proceedings

Abstract

Magnetic Tunnel Junction Based Chip to Detect the Magnetic Field of Neuronal Signals: A Platform for In Vitro Studies †

Daniela Moretti [1,*], Parikshit Pratim Sharma [2], Daniela Petti [2], Edoardo Albisetti [2], Riccardo Bertacco [2], Pietro Baldelli [1] and Fabio Benfenati [1]

[1] Center of Synaptic Neuroscience, Italian Institute of Technology, 16132 Genova, Italy; Pietro.Baldelli@iit.it (P.B.); fabio.benfenati@iit.it (F.B.)
[2] Department of Physics, Politecnico di Milano, 20133 Milan, Italy; parikshitpratim.sharma@polimi.it (P.P.S.); daniela.petti@polimi.it (D.P.); edoardo.albisetti@polimi.it (E.A.); riccardo.bertacco@polimi.it (R.B.)
* Correspondence: daniela.moretti@iit.it
† Presented at the 5th International Symposium on Sensor Science (I3S 2017), Barcelona, Spain, 27–29 September 2017.

Published: 29 November 2017

Magnetoencephalography (MEG) has revolutionized neuroscience, offering a tool with unprecedented spatial and temporal resolution. Today, MEG has clinical uses in detecting and localizing pathological activity in patients with brain tumors or intractable epilepsy [1].

Despite the wide clinical applications, the nature of MEG signals at local level is still not well understood [2]. In this context, there is evident crucial interest in developing a new generation of devices for local magnetic recording for an in vitro system. Several recent studies have implied that MagnetoResistive (MR) technologies can detect a biological magnetic field at local scale [3,4] (i.e., brain slice, muscle in vitro). However, to date, no attempts have been carried out for neurons in culture due to the long-term biocompatibility required.

In this work, we will present a platform based on MR sensors array, namely magnetic tunneling junctions (MTJs) to detect the activity of neurons in culture from a magnetic point of view. We will show the biocompatibility of our devices and the preservation of the physical properties of the sensors. Murine embryonic hippocampal neurons were grown on top of the MR sensors array. We achieve a lifetime of the on-chip neuronal networks of longer than 20 days. Neurite growth was studied during development with immunostaining analysis.

In conclusion, we achieved the biocompatibility conditions of a MR platform suitable for studying the magnetic field generated by the activity of in vitro neuronal networks.

Keywords: magnetic tunnel junction; biological magnetic field; neuron culture; in vitro; biocompatibility

---

Acknowledgments: The authors thank the Fondazione Cariplo for the UMANA project [grant number 2013-0735].

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Stufflebeam, S.M.; Tanaka, N.; Ahlfors, S.P. Clinical applications of magnetoencephalography. *Hum. Brain Mapp.* **2009**, *30*, 1813–1823.
2. Haueisen, J.; Knösche, T.R. *Magnetoencephalography*; Supek, S., Aine, C.J., Eds.; Springer: Berlin/Heidelberg, Germany, 2014; pp. 107–127.

3. Costa, T.; Piedade, M.S.; Germano, J.; Amaral, J.; Freitas, P.P. A Neuronal Signal Detector for Biologically Generated Magnetic Fields. *IEEE Trans. Instrum. Meas*. **2014**, *63*, 1171–1180.
4. Barbieri, F.; Trauchessec, V.; Caruso, L.; Trejo-Rosillo, J.; Telenczuk, B.; Paul, E.; Bal, T.; Destexhe, A.; Fermon, C.; Pannetier-Lecoeur, M.; et al. Local recording of biological magnetic fields using Giant Magneto Resistance-based micro-probes. *Sci. Rep*. **2016**, *6*, 39330.