Fiber Microelectrodes with Iron Core for histological Marking of Recording Positions in extracellular Recordings using Multiple Microelectrodes

Dirk Hoehl & Uwe Thomas

Thomas RECORDING GmbH, Giessen, Germany

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Abstract:

This technical report demonstrates a technique for deposition of iron in brain tissue to mark the recording electrode position. This technique uses a Thomas Microdrive system (e.g. Mini Matrix or Eckhorn System, Thomas RECORDING GmbH, Germany,[1]) to place up to seven single core microelectrodes with high precision in small brain nuclei. One of the seven fiber electrodes has an iron core while the other six are platinum-tungsten electrodes. When all electrodes are in the final recording position iron is deposited in the surrounding tissue. In a histological preparation with Perl´s Prussian blue technique we can stain the iron deposited in the nerve tissue blue in a histological preparation. This article describes the technical details of this technique.

1. Introduction

Quartz glass insulated fiber microelectrodes for extracellular recording were developed by Reitboeck and Thomas in the early 1970s and first published by Reitboeck 1981 [1, 2].

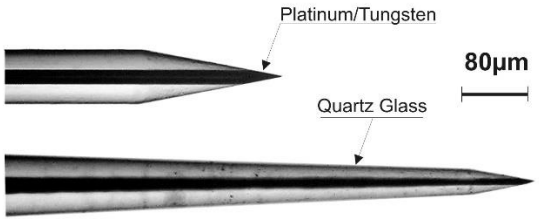

Figure 1: Thomas Quartz glass insulated platinum tungsten fiber electrodes with shaft diameter 80µm. From top to bottom: Only ground tip, electrode impedance @1kHz app. 0,5-0,8MΩ, pulled & ground tip, electrode impedance @1kHz app. 1-10MΩ in steps of 1MΩ.

One of the first users of these fiber microelectrodes positioned with a Thomas microdrive type "Reitboeck Matrix" (see Figure 2) was Mountcastle who published his results with this new recording technique in 1991 [3]. The author stated: "…The electrodes are remarkably atraumatic, and we have not been able to locate electrode tracks in the brains used, in spite of diligent search. A new method of track identification is badly needed…".

Figure 2: Thomas Microdrive type "Reitboeck Matrix" used by V. B. Mountcastle to place up to 7 fiber microelectrodes in the cortex of non-human primates.

This new technique was developed by Uwe Thomas in the late 1990s when he designed quartz-glass insulated iron electrode fibers. The goal was to deposit iron in brain tissue and to use a histological staining technique to visualize the deposited iron in the brain slices. Histology is the microscopic study of animal and plant cell and tissues through

staining and sectioning and examining them under a microscope. A literature review and case study of histological stains is given by Alturkistani et al. [4].

2. Materials and Methods

For extracellular recording multiple fiber microelectrodes are positioned in the brain target area by using a microdrive system like the Thomas Mini Matrix (see Figure *3*).

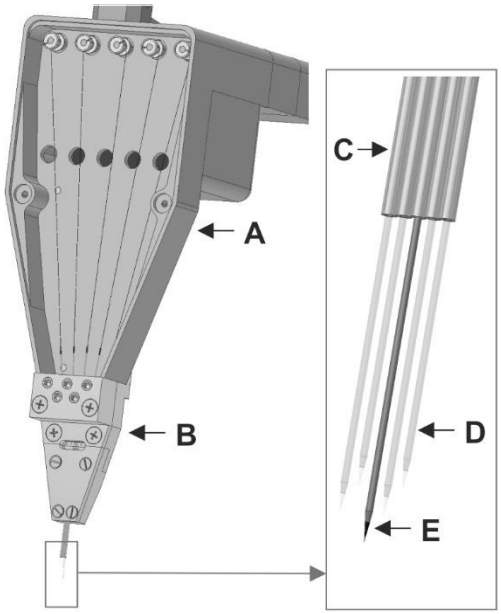

Figure 3**:** A 5-electrode Thomas Mini Matrix (A) with an exchangeable microdrive head (B) is used to realize customized electrode spacing and electrode configurations. The matrix enables software-controlled and independent positioning of the electrodes. Each fiber electrode is guided in a stainless-steel guide tube (C). In this case, 4 platinum-tungsten fiber electrodes insulated with quartz glass electrodes (D) and a quartz-glass insulated iron electrode (E) is used for the extracellular recording. For details see Eckhorn & Thomas 1993 [5].

