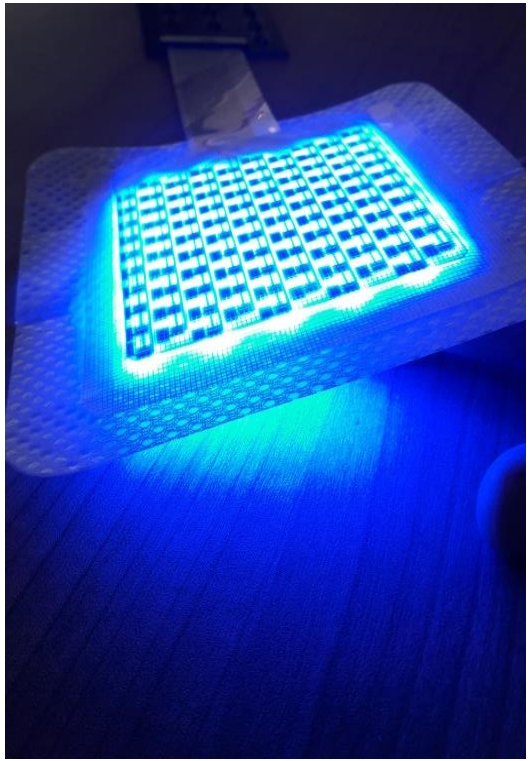
- ✓ Blood **oxygenation** and **temperature** sensors
- ✓ Flat, flexible and **homogenous illumination** system
- ✓ Heat Management (from LEDs)

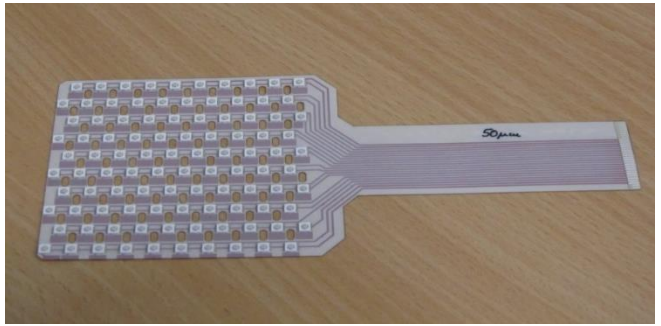


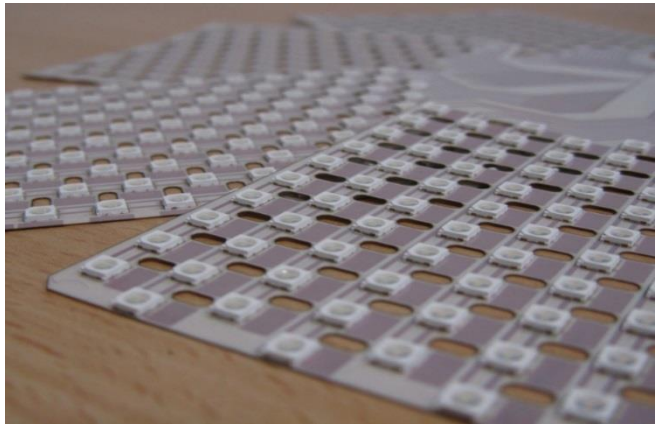
UV FREE

Innovative domain

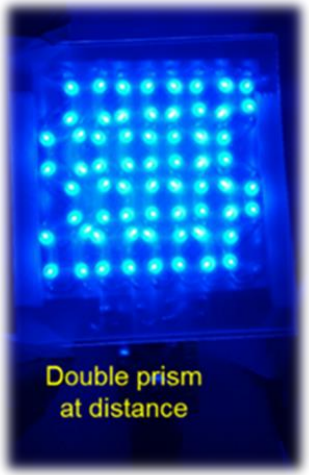
The illumination system: Lighting elements

