3D-PRINTED MICROFLUIDIC CHIP SYSTEM FOR DIELECTROPHORETIC MANIPULATION OF COLLOIDS

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INTRODUCTION

Microfluidics, as a crucial technology of recent years, enables numerous applications for Point-of-Care-Testing such as Lab-on-Chip-Systems (LOC) or Micro-Total-Analysis-Systems (µTAS). Especially the implementation of dielectrophoresis (DEP) in microfluidic chips has evolved to a subtle method for precise manipulation of cells, molecules or particles [1, 2]. Objective of the present analysis is the optimization of DEP due to a well-suited arrangement of copper electrodes within the chip system. Furthermore, the context between an applied voltage, the resulting strength of the electric DC-field as well as the deflection and acceleration of zirconium oxide particles is evaluated.

PRINCIPLE OF DIELECTROPHORESIS (DEP)

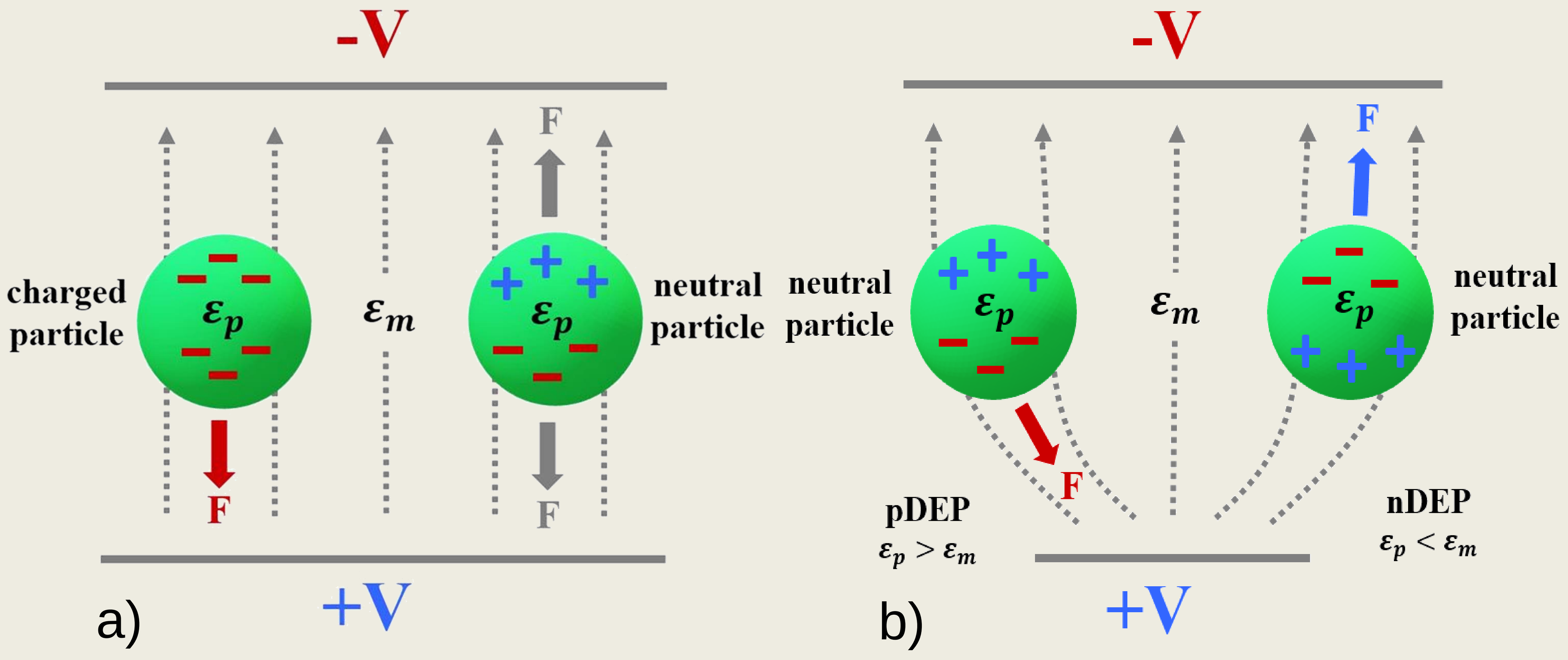


Figure 2. a) Uniform electric field; b) DEP in a non-uniform electric field: positive DEP (left) and negative DEP (right).

