Simulation of Microplasma Actuator for Directional Flow Control

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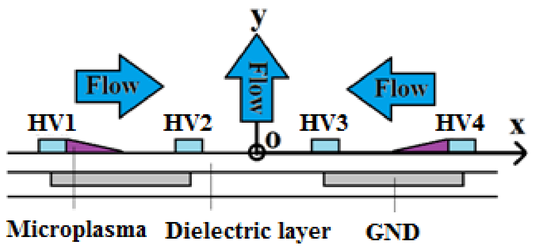
A dielectric barrier discharge microplasma actuator energized at low discharge voltage of 1.4 kV was applied for flow modification. An AC voltage was applied to the multi-electrode microplasma actuator. The numerical simulation of the flow was carried out using a fluid model, which assumed that the electric potential could be split in the potential due to the external electric field and the charge density of the plasma. Furthermore, the body-force was determined by calculating the potential. The body force was implemented in the Navier-Stokes equations, and the simulated flow was obtained.

1. Introduction

Depending of the duty ratio of the applied voltage for each channel induced flow with different directions was generated and collided, thus resulting in diagonal or upward flow.



Due to the small size of our microplasma actuator, experimental observations and measurements are more difficult near the electrode surface.

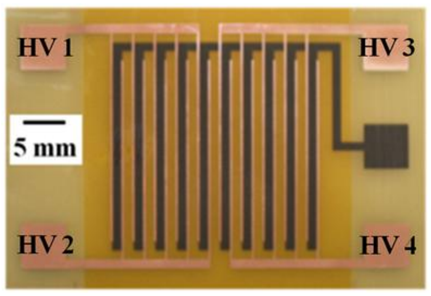
Numerical simulations were carried out with the experiments.

2. Experimental setup

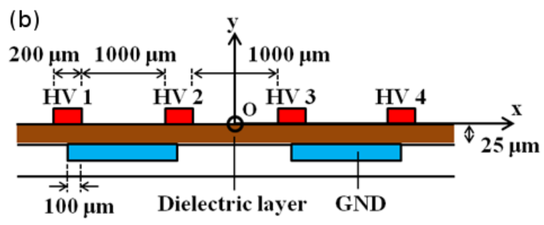
Experiment

Microplasma actuator

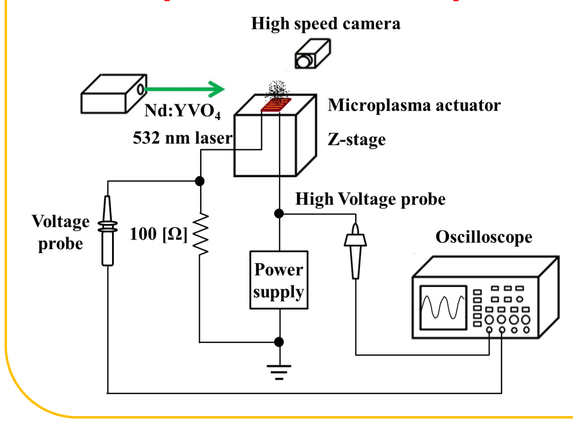
Top view



Side view



Experimental setup

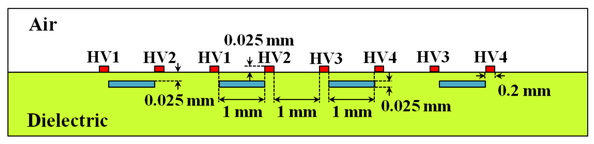


Voltage waveform

AC (1.4 kV & 20 kHz)