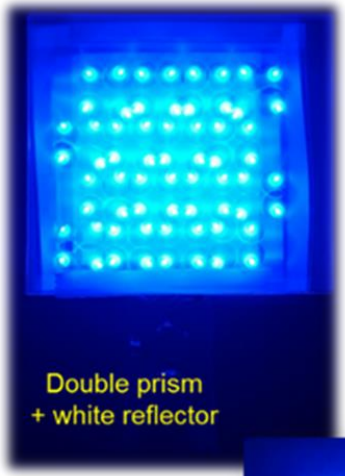


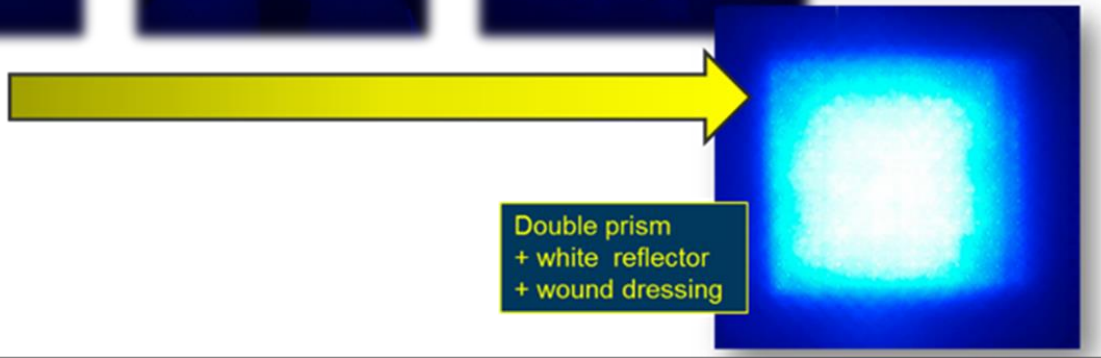


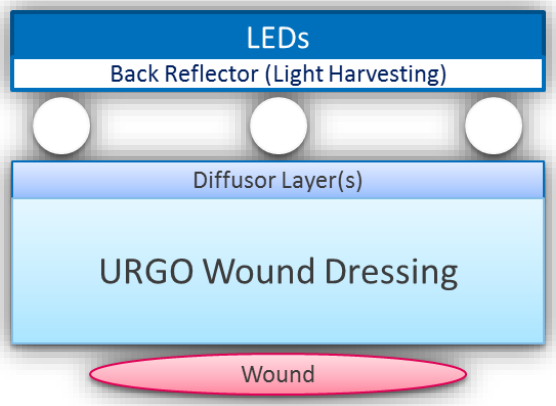


The illumination system: Optical elements

