Action Optical cochlear implant project

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Optical cochlear implant project *ACTION* (ACTive Implant for Optoacoustic Natural sound enhancement; Oct. 2013 – Sep. 2016)

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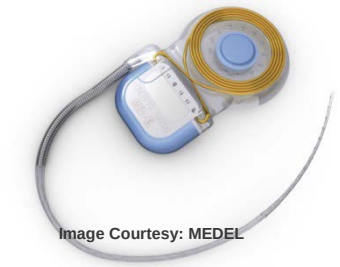
Introduction: This project is based on a recent discovery that relatively low levels of pulsed infrared laser light are capable of triggering activity in hair cells of the partially hearing (hearing impaired) cochlea and vestibule. The aim here is to develop a self-contained, smart, highly miniaturized system to provide optoacoustic stimuli directly from an array of miniature light sources in the cochlear.

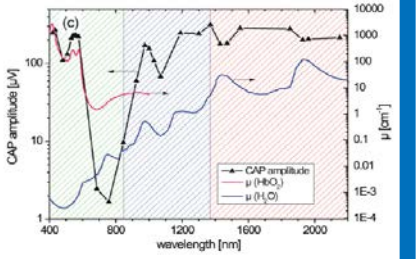
State of art & desired improvements

- Sensory recovery of auditory functions
- Electrical stimulation
- Poor spatial resolution with electric stimulation due to crosstalk
- Difficulty to align to the nerve cells to get optimum hearing



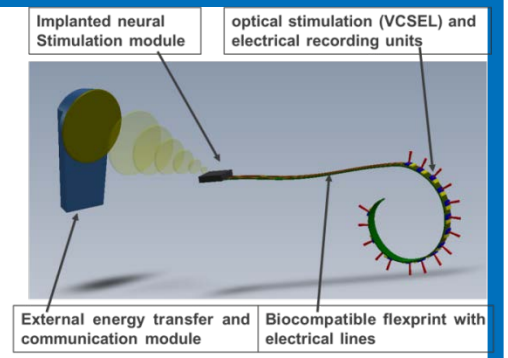
Principle

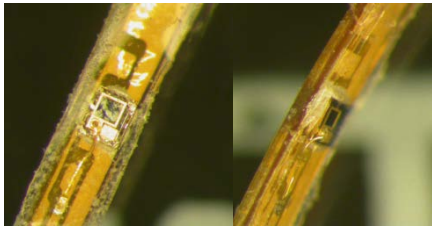
- Directly or indirectly stimulate nerves using light
- High absorption of specific light wavelengths and hemoglobin
- Principle of stimulation is optoacoustics



Technologies involved

- Long term implantable encapsulation
- Low temperature hermetic sealing
- Miniature biocompatible feedthroughs
- Long term biocompatible flex circuit
- Custom made VCSELs to suit the absorption
- Sapphire micro lens array for optimization of light
- Biocompatible coating to avoid cell adhesion
- Animal tests
- Module for remote charging and data communication





FP7 Consortium

MHH Medizinische Hochschule Hannover · ST life.augmented · MED EL · SUSS MicroOptics · VTT · VERTILAS · csem

Users' Needs and Unique Value

Unique situation: major *users* participate in project

MED EL — Commercial cochlear implant manufacturer

MHH Medizinische Hochschule Hannover — Medical university to conduct surgical studies and clinical trials (ethical approvements)

Innovation process and road to exploitation

- Direct exploitation through commercial and medical partner

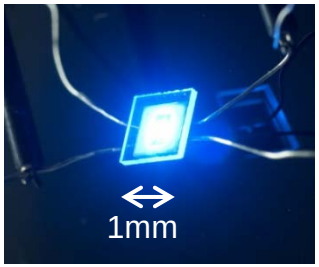
- Indirect exploitation individually by each project partner → next slides
  - Offering technology solutions which are beyond state-of-the-art
  - Can be used in similar applications as well

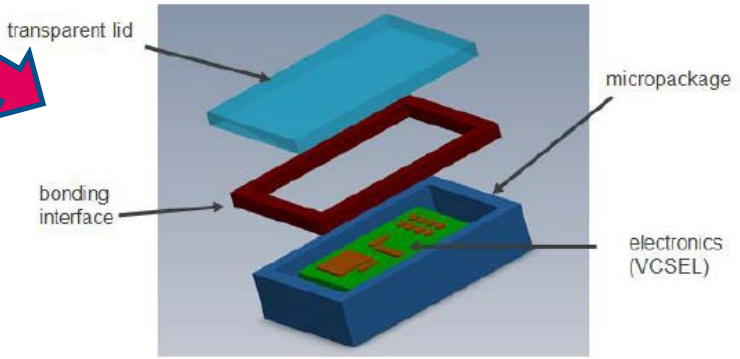
Optical Cochlear Microsystem I – Packaging - Housing

