

The Fabrication and Operation of a Continuous Flow, Micro-Electroporation System with Permeabilization Detection

 Joseph J. Sherba¹, Maria Atzampou¹, Hao Lin², Jerry W. Shan², David I. Shreiber¹, Jeffrey D. Zahn¹
¹The Department of Biomedical Engineering, Rutgers, The State University of New Jersey ²The Department of Mechanical and Aerospace Engineering, Rutgers, The State University of New Jersey

Corresponding Author

 Jeffrey D. Zahn
 jdzahn@soe.rutgers.edu

Citation

 Sherba, J.J., Atzampou, M., Lin, H., Shan, J.W., Shreiber, D.I., Zahn, J.D. The Fabrication and Operation of a Continuous Flow, Micro-Electroporation System with Permeabilization Detection. *J. Vis. Exp.* (179), e63103, doi:10.3791/63103 (2022).

Date Published

January 7, 2022

DOI

10.3791/63103

URL

jove.com/video/63103

Materials

Name	Company	Catalog Number	Comments
150-mm diameter petri dishes	VWR	25384-326	step 6.1.1 to secure wafer
24-well tissue culture plates	VWR	10062-896	step 10.3.6 to plate electroporated cells
33220A Waveform/Function generator	Agilent		step 9.2.3 electroporation pulse generator
4" Si-wafers	University Wafer		subsection 2.1 for microfluidic channel fabrication
6-well tissue culture plates	VWR	10062-892	step 8.1.8 to plate cells
Acetone	Fisher Scientific	A18-4	step 2.1.2 for cleaning and step 5.1 photoresist lift-off
Allegra X-22R Centrifuge	Beckman Coulter		steps 8.1.4 , 8.3.2. and 8.3.3. to spin down cells
AutoCAD 2018	Autodesk		subsection 1.1. to design transparency masks
Buffered oxide etchant 10:1	VWR	901621-1L	subsection 3.1 for HF etching
CCD Monochrome microscope camera	Hamamatsu	Orca 285 C4742-96-12G04	step 11.2.3. for imaging
CMOS camera- Sencicam QE 1.4MP	PCO		subsection 9.3 part of the experimental setup
Conductive Epoxy	CircuitWorks	CW2400	subsection 7.6. for wire attachment
Conical Centrifuge Tubes, 15 mL	Fisher Scientific	14-959-70C	step 8.1.4. for cell centrifuging
Dektak 3ST Surface Profilometer	Veeco (Sloan/Dektak)		step 2.1.15 and 5.4 for surface profilometry
Disposable biopsy punch, 0.75 mm	Robbins Instruments	RBP075	step 6.2.3 for inlet access
Disposable biopsy punch, 3 mm	Robbins Instruments	RBP30P	step 6.2.3 for outlet access
DRAQ5	abcam	ab108410	step 11.2.2. for live cell staining
Dulbecco's Modified Eagle's Medium	ThermoFisher Scientific	11885084	step 8.1.2. part of media composition