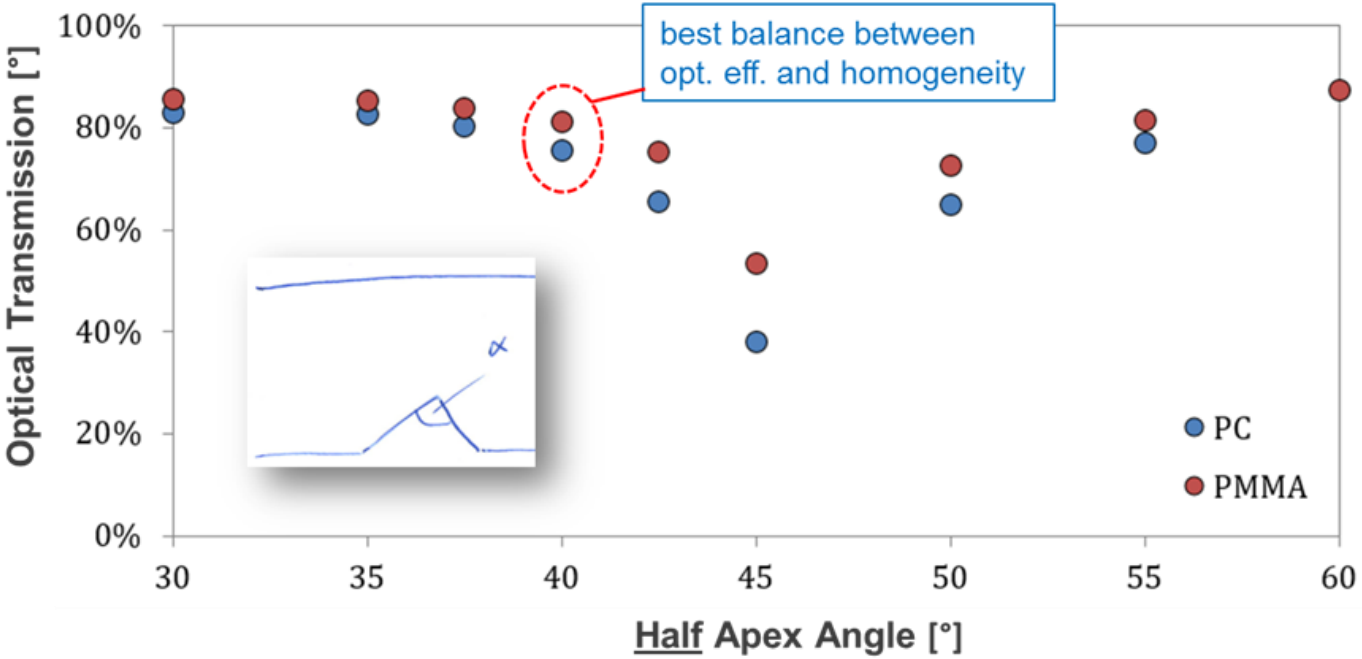


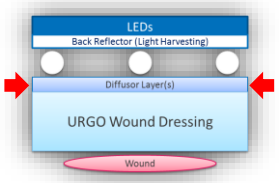




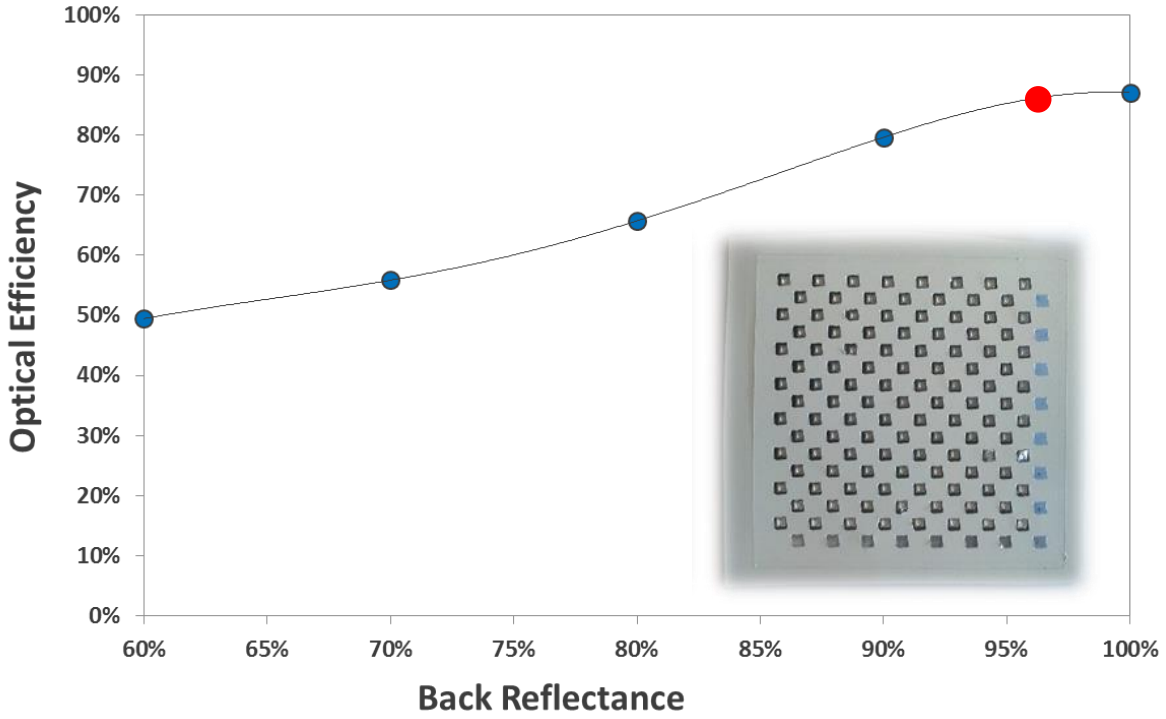


