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Isabela A. A. Andreotti
Gabriel Griep
Edgar A. Patiño-Nariño
Aline F. Oliveira
Martha Lucia M. Bejarano
Mario Ricardo G. Rubio
Henrique R. Wisinewski
Beatriz N. M. Miranda
Leonardo R. B. Silva
Bruno Marinaro Verona
Tiago A. Balbino
Martín H. Bonamino

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Instituto de Pesquisas Tecnológicas do Estado de São Paulo S/A - IPT
Av. Prof. Almeida Prado, 532 | Cidade Universitária ou Caixa Postal 0141 | CEP 01064-970
São Paulo | SP | Brasil | CEP 05508-901
Tel 11 3767 4374/4000 | Fax 11 3767-4099

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Enhancing Microfluidic Device Design for CAR-T Cell Transfection: Integrating Soft Lithography and CFD Simulation for Optimal Microvortex Patterns

Isabela A. A. Andreotti(R)[a]*, Gabriel Griep(PG)[b], Edgar A. Patiño-Nariño(R)[c], Aline F. Oliveira(R)[a], Martha Lucia M. Bejarano(R)[a], Mario Ricardo G. Rubio(R)[a], Henrique R. Wisinewski(R)[a], Beatriz N. M. Miranda(R)[a], Leonardo R. B. Silva(R)[d], Bruno M. Verona(R)[a], Tiago A. Balbino(R)[e], Martín H. Bonamino(R)[d,f]

[a] Institute for Technological Research, BioNano, São Paulo, SP, Brazil, 05508-901
[b] University of São Paulo, Department of Electronic Systems, São Paulo, SP, Brazil, 05508-010
[c] Basque Center for Applied Mathematics (BCAM), CFD Modelling and Simulation Group, Bilbao, Basque Country, Spain, 48400
[d] National Cancer Institute-INCA, Cell and Gene Therapy Program, Rio de Janeiro, RJ, Brazil, 20231-050
[e] Nanotechnology Engineering Program, Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering, Rio de Janeiro, RJ, Brazil, 21941-594
[f] Oswaldo Cruz Institute Foundation, Vice Presidency of Research and Biological Collections, Rio de Janeiro, RJ, Brazil, 20231-050
**e-mail: andreotti.isa@gmail.com*

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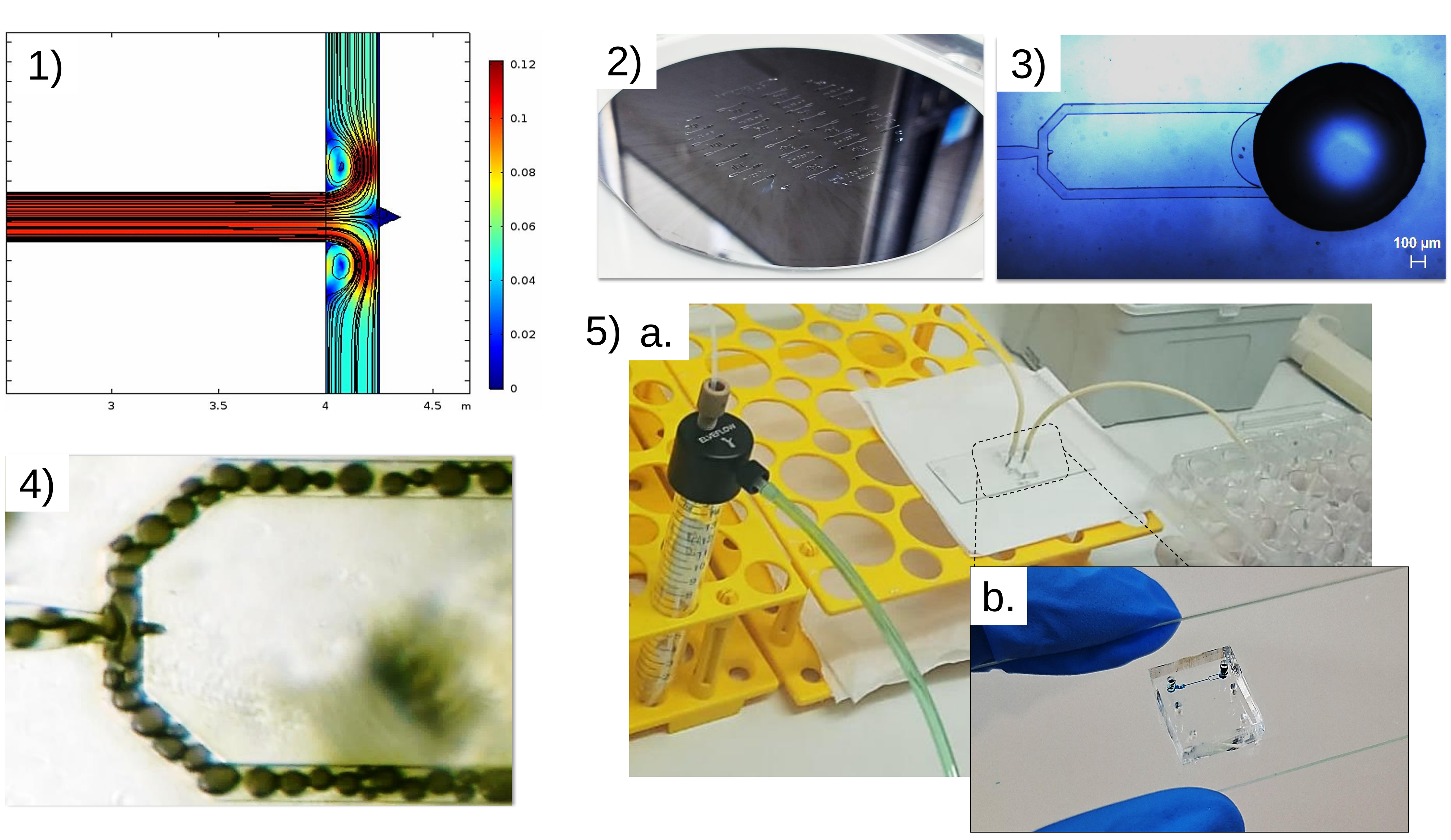
Highlights