MICROFLUIDIC CHIP SYSTEM

- Additive manufactured via MultiJet Modeling.
- Integrated Luer-Lock system for simple handling:

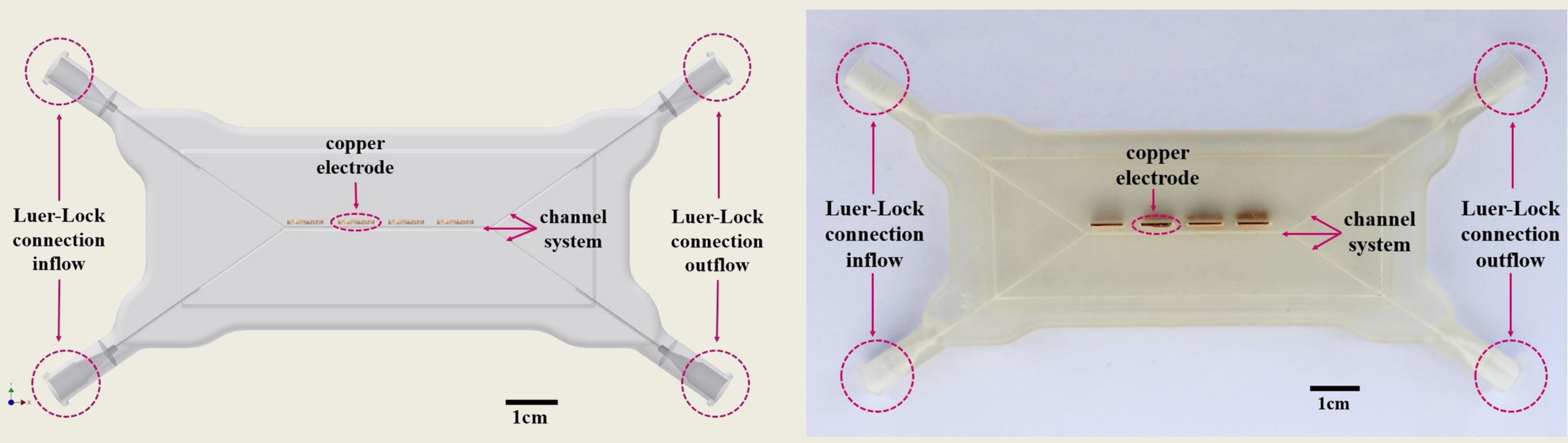


Figure 1. a) CAD-model of the microfluidic chip system; b) 3D- printed chip system with integrated electrodes for realization of DEP.

- DEP is part of electrokinetic phenomena.
- Movement of particles subjected to a non-uniform electric field.
- Interaction between dipole of the particle and spatial gradient of the electric field.
- Generated dielectrophoretic force [3]:

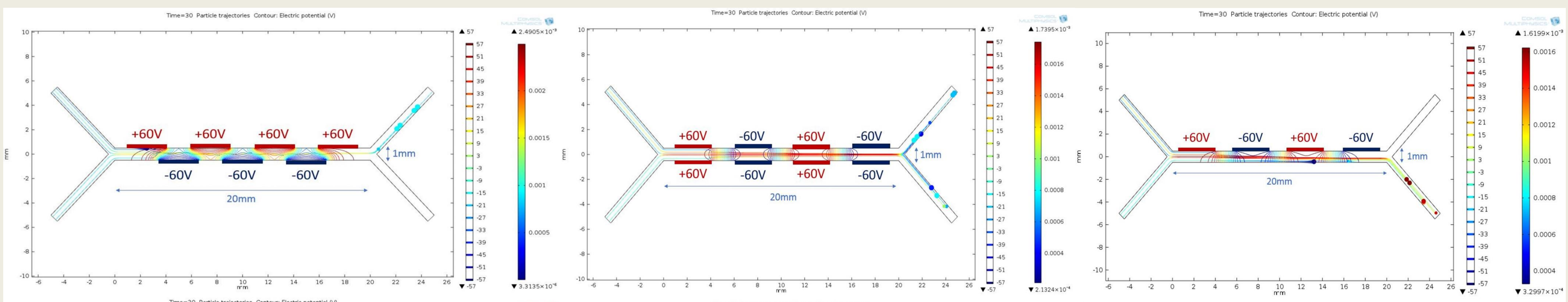
$$F_{DEP} = 2\pi r^3 \varepsilon_0 \varepsilon_m \Re[f_{CM}(\omega)] \nabla E_{rms}^2 \qquad (1)$$

