EGY Plasma School
Port Said

Plasma Flow control

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Abstract

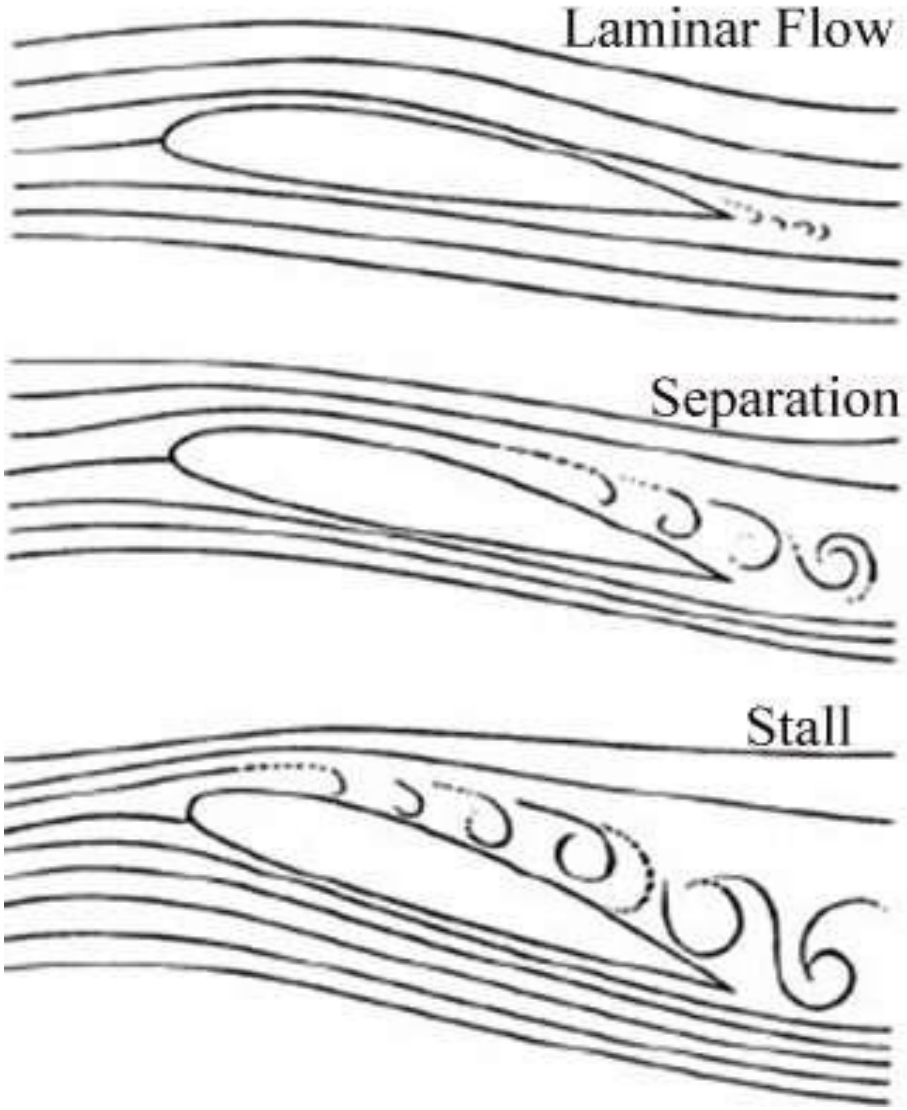
- Aerodynamic plasma actuators supplied by a dielectric barrier discharge (DBD) can used for active flow control
- Usually, sinusoidal voltages in the range 5–50 kV peak and frequencies between 1 and 100 kHz are utilized to ignite this plasma typology.
- The surface discharge produced by these devices is able to accelerate the flow field by means of electro-hydrodynamic (EHD) interaction, can induce speeds up to 10 m/s.
- Their use over airfoils, flaps, and blades have shown the possibility to prevent flow separation which enhance lift and reduce drag.