Prismatic diffuser: Efficiency vs. Homogeinity

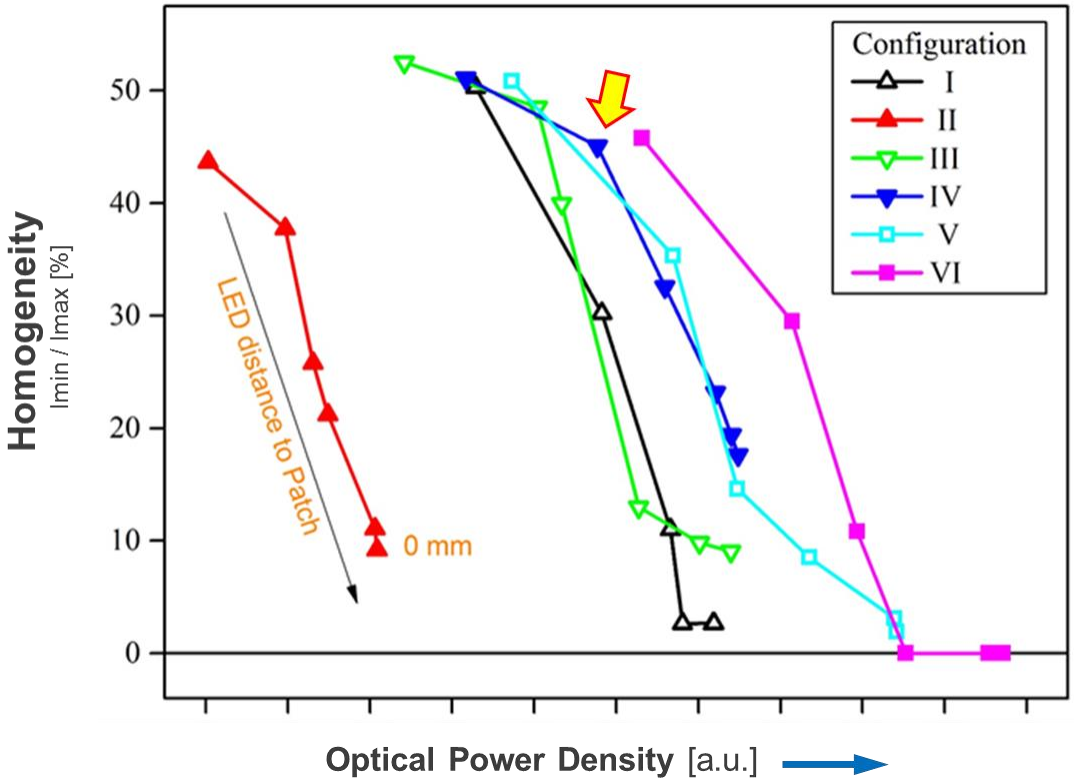




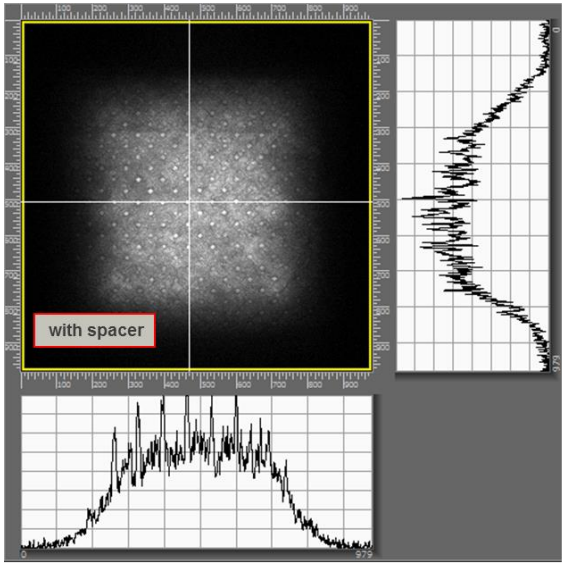
Back reflector: Optimized photon recycling

