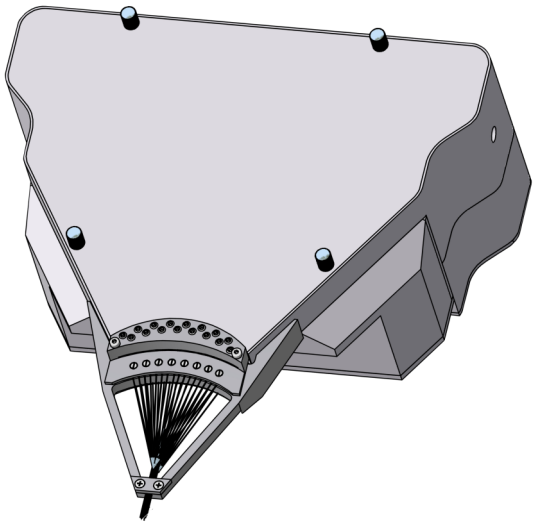
Thomas RECORDING GmbH

„We have the solution!“

32 Heptode Thomas Matrix System

224 Recording Channels

New Generation



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Product Features

- 32 **independently moveable** 7 core platinum/ tungsten microelectrodes (Heptodes)
- 2D– or 3D-Heptodes available (recording from **2 or 3 layers** simultaneously)
- **224 recording channels** on the area of a pin-head (app. 2.4 x 1.2mm)!
- Recording depth: 0 to **35mm** from dura surface (allows simultaneous cortical and deep brain recordings)
- Electrode depth variable with **1µm accuracy**
- Electrophysiological recordings in brain voxels of app. 100mm^3
- **Electrode spacing** selectable from **95µm** up to the millimeter range
- Various electrode guide tube arrangements available (linear, 4x8, 2x16, concentric, etc.)
- No hysteresis, slick or free motion due to **patented rubber-tube drive** (avoids drawbacks of cable, direct or hydraulic driven systems)
- **Minimal noise!** No electrode connection cables free in air! Complete metal shield around all microelectrodes
- **Minimal tissue damage** due to conical tips, thin shafts and successive electrode insertion
- Integrated headstage with data acquisition system

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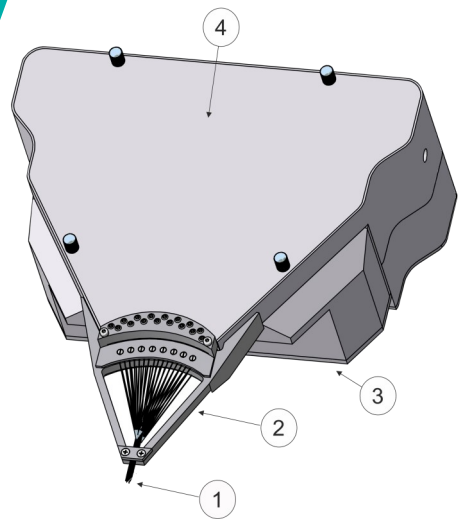

Fig. 1: 32 Heptode Thomas Matrix

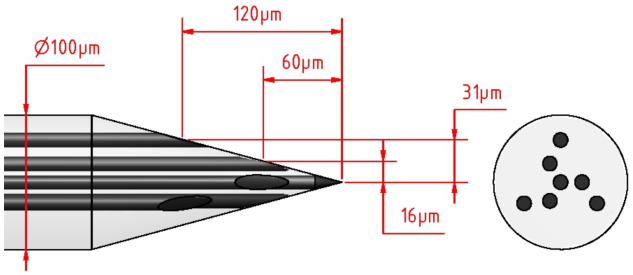

Fig. 2: 3D-Heptode tip dimensions. The distance between the centers of individual metal cores is app. 16µm.

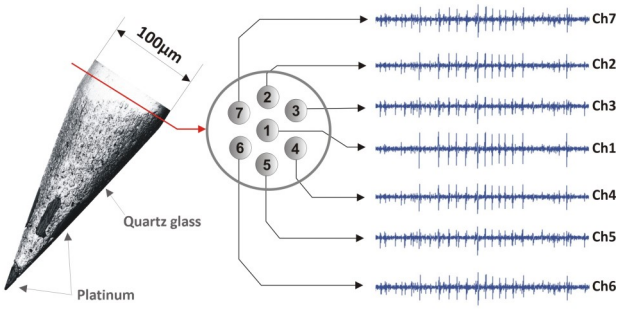

Fig. 3: Heptode tip with 7 recording contacts. The outer diameter of the heptode fiber is just 100µm. The 32 Heptode Thomas Matrix can drive up to 32 heptodes independently from each other to different depths of the brain.

