Characterization of optical microsystems designed to thermal control of the neural tissue

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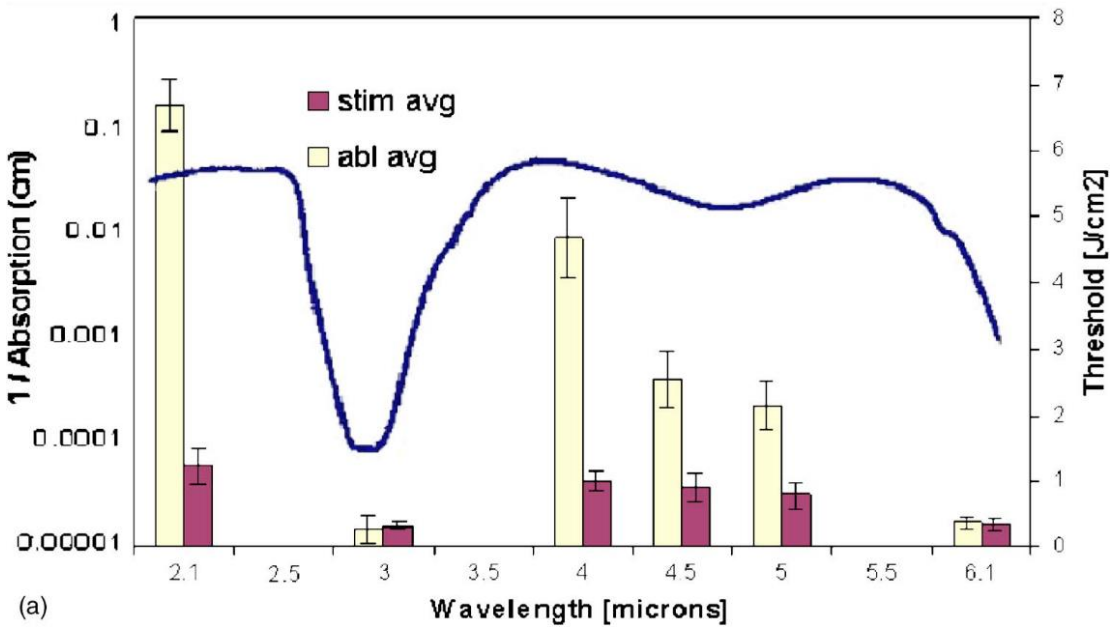
Neuroscientific motivations

- Effect of body temperature and brain temperature on neural activity
- Pulsed infrared neural stimulation (INS)
- Biological mechanism of INS?

- Precise, multimodal tool is needed
- Current INS is limited to cortical investigations



Wells et al., J. Biomed. Opt. 10 (2005)

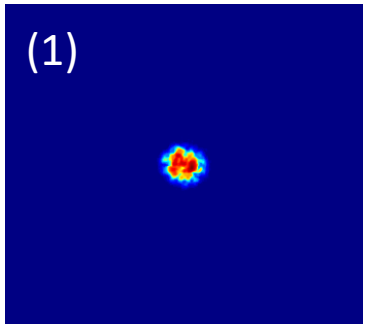
→ My work: multimodal Si brain electrode = optrode