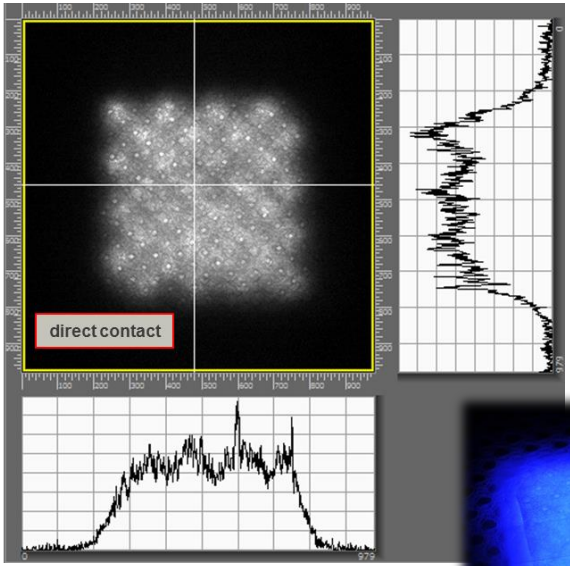


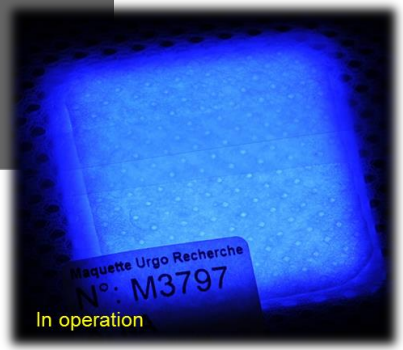
The full stack: Optical performance



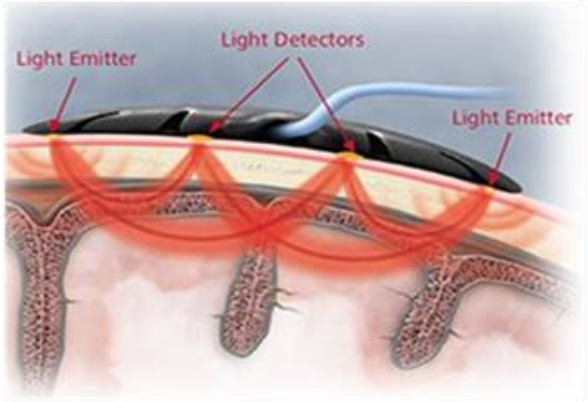
The illumination system: The spacer



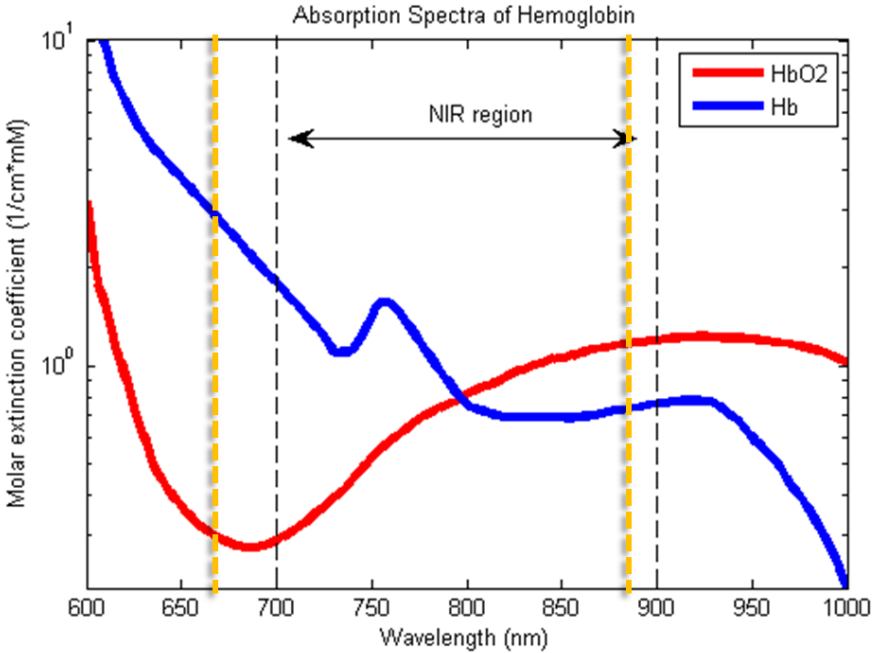




The sensing system: Blood oxigenation

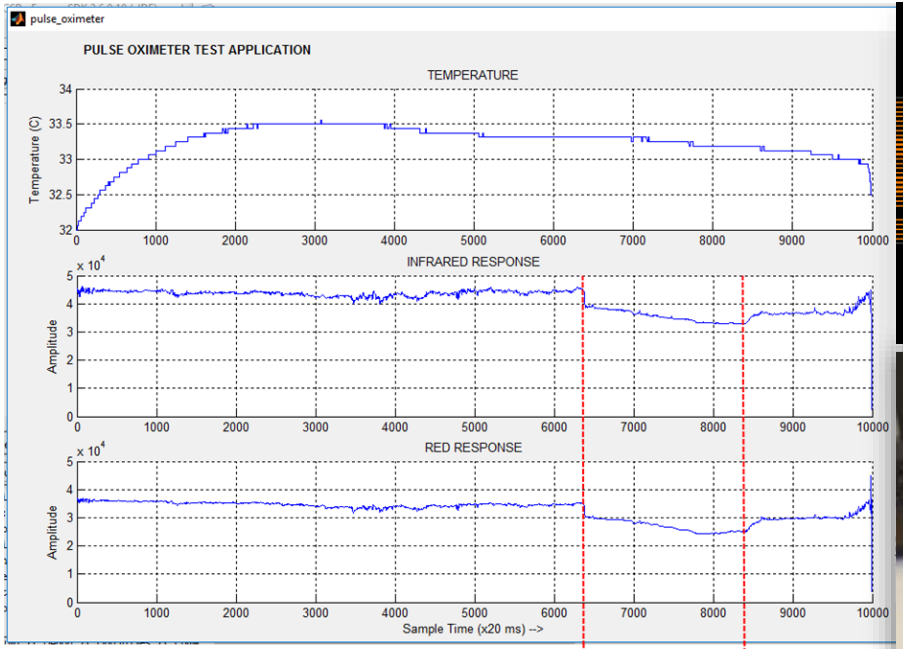


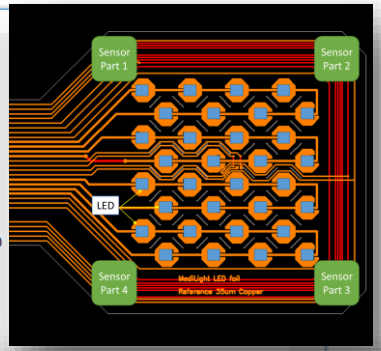
$$S_pO_2 = \frac{HbO_2}{HbO_2 + Hb}$$



Source: Wikipedia

The sensing system: Blood oxigenation & Temperature





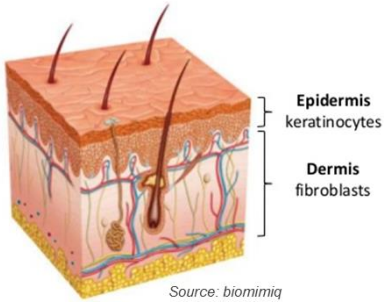
$$\frac{V_{red}}{V_{IR}} = \frac{V_{rms}(RED) - V_{DC}(RED)}{V_{rms}(IR) - V_{DC}(IR)} \rightarrow SpO_2$$

Pressure Applied

Pressure Released

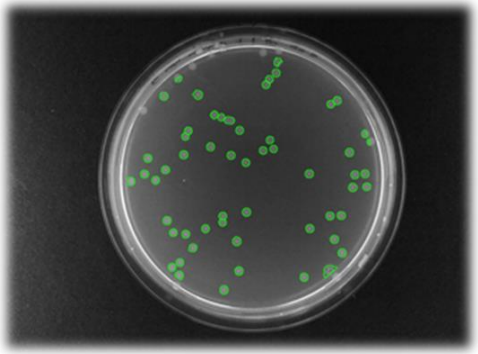
In-vitro testing: The healing stages

Healing stage	Infection (Bacteria)	Cleansing (Macrophages)	Granulation (Fibroblasts)	Epidermisation (Keratinocytes)
