FLEXIBLE AND REDUCED-SIZE NEURAL PROBE USING A PHOTOSENSITIVE POLYIMIDE

J. R. Freitas, R. B. Freitas, B. Esteves, D. J. Santos, M. J. Maciel, S. Pimenta, J. H. Correia

Emails:

id9493@alunos.uminho.pt

ruben.freitas@dei.uminho.pt

bruno.esteves@dei.uminho.pt

a83868@alunos.uminho.pt

mmaciel@dei.uminho.pt

sara.pimenta@dei.uminho.pt

higino.correia@dei.uminho.pt

CMEMS – UMinho, University of Minho, 4800-058, Guimarães, Portugal

LABBELS – Associate Laboratory, Braga, Guimarães, Portugal

Keywords: Microelectrodes, photolithography, thin-films deposition.

The understanding of the human brain function is one of the main challenges of modern science, as it comprises the study of an extremely complex organ. The majority of neural interfaces to study the brain rely on non-flexible and relatively thick structures, which do not adapt to the plastic nature of the brain, damaging the tissue and compromising data acquisition [1, 2]. This research presents the fabrication of a flexible, reduced-size, and single shaft neural probe, integrating microelectrodes. The main relevant aspect was the use of a flexible and photosensitive substrate of polyimide, where the metallic tracks, microelectrodes, and pads were patterned. Additionally, the neural probe passivation was performed using the same polyimide. This flexible device will adapt to the subtle movements of the brain, which can improve brain signals recording. The ultimate goal is to extend this fabrication process to the implementation of a single device with microelectrodes and also a waveguide for light delivery in neural cells. The neural probe flexibility and reduced dimensions can also allow its future applicability in studies using brain organoids (mini-brains), which are a novel approach in neuroscience that avoids experiments in animals [3,4].

Briefly, the neural probe fabrication process consisted of three stages: (i) photolithography to pattern the body of the probe; (ii) photolithography and thin-films deposition to pattern the tracks, microelectrodes, and pads; and (iii) photolithography to passivate the probe. Firstly, polyimide is spin-coated on a sacrificial Si substrate. Then, the polyimide was exposed to UV light, followed by a development process. The polyimide was completely cured in an oven, defining the body of the probe (its geometry). Secondly, a photoresist is spin-coated, followed by its exposition to UV light and its development, forming patterns on the body of the probe. Then, thin-films of Ti, Al, and Pt were deposited by e-beam and DC Sputtering, and after a lift-off process (photoresist removing) the metallic tracks, microelectrodes, and pads were patterned on the body of the probe. Thirdly, the neural probe was passivated with the same polyimide, through a similar photolithography process, leaving only the microelectrodes and pads exposed. Figure 1 shows the fabricated neural probe with 7.5 mm length, 105 μm width, and 8 μm thickness. The probe has 9 Pt microelectrodes ($\sim 9 \times 9$ μm^2) and the metal tracks width is 5 μm (pitch of 5 μm).

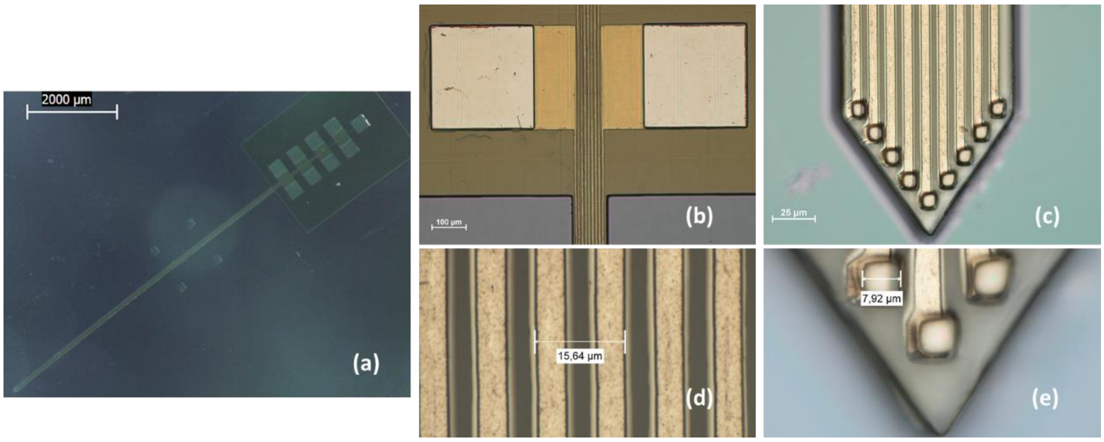

Figure 1: Microscope images of the fabricated neural probe: (a) Fabricated reduced-size neural probe, (b) exposed metal pads; (c) exposed microelectrodes; (d) metal tracks width and pitch; (e) exposed microelectrodes width.

Acknowledgments

This work was supported by FCT with the project MPhotonBiopsy, PTDC/FIS-OTI/1259/2020. J. R. Freitas, R. B. Freitas, and B. Esteves thank to FCT for the Ph.D. grants, 2020.07708.BD, 2021.06966.BD and 2021.07239.BD, respectively.

References

[1] S. Myllymaa, K. Myllymaa, R. Lappalainen, “Flexible implantable thin film neural electrodes”, in Recent Advances in Biomedical Engineering, InTech, pp. 165-189 (2009).

[2] “Partially flexible MEMS neural probe composed of polyimide and sucrose gel for reducing brain damage during and after implantation”, M. Jeon et al., Journal of Micromechanics and Microengineering, 24, 2, 025010 (10pp) (2014).

[3] “Brain organoids: advances, applications and challenges”, X. Qian, H. Song, G. Ming, Development, 146, dev166074 (2019).

[4] “Complex Oscillatory Waves Emerging from Cortical Organoids Model Early Human Brain Network Development”, C.A. Trujillo et al., Cell Stem Cell, 25, 4, 558-569.e7 (2019).