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INFLUENCE OF DIELECTRIC MATERIALS AND ACTUATOR LENGTH ON DBD ACTUATOR PERFORMANCE

Abstract

The investigation of the performance parameters of Dielectric Barrier Discharge (DBD) actuators, including voltage, electrode distance, AC frequency, dielectric material, and electrode geometry, has been extensive explored due to their significant advantages in flow control applications. DBD actuators are simple devices with ease manufacture, low mass, low cost, rapid response time compared to passive flow control, and no moving parts. However, several studies have reported durability issues with the dielectric layer, and there remains a lack of comprehensive documentation on the performance of actuators as a function of actuator length. These parameters are crucial for the effective integration of DBD actuators into specific applications, such as enhancing micro plasma thrusters, delaying stall on airfoils, anti-icing, plasma-assisted combustion, among others.

This experimental study systematically evaluates the use of various dielectric materials, including PIB, PET, acrylic, and Kapton of various sizes for DBD actuator fabrication. DBD actuators are analyzed in terms of their electrical properties, efficiency, temperature distribution and three-dimensional velocity profiles as a function of actuator length. The performance of these parameters was assessed along a flat plate at low velocities using Particle Image Velocimetry (PIV) and infrared thermal imaging. Additionally, the study discusses the advantages and disadvantages of each dielectric material, offering a thorough examination of key factors influencing DBD actuator behavior, as highlighted in the literature.

Results show that the actuator length has a significant influence on performance parameters, illustrating how the ionic wind induced by the dielectric barrier discharge significantly modifies the original airflow, thereby increasing velocity. This systematic analysis of the parameters and their interactions highlights the importance of a comprehensive characterization of DBD plasma actuators for a precise understanding and practical applications. Furthermore, the study provides a general guideline for optimizing the fluid dynamic performance of a DBD actuator.