The scalable ***32 Heptode Thomas Matrix System*** can position up to 32 Heptodes (with up to 224 recording contacts) in a small brain area (minimum 2.4x1.2mm). This system is available in a 4-, 7-, 16– and 32-heptode Version. Figure 1 shows a ***32 Heptode Thomas Matrix system*** with the following features: (1) Stainless steel guide tubes, (2) exchangeable microdrive head for different electrode configurations (e.g. linear, concentric, etc.), (3) 224 channel preamplifier integrated in the Microdrive chassis, (4) Thomas Matrix chassis with closed cover. The microdrive is equipped with the patented Thomas rubber-tube drive that avoids positioning errors well known from other microdrive systems [1].

The ***32 Heptode Thomas Matrix*** has an integrated 224 -channel low-noise preamplifier. The microelectrodes are shielded by the microdrive chassis resulting in no electrical noise pickup from the environment.

Different electrode configurations are realized by an exchangeable microdrive head. Very close electrode spacings are possible (down to 95µm). The ***32 Heptode Thomas Matrix*** is well suited for **cortical** and also for **deep brain recordings**. The electrode travel distance is up to 35mm, larger travel distance on request!

The ***32 Heptode Thomas Matrix System*** is delivered completely with microprocessor motor control unit, software, multichannel preamplifier, xyz-manipulator, and a set of microelectrodes.

The heptodes consist of 7 individual platinum/tungsten cores (Fig. 2) and support **spike sorting** based on the stereotrode effect (Fig. 3), which allows superior single unit isolation as compared to typical spike sorting techniques (e.g. template matching) [2].

[1] Eckhorn R, Thomas U (1993);
A new method for the insertion of multiple microprobes into neural and muscular tissue, including fiber electrodes, fine wires, needles and microsensors. J Neurosci Methods 49:175-179.

[2] McNaughton BL, O'Keefe J & Barnes CA (1983);
The stereotrode: A new technique for simultaneous isolation of several single units in the central nervous system from multiple unit records. J Neurosci Methods 8:391-397.

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The 32 Heptode (224 channel) Thomas Matrix is a device that offers the following unique features for neurophysiological recording:

Simultaneous display of electrode position and signals recorded at this electrode position

The integration of Thomas RECORDING multichannel motor control software and the intan TECHNOLOGIES data acquisition hard– and software in one graphical user interface allows to drive each heptode, tetrode or electrode independently from each other while the signal from every recording channel is continuously displayed on the monitor screen (see figure 4 below).

