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

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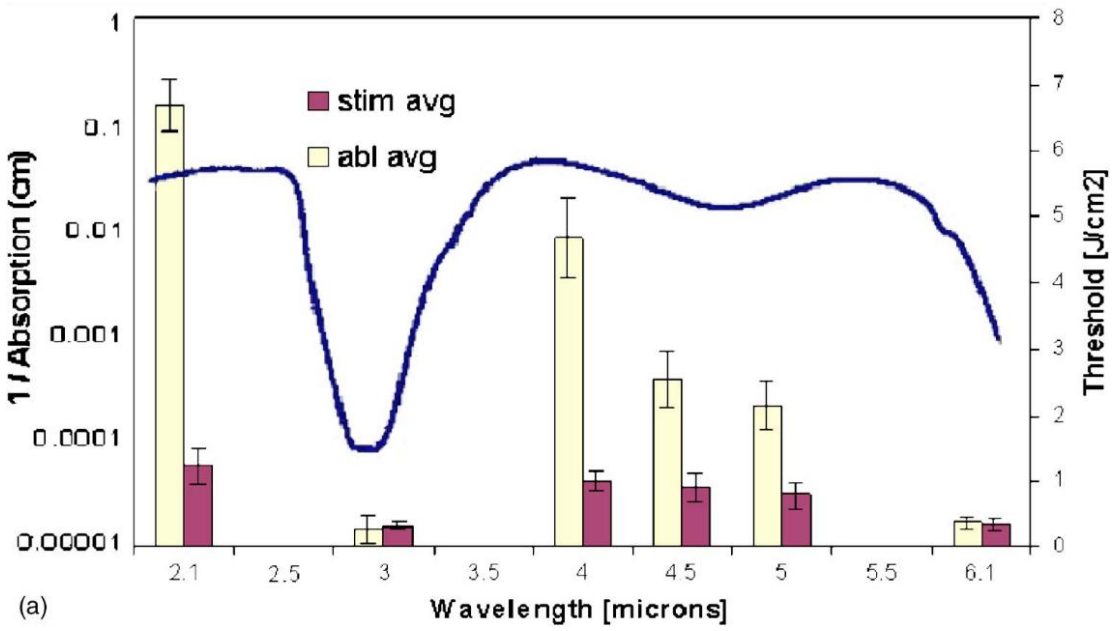
Neuroscientific motivations

- 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

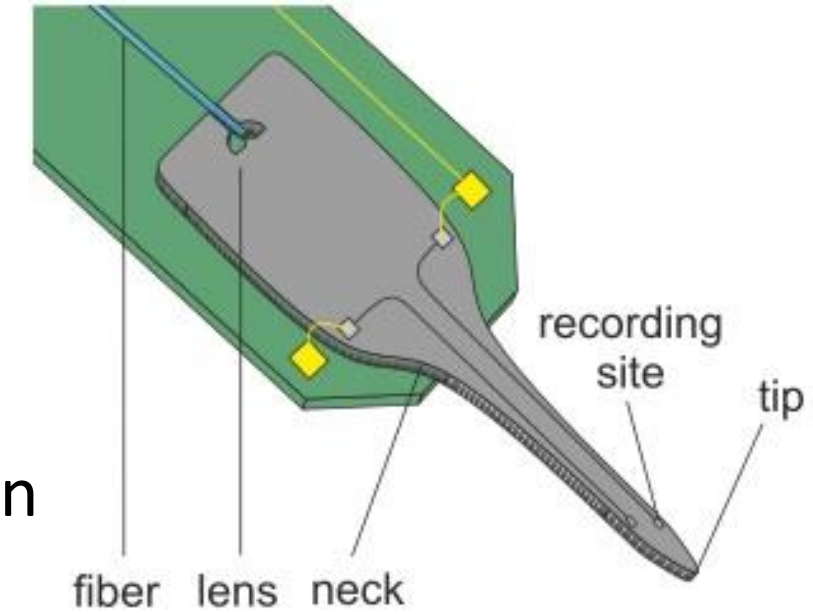


Wells et al., J. Biomed. Opt. 10 (2005)

→ My work: multimodal Si brain electrode = optrode

Multimodal brain electrode

- Modality 1: Optical stimulation
  - Bulk Si: mechanical carrier and IR waveguide (2 in 1)
- Modality 2: Monitoring heat accumulation
  - Pt thinfilm thermometer (100 x 100 µm^2) at tip
- Modality 3: Electrophysiology
  - 900 µm^2 Pt recording sites with 100 µm spacing