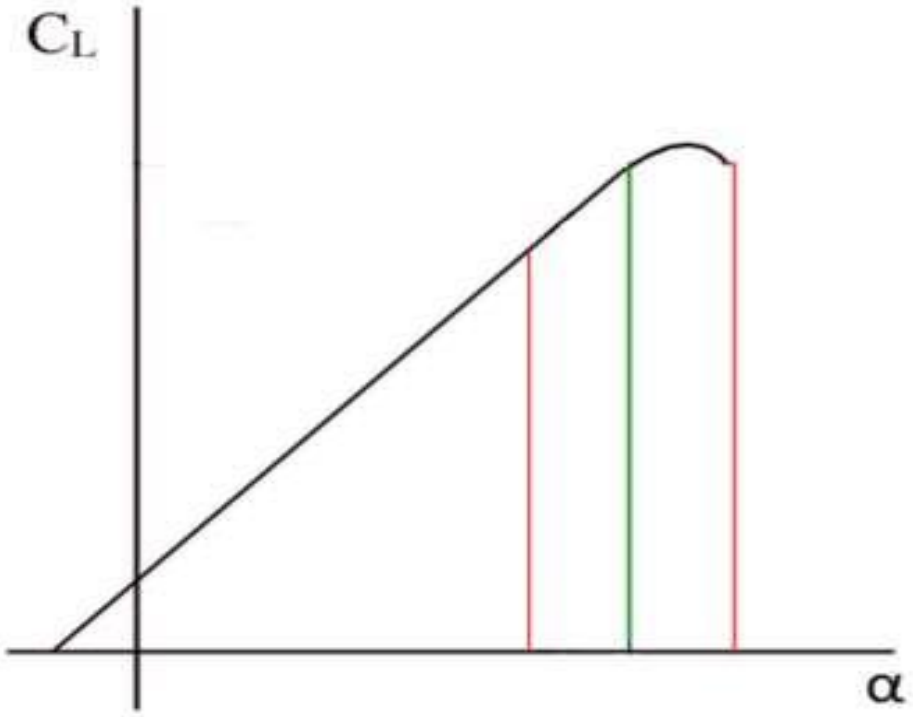
Airfoil Separation and Stall

Lift coefficient varies with angle of attack. For efficient performance, It should be as high as possible.

Wind gusts cause separation and stall to occur if angle of attack increases past maximum levels.

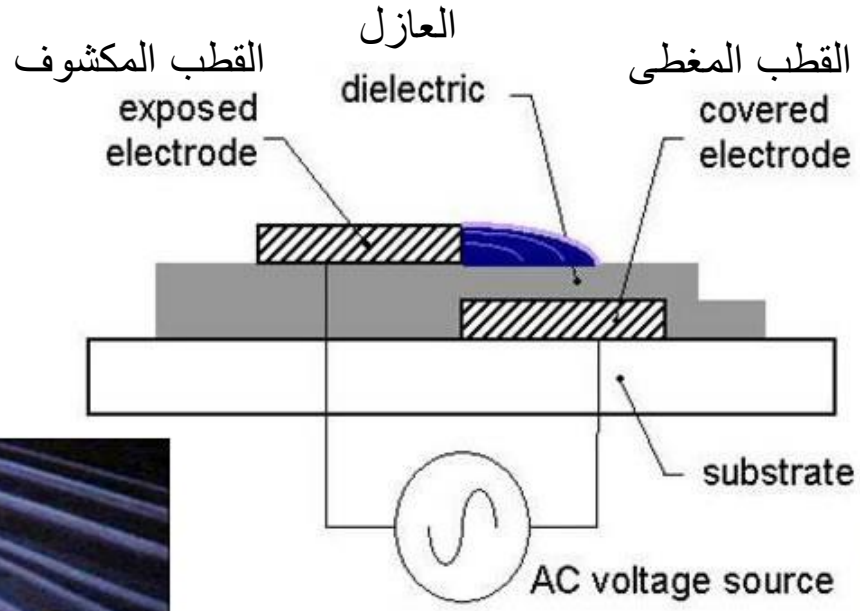
Lift coefficient with flow angle of attack