E3631A Bipolar Triple DC power supply	Agilent		step 9.2.1.-9.2.2. part of the experimental setup
Eclipse TE2000-U Inverted Microscope	Nikon		subsection 9.3. part of the experimental setup
EVG620 UV Lithography System	EVG		step 2.1.9. and 2.2.7. for UV Exposure
Fetal Bovine Serum	Neuromics	FBS001	step 8.1.2. part of media composition
FS20 Ultrasonic Cleaner	Fisher Scientific		subsection 5.1. for photoresist lift-off
Glass Media Bottle with Cap, 100mL	Fisher Scientific	FB800100	step 8.2.1. for buffer storage
Glass Media Bottle with Cap, 500mL	Fisher Scientific	FB800500	step 8.1.2. for media storage
HEK-293 cell line	ATCC	CRL-1573	subsection 8.1 for cell culturing
HEPES buffer solution	Sigma Aldrich	83264-100ML-F	step 8.2.1 part of electroporation buffer composition
Hexamethyldisilazane	Sigma Aldrich	379212-25ML	step 2.2.3 adhesion promoter
HF2LI Lock-in Amplifier	Zurich Instruments		subsection 9.2 part of the experimental setup
HF2TA Current amplifier	Zurich Instruments		subsection 9.2 part of the experimental setup
Isopropyl Alcohol	Fisher Scientific	A459-1	step 2.1.2 for cleaning, step 2.1.14 for rinsing wafer following SU-8 development, and step 6.3.1 for cleaning PDMS
IX81 fluorescence microscope	Olympus		step 11.2.3 for imaging
L-Glutamine Solution	Sigma Aldrich	G7513-20ML	step 8.1.2. part of media composition
M16878/1BFA 22 gauge wire	AWC	B22-1	subsection 7.5 for device fabrication
Magnesium chloride	Sigma Aldrich	208337-100G	step 8.1.2 part of electroporation buffer composition
MF 319 Developer	Kayaku Advanced Materials	10018042	step 2.2.9. photoresist developer
Microposit S1818 photoresist	Kayaku Advanced Materials	1136925	step 2.2.4 positive photoresist for electrode patterning
Microscope slides, 75 x 25 mm	VWR	16004-422	step 2.2.1 electrode soda lime glass substrate
Model 2350 High voltage amplifier	TEGAM	2350	step 9.2.5. part of the experimental setup
National Instruments LabVIEW	National Instruments		data acquisition
Needle, 30G x 1 in	BD Scientific	305128	step 10.1.1. part of the system priming
PA90 IC OPAMP Power circuit	Digi-key	598-1330-ND	Part of the custom circuit
Penicillin-Streptomycin	Sigma Aldrich	P4458-20ML	step 8.1.2. part of media composition
Plasmid pMAX-GFP	Lonza	VCA-1003	step 8.3.4. for intracellular delivery
Plastic tubing, 0.010" x 0.030"	VWR	89404-300	step 10.1.2. for system priming
Platinum targets	Kurt J. Lesker		subsection 4.2. for physical vapor deposition
Potassium chloride	Sigma Aldrich	P9333-500G	step 8.2.1. part of electroporation buffer composition
Pump 11 PicoPlus microfluidic syringe pump	Harvard Apparatus	MA1 70-2213	step 10.1.4. for system priming
PVD75 Physical vapor deposition system	Kurt J. Lesker		subsection 4.1. for physical vapor deposition
PWM32 Spinner System	Headway Research		steps 2.1.6 and 2.2.2. for substrate coating with photoresist
PX-250 Plasma treatment system	March Instruments		subsection 7.2 for PDMS and glass substrate bonding
SDG1025 Function/Waveform generator	Siglent		step 9.2.2. part of the experimental setup

Sodium hydroxide	Sigma Aldrich	S8045-500G	step 8.2.1. part of electroporation buffer composition
SU-8 2010 negative photoresist	Kayaku Advanced Materials	Y111053	step 2.1.7. for microfluidic channel patterning
SU-8 developer	Microchem	Y010200	step 2.1.12. for photoresist developing
Sucrose	Sigma Aldrich	S7903-1KG	step 8.2.1. part of electroporation buffer composition
Sylgard 184 elastomer kit	Dow Corning	3097358-1004	step 6.2.1 10 : 1 mixture of PDMS polymer and hardening agent
Syringe, 1 ml	BD Scientific	309628	step 8.3.4. part of system priming
SZ61 Stereomicroscope System	Olympus		subsection 7.3. for channel and electrode alignment
Tissue Culture Treated T25 Flasks	Falcon	353108	step 8.1.2 for cell culturing
Titanium targets	Kurt J. Lesker		subsection 4.2. for physical vapor deposition
Transparency masks	CAD/ART Services		steps 2.1.9. and 2.2.7. for photolithography
Trichloro(1H,1H,2H,2H-perfluorooctyl)silane	Sigma Aldrich	448931-10G	step 6.1.2. for wafer silanization
Trypsin-EDTA solution	Sigma Aldrich	T4049-100ML	steps 8.1.3. and 8.3.1. for cell harvesting