Three-dimensional numerical simulation of discharge and flow related to airflow control using plasma actuator

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Abstract

Plasma actuator has attracted attention as a fluid control device using dielectric barrier discharge. In the experimental study, it has been pointed out that the discharge has a spanwise distribution of the electrode and has a three-dimensional structure. The three-dimensional structure affects the induced flow distribution of the plasma actuator. In this study, we perform the three-dimensional numerical calculation of discharge and flow for verification of airflow control effect of plasma actuator.

Reasons and benefits of using JAXA Supercomputer System

In the calculation of the discharge phenomenon, it is necessary to solve Poisson's equation at every time step, and it is solved using a convergence calculation, which calculation cost is high. In addition, since three-dimensional calculations are performed in this research, the required memory capacity is so large, and a supercomputer is necessary.

Achievements of the Year

We conducted a three-dimensional calculation of the discharge process toward the coupled calculation of the discharge and the fluid. Previous research has pointed out that the electrodes of plasma actuators have protrusions of several tens of micrometers. We established a calculation method using general coordinate transformation to reproduce the protrusions of the electrodes, and the calculation was performed using a boundary-fitted mesh that fit the shape of the protrusion. In addition, we investigated influences of splitting the covered electrode on discharge structures. As a result, with splitting the covered electrode, the effect of the protrusions on the discharge structure becomes weak, and the identical discharge structure was maintained regardless of the position of the protrusion (Fig.1). We will conduct coupled calculation of discharge and fluid in future work to investigate the effect of the three-dimensional discharge structure on the fluid field.

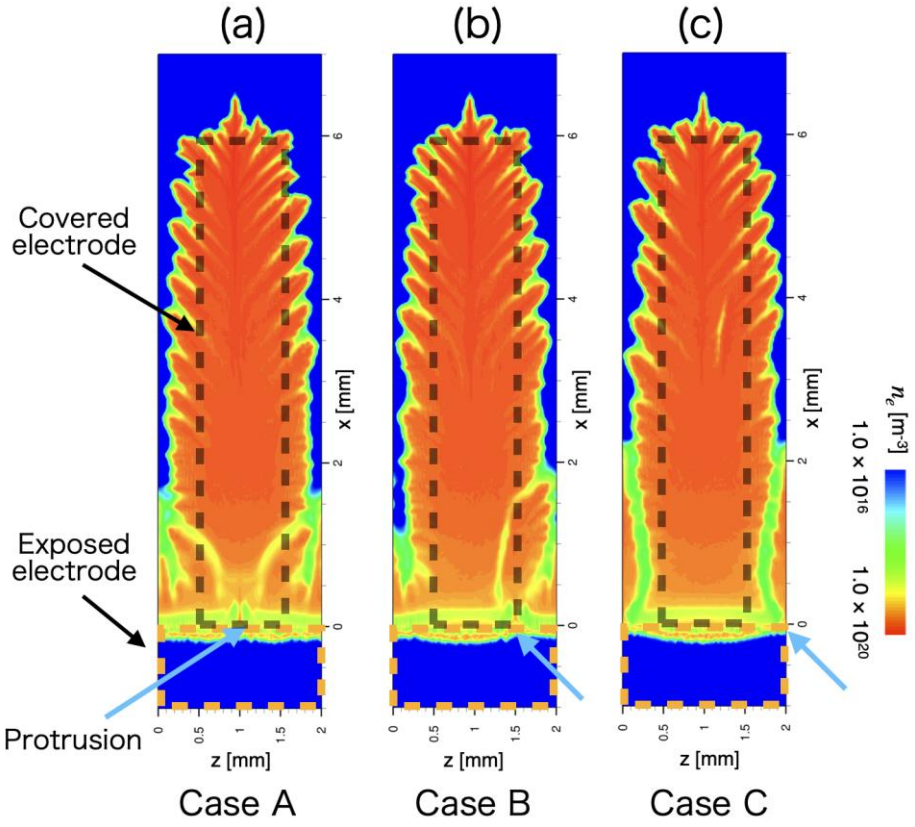

Fig. 1: The discharge structure with splitting the covered electrode.

Publications

- Oral Presentations

(1) Hideto Tamura, Shintaro Sato, and Naofumi Ohnishi, Discharge structure control of surface dielectric barrier discharge by splitting

covered electrode, 46th Conference of the institute of electrostatics, September 7-10 2022.

(2) Hideto Tamura, Shintaro Sato, and Naofumi Ohnishi, Numerical simulation of discharge process in surface dielectric-barrier-discharge on split covered electrode, 75th Annual Gaseous Electronics Conference, American Physical Society, October 3-7 2022.

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	8 - 720
Elapsed Time per Case	9 Hour(s)

- **JSS3 Resources Used**

Fraction of Usage in Total Resources[*1](%): 0.36

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	1,224,519.16	0.05
TOKI-ST	2,473,963.96	2.47
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2] (%)
/home	113.33	0.10
/data and /data2	35,840.00	0.28
/ssd	183.33	0.03

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	3.47	0.02

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage[*2] (%)
ISV Software Licenses (Total)	144.79	0.10

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.