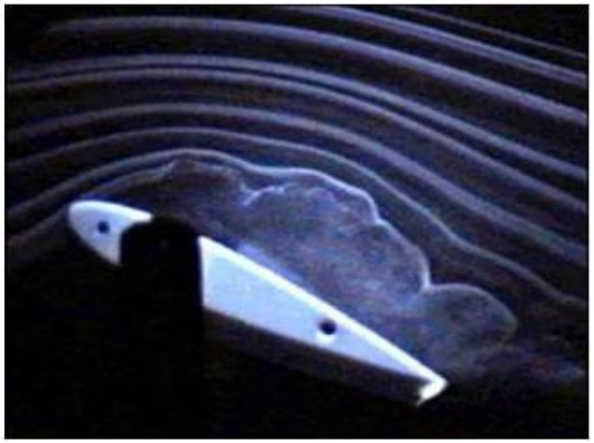




Adapted from http://www.sportpilot.org

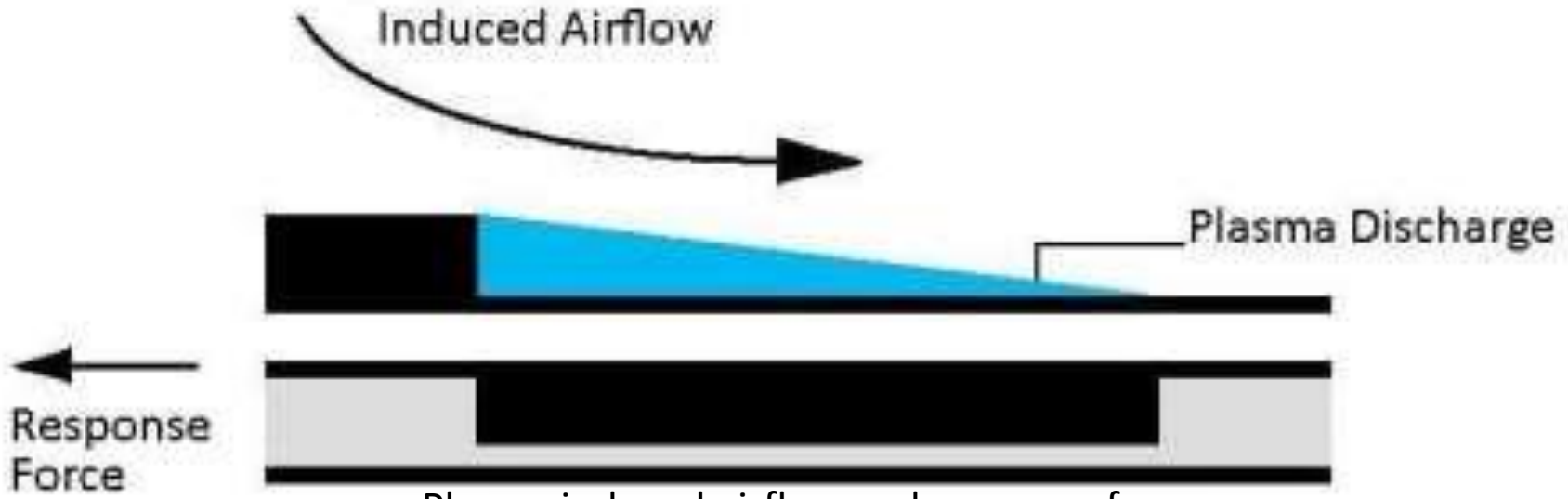
Plasma Actuators





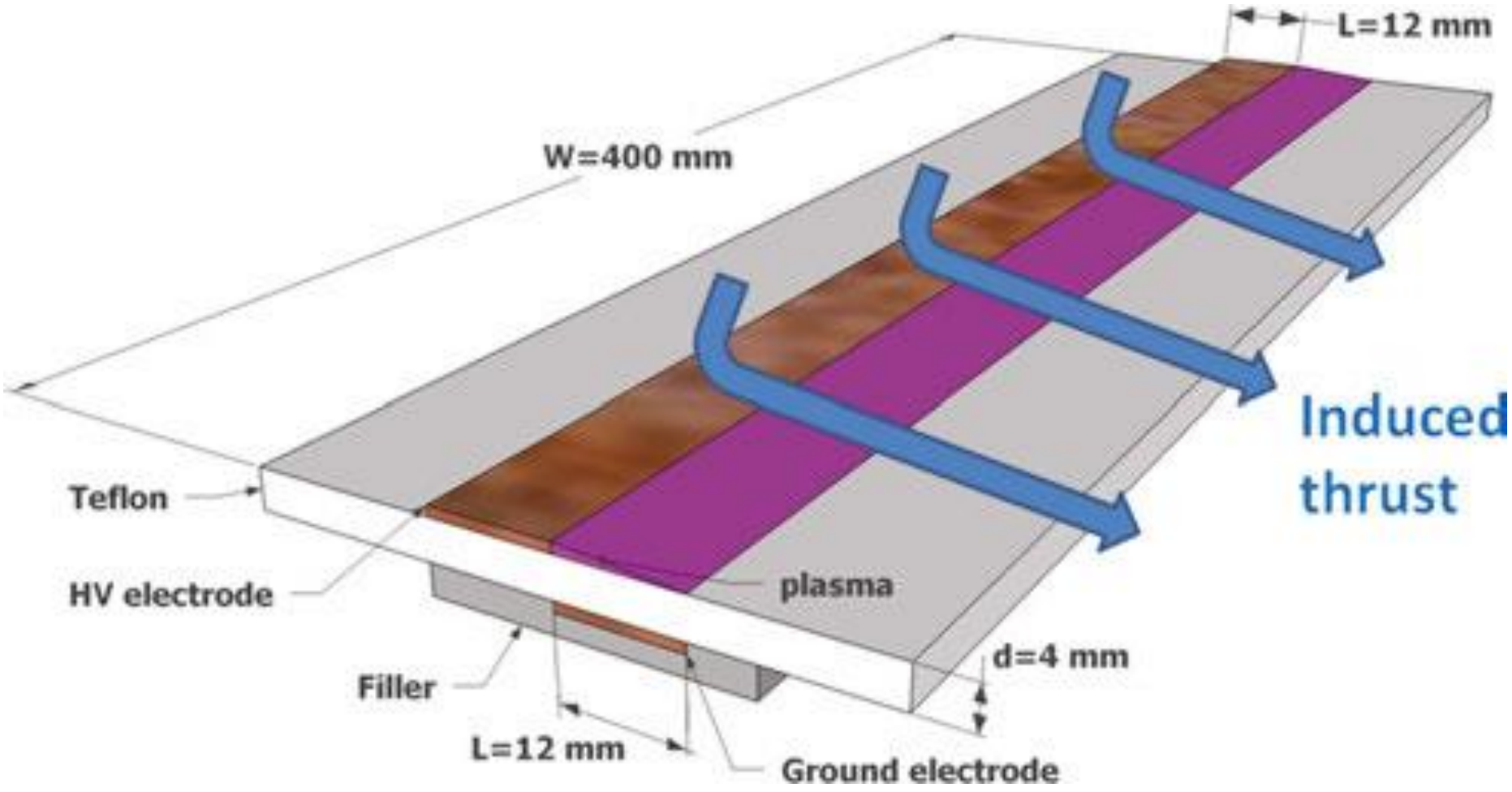
DBD Actuator Physics

