Simulation of inductive flow controlled by using Microplasma Actuator

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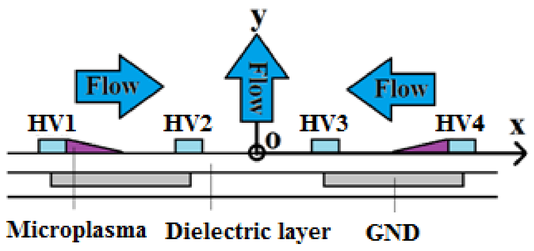
Plasma actuator is a flow control device that has been investigated for flow separation control, drug reduction, and so on, due to its advantages such as simple construction, no moving part, and quick response.

In this study, numerical simulations were carried out in order to investigate the flow velocity near the electrode surface where experimental measurements were difficult. The microplasma actuator was used in the series of experiments and numerical simulations. Our microplasma actuator with four independent channels can generate four types flow (up, down, right, and left) by controlling the applied voltage.

1. Introduction

The induced flow with different directions was generated and collided, thus resulting upward flow.



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

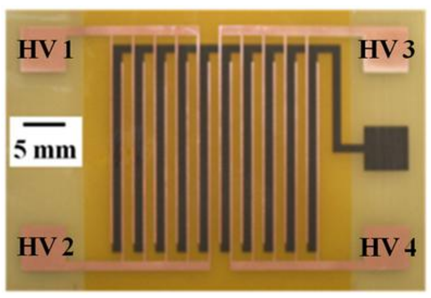
Numerical simulations were carried out with the experiments.

2. Experimental conditions

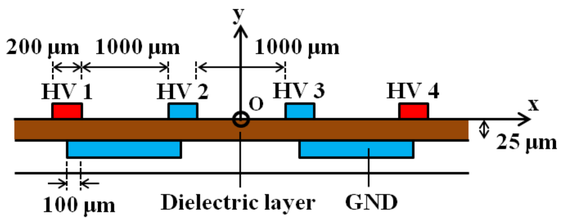
Experiment

Microplasma actuator

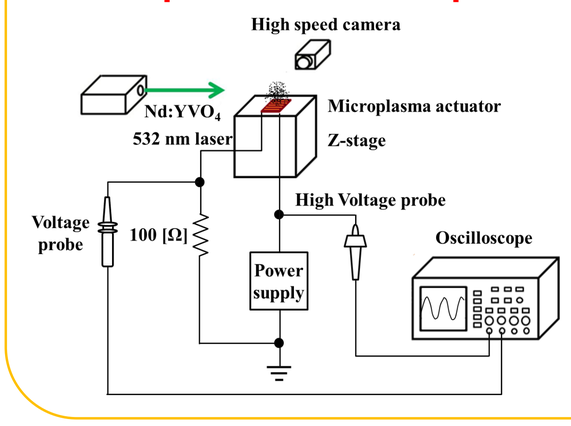
Top view



Side view

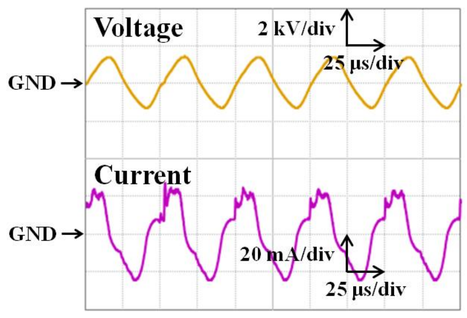


Experimental setup



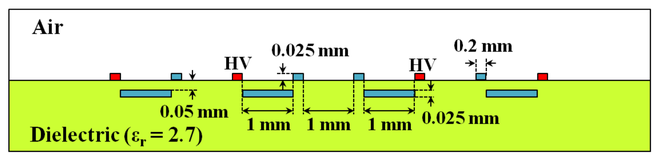
Voltage & current waveform

AC (1.4 kV & 20 kHz)