CFD Optimization for Cell Transfection: This study uses CFD to make cell transfection more efficient in microfluidic devices by creating chaotic movement

Advanced microfabrication techniques of lithography on Si/SU-8 molds and replicated in glass/PDMS

Abstract

This work proposes a cell transfection device using generation of microvortices which induce temporary opening of micropores in the cell membrane. The mechanism involves a turbulent flow of the solution with CAR-T cells with genetic material, submitting a T-junction with a cavity in the outlet[1].



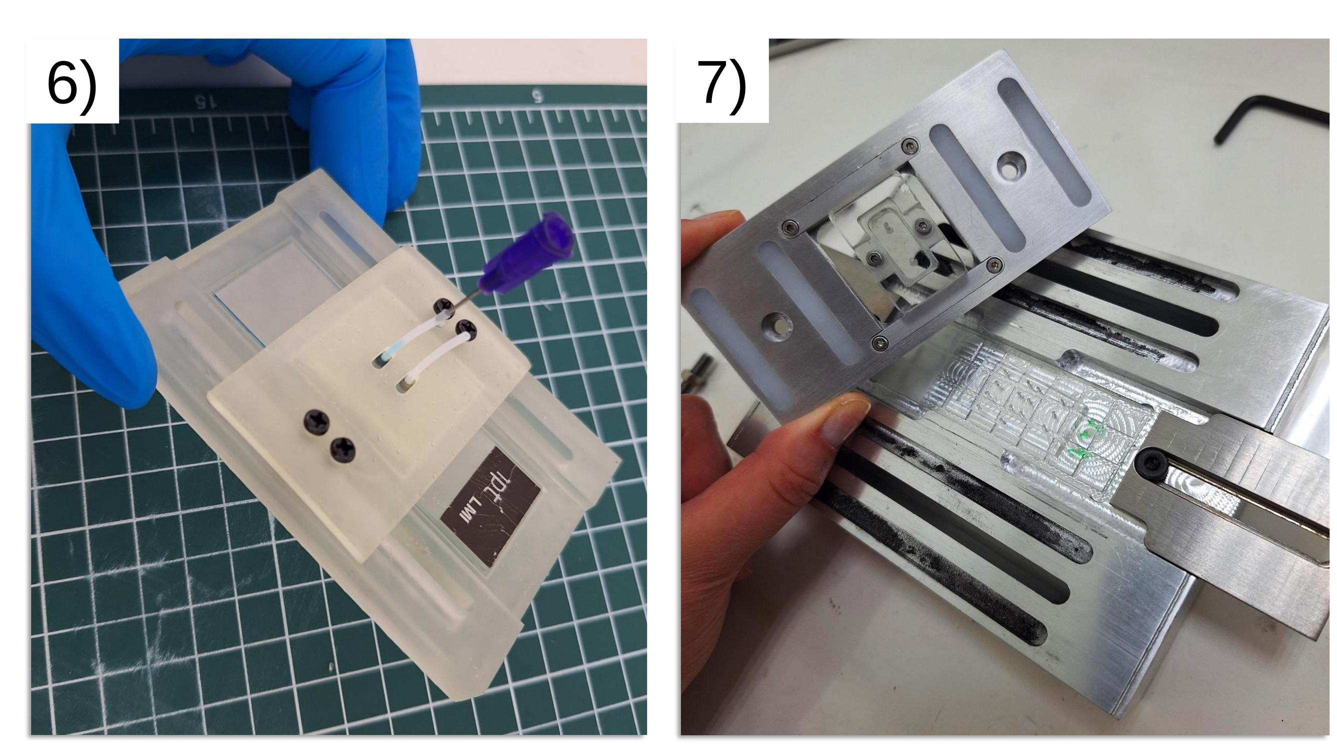


Figure 1. (1) Geometry and computational simulation of the transfection channel framework with the outlet featuring a small protrusion, showing the velocity field and streamlines distribution prediction with chaotic advection and two oblate vortices. (2) Image of mold fabricated on a Si wafer with SU-8 by lithography and (3) T-junction in the device. (4) An example of emulsion flow after fabrication in glass/PDMS, captured with a high-speed camera, is shown. (5a.) Experimental setup and b.) A glass/PDMS device after plasma bonding is also depicted, containing three transfection channels, one filled with a blue-colored solution. (6) and (7) Holders developed by 3D printing and aluminum/PMMA to enhance mechanical robustness of the connections and prevent leaks.

[1]HUR, Jeongsoo et al. Microfluidic cell stretching for highly effective gene delivery into hard-to-transfect primary cells. **ACS nano**, v. 14, n. 11, p. 15094-15106, 2020.

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