Purpose	• Limitation of cell proliferation • Inhibition of virulence • Formation of biofilm	• Modulation of macrophage activity (inflammation mediators) • Enhancement of granulation phase	• Proliferation • Migration • Dermis synthesis (collagen)	• Proliferation • Migration • Differentiation
Light Schedule	Confidential Data			
Device Application	Permanent	Permanent	Permanent	Permanent
Sensors	Temperature O_2	Temperature O_2	O_2	O_2

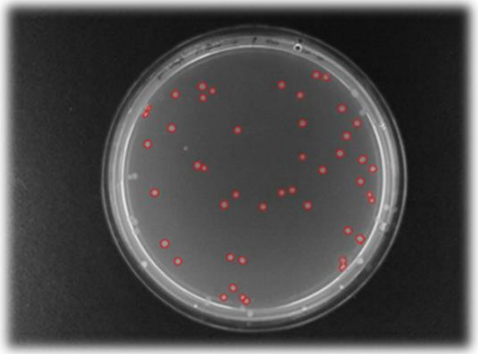


In-vitro testing: Bacteria

- Image analysis software „ZMFsoft“ developed
- Different blue light irradiation times and cycles tested
- Image acquisition performed 24h after irradiation
- Evaluation of colony count, area, radius and eccentricity
- Subsequent statistical comparison between the light and control experiments
- Growth inhibiting effects were found for different strains (details are confidential)