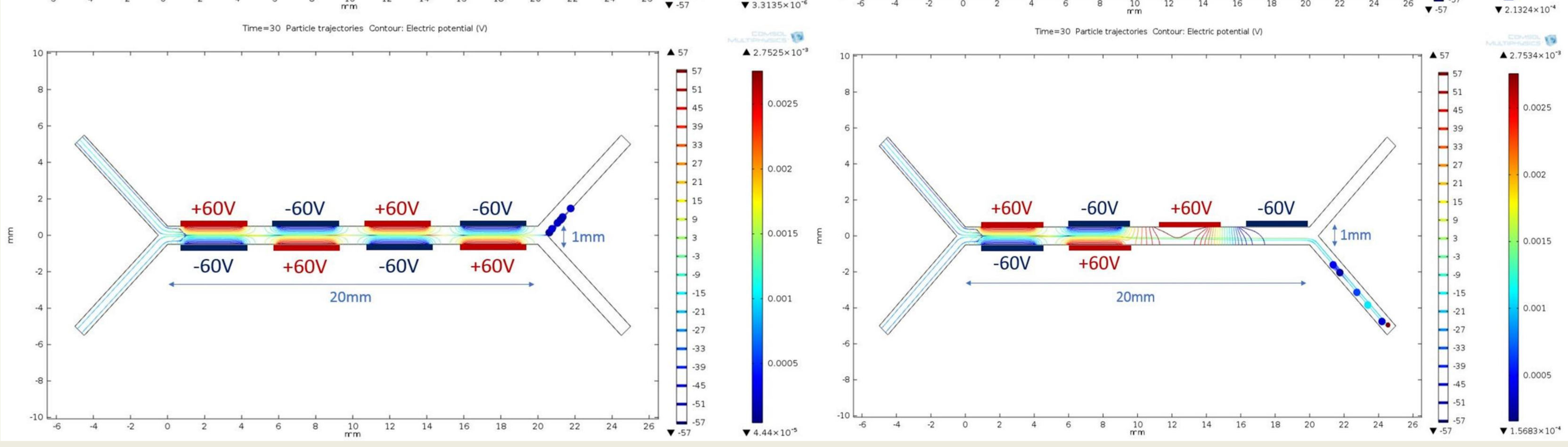
- Clausius-Mossotti-Factor reflects the extent of particle polarization in DC-fields via [4]:

$$f_{CM}(\sigma_p, \sigma_m) = \frac{\sigma_p - \sigma_m}{\sigma_p - 2\sigma_m} \qquad (2)$$

- Two principles of DEP: positive dielectrophoresis (pDEP) and negative dielectrophoresis (nDEP).

INVESTIGATION OF VARIOUS ELECTRODE CONFIGURATIONS





configuration	evidence DEP	deceleration/ acceleration of particles	flow profile
a)	no	low	symmetrical
b)	no	significant	symmetrical
c)	no	weak	symmetrical
d)	yes	low	asymmetrical
e)	yes	significant	asymmetrical

- COMSOL Multiphysics ® (Electrostatics, Laminar Flow).
- Use of Particle Tracing Module.
- Particle diameters: 30-60µm.
- Biased configuration generates distinct DEP.
- Applied voltage: threshold at least ±50V.

Figure 3. DEP: Electrode configurations.

Table 1. Summary of the simulation results.

CONCLUSIONS

A COMSOL Multiphysics® model of a microfluidic chip system for DEP manipulation of colloids was successfully established. In this context, an optimized arrangement of copper electrodes to generate a mandatory non-uniform electric DC-field was found as well as a threshold, which must be exceeded to achieve reliable and reproducible results.

REFERENCES

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