Smart wearable system for light treatment of chronic wounds


SPIE Photonics West – BIOS, 29.01.2018
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

- Microsystems
- Surface engineering
- Systems
- ULP integrated systems
- PV-center & energy

- MEMS
- Printable electronics
- Automation
- Vision systems
- PV cells & Modules

- Functional packaging
- Nano-surface engineering
- Scientific instrumentation
- System-on-chip
- Energy systems

- Advanced micro-manufacturing
- Bio-surface engineering
- Medical technologies
- Wireless
- 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
H2020 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
H2020 MEDILIGHT

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
H2020 MEDILIGHT

The system

✓ Treats chronic wounds with blue light

**Antibacterial & Proliferative**

✓ Management of patient’s exudates

✓ Breathability

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

Waterproof backing - **Breathable**

Highly absorbing layers - **Exudates management**

Soft adherent layer - **Atraumatic withdrawal**

**Chemical free**

URGO know-how

**UV FREE**

Innovative domain
The illumination system: Lighting elements
H2020 MEDILIGHT at CSEM

The illumination system: Optical elements

Double prism in contact
Double prism at distance
Double prism + white reflector

LEDs
Back Reflector (Light Harvesting)
Diffusor Layer(s)
URGO Wound Dressing

Wound

Double prism + white reflector + wound dressing
Prismatic diffuser: Efficiency vs. Homogeneity

best balance between opt. eff. and homogeneity
Back reflector: Optimized photon recycling
H2020 MEDILIGHT at CSEM

The full stack: Optical performance
H2020 MEDILIGHT at CSEM

The illumination system: The spacer

[Images of illumination system with and without spacer]
H2020 MEDILIGHT

The sensing system: Blood oxigenation

\[ S_pO_2 = \frac{HbO_2}{HbO_2 + Hb} \]

Absorption Spectra of Hemoglobin

The sensing system: Blood oxygenation & Temperature

\[ \frac{V_{\text{red}}}{V_{IR}} = \frac{V_{\text{rms(RED)}} - V_{\text{DC(RED)}}}{V_{\text{rms(IR)}} - V_{\text{DC(IR)}}} \Rightarrow \text{SpO}_2 \]

Pressure Applied | Pressure Released
### In-vitro testing: The healing stages

<table>
<thead>
<tr>
<th>Healing stage</th>
<th>Infection (Bacteria)</th>
<th>Cleansing (Macrophages)</th>
<th>Granulation (Fibroblasts)</th>
<th>Epidermisation (Keratinocytes)</th>
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</thead>
</table>
| 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)

→ Reduction of colony size!
In-vitro testing: 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”
Consecutive irradiations with 7.5min of blue light induce a change in cell cycle phase proportion of HaCaT cells

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”
Prevention of overshooting epidermisation

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

Inkjet printed nano- and micro-optics at CSEM

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!

Visit us at booth #5658

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www.csem.ch

www.medilight-project.eu