Kiss et al., S&A B: Chemical (2016) 676

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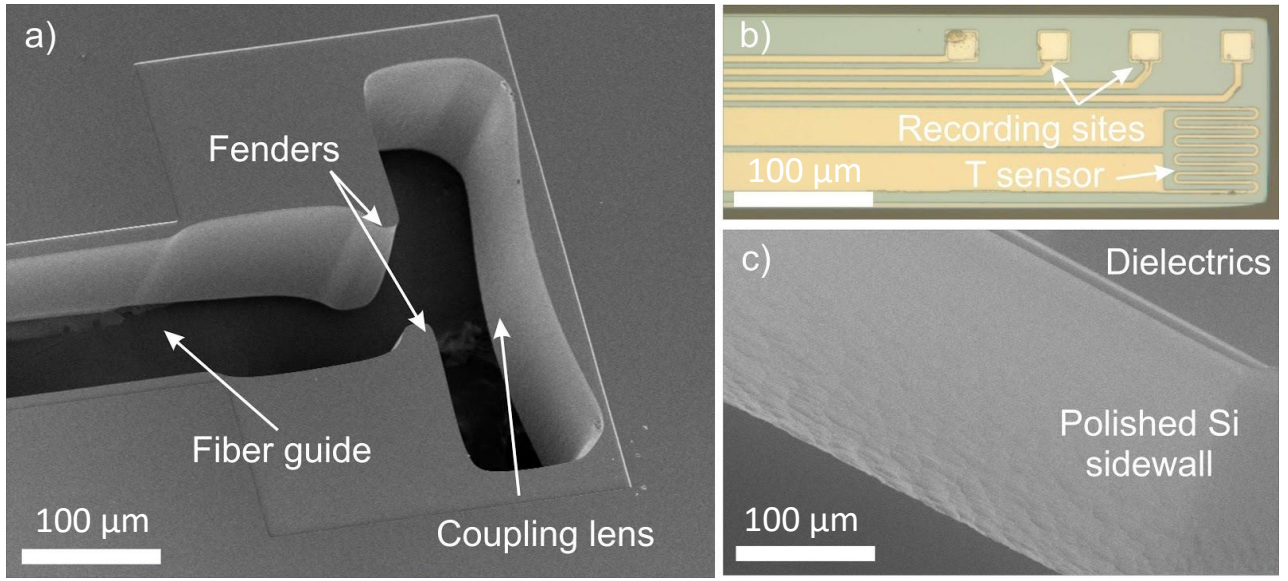


