Phase I Project Summary

Firm: Tech-X Corporation
Contract Number: NNX10CE78P
Project Title: Simulation Tool for Dielectric Barrier Discharge Plasma Actuators at Atmospheric and Sub-Atmospheric Pressures

Identification and Significance of Innovation:

Identification of Innovation:

- ✓ Simulation tool for dielectric barrier discharge (DBD) plasma actuator
- ✓ Analyzes and predicts DBD operation at wide range of ambient gas pressures

Significance of Innovation:

- ✓ Traditional DBD codes are limited to low-speed applications and have weak prediction capabilities
- ✓ Proposed tool allows DBD analysis/prediction for subsonic/hypersonic applications

Technical Objectives and Work Plan:

Objectives:

- Demonstrate VORPAL's capability of modeling DBD plasma actuator at low pressures using kinetic plasma modeling approach;
- Demonstrate VORPAL's capability of modeling DBD plasma actuator at moderate to atmospheric pressures using hydrodynamic plasma modeling approach;
- Validate developed DBD simulation tool by comparison between simulation results and experimental data.

Work Plan:

- ✓ Develop prototype DBD simulation tool for low pressures;
- ✓ Develop prototype DBD simulation tool for moderate to atmospheric pressures;
- ✓ Perform experimental study of the Pulses+Bias DBD configuration;
- ✓ Validate developed prototypes by comparing simulation and experimental results;
- ✓ Reporting.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

- Developed prototype DBD simulation tool using kinetic approach and demonstrated simulations of the DBD plasma actuator, driven by nanosecond pulses, at reduced and atmospheric pressures;
- Developed prototype DBD simulation tool using fluid approach and demonstrated simulations of the DBD plasma actuator, driven by nanosecond pulses, at atmospheric pressures;
- Demonstrate hybrid capabilities of the prototype DBD simulation tool;
- Integrated state-of-the-art numerical concepts, such as variable time step, parallel computing and variable weight particles into DBD simulation tool for increasing computational speed;
- Performed complex experimental study of the DBD, driven by nanosecond pulses;
- Qualitatively validated numerical results against experimental data.

NASA Application(s): The primary NASA applications of the proposed DBD simulation tool are active flow control concepts for both subsonic and hypersonic flights. Predictable active flow separation control, achieved using the proposed tool, will benefit many NASA Projects, such as Subsonic Fixed Wing Project, Subsonic Rotary Wing Project and Hypersonic Project. In addition to the flow separation application, DBD simulation tool can be used for a number of NASA problems, associated with gas discharges at different pressures. For example, DBD simulation tool can be used for the description plasma-assisted combustion for the reduction of carbon emissions.

Non-NASA Commercial Application(s): Proposed tool will be beneficial for subsonic/hypersonic programs which involve active flow separation control. These programs include, but are not limited to, flow separation control at commercial airplanes during take-off or landing, increase in lift for tiltrotor aircrafts, improvement of engine performance, active flow control at hypersonic vehicles. Besides the primary application for a description of DBD operation, DBD simulation tool can be used for a wide range of plasma aerodynamics applications, such as plasma-assisted combustion, flow control using different types of discharges, reduction of carbon emission, optimization of air vehicle operation, MHD and EHD application.

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