The Thomas Mini Matrix uses the patented rubber tube driving mechanism for the positioning of up to five fiber microelectrodes independently from each other in different depths of the brain. This rubber tube technique was developed by Eckhorn and Thomas and published in 1993 [5]. Although a motor control software displays the exact axial recording position from the starting point in micrometers, it might be required to confirm this position with a staining technique if it is possible to make a histological preparation after the recording session. In Figure 4 we show how this technique works.

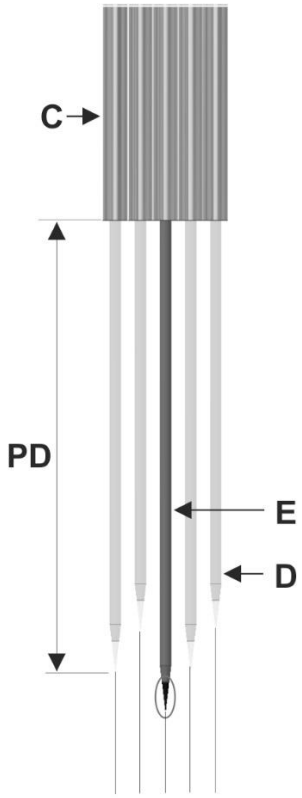

Figure 4: If a small amount of iron from the iron electrode (E) tip is deposited into the surrounding brain tissue the final position of the iron electrode is marked for later staining in the histological preparation. The lateral distance between all five electrodes is constant and determined by the guide tube (C) outer diameter which is 30 gauge or 305µm in this case. The penetration depth is determined by the motor control software in micrometers.

At the end of the recording session a stimulus generator is connected to the iron electrode. In constant-current mode, a anodal direct current (d.c.) in an amount of 10-30µA is fed into the electrode for app. 1 minute, so that a small amount of iron ions is deposited in the surrounding brain tissue.

3. Experimental results

The histological verification of the recording position of Thomas fiber microelectrodes in brain tissue of a gerbil was demonstrated by M. Woldeit & J. Mylius (LIN, Magdeburg, 2013). The histological detection method is the Prussian Blue staining of brain tissue. This original formular of this technique was first described in 1867 by German pathologist Max Perl, hence why it is often known as Perl´s Prussian blue staining technique. Many different staining protocols have been developed since the original description by Perl, each used to reach the same goal, to demonstrate iron in tissue. Since this is a standard procedure, we have dispensed with a detailed description of the procedure at this point. If required, please contact the corresponding author for a detailed protocol. The results of the staining process are shown in Figure 5 and Figure 6.

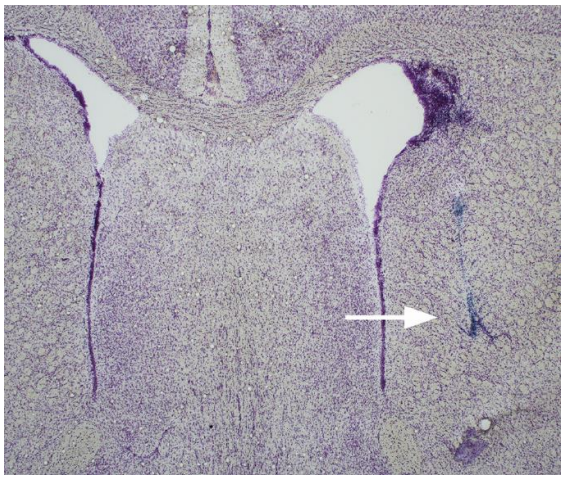

Figure 5: This picture shows a brain slice treated with the Nissl staining. This technique is a histological staining technique named after the German psychiatrist and neuropathologist Franz Nissl that is used in particular to visualize cell nuclei and ribosomes in nervous tissue in blue or purple. Prussian blue technique was used to stain the iron ions deposited from the iron electrode blue (white arrow). (Made by Dr. Marie Woldeit, LIN, Magdeburg, courtesy of Dr. Judith Mylius, 2013)

The iron sections in the tissue (arrows in Figure 5 and Figure 6) are blue colored deposits while other tissue components are colored red in the counterstain in Figure 6.