Horváth et al., S&A B: Chemical (2018) 263

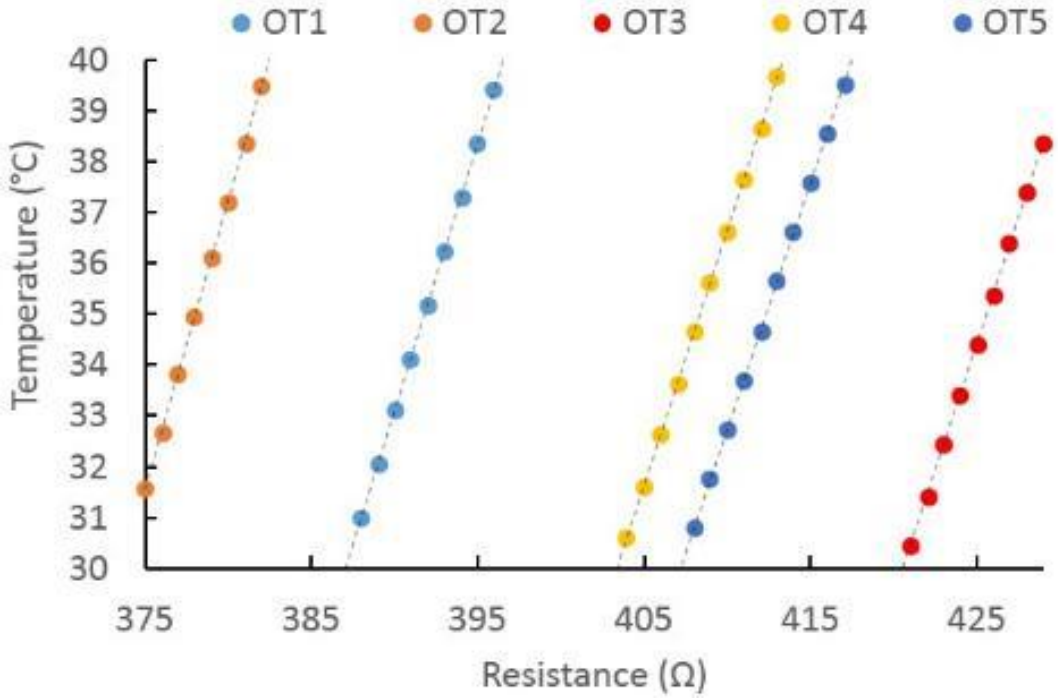
Characterization of modalities

- The optrode device has 3 modalities:
  - Temperature sensor → thermometer calibration (in earlier semesters)
  - IR waveguiding → optical characterization:
    - Waveguiding efficiency
    - Optical power
    - Beam size, beam divergence
    - Optical heating: spatial distribution
  - Electrophysiological recording → reduction of the recording sites' impedance

Temperature sensor

- Pt thin film resistance thermometer
- Calibration:
  - Simultaneous measurement with a NTC thermistor (±0.14 °C)
  - 0.5 dl physiological saline
  - Control and recording: Matlab

IR optrode thermometer characteristic



Horváth et al., S&A B: Chemical (2018) 263

- TCR = 2636.7 ± 75.5 ppm/°C

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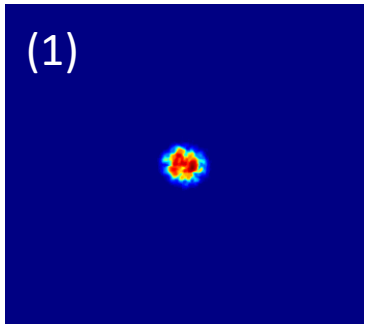
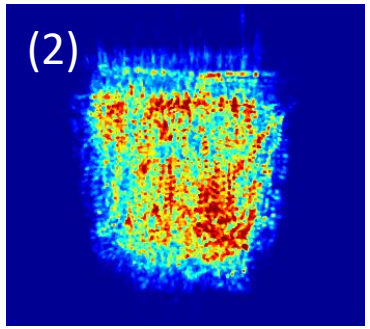
Optical characterization

- Relative LASER beam power measurement

CMOS beam profiler (CINOGY Techn. GmbH)

1. Reference image: optical power coupled out from the optical fibre (λ = 1310 nm)
2. Electrode image: optical power coupled out from the blunt-type electrode tip (fibre inserted into the chip's fibre guide)
3. Overall coupling efficiency: ratio of (2) and (1)





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Summary

- Multimodal MEMS brain electrode development
  - 3 integrated modalities: electrical recording, thermal measurement, IR wave guiding
- Measurements
  - Characterization of the spatial distribution of the optical heating
  - *In vivo* validation of the optrode device

✓Second language exam: French B1

- I started writing my thesis
- Further aims:
  - Redesign the layout of the optrode chips: optimization and development
  - Compare the old and the new versions
  - Finish my thesis and make my defence

- New National Excellence Foundation (ÚNKP): I was 2nd time awarded a 10 months scholarship

NEMZETI KUTATÁSI, FEJLESZTÉSI ÉS INNOVÁCIÓS HIVATAL

- Publications
  - Horváth Á. Cs.: Multimodális mélyagyi MEMS tűelektróda infravörös idegi ingerléshez, *oral presentation at the Forum of Young Graduates (FiDiFó2019)*, Óbuda Univ. Rejtő S. Faculty, 11 December 2019
  - Ágoston C. Horváth, Sándor Borbély, Örs C. Boros, Lili Komáromi, Pál Koppa, Péter Barthó, Zoltán Fekete, Infrared neural stimulation and inhibition using an implantable silicon photonic microdevice, *Microsystems & Nanoengineering (IF: 5.616), article under minor revision*
  - Á. Cs. Horváth, S. Borbély, Ö. C. Boros, L. Komáromi, P. Koppa, P. Barthó, Z. Fekete, In vivo infrared neural stimulation and inhibition using an implantable microdevice, *poster presentation at the 17th annual meeting of the Hungarian Neuroscience Society,* Szeged, 30 January 2020