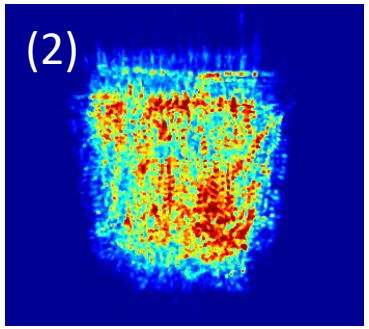
Multimodal brain electrode

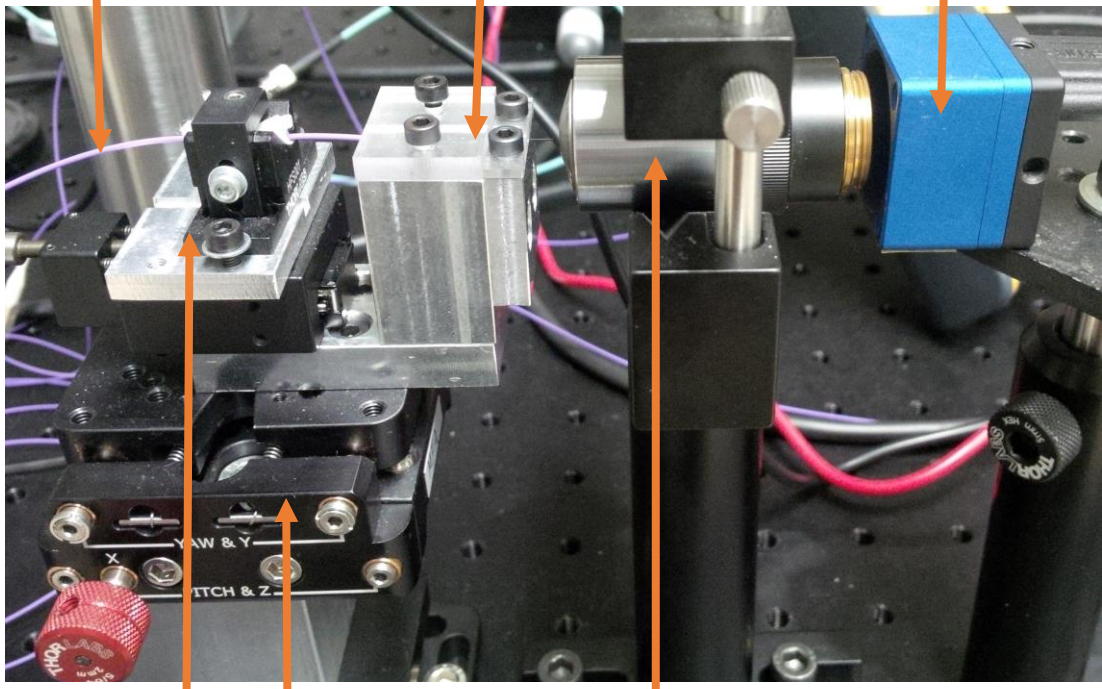
- Electrophysiology
  - Rectangular-shape Pt thinfilm
  - 30×30 μm^2 recording sites per 100 microns
- Thermometer
  - Meander-shape Pt thinfilm
- Optical stimulation
  - Bulk Si: mechanical substrate and IR waveguide

Modality 1 – Optical measurement

- Relative LASER beam power measurement
  - CMOS beam profiler (CINOGY Techn. GmbH)
  1. Reference image: optical power coupled out from the optical fibre (max. 5 mW)
  2. Electrode image: optical power coupled out from the blunt-type electrode tip (fiber inserted into the chip's fiber guide)
  3. Overall coupling efficiency: ratio of (2) and (1)







Modality 1 – Wave guiding efficiencies

Chip sample ID	Eff. (%)	SD	Rel. SD
c_T_4			
c_T_4			
c_T_4			
c_T_4			
c_T_4			
c_S-16			
c_S-16			
c_T_4l			
c_T_4l			

Packaged sample ID.	Eff. (%)	SD	Rel. SD

Current investigation: impact of packaging

- Precise fibre connector: LC → ST
- Fibre facet polishing
- Position of fibre facet from coupling lens

→ Improvement expected

- Repetition: 5 times on each sample
- One by one calibration is needed

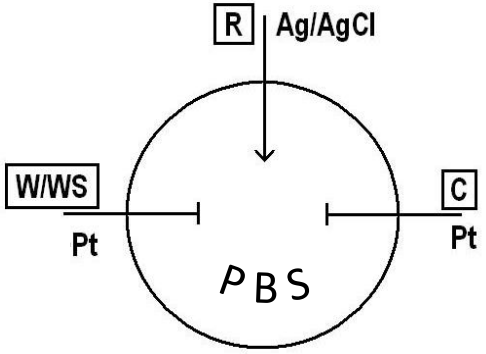
→ Repeatabilty improved

Modality 2 – Thermal measurement

- Pt thin film resistance thermometer
- Calibration:
  - Simultaneous measurement with a NTC thermistor (±0.14 °C) as reference
  - 0.5 dl physiological saline as a good model of neural tissue
  - Control and recording: custom-developed Matlab code

Modality 3 – Electrical recording

- Potentiostatic EIS: |Z| @ 1 kHz
- Long-term impedance stability test
- Passivating layer avoids short-circuit



Summary

- Multimodal MEMS brain electrode development
  - 3 integrated modalities: electrical recording, thermal measurement, IR wave guiding
- Test measurements
  - Relative beam power measurement
  - Thermometer calibration
  - Electrochemical impedance spectroscopy
  - Long-term impedance stability test of the recording sites
- Further aims:
  - Optical measurement: fibre position, beam divergence, packaging upgrade
  - Simultaneous testing of the three modalities on packaged devices

Summary

- Publications:
  - Z Fekete, M Csernai, K Kocsis, **Á C Horváth**, A Pongrácz and P Barthó: Simultaneous in vivo recording of local brain temperature and electrophysiological signals with a novel neural probe, *J. Neur. Eng., Vol. 14, Num. 3*, 14 March 2017 (2015 Impact Factor **3.493**)
  - **Á. Cs. Horváth**, Ö. Sepsi, Cs. Ö. Boros, Sz. Beleznai, Pál Koppa, Z. Fekete, *submitted abstract to 31st Eurosensors conf. in sept. 2017.*
  - **Á. Cs. Horváth**, Ö. Sepsi, Sz. Beleznai, Cs. Ö. Boros, P. Koppa, Z. Fekete, *manuscript in prep.*