Design and Evaluation of Enhanced Dielectric-Barrier-Discharge Actuators

Investigator(s): Emilie J. Siochi, Stephen P. Wilkinson, (NASA Langley Research Center), Godfrey Sauti and Tian-Bing Xu (National Institute of Aerospace)

Purpose

The purpose of this investigation is to improve Dielectric- Barrier-Discharge (DBD) actuator performance by studying the influence of fundamental dielectric material properties on surface-plasma-induced fluid body force.

Background

Dielectric-Barrier-Discharge (DBD) actuators are surface-mounted, weakly ionized gas (plasma) devices consisting of pairs of electrodes separated by a dielectric and operated at high AC voltages. The electrically charged dielectric surface attracts charged ions in the air plasma, imparting momentum to the non-ionized air through many molecular collisions. Increasing the surface polarization charge magnitude and/or increasing the net charge density in the air plasma can increase momentum exchange to create an aerodynamic body force that accelerates neutral gas in the vicinity of the plasma for boundary layer separation control. ***A barrier to widespread use of DBSs is low force generation capability relative to aeronautical flow requirements.***

The Phase 2 project objective is to continue design and evaluation of enhanced DBD actuators based on work started in Phase 1. In Phase 1, the possible influence of chemical structure on DBD actuator performance was suggested by the data. In particular two factors influencing performance were indentified: functional group polarizability and electronegativity. This information may lead to molecular designs that contain significant aromatic content in the polymer chain, as well as the incorporation of functional groups with high electronegativity. The innovation and novelty of the proposed study is that we are looking beyond the much-studied asymmetric DBD actuator in its conventional configuration and are focusing on the specific features of materials that either enhance or inhibit performance, with the goal of inventing new materials to produce better actuators.

While DBD actuator technology is still in its nascent stages of development, the outlines of potential applications are becoming clear and materials play a vital role in these visions. The impact of DBD technology on NASA's aeronautical challenges depends upon the ultimate level of flow forcing that can be obtained. Beyond the demonstrated flow separation capability of the DBD actuator, a major, long acknowledged aeronautical challenge for NASA is to reduce viscous drag on aircraft across the speed ranges from low subsonic to supersonic. While we continue to seek higher performance DBD actuators, by focusing on and exploiting the very low speed of the viscous sublayer in a turbulent boundary

layer, current DBD technology may be sufficient to yield drag reduction results if deployed in creative ways.