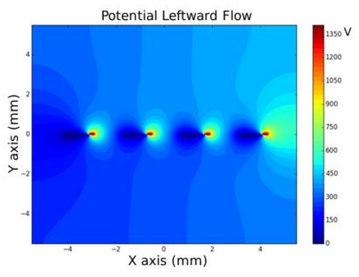
Simulation

Computational geometry

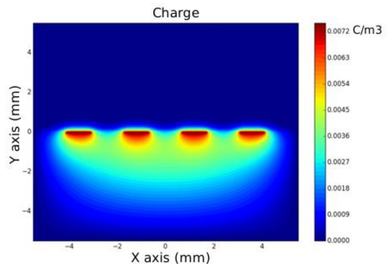


Numerical simulations using Suzen model

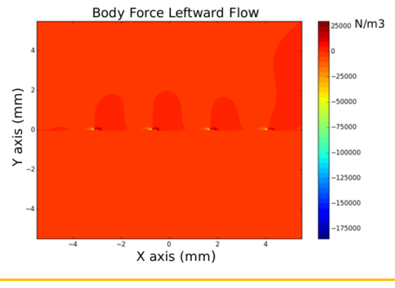
Electric potential



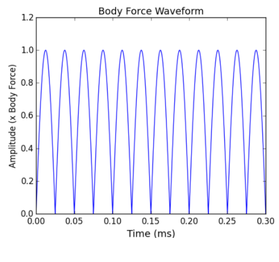
Electric charge



Body force



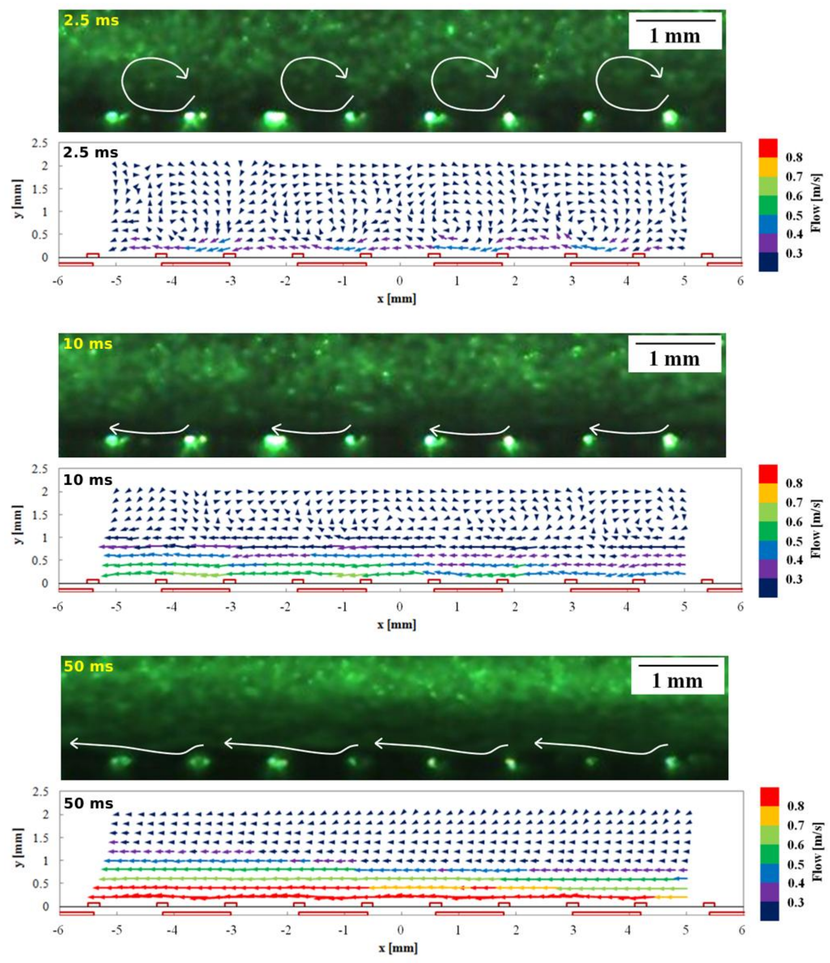
Voltage waveform



3. Results and Discussion

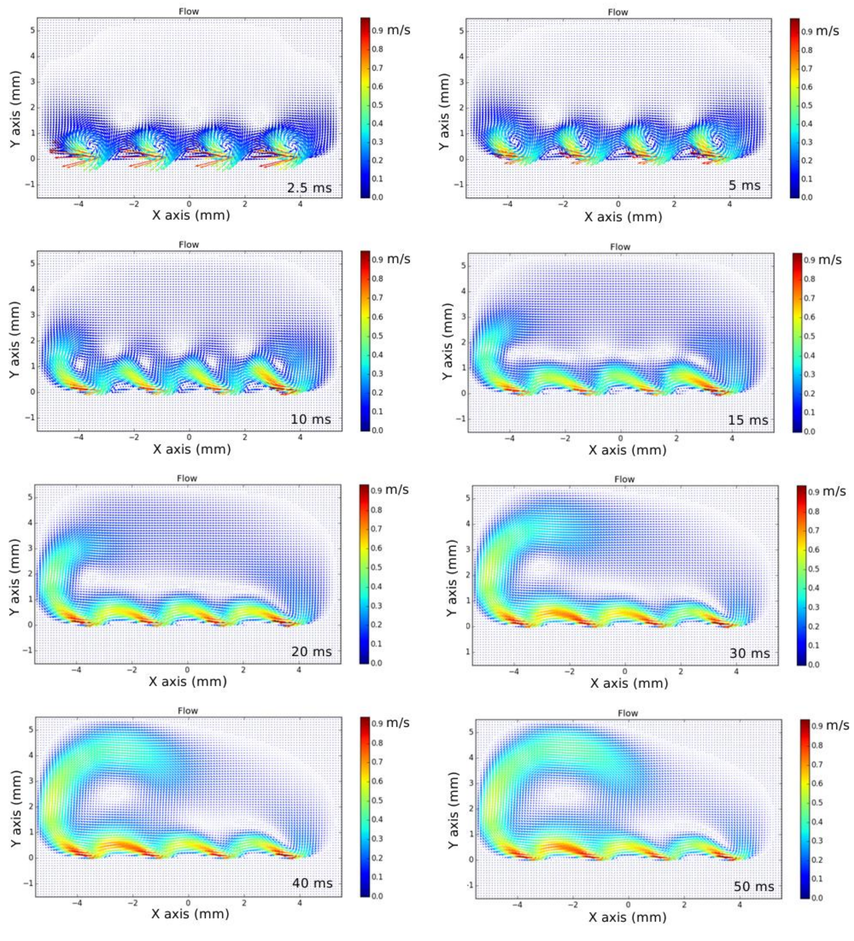
Experiment

- Vortexes appeared near the active electrodes in the initial stages
- After 10 ms the vortexes merged in a left ward flow
- Left ward flow was measured at steady state after 50 ms
- After 50 ms flow was about 0.9 m/s above electrodes
- Near the electrodes due to the microplasma light emission measurements were not accurate



Simulation

- Vortexes appeared near the active electrodes in the initial stages
- After 10 ms the vortexes merged in a left ward flow
- Left ward flow was obtained
- After 50 ms flow was about 0.93 m/s above electrodes
- Near the electrodes due to the microplasma light emission measurements were not accurate thus simulation data gave us important information about the flow



4. Conclusions

- It was confirmed that vortices developed with the lapse of time.
- Up to 5 ms, vortices with the height of about 1.5 mm occurred in both cases of experiments and the numerical simulations.
- Steady state left ward flow was obtained after 50 ms.
- The simulation data gave us important insight to the phenomena that was difficult to measured experimentally.