EVOLUTION OF THE WALL VOLTAGE ON A DBD FOR FLOW CONTROL: EXPERIMENTAL AND NUMERICAL INVESTIGATIONS

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Abstract. A comparison between experimental and numerical determination of the wall voltage of a dielectric barrier discharge (DBD) for flow control in air is presented. We measured the wall voltage by the longitudinal electro-optic amplitude modulation method with a BGO ($Bi_{12}GeO_{20}$) single crystal as the dielectric. Experiments confirm that the negative phase (i.e. when anode is under the dielectric) is associated with a propagation of a negative ion cloud that can generate an EHD force as large or even larger than the force generated by positive ions during the positive phase. The propagation velocity of the memory voltage in the experiment is about 0.4 km/s µs in air at 50 torr in agreement with the evolution of the charge calculated with the model.

1. INTRODUCTION

Surface dielectric barrier discharges at atmospheric pressure can generate a flow or modify the boundary layer of a flow and have been proposed as actuators for flow control [1]. We have shown in previous papers [2,3] that the generation of the ElectroHydroDynamic (EHD) force in a surface dielectric barrier discharge (DBD) is similar to that related to the ion wind in a corona discharge. The EHD force is generated during low currents phases of the DBD, when ion clouds form in the large electric field over the surface and transfer their momentum to the neutral molecules. Depending on the polarity of the applied voltage, positive or negative ions are responsible of the EHD force in air. To confirm these numerical results we designed a simple DBD experiment in air at pressure below atmospheric pressure in order to better control the discharge. Electric and optical (ICCD imaging) diagnostics have been used to study the space and time development of the discharge. In parallel we set-up an experiment based on the use of the Pockels effect [4] to measure the spatio-temporal evolution of the wall voltage at the dielectric surface. In the present paper we'll focus on this last point.

2. BRIEF DESCRIPTION OF THE MODEL AND BASIC PRINCIPLE OF THE ELECTRO-OPTIC MEASUREMENT

2.1. Model description

The model is based on fluid equations for electrons and ions, coupled with Poisson's equation for the electric field. The time dependent electron and ion continuity equations with a drift–diffusion flux are coupled with Poissons's equation and integrated in time (see [2,3] and references therein). In this study, a very simple model of the plasma chemistry has been considered, with one type of positive ion and one type of negative ion species (for air) and no complex plasma chemistry is included. The surface charge density is calculated self-consistently by integrating the electron and ion fluxes to the surface. Electrons and ions in each surface element are supposed to recombine instantly with oppositely charged particles on the surface if present. More details can be found in reference [3].

2.2. Electro-optic measurements

These measurements are based on the Pockels effect [4]. When an electromagnetic radiation is