State of the art:
Biocompatible housing materials Ti, Ta

Drastic size reduction (< 800 µm dia), hermetic enclosure with low temperature sealing process (< 250°C for few seconds)

Beyond state of the art:

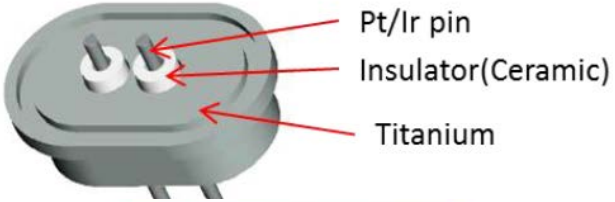




Transparency in IR range

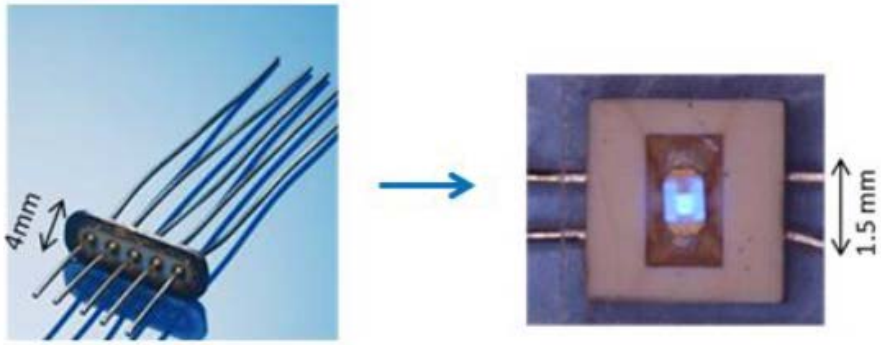
Optical Cochlear Microsystem II – Packaging - Connections

State-of-the-art feedthrough 4 mm width



Beyond state of the art:

hermetic low temperature sealing with approved long term biocompatible materials
(ceramics and highly biocompatible metals such as Nb, Pt, Ti)

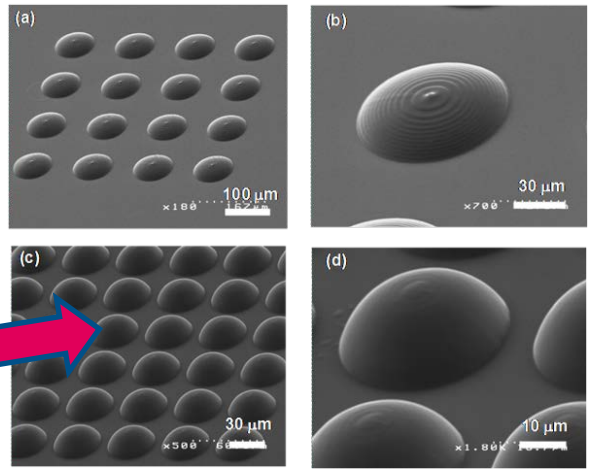


Optical Cochlear Microsystem III – Biocompatible Sapphire Lens

Beyond state of the art:

