Analysis of Fine Dielectric Particles Behavior in a Traveling Wave Electric Field

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***Abstract*—The manipulation of solid and liquid particles by applying an electric field is a process widely used in different industrial applications. Indeed, the charged particles are generally manipulated using the Coulomb force, as in the case of electrostatic precipitators and electrostatic separators. The neutral particles also can be transported in a non-uniform electric field by using the dielectrophoretic force (DEP). This process is used in particular for the transport and treatment of biological cells in microfluidic devices and in surface cleaning systems. In this work, we are interested in the transport of particles using a traveling wave electric field. The experimental device, called electrodynamic board (EDB), consists of several electrodes deposited in parallel on a dielectric surface and powered by a multiphase AC voltage. The non-uniform electric field created leads to the motion of the particles due to electrostatic forces.**

The aim of this work was to understand the transport mechanism of fine dielectric particles on the EDB using an experimental bench and numerical simulation. In the first part of this work, the movement of particles was captured using a high-speed camera. The effect of several experimental parameters such as the frequency, the applied voltage and the EDB configuration (two and three phase configurations) was investigated. The particles studied were calibrated spheres made of PMMA; their size was ranging between 50 and 100 microns. The results show that in a three-phase configuration, the particles have a preferential unilateral movement because of the progressive electric field wave. The behavior of the particles depends on the frequency of the applied voltages. There is a frequency range where the evacuation of particles is more efficient.

In the second part of this work, which was dedicated to numerical simulation, the study was focused on the spatiotemporal distribution of the electric field and electrostatic forces including the Coulomb force and the dielectrophoretic force. Two approaches were adopted: the instantaneous forces approach, to characterize their evolution in time, and the time averaged forces approach, to quantify the travelling wave DEP effect. The results show that the time averaged travelling wave DEP force can be neglected compared to other forces. The spacial distribution shows that dielectrophoretic force is dominant near the edges of the electrodes. However, the Coulomb force dominates in the regions above the electrodes and in the space above the EDB

surface. In the case of PMMA particles in the air, the DEP force is positive, so it attracts the particles to the areas where the electric field is stronger.