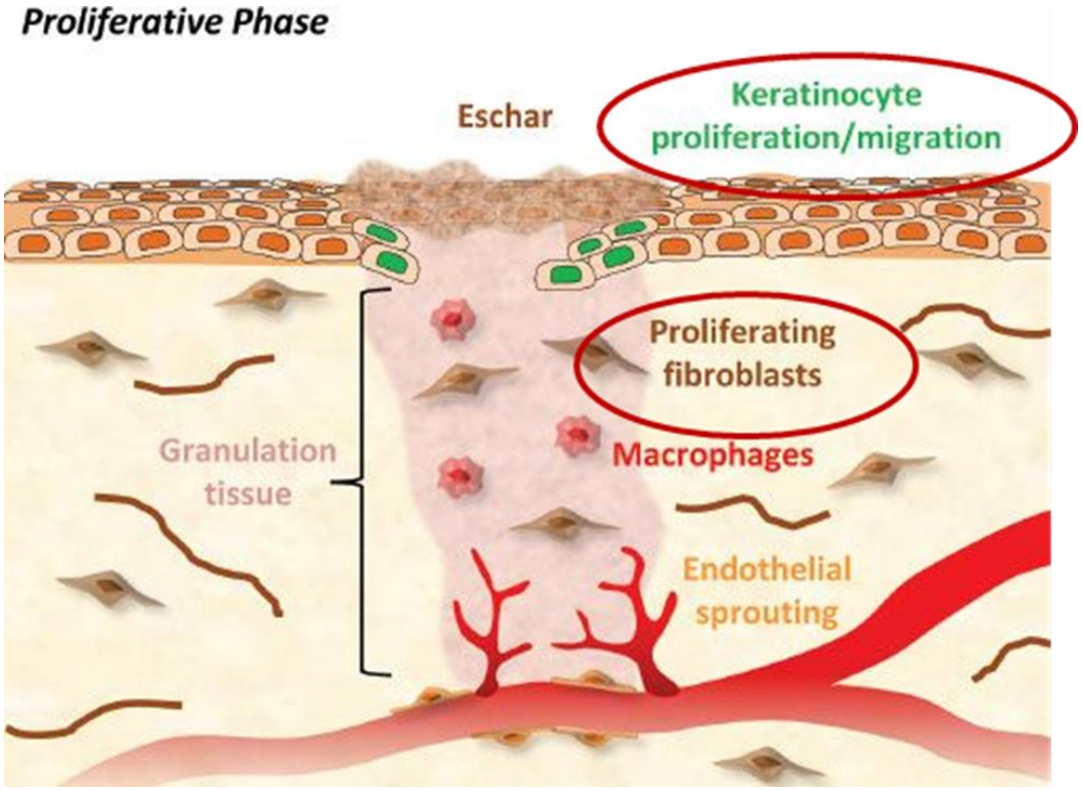
Control plate



Light-treated plate

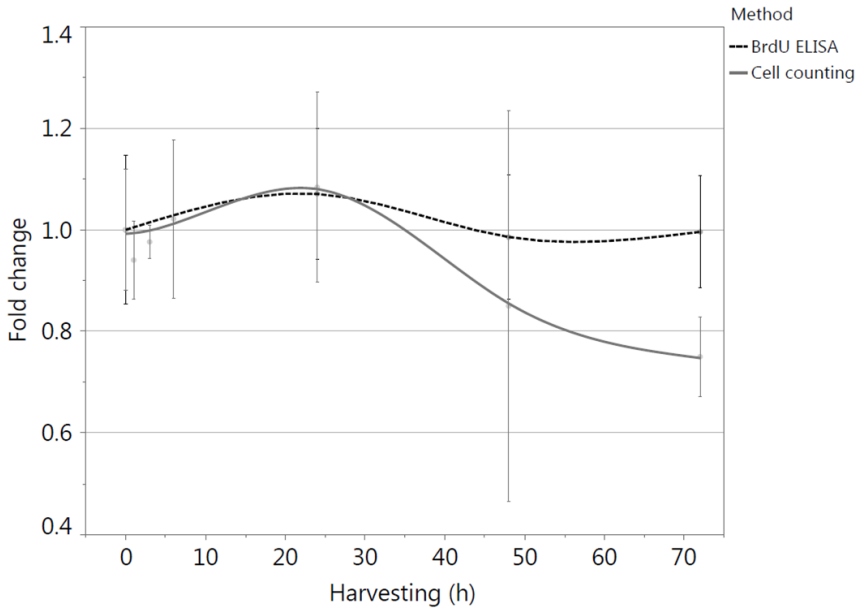
→ **Reduction of colony size!**

In-vitro testing: Keratinocytes & Fibroblasts



Proliferation/Migration of Keratinocytes & Fibroblasts

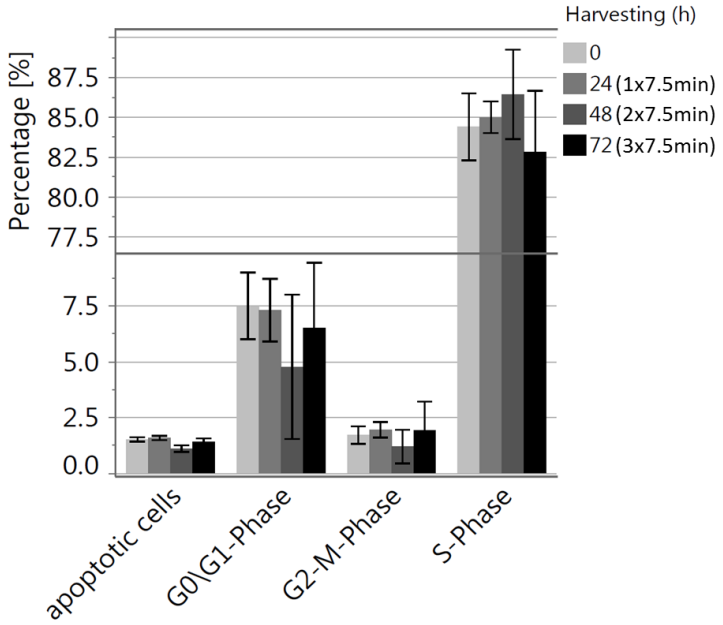
Increase in proliferation of HaCaT cells (keratinocytes) by consecutive irradiations with 7.5min of blue light



A. Becker et al., submitted to PLOS ONE (December 2017):
" Photobiomodulation by blue light induces a dose dependent biphasic response curve in human keratinocytes which is transmitted by aryl hydrocarbon receptor"

Proliferation/Migration of Keratinocytes & Fibroblasts

Consecutive irradiations with 7.5min of blue light induce a change in cell cycle phase proportion of HaCaT cells



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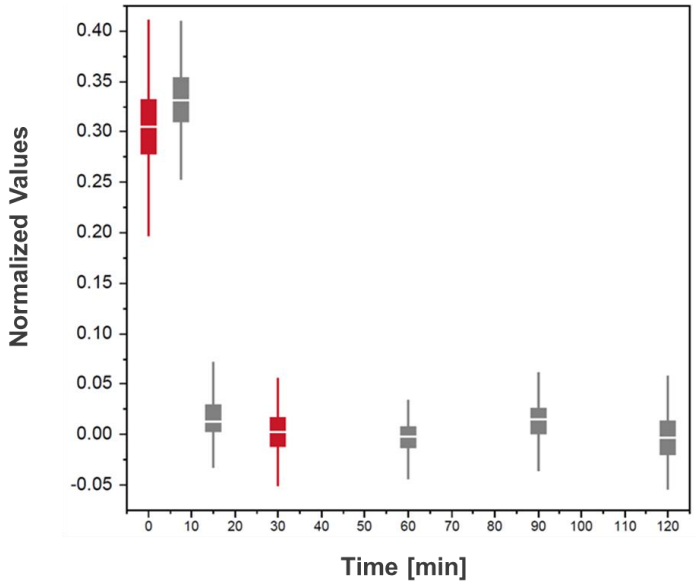
Prevention of overshooting epidermisation

Preventing the wound to close too early (in premature healing phase)



Becker, A., *et al.*: Impact of blue LED irradiation on proliferation and gene expression of cultured human keratinocytes. In: SPIE (Ed.) *SPIE BiOS.* San Francisco, International Society for Optics and Photonics, 2015 pp 930909-930909-930912

Conclusions

- Treatment of chronic wounds with blue light
- Flat, flexible, and homogenous illumination system
- Breathability (management of patient's exudates)
- Heat Management (from LEDs)
- Measurement of blood oxygenation & temperature
- Growth of bacteria significantly reduced
- Indications for proliferation of skin cells
- Overshooting of skin cell growth in early wound healing phase prevented

Thank you for your attention!

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