Sapphire lens for high biocompatibility

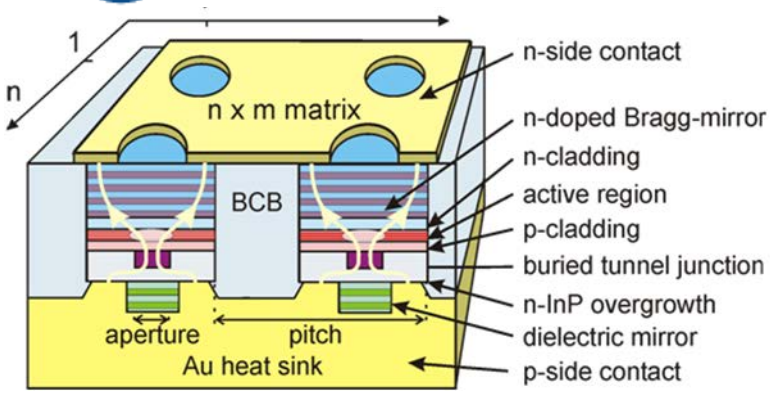
SÜSS MicroOptics



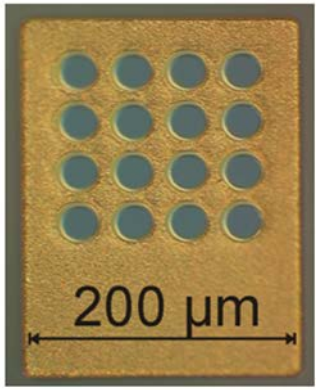
Plasma reactive ion etching (RIE-ICP) only manufacturing option for micro-optics in sapphire on Wafer Level

Optical Cochlear Microsystem IV – VCSEL arrays

VERTILAS®



Beyond state of the art:

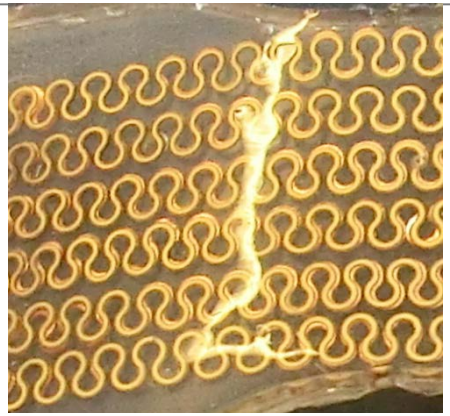


Long wavelength VCSEL with superior performance for $1.3\ \mu m < \lambda < 2.3\ \mu m$

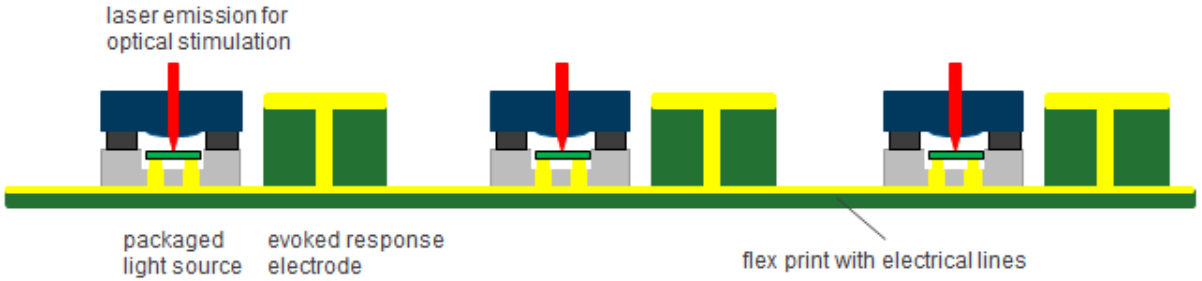
Parameter	Value
Laser array	10 x 10
Wavelength	1400 – 1900 nm
Peak output power	> 20 mW
Operating range	20 – 45 °C
Drive current	<30 mA

optimized for maximum efficiency at human body temperature

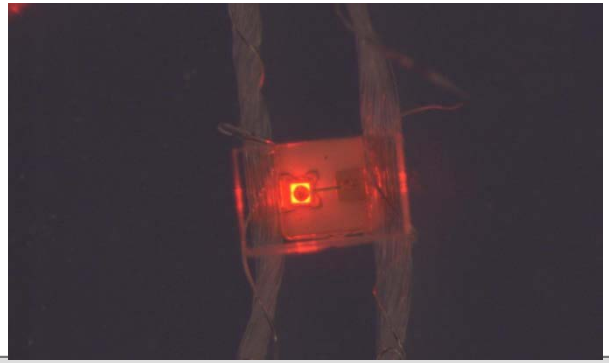
Optical Cochlear Microsystem V - Biocompatible flex circuit



