University of Basel

Department of Biomedical Engineering

Silk reinforced, micro-patterned cellulose films for soft neural implants

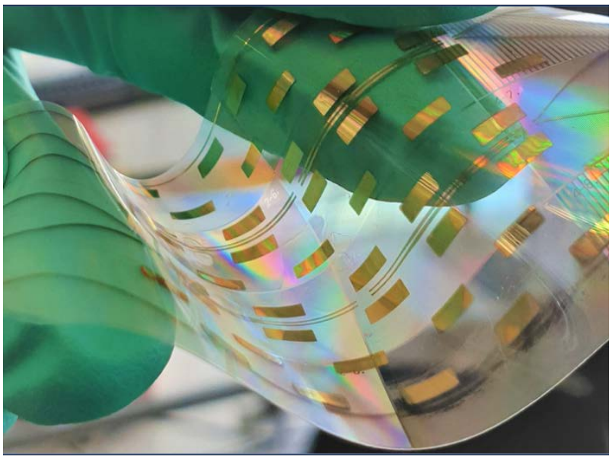

FIG. 1. Prototype of cellulose base flexible micropatterned electrodes for implantable devices. It softens by water uptake, stays stable for extended periods of time, and is easy to handle during surgical interventions. (Photographer: Mahyar Joodaki)

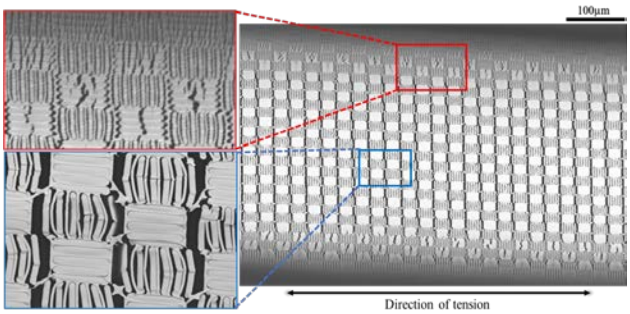

FIG. 2. The flexible, microstructured electrode, micropatterned Au on cellulose, withstands up to 30 % strain**.** Electron micrographs after tensile testing (Image: Mahyar Joodaki)

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Neuromodulation therapy with MHz to GHz signals has attracted attention for progressive neurodegenerative diseases. For these treatments, the spatial proximity of the electrodes to the neural tissue must be guaranteed, requiring neural probes to be implanted into the human brain. Creating a glial scar-free neural-probe interface for extended periods of time is, however, challenging (1,2). Soft and flexible electrodes are therefore a key for next-generation probes (3).

This thesis dealt with the brain-probe interface. The cellulose films used soften in aqueous environments and therefore adapt to the tissue's curvature at the implantation site. The ratio of the bio-based polymer, plasticizer and solvent was optimized to create films with desired softness via blade coating. These films were reinforced using silk networks and reached an elastic modulus of 124 ± 7 MPa. The silk embedding improved the tear strength by a factor of seven, maintaining flexibility and softness, see Fig. 1. The metal adhesion on these films was enhanced by micropatterning with a determined height-to-width ratio. They were stable in phosphate buffer saline over 10,000 loading cycles. Contrary to flat electrodes, the two-directional micropatterned Au remained conductive up to 30 % strain because of the framework behaviour, see Fig. 2.

The fabricated neural probes are considered to be compliant interfaces to the human brain and spinal cord. They adapt to the tissue's anatomy, withstand substantial bending without losing electrical conductivity, and provide long-term stability under physiological conditions. Our clinical partners proved the easy handling of the biocompatible implants during surgical interventions. Their effective fabrication can be adapted to large-scale production.

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