הטכניון מכון טכנולוגי לישראל TECHNION Israel Institute of Technology

Faculty of Mechanical Engineering הפקולטה להנדסת מכונות

MECHANICAL ENGINEERING MSc SEMINAR (30 min.)

Thursday, January 8 2025 at 13:30-14:00, D. Dan and Betty Kahn Building, Room 217

Development of dielectric barrier discharge plasma actuators for hypersonic boundary layer control

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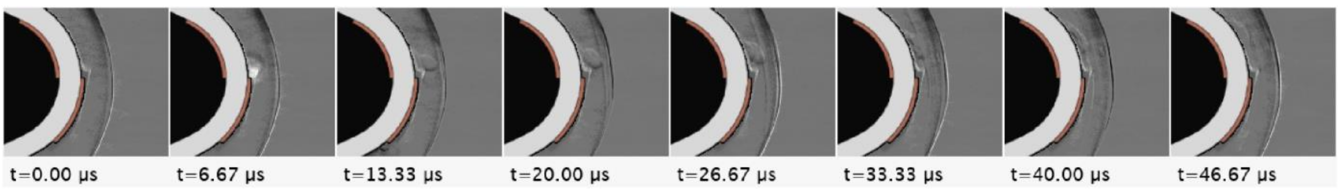
Low enthalpy hypersonic wind tunnel testing is limited by a mismatch between the specified Mach number and the Reynolds number of the full-scale (target) vehicle. This is due to both the difference in physical dimensions and the universal reliance on expansion nozzles, causing the laminar to turbulent transition not to occur naturally. A central challenge, therefore, is to force boundary layer transition and thereby obtain an accurate representation of the loads on the target vehicle. The method employed thus far is to use roughness elements or other mechanical protrusions, but these are intrusive and distort the target geometry and flow field. This research examines the viability of using AC and nanosecond pulsed-DC dielectric barrier discharge (DBD) plasma actuators—integrated into the geometry of the body to force boundary layer transition. The actuators were initially characterized in a vacuum chamber using schlieren photography and by measuring their thrust and light emissions. Subsequently, they were evaluated at the leading edge of a blunt body in a Mach 6 Ludwieg tube wind tunnel, with a run time of approximately 15 milliseconds, using schlieren photography. The thrust produced by AC DBD actuators operated in the 20 kHz to 30 kHz range exhibited a peak as the quiescent pressure was reduced below atmospheric conditions, consistent with other investigations at lower frequencies. However, in the Ludwieg tube experiments, the transient response of the AC actuator was too slow to react to the changing local pressure, and the resulting weaker electric field did not produce any measured perturbation of the boundary layer. The nanosecond pulsed-DBD plasma actuators produced rapid energy deposition—high instantaneous power (MW and nanosecond scales) that did not vary significantly with pressure. Under controlled vacuum conditions, the rapid energy deposition produced a hemicylindrical shock wave that weakened with reductions in pressure. In Ludwieg tube experiments, the blast wave interacted with, and slightly displaced, the bow shock. An apparent vortical structure formed between the body and bow shock, never seen previously, was advected and stretched by the expansion around the body. The observation of this large-scale perturbation provides a strong motivation to use nanosecond pulsed-DC DBD plasma actuators to force boundary layer transition in Ludwieg tube and blowdown hypersonic wind tunnel.



Seminars Coordinator: Prof. Givli Josef

Note: the seminar will be given in English