Fabrication and characterisation of thin-electrode AC-DBD plasma actuators

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Keywords: AC-DBD fabrication, effect of electrode thickness

AC-DBD plasma actuators have received considerable attention from the flow control community in the past two decades. However, as boundary-layer flow-phenomenon are receptive to surface roughness (Saric et al., 2003), the thickness and roughness of the air-exposed electrode of an AC-DBD actuator can amplify boundary-layer instabilities and result in promotion of transition. For this purpose, a novel fabrication technique was envisioned to produce AC-DBD actuators with very thin electrodes. This involves computer-controlled spraying of micrometric conductive silver particles.

The fabrication process is as follows. A self-adhesive sheet is fixed on the dielectric substrate and the shape of the required electrode is cut using a laser tool head fixed to an CNC-XY plotter, to generate the necessary masks. Sub-micron sized silver particles are mixed with an industrial solvent (*Methyl-Ethyl-Ketone*) to produce a metallic ink. An airbrush tool head is fixed to the CNC-XY plotter and the metallic ink is sprayed in the negative space generated by the mask. When sprayed, the solvent evaporates, leaving a thin deposit of silver particles on the dielectric surface. The mask is then removed and the actuator is cleaned with *Ethyl alcohol*. The electrodes thus generated are in the order of a few micrometers thick and it is possible to produce electrodes with intricate geomteries with this method. AC-DBD actutors produced using this technique have been used to control cross-flow dominated transition in swept-wing boundary layers by Serpieri et al. (2017) and Yadala et al. (2018). In both these works, no promotion of transition due to the mere presence of the electrode was reported.

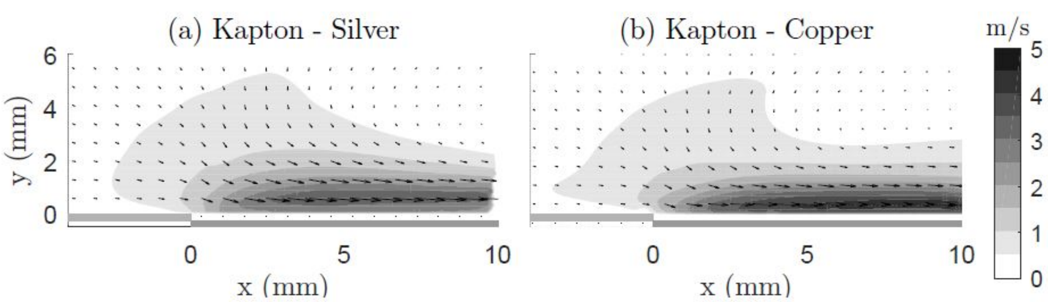

Figure 1: Preliminary time-averaged velocity fields generated by AC-DBD plasma actuators with *Kapton* as dielectric. $V_{pp} = 18$kV, $f_{ac} = 2600$Hz.

In the current study, thorough characterisation of the novel AC-DBD actuator produced by the above mentioned fabrication technique will be presented. The preformance of this actuator is compared with a conventional actuator with 60μm thick copper electrodes. This comparison is carried out on both thin (*Kapton*) and thick (*Plexiglass*) dielectric substrates. High-speed planar PIV fields of the induced jet were acquired. Preliminary results of the mean induced velocity of the *Kapton* actuators is shown in figure 1. The thrust generated and the body force distribution of these actuators are computed from these PIV vector fields (Kotsonis et al., 2011) and show that the performance of the novel actuator is comparable to that of the conventional actuator. Furthermore, the power consumed by these actuators were also measured.

Additionally, the effect of thickness of the air-exposed electrode on the induced velocity and body force distribution will be presented. For this purpose, AC-DBD actuators with silver electrodes were fabricated using the above discussed technique. Different air-exposed electrode thicknesses were achieved by performing the spraying step multiple times. The thickness of the generated electrodes are quantified using an electron microscope. This particular exercise is carried out to observe the effect of the air-exposed electrode's thickness on the structure of the induced jet and the performance of an actuator.

Acknowledgements
S. Yadala Venkata is funded by the French Government program "Investissements d'Avenir" (LABEX INTERACTIFS, reference ANR-11-LABX-0017-01).

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