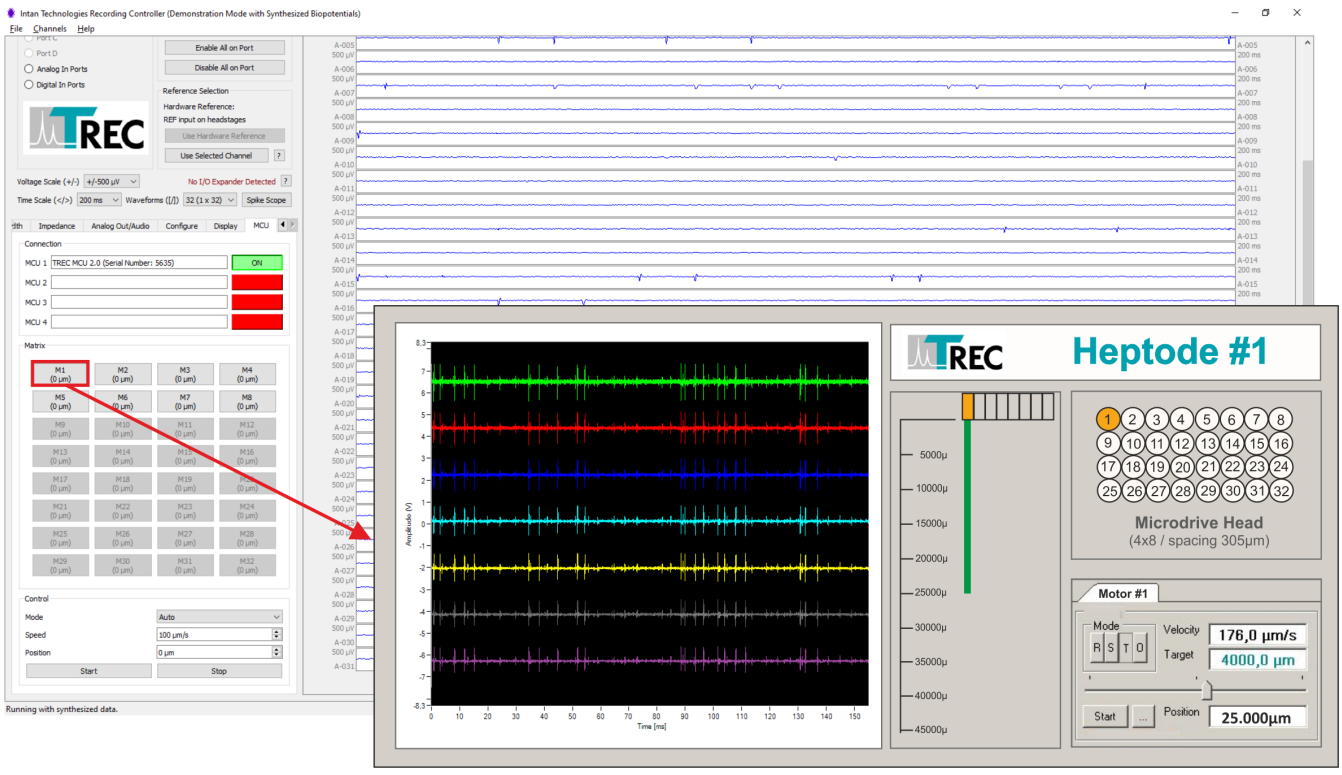


Fig. 4: Graphical user interface of the motor control and data acquisition software for the 32 Heptode Thomas Matrix system. This software allows simultaneous display of electrode position and signals recorded at this electrode position.

This software offers all controls and information necessary to position a recording electrode in the target, for example controls for electrode moving direction and speed, displays for penetration depth as well as relative and absolute electrode position. Signals from all channels are recorded while the electrode is moving and are displayed continuously on the monitor screen.

Moveable Heptode Arrays

In contrast to fixed electrode arrays like silicon probes or Utah arrays (see figure 5A) our 224 channel recording system offers individually moveable electrodes, tetrodes or heptodes (see figure 5B). The Thomas fiber electrodes cause only minimal tissue damage, which allows to use them many times in the same recording area.

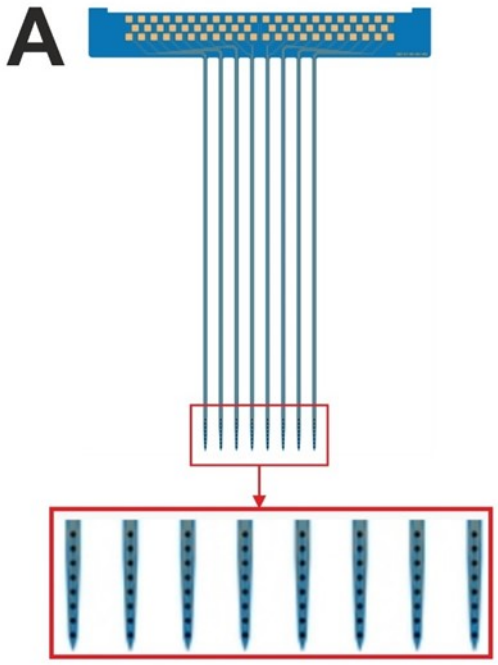


Fig. 5A: Fixed silicon probe array

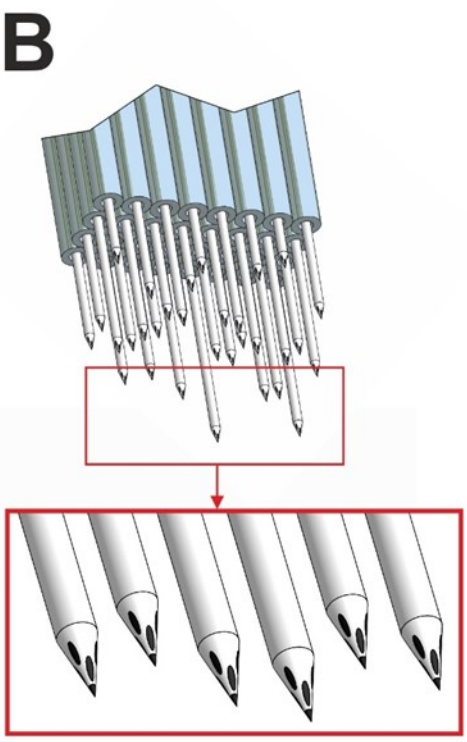


Fig. 5B: Array with 32 moveable heptodes

The 32 Heptode Thomas Matrix is able to move the 32 fiber-electrodes, -tetrodes or –heptodes with an axial resolution of 1µm. The maximum electrode travel distance is 35mm (longer travel distances on request). The lateral spacing of the electrodes can be varied by using distinct exchangeable heads with other electrode spacings (305µm, 500µm, 750µm etc.). It is also possible to select between different electrode arrangements like linear 1x32, 2x16, 4x8, concentric, etc.

Automatic Heptode Movement

The 32 Heptode Matrix is a novel multi-electrode recording system that is able to automatically position heptodes inside the brain by isolating and analyzing single unit activity unsupervised. The automatic heptode positioning allows to improve the quality and efficiency of acute multichannel recordings.

