In vivo recordings of brain activity using organic transistors

Dion Khodagholy[1], Thomas Doublet[1,2,3,4], Moshe Gurfinkel[1], Pierre Leleux[1,2,3,4], Pascale Quilichini[2,3], Antoine Ghestem[2,3], Esma Ismailova[1], Thierry Herve[4], Sébastien Sanaur[1], **Christophe Bernard**[2,3] & George G. Malliaras[1]

[1] Department of Bioelectronics, Ecole Nationale Supérieure des Mines, CMP-EMSE, MOC, 13541 Gardanne, France. [2] Aix Marseille Université, INS, 13005, Marseille, France. [3] Inserm, UMR_S 1106, 13005, Marseille, France. [4] Microvitae Technologies, Pôle d'Activité Y. Morandat, 13120 Gardanne, France.

Most breakthroughs in our understanding of the basic mechanisms of information processing in the brain have been obtained by means of recordings from electrodes implanted into, or placed on the surface of the brain. *In vivo* electrophysiological recordings of neuronal circuits are also necessary for diagnosis purposes and for brain-machine interfaces. State-of-the-art recordings are currently performed with microfabricated arrays of metal electrodes, which capture the local field potentials (LFPs) generated by the spatio-temporal summation of current sources and sinks in a given brain volume. However, key technological advances are still needed: the probes must be fully biocompatible (to enable long-term recordings), small/thin (to decrease invasiveness), highly conformable (to comply with the complex 3D architecture of the brain), but most importantly, they must provide an increased SNR through a built-in pre-amplification/processing system. Organic electronic devices constitute a promising solution because of their mechanical flexibility and biocompatibility. Here we demonstrate the engineering of an organic electrochemical transistor embedded in an ultrathin organic film designed to record electrophysiological signals on the surface of the brain. The device, tested *in vivo* on epileptiform discharges, displayed superior signal-to-noise ratio, due to inherent amplification, as compared to surface electrodes. Importantly, the organic transistor was able to record activity, which was poorly detected by regular ECoG. This study introduces a new class of biocompatible, highly flexible devices for recording brain activity with superior signal-to-noise ratio (SNR), of great promise for medical applications.

Khodagholy et al., ***Nature Communications***; 4:1575, 2013