Micro array of Ag-AgCl electrodes for cellular stimulation and sensing

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Introduction

Most novel efforts of miniaturizing electrophysiology techniques consist of designs based on gold and platinum microelectrodes for sensing and stimulation, which results expensive. In this study, silver–silver chloride as microelectrode material is investigated as an alternative, considering the benefits of its low cost, biocompatibility and high conductivity.

Microelectrode array design guidelines

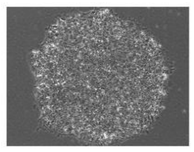
Electrode materials

	Silver – Silver Chloride	Gold	Platinum
Conductivity [MS/m]	62.9	45.17	9.52
Cost [USD/g]	15	198	171
Biocompatible	Yes	Yes	Yes

Available online: http://www.sigmaaldrich.com/, last viewed 09/04/2014

Array shape

-Cell aggregate

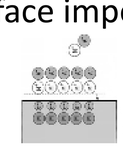


-Tissue portion

Microelectrode size

-Cells

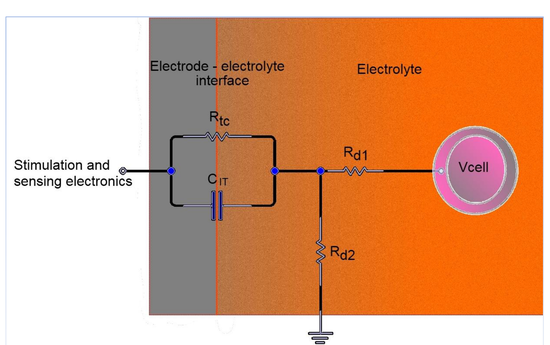
-Interface impedance



-Crosstalk

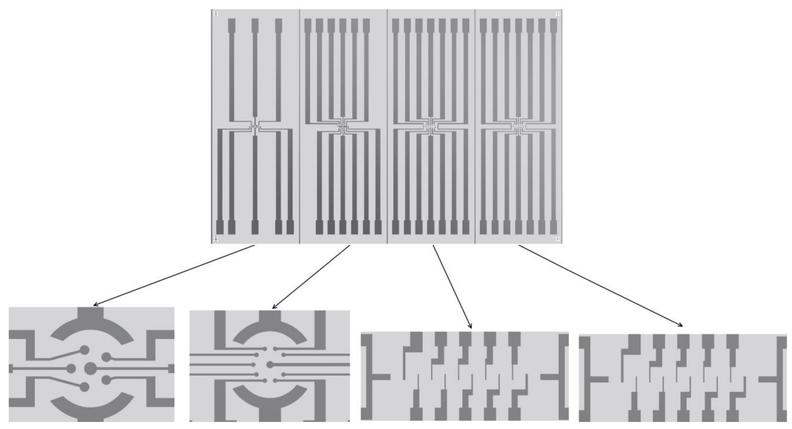
Electrical model

- Electrode-electrolyte capacitance
  - Helmholtz capacitance (C_H) $C_H = \frac{\epsilon_0 \epsilon_r A}{d_{PEH}}$
  - Gouy – Chapman capacitance (C_{GC}) $C_{GC} = \frac{\epsilon_0 \epsilon_r A}{L_D} \cosh\left(\frac{zV_0}{2V_t}\right)$
  - Stern and total interface capacitance (C_{IT}) $C_{IT} = \frac{1}{C_H} + \frac{1}{C_{GC}}$
- Electrode-electrolyte resistance
  - Charge transfer resistance (R_{tc}) $R_{tc} = \frac{V_t}{J_{eq} z}$
- Electrolyte resistance
  - Dispersion resistance (R_d) $R_d = \frac{\rho}{4r}$



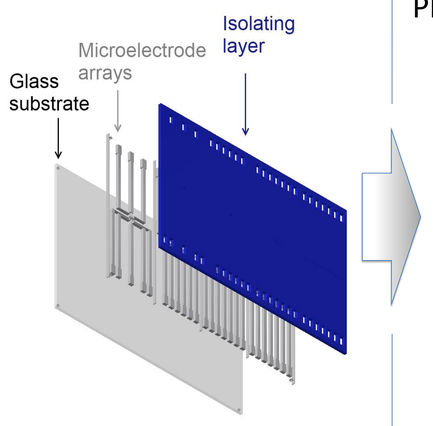
Equivalent circuit of the electrode – electrolyte interface and electrolyte impedances, as described by the electrical model