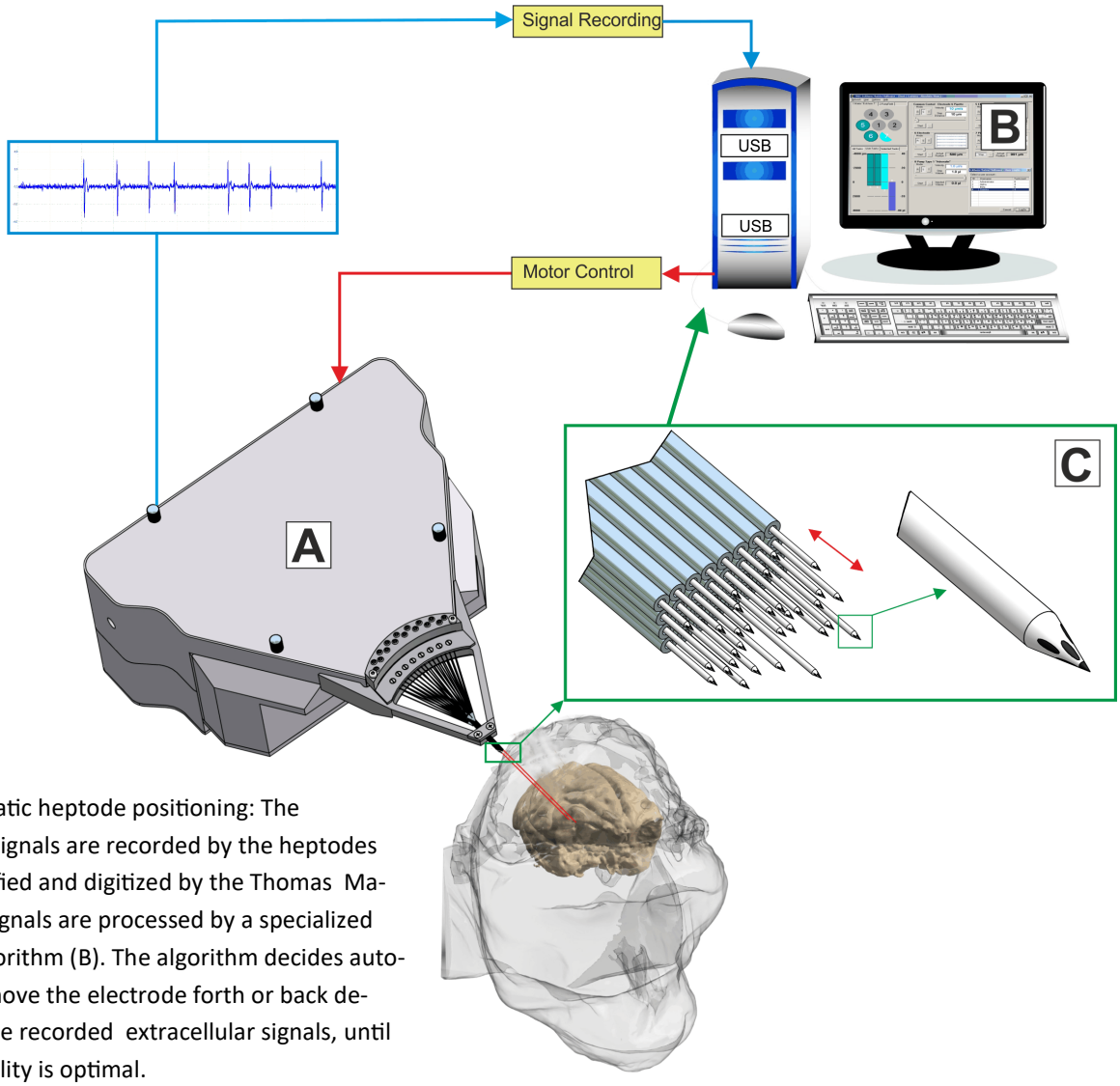


Fig. 6: Automatic heptode positioning: The extracellular signals are recorded by the heptodes (C) and amplified and digitized by the Thomas Matrix (A). The signals are processed by a specialized computer algorithm (B). The algorithm decides automatically to move the electrode forth or back depending on the recorded extracellular signals, until the signal quality is optimal.

This feature is currently under development and will be available soon!

Neuronavigation

The 32 Heptode Thomas Matrix software platform has an interface to the neuronavigation software of our Austrian partner.
This enables the researcher to create a precise 3D-representation of The recording subject based on multi modal medical images, such as CT, MRI and fMRI.