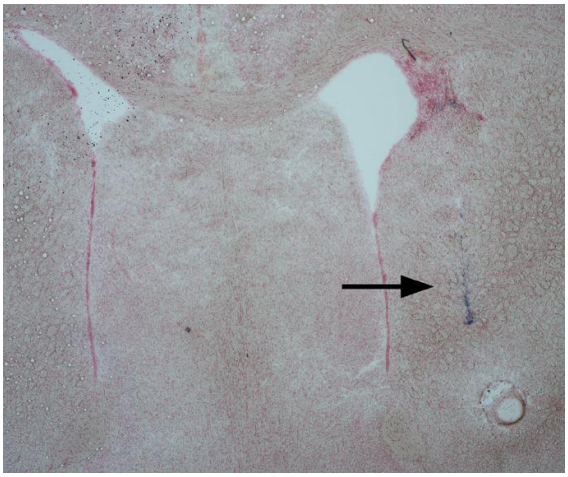

Figure 6: Counterstain of the slice with nuclear fast red (NFR) stain (Kernechtrot). Black arrow shows the iron deposited in the tissue. (Made by Dr. Marie Woldeit, LIN, Magdeburg, courtesy of Dr. Judith Mylius, 2013)

In Figure 7 a photomontage is shown. The recording positions of all five recording electrodes could be determined in the brain slice according to the position of the iron electrode tip.

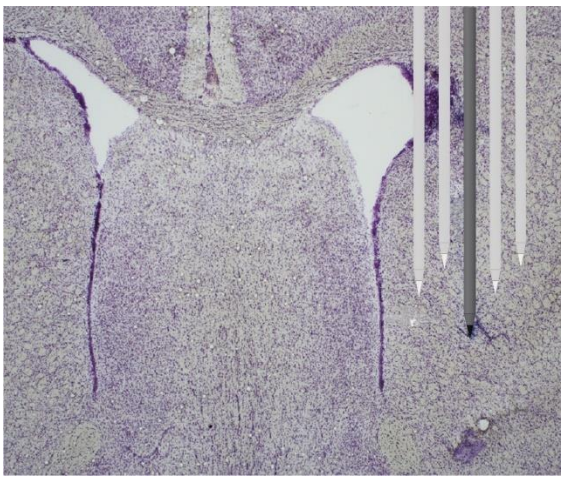

Figure 7: This figure shows a photomontage where the electrode recording positions were reconstructed according to the blue colored iron electrode tip position.

If a histological preparation is not possible, because the animal is still used in experiments, it should in principle be

possible to make MRI images of iron deposition in brain tissue. We recommend making a test deposition in agar to determine the required amount of iron.

4. Ordering information

Thomas RECORDING offers ready for use quartz glass insulated iron microelectrodes for Thomas microdrives and microelectrode fiber raw materials for iron electrode manufacture.

Article number	Description
AN000291	Box of iron electrodes for Thomas Mini Matrix
AN001103	Box of iron electrodes for Thomas Mini Matrix
AN000951	Quartz glass insulated iron electrode fiber raw material, outer diameter(D1)=80µm, core diameter(D2)=25µm; Quantity: 1m

Other iron electrodes on request. Please feel free to contact us for more information under info@ThomasRECORDING.com

5. References

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Authors:

Uwe Thomas
(Owner Manager),
Thomas RECORDING GmbH, Germany

Dipl.-Ing. Dirk Hoehl
(Technical Director),
Thomas RECORDING GmbH, Germany

Email: info@ThomasRECORDING.com
Web: www.ThomasRECORDING.com