Development of Intracortical Probes (Geneva Electrode Array)

First steps towards novel 3-D glass-based intracortical microelectrode arrays intended for long-term implantation into Human

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Brief description

The current generation of intracortical microelectrode arrays presents reliability issues after implantation, resulting in degradation of performance. In this project, we have developed a novel glass-based intracortical electrode array named Geneva Electrode Array (GEA) for long-term implantation. It is the result of the combination of recent 3-D glass printing microsystem technologies and an electrical functionalization by inserting and sealing conductive metal wires within its hollow tips.

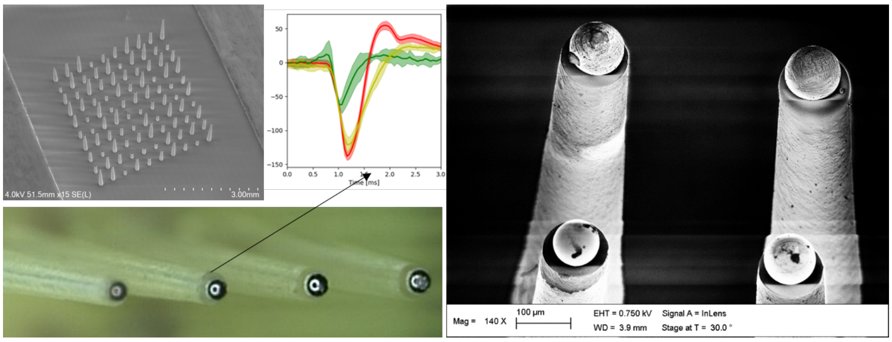
Key points

Intracortical probes:

- Based on glass substrates presenting good long-term stability within biological environment.
- Platinum/Iridium electrodes allow excellent brain activity monitoring characteristics.
- First probe insertion tests showed implantation capabilities without any probe damage.

Probes characterization platform:

- In vitro electrophysiology platform using 3-D neuronal tissues derived from human induced pluripotent stem cells (hiPSC) to check for neural activity recording capabilities.



Geneva Electrode Array, a novel glass-based intracortical MEAs functionalized with Pt/Ir metal wires

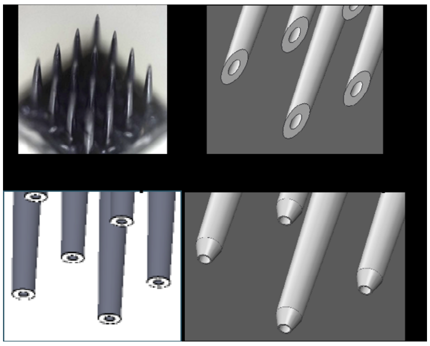
Nowadays, human grade intracortical microelectrode arrays such as the Utah Array (current gold standard) present reliability issues during short-term implantation.

The developed glass probes are made of an array of hollow glass shanks (capillaries) that were designed and commercially manufactured (FEMTOprint SA, Switzerland). Different shapes at the end of the glass shanks have been realised. To be able to use the probes as an electrode array, the glass shanks need to be filled with Pt/Ir metal wires.

The obtained probes have been tested in vitro for their functionality using human stem cells derived 3-D neuronal tissues. Results were compared to Utah Arrays showing that the electrode noise level and the obtained signal to noise ratio are in the same range.

To investigate the probes implantability capabilities, insertion tests into agarose samples have been carried out using a push/pull test equipment. The Utah Array shanks being very sharp and smaller in diameter, the resulting measured insertion force necessary to penetrate the agarose samples on its full length was the smallest of all tests. GEA glass probes with bevelled glass shanks presented the best GEA results due to their sharp shape at their extremities.

Novel glass-based intracortical probes have been electrically functionalized and successfully connected to a data acquisition system. Its electrophysiological measurement characteristics are similar to currently commercially available intracortical probes. Nevertheless, the required force for insertion of the glass-based probes are higher due to the large shank diameter, making it a little bit more difficult to implant. Despite these encouraging results, further characterisation about probes aging behaviour as well as further technical improvements still need to be achieved.



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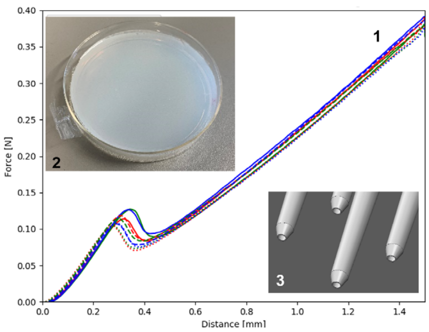

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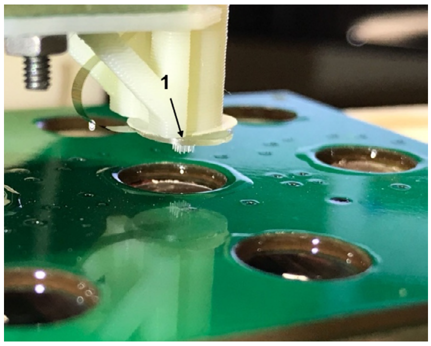

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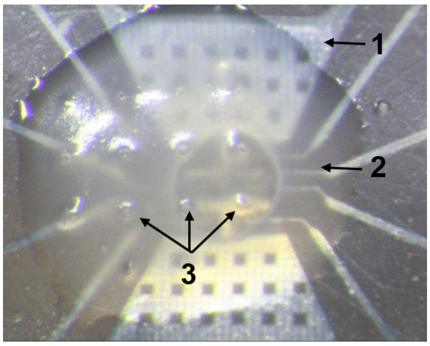

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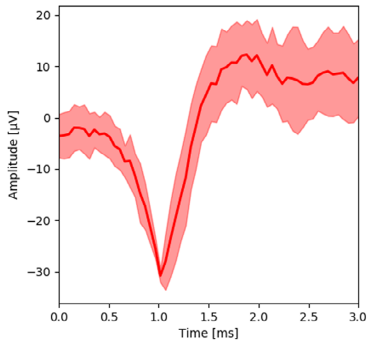

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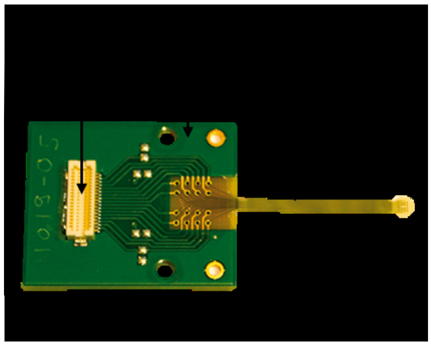

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Output

This work has resulted in a filed PCT patent: PCT/IB2020/050543, Tissue Access Device, 23 Jan 2020.

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Special equipment

- An *in vitro* electrophysiology data acquisition platform, a homemade system developed by HEPIA.
- A push/pull test equipment from ZwickRoell, Ulm, Germany.
- A welding laser setup available at Wyss Center, Geneva, Switzerland.

Legends

1 - Three GEA shank shapes compared to a Utah-Array probe (4x4 layout with inter-shank pitch of 400μm)
2 - Insertion test curves (1) of the chamfered GEA glass probe (3) in 5% agarose fantom (2)
3 - View of in vitro microelectrode array testing platform for tissue assessment used to test the GEA probes (1)
4 - GEA insertion test into Human 3D neuronal tissues (2) on MEA testing platform (1). The penetration pattern of the 4x4 probe remains visible in the tissue (3)
5 - Example of a neuronal signal recorded with the GEA probe functionalized with Pt/It wires
6 - GEA assembly: 1. connector 2. adapter printed circuit board, 3 flexible polyimide cable, 4. GEA probe

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