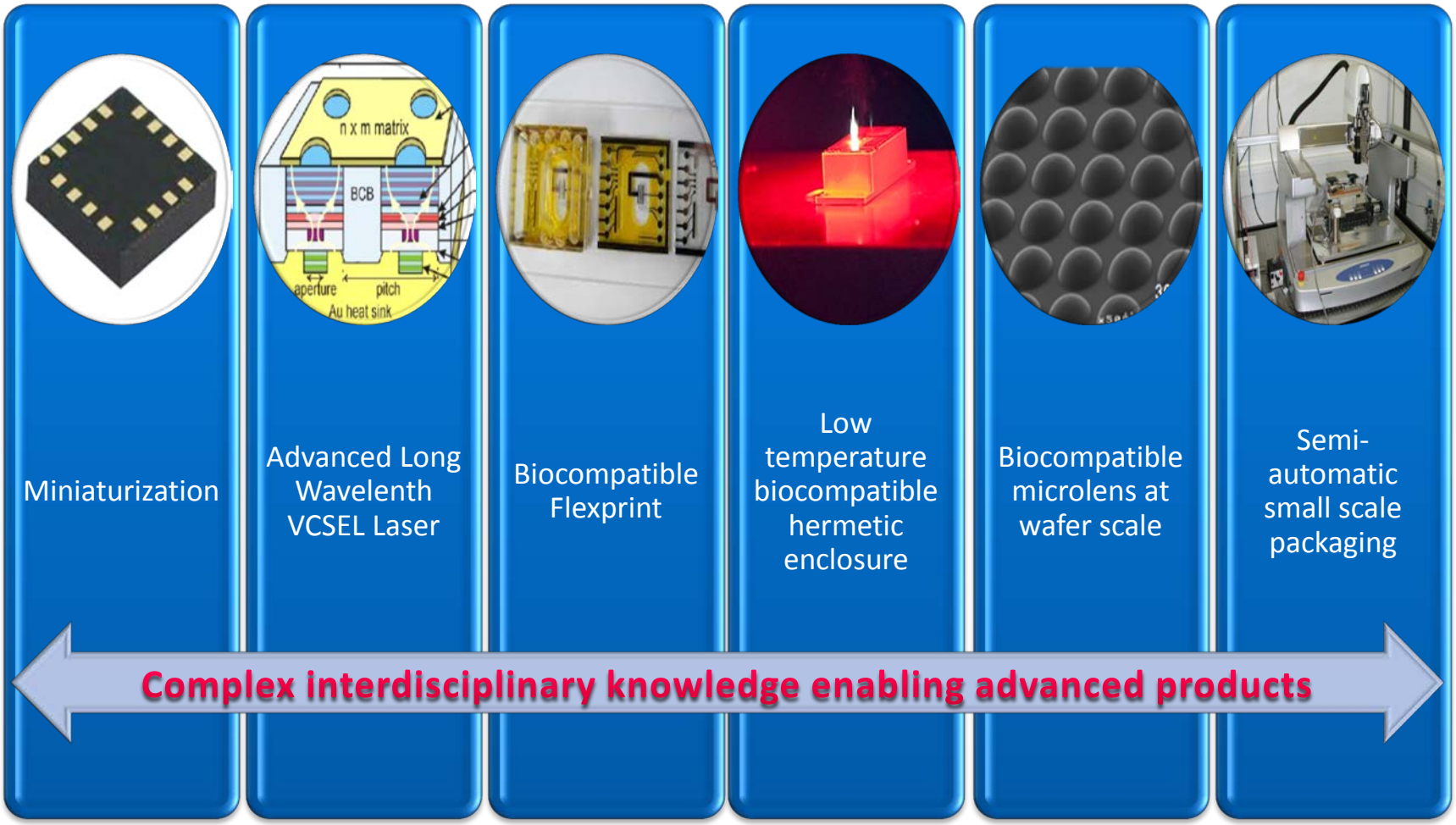
- Flex circuit
- Platinum, Niobium, Tantalum, Biocompatible polymers
- Highly flexible



- Chip on wire technology
- Chip integrated directly on wire
- High throughput



Leading edge european medical device manufacturing



Distance to the market

- High risk project in biomedical application beyond state of the art in a niche market
- Typical public funded research project: industry players cannot absorb too many technology risks at once and prefer incremental innovation
- A suitable cooperation between research partners and industry players pave the ground for next generation products in promising markets, which are not supported by established medical device solution providers
- Targeted usage of device
  - In vitro tests and signal quantification (cell resolution)
  - Acute and chronic in vivo animal studies of multichannel devices
- Cochlear implant in humans beyond the scope of this project
  - Basic research required, preparation for human clinical studies takes years

EU Project STREP-ICT FP7 ACTION -

ACTive Implant for Optoacoustic Natural sound enhancement

Enhance hearing experience for severely impaired patients by eliminating limitations in spatial and temporal excitation of cochlear implants based on electrical stimulation