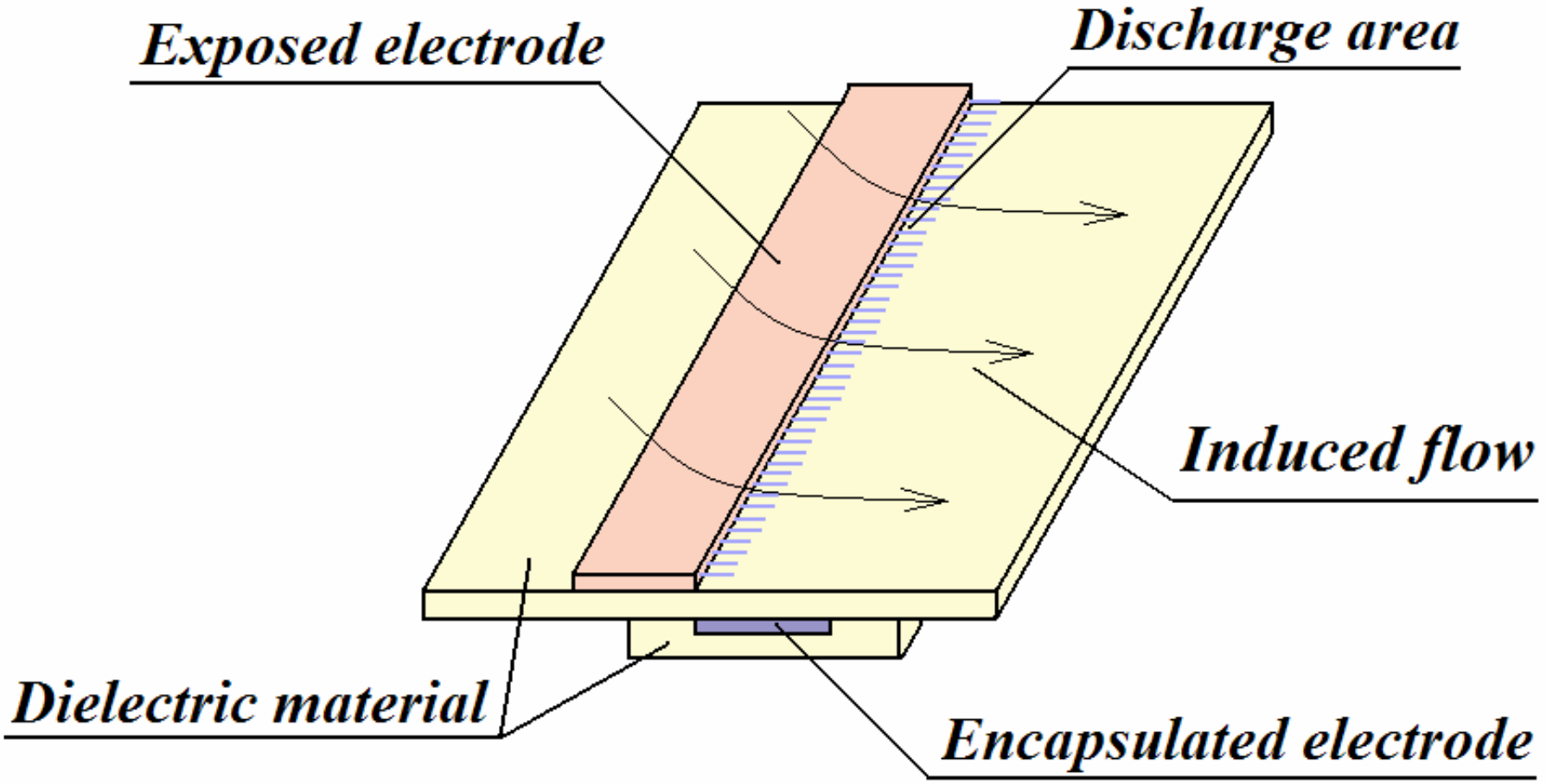
Plasma aerodynamic actuators are based on the electro-hydrodynamic (EHD) interaction. Appling High electric fields can locally ionize the air. **The produced** heavy-charged are accelerated by the applied electric field and by means of collisions, they can yield momentum to the surrounding air. **The induced airflow**, called 'Ionic Wind' results



