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Single step UV-photolithography fabrication of SU-8 honeycombs with microchannels for cells positioning on silicon oxide-based nanopillars

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Objectives

We report on the **fabrication, functionalization, and testing** of SU-8 microstructures for cell culture and positioning over large areas. The microstructure consists of a **honeycomb** arrangement of **cell containers** interconnected by microchannels and centered around **nanopillar arrays** designed for promoting cell positioning. The structures are fabricated using a **single ultraviolet photolithography exposure** on the SU-8 resist. The proof of concept is given by the successful growth of **interconnected PC12 cells**.

Introduction

Honeycomb structures interconnected by microchannels are fabricated using a **single UV-photolithography** exposure. With optimized process parameters i.e. **focus depth d_f** and **exposure dose D_{exp}** , microchannels of various aspect ratios are produced after photoresist dissolution.

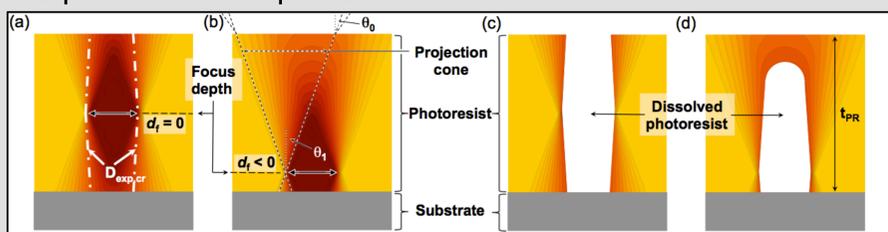


Figure 1: Principle of focus depth d_f variation for producing different types of microchannels in negative photoresist; (a,c) focus in the middle of the photoresist of thickness t_{PR} , (b,d) focus depth shifted downward; darker and clearer shades in photoresist indicate lower and higher exposure doses.

Honeycomb structure characterization

Choosing $d_f < 0$ allows us to focus the reticle in the lower part of the SU-8 film. As a consequence, in Fig. 3(b) pairs of neighboring SU-8 columns are connected in their upper parts by arches and separated in their lower parts by microchannels.

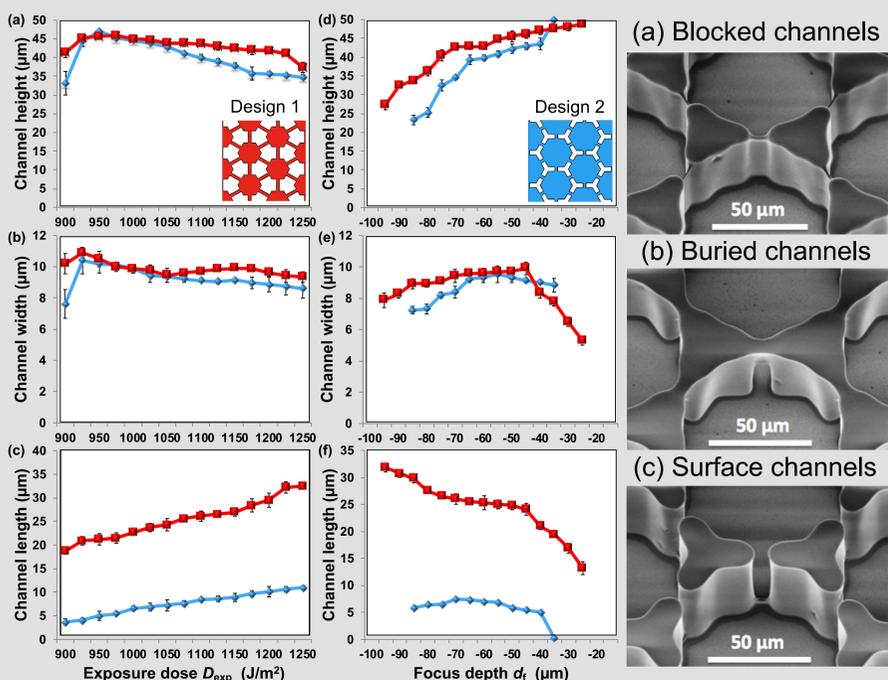


Figure 2: Measured height (a,d), width (b,e) and length (c,f) of microchannels as a function of (a,b,c) D_{exp} for $d_f = -50 \mu m$ and (d,e,f) as a function of d_f for $D_{exp} = 1100 J/m^2$ for Designs 1 (red symbols) and 2 (blue symbols) with $t_{PR} = 50 \mu m$.

Figure 3: SEM of cell container honeycombs of Design 2 obtained with 3 different values of d_f ($d_{f(a)} < d_{f(b)} < d_{f(c)}$).

Cell pre-positioning on nanopillars by interconnected cell containers

Design 1 and 2 cell container structures were realized around 3 sizes (types A-C) of nanopillar arrays to study the influence of nanopillars on cell growth. PC12 cells were cultured on chips with nanopillars and SU-8 cell containers for 5 days.