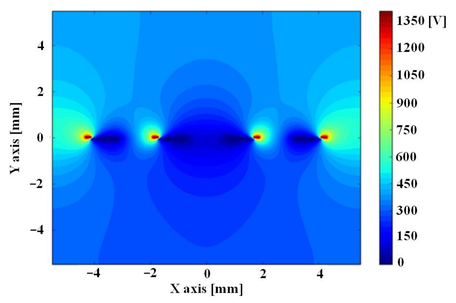
Simulation

Computational geometry

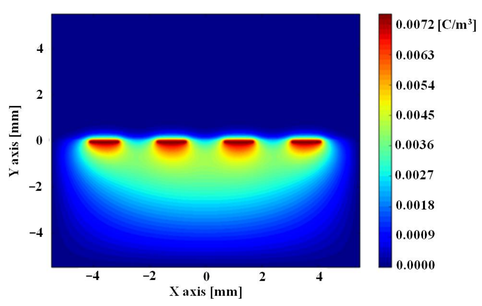


Numerical simulations using Suzen model

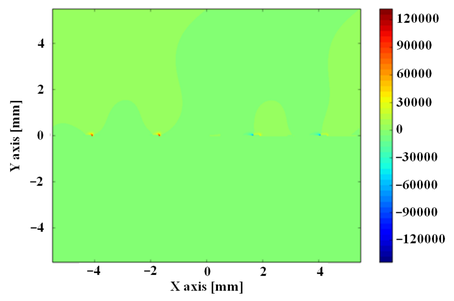
Electric potential



Electric charge



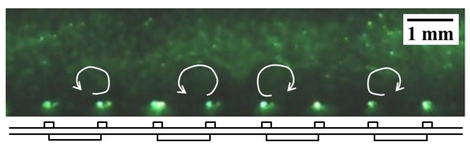
Body force



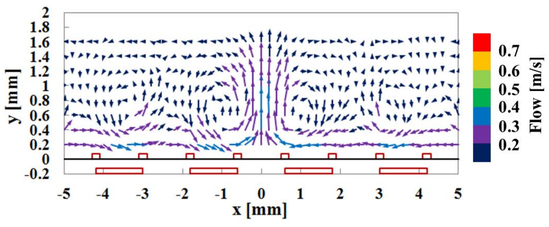
3. Results and Discussion

After 2.5 ms

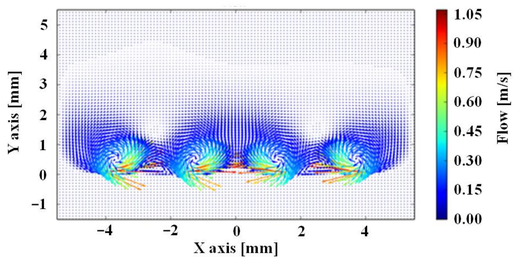
Visualized flow



PTV results

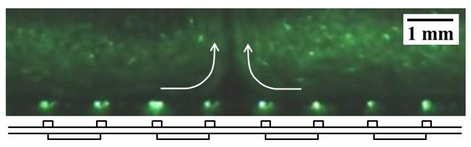


Simulation results

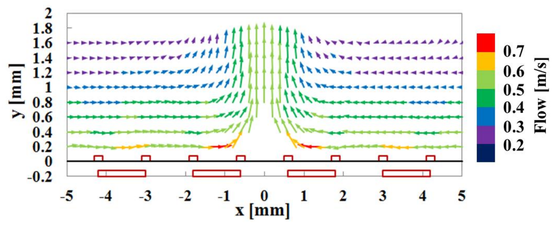


After 60 ms

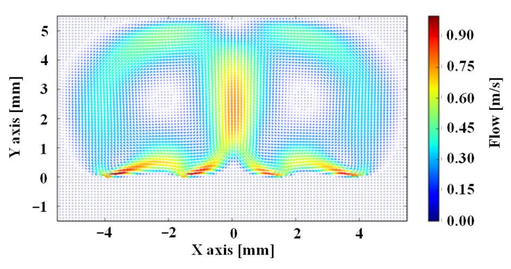
Visualized flow



PTV results



Simulation results



After 2.5 ms

- Vortices of 1.5 mm in height
- Maximum flow velocity
  - Experiment : 0.3 m/s
  - Simulation : 1 m/s
- Vortices have been still developing (Transient state)

After 60 ms

- Maximum flow velocity (near the electrode surface)
  - Experiment : 0.8 m/s
  - Simulation : 1 m/s
  - (at center)
  - Experiment : 0.6 m/s
  - Simulation : 0.7 m/s
- Vortex development stopped (Steady state)

4. Conclusions

- It was confirmed that vortices developed with the lapse of time.
- After 2.5 ms, vortices with the height of about 1.5 mm occurred in both cases of experiments and numerical simulations.
- After 60 ms, 0.6 m/s and 0.7 m/s upward flow at the center was obtained in the experiments and simulations, respectively. This stage was considered to be the steady state.