Plasma induced airflow and response force

Adapted from Cheong et al. 2010

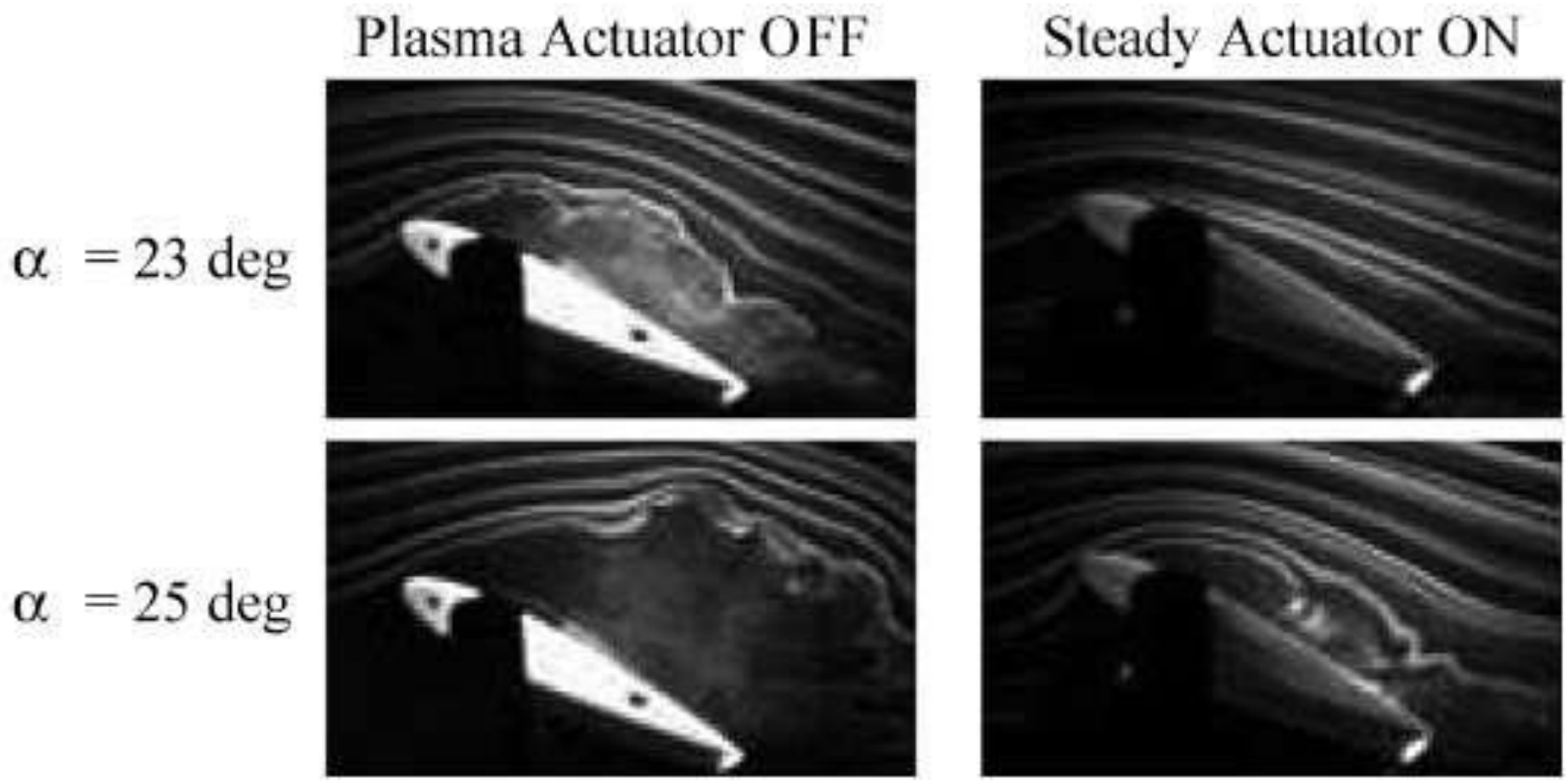

L=12 mm
W=400 mm
Induced thrust
Teflon
HV electrode
plasma
Filler
d=4 mm
L=12 mm
Ground electrode