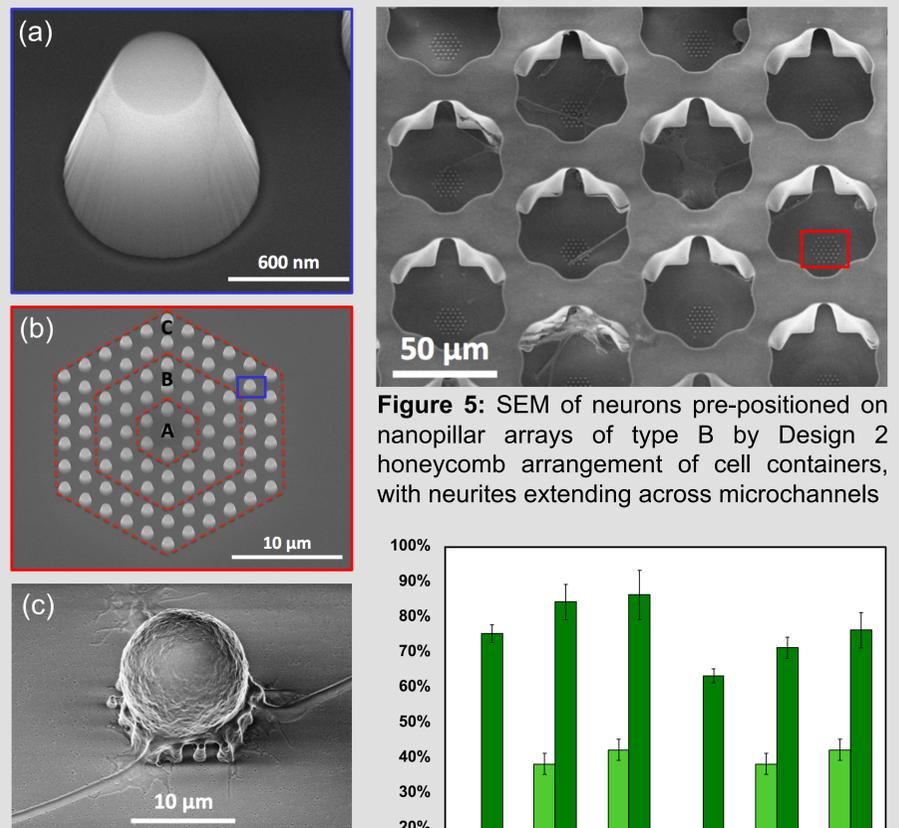


Figure 4: SEM of (a) a nanopillar and (b) a hexagonal array of 91 nanopillars termed type C. Smaller arrays have 37 (type B) and 7 (type A) nanopillars, as outlined in (b). (c) A neuron on a nanopillar array of type B with neurite growth.

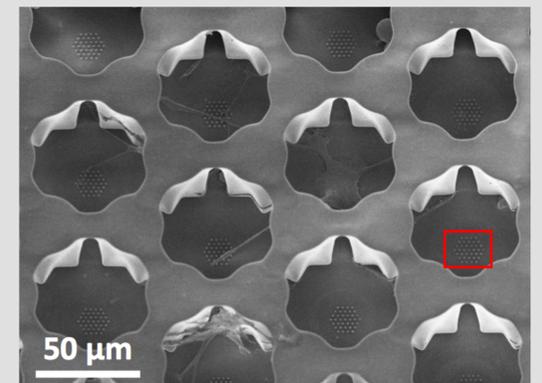


Figure 5: SEM of neurons pre-positioned on nanopillar arrays of type B by Design 2 honeycomb arrangement of cell containers, with neurites extending across microchannels

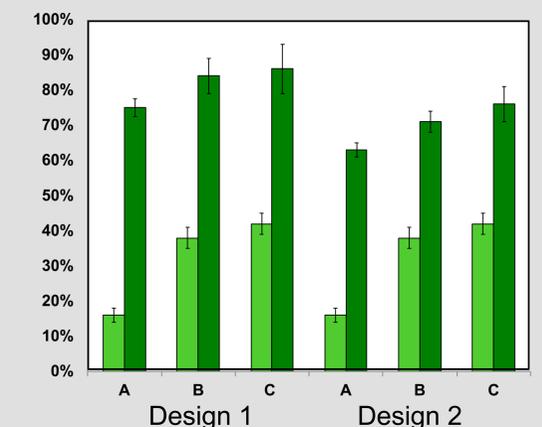


Figure 6: Percentages of cells connected to nanopillar arrays of types A to C on silicon substrates without SU-8 structures (darker green bars) and embedded in interconnected honeycomb structures of Designs 1 and 2 (lighter green bar).

Conclusions

UV stepper projection lithography was used in a non-standard way to fabricate SU-8 based cell containers arranged in a honeycomb structure and connected by microchannels around nanopillars. Thanks to cell culture, we have proven that the interconnect SU-8 cell containers significantly increase the fraction of cells connected to nanopillars.

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