Trielectrode Plasma Actuator for Enhanced Thrust Generation

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Plasma actuator demonstrates their potential in delaying separation and significant improvement in aerodynamic performances [1]. However, due to the limitation of the physical mechanism of dielectric barrier discharge, it is difficult to increase plasma density to enhance thrust of induced jet of single DBD plasma actuator. The use of additional electrode is one of the solutions for this problem, to enhance discharge and assist acceleration of ions from that discharge. Sosa et al. have tested a multi-electrode (trielectrode) plasma actuator that has additional electrode to apply DC voltage [2, 3]. Figure 1 shows the configurations of the trielectrode plasma actuator and photograph of sliding discharge between electrodes when negative DC voltage is applied to the additional (DC) electrode. Characteristics of the trielectrode plasma actuator have been investigated on the electric aspect [4] and improvement of tangential thrust compared to SDBD plasma actuator [5, 6].

In this research, the effects of the driving conditions and physical configuration of the trielectrode plasma actuator on their thrust characteristics have been investigated by the experiment. The numerical simulation [7] has been carried out to analyse their physical mechanism. In the experiment, the induced body force of the trielectrode plasma actuator was measured by the precise lab balance in quiescent air. From the results of the experiment, the effect of the gap length between the exposed electrodes and the frequency on the thrust characteristics has been clarified. The impact of the gap length on the thrust becomes significantly small at large gap. At small gap, the thrust shows rapid increase as the frequency rise. For the case that 2 mm thick Aluminium Oxide plate was used for the dielectric layer, the thrust exceeded 130 mN/m under the maximum DC voltage conditions (as shown in figure 2). The application of DC voltage extends the ionization region and produce counter jet at the edge of the DC electrode. In such a case, the numerical simulation clarified that the electrons produced from the AC discharge are attracted by the DC electrode, then they trigger the ionization to generate positive ions at the DC electrode. The drift motion of the generated positive ions results in the strong negative body force, resulting large total thrust enhancement.

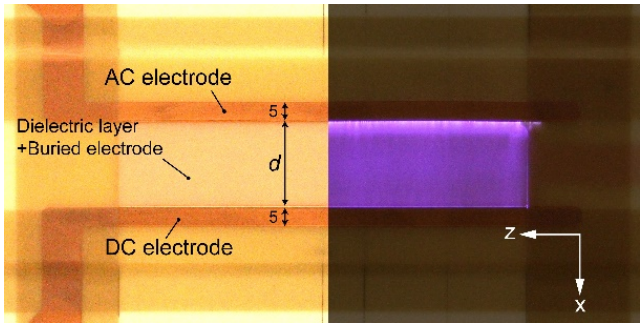

Figure 1: Photograph of the trielectrode plasma actuator element and its discharge.

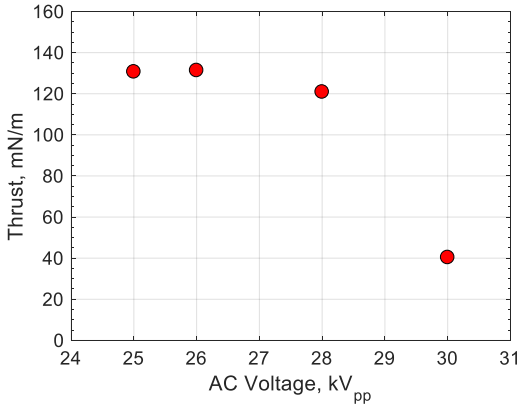

Figure 2: Total thrust versus AC voltage at maximum DC voltage.

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