Integrated high-resolution nano-modified multi-electrode arrays (InMEAs)

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Macroelectrodes for stimulation of nerve cells or recording of action potentials are widely used today. Examples of clinical applications are cardiac pacemakers, cochlear implants or deep brain stimulators. In contrast, microelectrodes are typically applied in so called microelectrode arrays (MEAs) which are mainly used in medical and biological research. For cardiac pacemaker a further electrode miniaturization is not mandatory. But in case of cochlear implants or retinal implants the use of microelectrodes would bring a significant progress by increasing the numbers of electrodes. Electrode miniaturization is only reasonable when improving the electrical and electrochemical properties at the same time. To reach this objective the approach within InMEAs will be the nanomodification of the electrodes.

The flexibility of the CMOS-chips will be reached by thinning them to thicknesses below 20 µm. These flexible CMOS-chips, gold conductors and each of 25 microelectrodes will be integrated in a polyimide carrier and encapsulated with parylene. This structure is called BASIS-FLEX-MEA, shown schematically in figure 2.

The electrodes are made of iridium oxide, shown in figure 3. Iridium oxide is already used by many research groups worldwide, since it is best suited for stimulation of nerve cells with a charge-transfer capacity over 90mC/cm² [1-5].

One subproject within InMEAs is to build up an “intelligent electrode”. That means the integration of the necessary microelectronic chip for stimulation into a flexible carrier in close proximity to a group of stimulation electrodes. The flexibility has the great advantage that subsequent implants can be better adapted to the properties of a human body. Additions of the number of microelectrodes can be increased by connecting these “intelligent electrodes” to a bus system (compare figure 1).

As a result of the project a demonstrator will be presented which will serve as a basic unit for the “intelligent electrode”. A flexible CMOS-chip embedded into polyimide will control 25 electrodes (compare figure 1 and 2).

There will be developed 25 electrodes for stimulation into a flexible polymer film, shown in figure 3. The electrodes will be coated with Carbon Nanotubes (CNTs). This is done in order to increase the charge transfer capacity even more. In addition, the cell growth on CNTs is reported to be very excellent [6]. Unfortunately, vertical CNTs cannot be deposited directly on the electrodes because the polyimide is only stable up to 400°C. But in the moment the deposition of vertical CNTs requires 700°C. The challenge now lies in the development of a transfer process for the deposition of vertical CNTs on the electrodes. Alternatively, CNTs will directly be deposited onto the electrode surface electrochemically out of a suspension.

In the second subproject a high-resolution highly-integrated CMOS-based microelectrode array for medical studies of cells and tissue sections will be developed. This so called BASIS-CMOS-MEA is shown schematically in figure 4.

As in the first subproject the electrodes will also be coated with CNTs in order to increase the charge transfer capacity.
The structure shown in figure 4 exhibits a plane surface topology and can be used as a flexible platform for the integration of the CNTs on a CMOS circuitry.

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**References**


