



A New Active Flexible High Resolution Micro Electrode Array

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Motivation

Microelectrode arrays (MEAs) are common tools for the evaluation of side effects of pharmaceuticals and have helped to answer many questions in neuroscience [1, 2]. In the market many different MEAs are available for in vivo and in vitro applications. However, there is a gap between passive MEAs limited in resolution and CMOS-based active MEAs which are mostly rigid and offer limited usable area.

The aim of our work is the development of an active flexible micro electrode array, the NEUROFLEXARRAY (NFA), with more than 10 electrodes/mm² and an active area of several square centimeters allowing recording as well as stimulation.

Material and Methods

The proposed MEA will consist of ASICs developed in this project. Each of these small silicon dies (250 x 250 µm²), is connected to a stimulation electrode, a reference electrode and 25 recording electrodes and offers pre-amplification, filtering and multiplexing. The midband gain of the pre-amplifier is set to 28 dB, the cut-off frequencies of the bandpass filter are 0.1 Hz and 10 kHz, and the multiplexing frequency is 500 kHz. Frequency and transient behavior have been simulated on the Mentor's Pyxis Custom IC Design Platform with the XHO35 XFAB technology.

A substantial task of the project is the development of a chip transfer technology that allows picking up a defined subgroup chips array on the production wafer and place it on a second substrate without shifting or twisting the relative position of the dies. This approach is important since the arrangement of dies on the wafer is densely packed while the distribution in the MEA requires larger areas between the chips. One possibility is the application of a casted silicone stamp [3]. The idea is to increase the relative spacing between the dies by picking and transferring only every Nth die onto a new substrate.

The electrode array is completed by embedding the dies into a polymer such as polyimide and deposition of 2 layers of conducting tracks and electrodes on top using standard MEMS processes.

To make sure long-term stability in vitro and in vivo the array will be encapsulated with thin layers of Al₂O₃ and TiO₂ deposited by atomic layer deposition (ALD).

Results and Discussion

Considering resolution limits of different fabrication steps the array is designed to exhibit a pitch of 1200 µm between the chips in x and y direction, each chip addressing a cluster of 25 electrodes with an electrode pitch of 200 µm, thus resulting in an almost homogeneous distribution of the sensors (Figure 1). The array will consist of 7 x 7 clusters, offering a total of 1225 recording electrodes covering an area of 8 x 8 mm².

The frequency and transient behaviors of the pre-amplifier stage were simulated and have shown so far that the requested bandwidth and gain can be obtained with the proposed circuitry. The transient analysis showed that multiplexing is also possible, though challenging. The pre-amplifier stage circuitry has many challenges [4]. Its design must be e.g. low power, low noise and still occupy a very small area in chip. Therefore, the operational amplifier's design is a crucial step for the system functionality. The multiplexing is also a very challenging feature because of the switching speed of the system. The main goal of the design is balancing speed and performance of the pre-amplifier stage and adapting it to the read-out electronics.

PDMS-stamps for the transfer of dies have been fabricated and tested. Wafer pieces were cut into arrays of 300 x 300 µm² squares that were picked off UV release dicing tape. The principle applicability was shown, but the yield must be improved.

For the deposition of Al₂O₃ and TiO₂ layers plasma enhanced ALD processes have been established allowing deposition at 100°C.

Conclusion and Outlook

A new kind of active micro electrode array is being developed. So far the dies are designed and all fabrication steps are being implemented. In spring 2017 the first real dies will arrive. The first NFA will then be finished in summer 2017. It will have 1225 recording electrodes as well as some stimulation electrodes. The prototype will cover less than 1 cm², however there is the possibility for scale up. There is also the possibility to adjust the design in a further step to a specific application.

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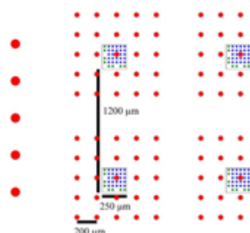
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Figure Legend

Figure 1: The large red circles represent the electrodes, which are spread to a nearly homogeneous distribution from the contacts (blue squares) of the individual dies. The small green squares indicate the contacts for power supply, data, reference electrodes, reset and biasing. For the sake of clarity the conductor tracks are omitted.

Figure 1



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