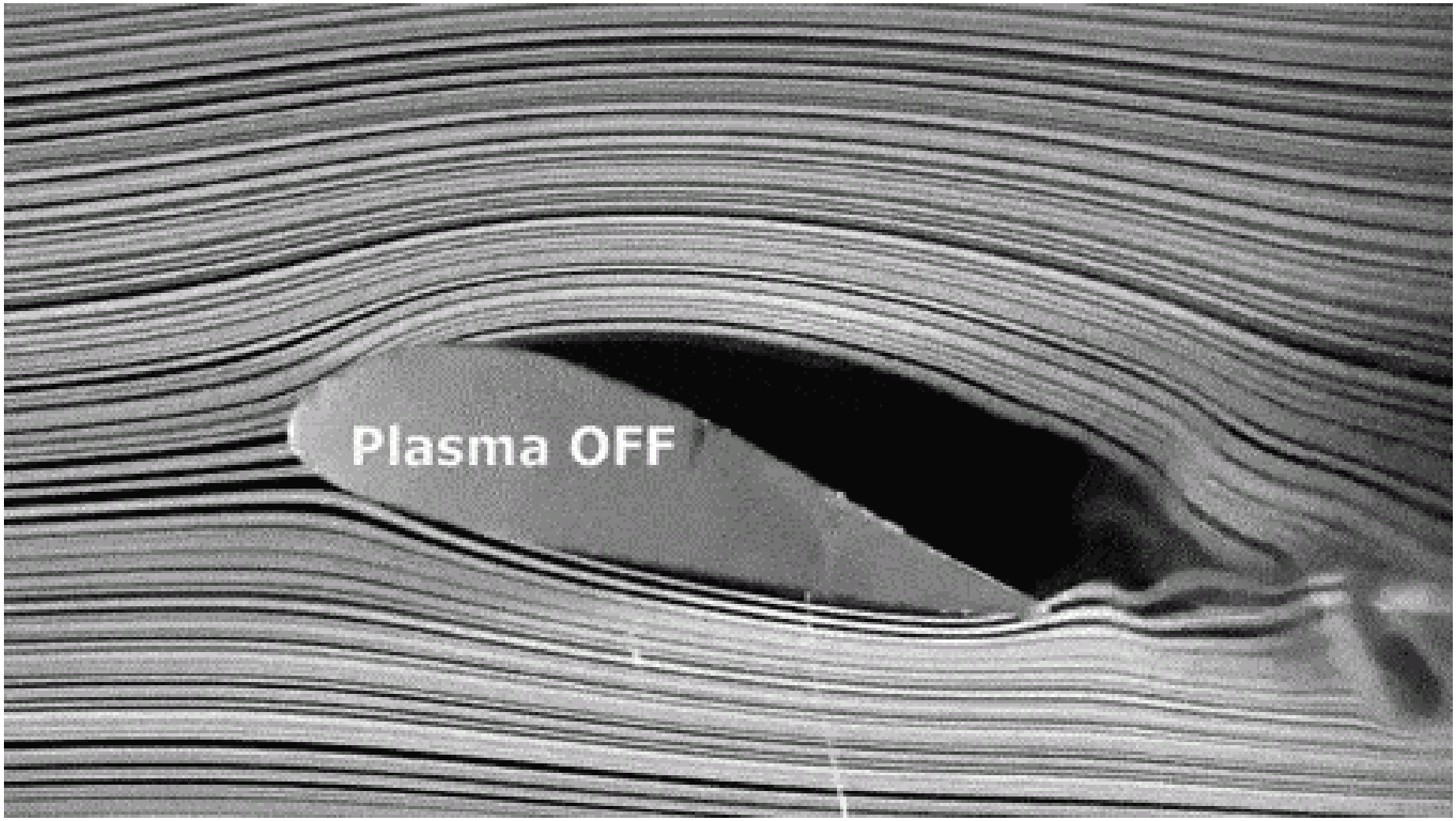

Exposed electrode
Discharge area
Induced flow
Dielectric material
Encapsulated electrode

Massless Wall Jets

- DBD actuators modify fluid flow characteristics by generating massless wall jets in the boundary layer of the flow
- Introduction of these jets injects momentum into the boundary layers to delay separation or even reattaching separated flow

DBD Actuators for Flow Separation




Plasma OFF

References

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- S. Kiel Hockett Jr. and Kyle Higdon, “Plasma Actuators as Active Flow Control on Wind Turbine Blades”, University of Notre Dame.
- Gabriele Neretti, “Active Flow Control by Using Plasma Actuators”, INTECH-chapter 3, http://dx.doi.org/10.5772/62720
- Dmitry F. Opaits, “Dielectric Barrier Discharge Plasma Actuator for Flow Control”, NASA/CR—2012-217655 Final Report, Princeton University.