Microelectrode array design prototype

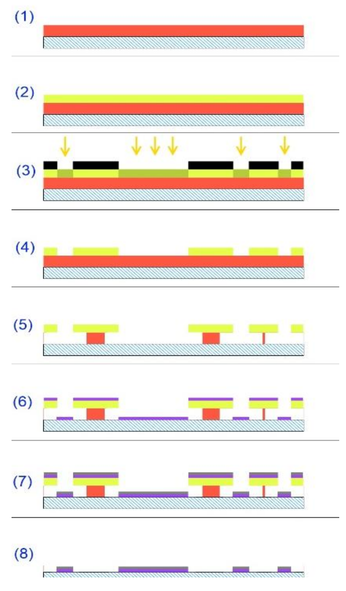


Fabrication process

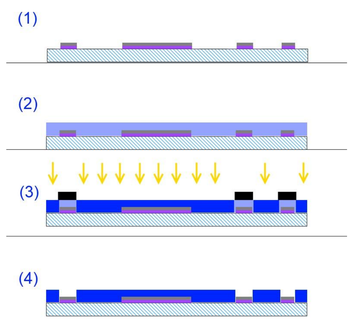
Computer aided design



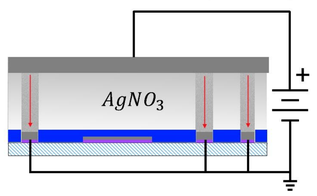
Photolithography and *lift off for* silver deposition and patterning



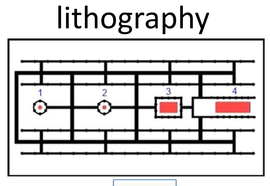
SU-8 isolating layer deposition and patterning



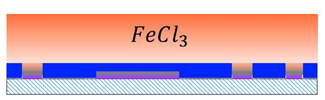
Electrode electroplating



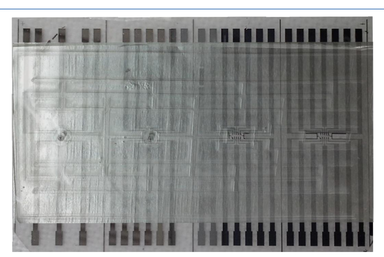
Open PDMS microfluidic layer fabricated with soft lithography



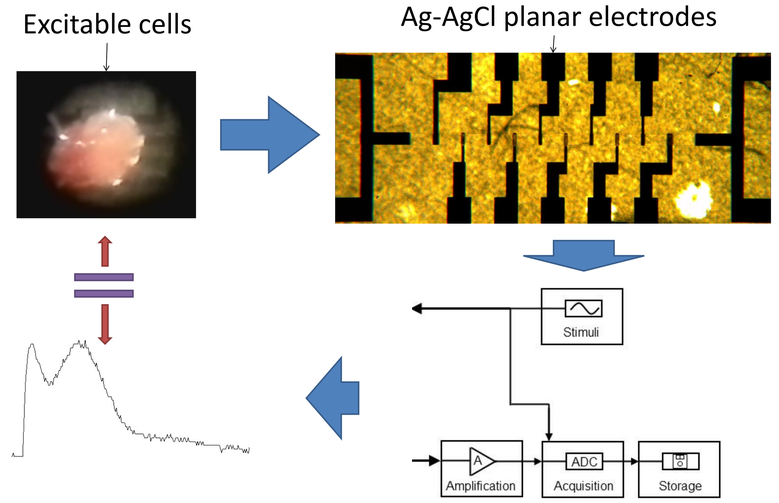
Chlorinate exposed silver electrodes



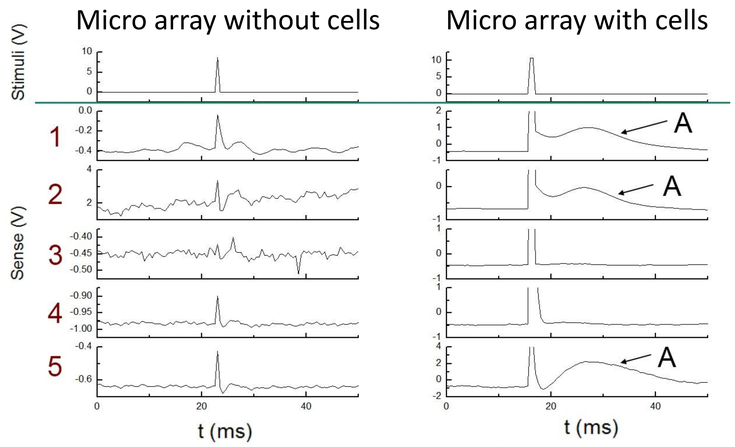
Finished prototype



Experimental setup

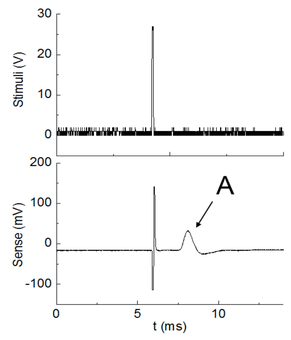


Experimental results



"A" Shows a subgroup of stimulated cells

Same experimental setup with macro electrodes



Conclusions

The platform was tested using bull frog sciatic nerve, zebra fish heart and bull frog heart, as samples of excitable cells, giving similar results to conventional macro electrodes, confirming that Ag-AgCl is a feasible material for microelectrodes aimed to stimulate and sense excitable cells.

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