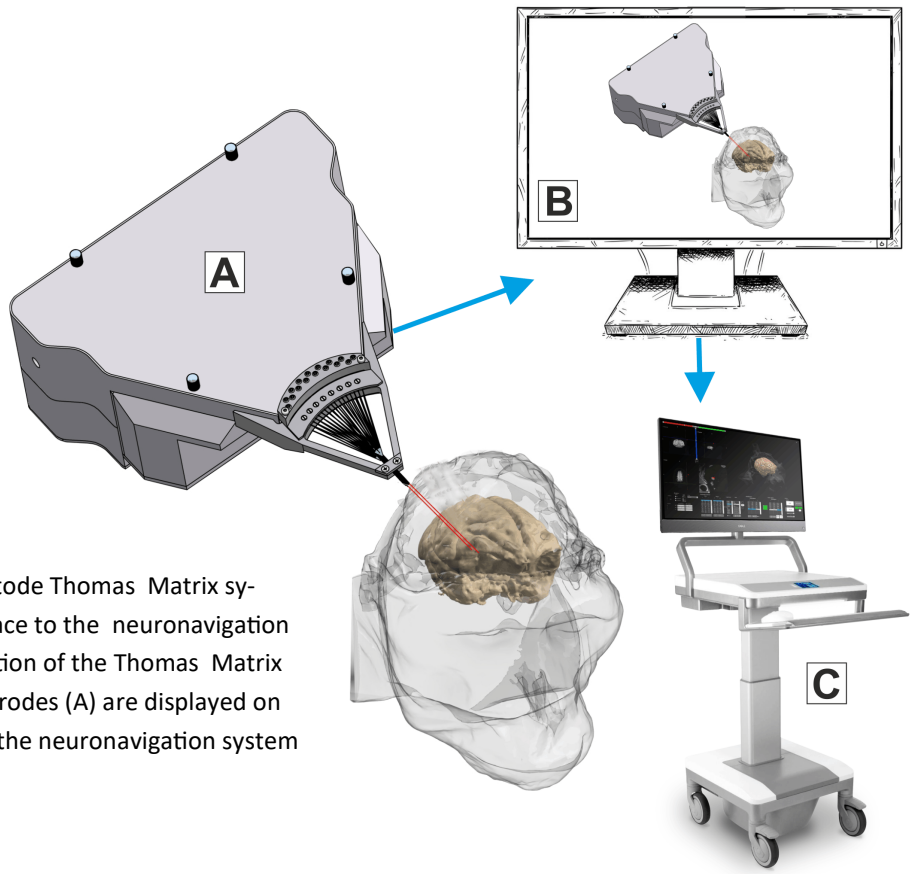


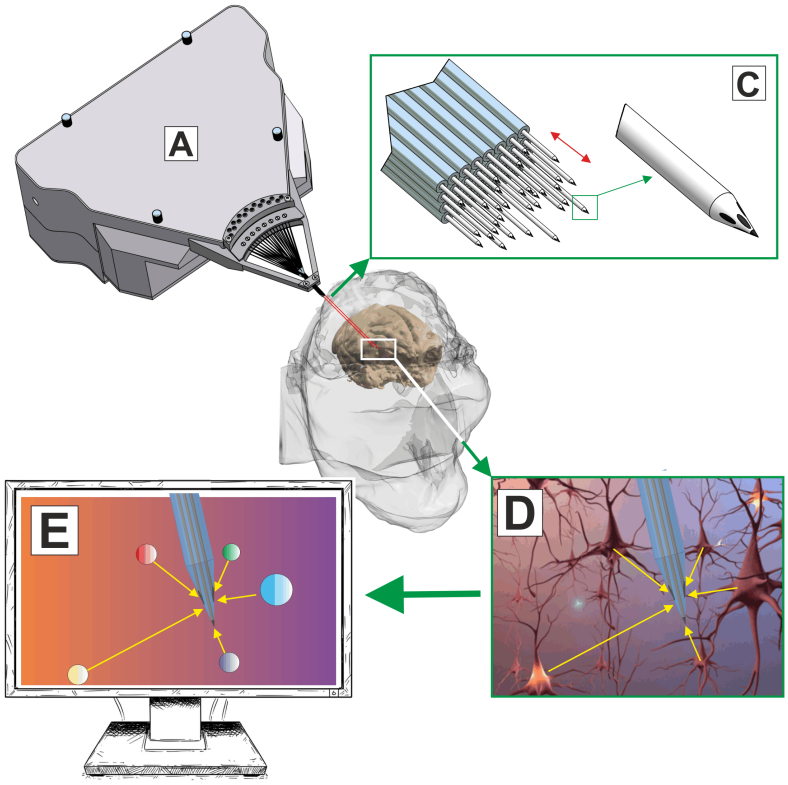
Fig. 7: The 32 heptode Thomas Matrix system has an interface to the neuronavigation software. The position of the Thomas Matrix drive and the electrodes (A) are displayed on the monitor (B) of the neuronavigation system (C).

Skin, bones, blood vessels, cortex and activated brain areas constitute the basis for planning neurophysiological experiments in depth within minutes. The software interface allows to project the anatomy on the computer screen to observe the experiment plan at real scale and in 3D.

