Self-organized pattern formation and kinetic simulation in dielectric barrier discharge

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From zebra stripes to a honeycomb lattice, nature features breathtaking patterns. These mysterious shapes cause for wonder and fascination throughout human history. As a new kind of pattern formation system, dielectric barrier discharge (DBD) has attracted increasing attention in recent years. It is capable of producing the most varieties of patterns with simple experimental setup. By using the special designed DBD system with two water electrodes, we have obtained more than 40 kinds of patterns through nonlinear self-organization of the filaments, as shown in Figs.1-2. Generally, these plasma patterns exhibit high spatial-temporal symmetries at the macroscopic level, while are characterized by complex dynamics and interactions from the microscopic view. In this presentation, the spatio-temporal dynamics of the patterns, the plasma diagnostics by light emission spectrum as well as the applications of the patterns as a tunable plasma photonic crystal are presented.

To get a further understanding of the physical mechanism of pattern formation in DBD, two-dimensional particle-in-cell simulations with Monte Carlo collisions included (PIC-MCC) have been performed. The formation of multiple filaments and the involved electric fields, electric potentials, plasma densities, and particle temperatures are studied. The transition of the electron energy probability function (EEPF) from a bi-Maxwellian to a Maxwellian distribution is observed as the discharge proceeds. The evolution of two successive filamentary discharges is studied, which displays strong spatio-temporal memory effect (Fig. 3). Moreover, the formation of 'side discharges' is presented, which is generally supposed to be a key factor responsible for diversity and rich dynamical behaviors of DBD patterns. The simulation results explain the dynamical behaviors of the DBD filaments observed in experiments.

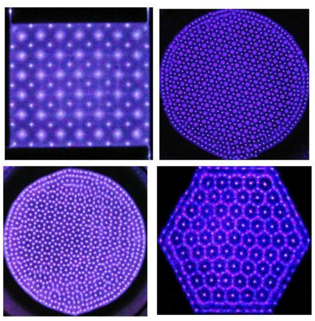

Fig.1 Superlattice patterns in DBD

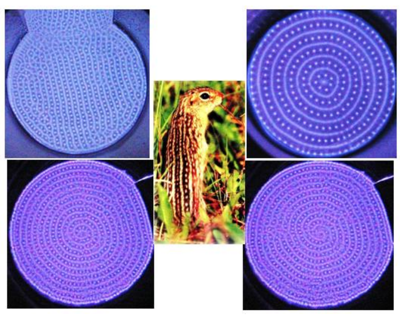

Fig. 2 Dot line patterns in DBD.

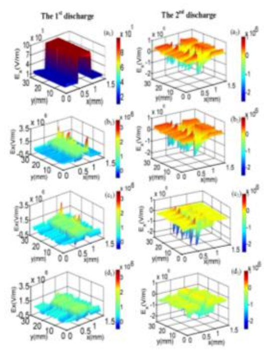

Fig. 3 The electric field distribution in the discharge.