Fabrication and Characterization of Electroporation Devices with Micropore Arrays for Drug/Gene Delivery

Kunyeh Chiang[†], Brian E. Henslee*, Hyunchul Jung[†], Zhengzheng Fei*,
L. James Lee*[‡], and Wu Lu[†‡]

[†]Department of Electrical and Computer Engineering, The Ohio State University, Columbus, OH 43210
*Department of Chemical and Biomolecular Engineering, The Ohio State University, Columbus, OH 43210

Electroporation is a common technology for delivering genes and small or large molecules into cells. Local electroporation using a thin track-etch membrane with random micropores in a membrane sandwich electroporation (MSE) device has shown significant enhancements over bulk electroporation on transfection efficiency and cell viability [1]. In this study, a poly (e-caprolacton) (PCL) membrane with well defined micro-pore arrays is used for cell immobilization and uniform gene delivery. For device fabrication, the PCL membrane films are replicated from patterned SU-8 structures. The hollow microarrays in SU-8 with 15 um in height are transferred to micro pillar arrays on a PDMS (Polydimethylsiloxane) film (Fig. 1a) by soft lithography. The PDMS film with transferred circular micro pillar arrays is used as the mold for another replication of uniform PCL thin polymer films with a thickness of 5 to 8 um for micro pore arrays (Fig. 1b). For cell distribution study, NIH 3T3 cells are trapped and immobilized on micro-pore arrays by applying vacuum with uniform distribution. Cells are immobilized on a single PCL membrane or between two PCL membranes of a sandwich structure. For electroporation experiment, Opti-MEM ITM reduced-serum medium is filled into the channels of the device and the center reservoir before the DNA sample is loaded into the inlet reservoir (Fig. 2). Electroporation is carried out followed by a cell culture process for transfection efficiency characterization. The fluorescence images of NIH 3T3 cells after DNA delivery by electroporation in a PCL device with 5 μm pores array indicate a more uniform gene delivery in both single membrane and sandwich structures. Evidently, the cells are uniformly trapped on the micro-pores array and each cell experiences essentially the same condition during electroporation, giving a more uniform gene delivery (Fig. 3). Such devices for local electroporation with well-defined micro-pore array structures have demonstrated great improvement in uniformity in comparison of devices with random pores in a track-etch membrane. The results on impedance measurements and device modeling of the PCL devices at different biases and frequencies will be presented at the conference.

This work is supported by NSF Grant EEC-0425626. [‡] Corresponding authors (lu@ece.osu.edu or leelj@chbmeng.ohio-state.edu)

[1] Zhengzheng Fei, Shengnian Wang, Yubing Xie,, Brian E. Henslee, Chee Guan Koh, and L. James Lee, *Analytical Chemistry*, **79**, 5719-5722 (2007).

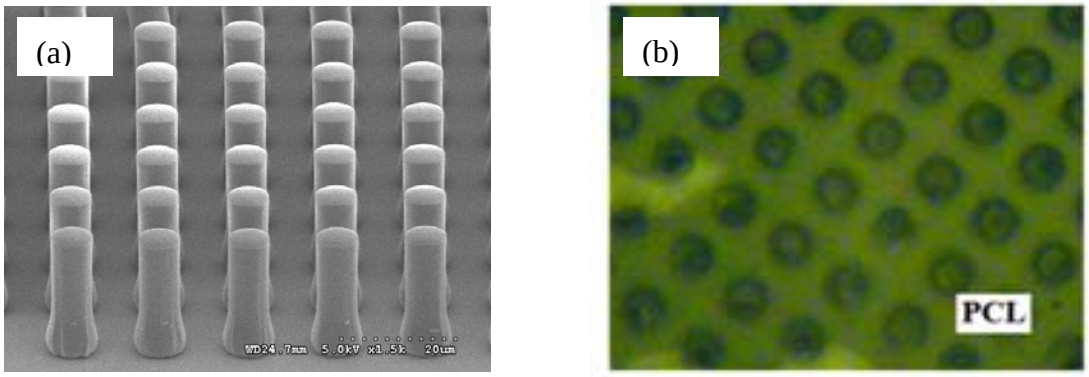

Fig. 1. (a) An SEM image of micropillar arrays on PDMS and (b) a microscope image of PCL.