Neural Network Reconstruction

The 3D-reconstruction of the neural network from the heptode data is a feature currently under development. Similar to microscope the system will display the neural network on a cellular level, by showing active neurons around the heptode tip in a micrometer scale.

Fig. 8: 3D-reconstruction of the neural network around the heptode tip.



The microdrive (A) places up to 32 heptodes in a small brain area of max. 2.4 x 1.2 x 35 mm which spans a voxel of brain tissue of about 100mm^3. Each heptode (C) records the brain activity from multiple neurons in the close environment of the heptode tip (D). The Thomas heptode sorter and 3D-reconstruction algorithm calculates the position of each active neuron near the heptode and displays the result on the computer screen of the system (E).

This unique feature offers new opportunities for neurophysiological research experiments like connectome research.

Around each heptode tip, neurons in an area of approximately 100µm will be reconstructed, since the signals will fade out into noise for larger distances. As the distance between two heptodes in our microelectrode manipulator can be down to 200-300µm, one can reconstruct a complete brain voxel of a few cubic millimeters, e.g. with an 8x4 array of movable heptodes. Our system will allow to graphically depict the activity of the living brain on a neuronal level and to observe changes in real time, e.g. caused by neuropharmaceuticals or microstimulation in another area.

Combination of different techniques

The 32 heptode Thomas Matrix allows to replace single electrodes by stimulation electrodes, injection cannulas or optical fibers. This allows to stimulate the neurons with electrical current, by drug injection or by light and to record the response of the neural network with the recording electrodes, tetrodes or heptodes.

