

# Microfabricated auditory brainstem implants on polyimide film

Amélie Guex, Pierre Joris, Michael C. C. Slama, M. Christian Brown, Philippe Renaud, Daniel J. Lee,  
Stéphanie P. Lacour, *Member, IEEE*

THE auditory brainstem implant (ABI) provides hearing sensations to patients with deafness due to conditions that cannot be helped with the cochlear implant (CI). ABI patients suffer from a disconnection of the peripheral to central auditory system due to tumor growth or removal, congenital inner ear malformation or trauma. Current ABI designs consist of 12-21 stimulation electrodes of 550 $\mu$ m-700 $\mu$ m diameter embedded in silicone rubber. Most ABI users have enhanced sound awareness that aid in lipreading, unlike the majority of CI users who enjoy both sound and speech perception. Therefore, ABI clinical outcomes are often poor compared to those of CI: the functional electrical stimulation (FES) can only access a limited range of the tonotopical arrangement, and often induces extra-auditory sensations because of current spreading in neighboring non-auditory structures<sup>[1]</sup>. Polymer microfabrication techniques as well as miniaturization of the ABI can produce implants with higher spatial and tonotopical selectivity. Our main hypothesis is that thin (<100 $\mu$ m thick) and small (<500 $\mu$ m diameter) electrodes integrated on flexible polyimide (PI) substrate will offer a better physical interface with the curvilinear surface of the cochlear nucleus and allow for a reduction of the stimulation currents thereby limiting the recruitment of neighboring non-auditory neurons.

Microelectrode arrays are fabricated on polyimide substrate using standard microfabrication processes. They consist of a layer of 350nm-thick Pt sandwiched between two 22um-thick polyimide layers<sup>[2-3]</sup>. After PtBlack deposition on the electrode sites, impedance modulus at 1kHz is 5.1k $\Omega$  (S.D: 0.27 k $\Omega$ ) for 200 $\mu$ m diameter electrodes and 6.47k $\Omega$  (S.D: 0.06 k $\Omega$ ) for 100 $\mu$ m diameter electrodes. Acute *in vivo* experiments are performed on anesthetized Sprague Dawley rats (350-500g). The MEA is placed on the exposed surface of the dorsal cochlear nucleus (DCN) and a bipolar stimulation is induced, consisting of symmetric biphasic waveforms with 0.2ms phase duration, at a frequency of 23Hz. Generated auditory brainstem responses (eABR) are recorded.

Results show a proof of principle of auditory system stimulation with the microfabricated device. Indeed, eABRs were recorded at various stimulus levels, with different electrode diameters and inter-electrode distances. The amplitude of the main peak obtained during bipolar stimulation as well as the RMS of the recorded signals show a dependence on the stimulation level, the inter-electrode distance and the diameter of the electrode site. These results are consistent with the recruitment of different sizes of neuronal populations depending on the stimulation parameters, with smaller currents recruiting a lower number of neurons. This indicates the possibility to increase spatial specificity of stimulation by choosing appropriate electrode diameter, inter-electrodes distance and stimulation waveform parameters.

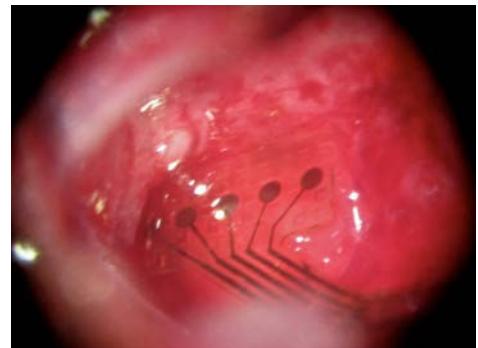


Figure 1 MEA positioned on the DCN surface.  
Electrodes diameter: 200 $\mu$ m

- [1] Coletti et al., "Progress in restoration of hearing with the auditory brainstem implant", *Progress in Brain Research*, Volume 175, 2009, pp333-345
- [2] Stieglitz et al., "Micromachined, Polyimide-based devices for flexible neural interfaces", *Biomedical microdevices*, Volume 2, Issue 4, December 2000, pp 283-294
- [3] Mercanzini et al., "Demonstration of cortical recording using novel flexible neural probes", *Sensors and Actuators A: Physical*, Volume 143, Issue 1, May 2008, pp90-96.