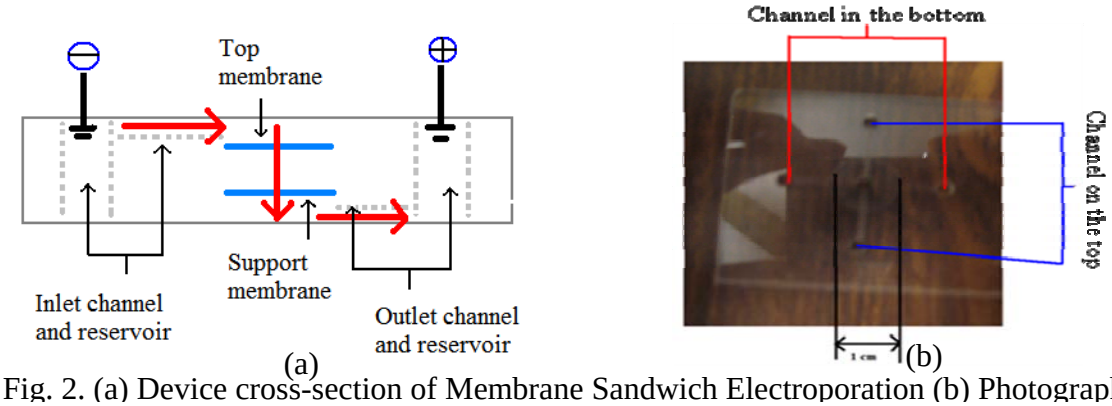

Fig. 2. (a) Device cross-section of Membrane Sandwich Electroporation (b) Photograph of MSE.

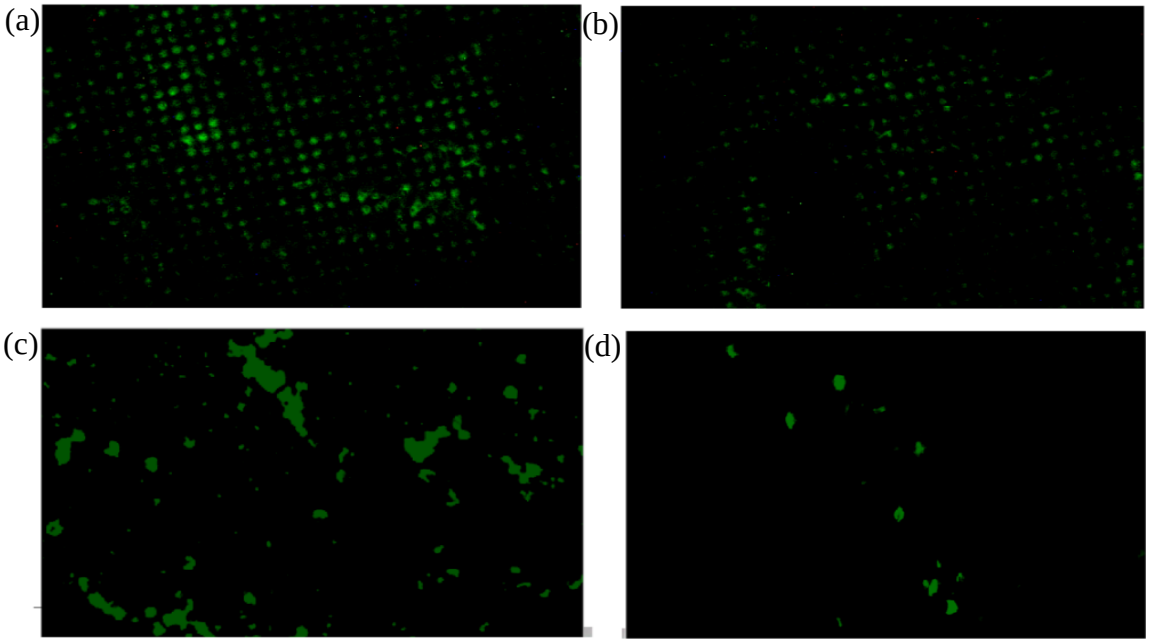

Fig. 3. (a) The green fluorescence on PCL membrane indicated green fluorescence protein (GFP) expression 48 hours after single membrane electroporation, (b) the GFP on PCL membrane 48 hours after sandwich membrane electroporation, (c) the green fluorescence on track-etch membrane with random pore for MSE [1], and (d) the green fluorescence on track-etch membrane for bulk electroporation [1].