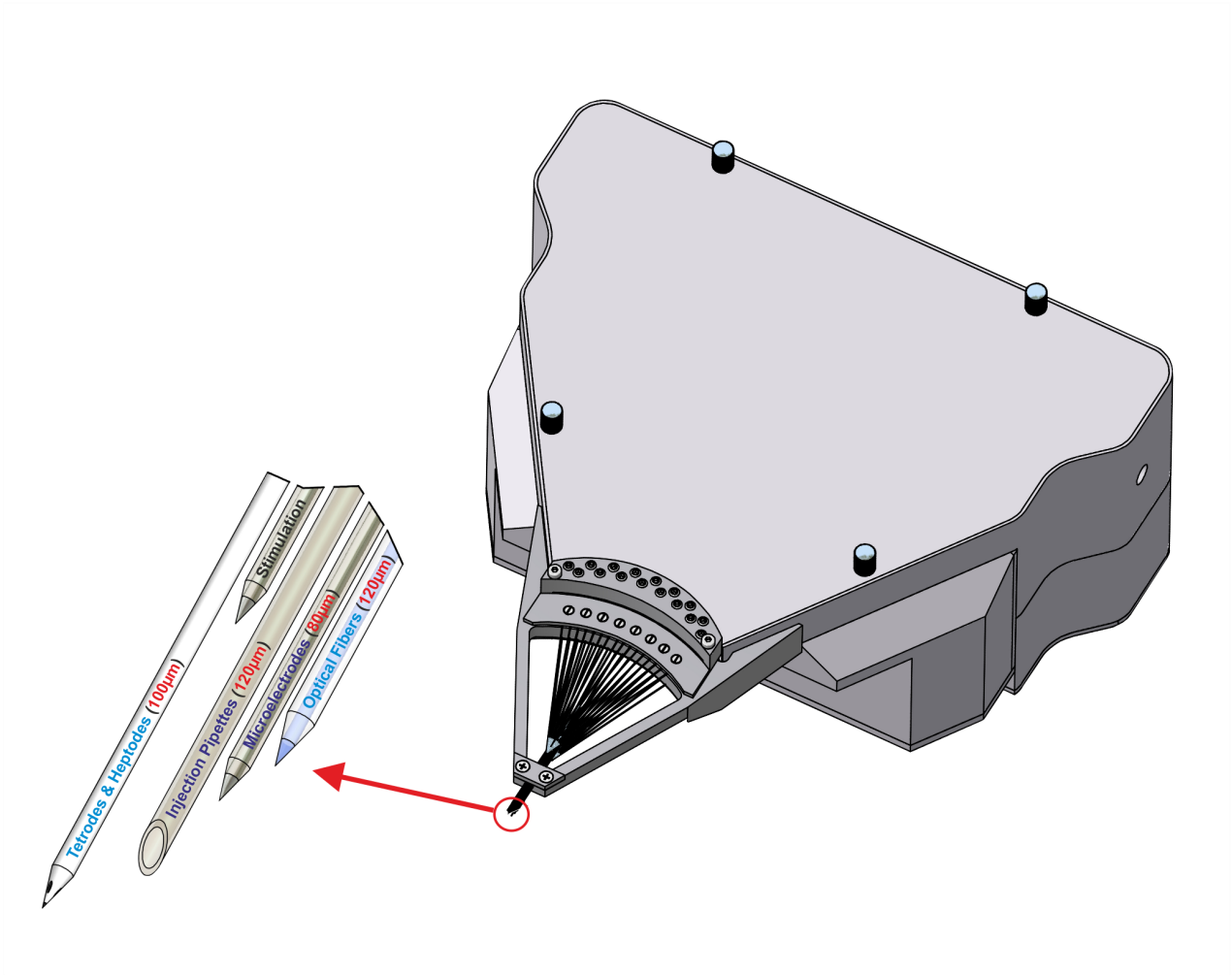


Fig. 9: The left side of the picture shows the techniques that can be combined in the Thomas Matrix drive. You can move recording electrodes (e.g. single core electrodes, tetrodes, heptodes), stimulation electrodes for electrical stimulation, injection cannulas for drug pressure injection as well as optical fibers for stimulation with light via LED or laser. Of course you can also use any combination of these techniques. For example inject drugs and record the response of the neurons with the remaining recording microelectrodes.

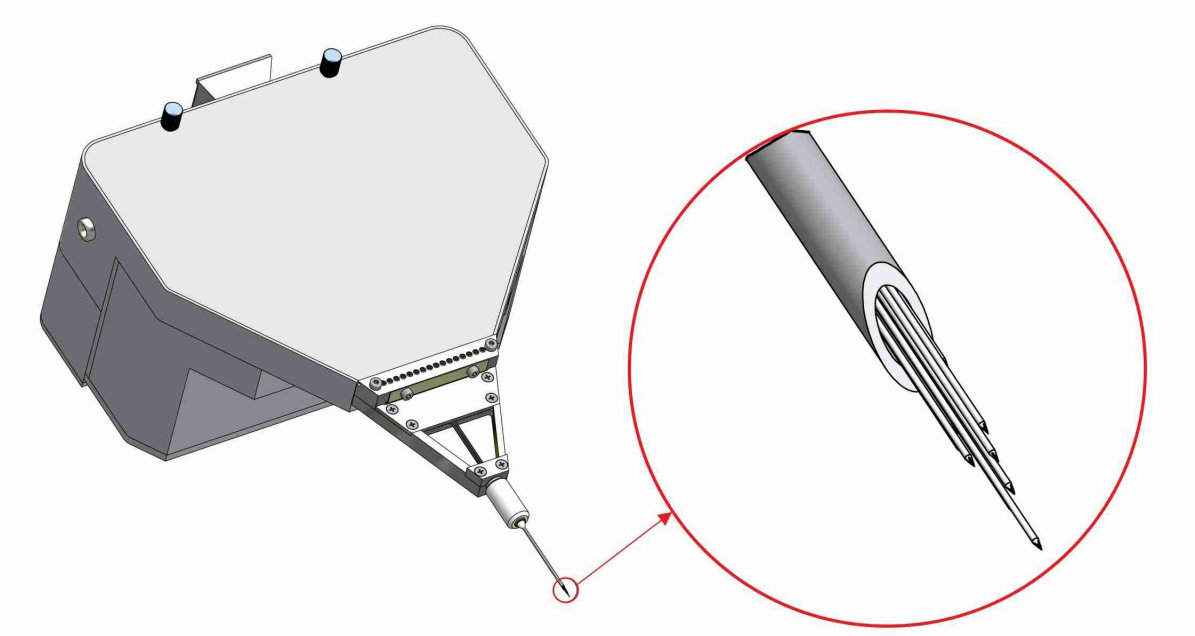


Fig. 10: Heptode Thomas Matrix loaded with 16 Heptodes. Each Heptode is independently moveable. The travel distance of each Heptode is 35mm (more on request). The axial resolution of the microdrive is 1µm.

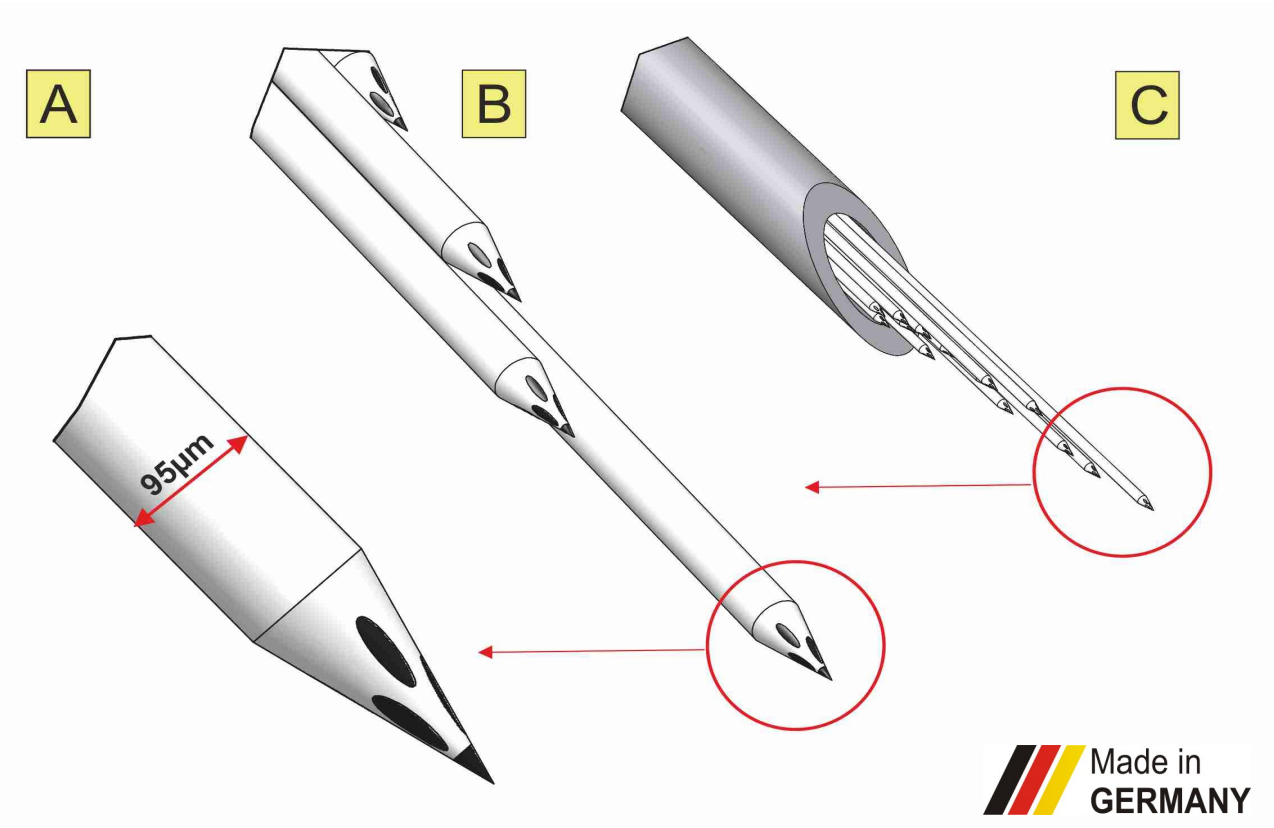


Fig. 11: (A) Tip of a Thomas 3D-Heptode. This Heptode has contacts in 3 different planes to allow recording from different layers. The tip has a conical shape and a shaft diameter of 95µm to minimize tissue damage in the target area. (B,C) Each Heptode is moveable independenttly from each other to different depth of the brain. Picture (C) shows the frontal end of the microdrive guide tube. The minimum spacing between individual Heptodes is 95µm.

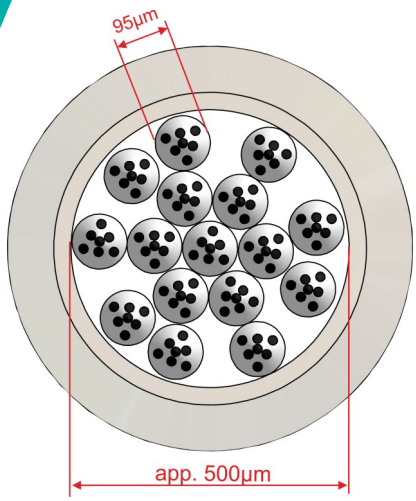


Fig. 12: 16 Heptode tips (frontal view on microdrive guide tube loaded with 16 heptodes)

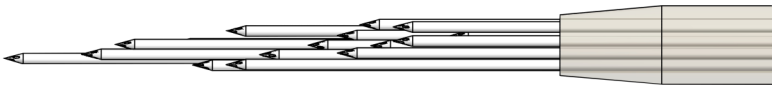


Fig. 13: Side view on microdrive guide tube loaded with 16 heptodes in a concentric arrangement

Table 1: Comparison between the fixed electrode Utah array and a 32 Heptode Thomas Matrix

Specification	Heptode Matrix Array	Electrode Utah Array
Number of recording contacts	224	128
Electrode positioning	movable, 1µm steps	fixed
Electrode shaft length	up to 35mm	up to 1.5mm
Recording layers per electrode	up to 3	1
Single cell isolation	stereotrode effect	e.g. template matching
Impedance per contact	1-3MΩ	0.4MΩ
Electrode shaft spacing	95µm up to the mm range	400µm
Insulation	Quartzglass	Parylene
Recording site arrangement	Linear, concentric, squared, rectangular, etc., spacing is customizable	Squared with fixed spacing
Location of recording targets	cortical and deep brain	cortical
Electrode placement	Successive insertion with low velocity	Pressure injection
Access to brain area of interest	Recording chamber allows **continuous** access to brain area	Brain area is **occupied** by implanted array, no further access possible