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# Nonlinear 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 an excellent physical system for the study of pattern formation, dielectric barrier discharge (DBD) has attracted increasing attention in recent years. It is capable of producing the most varieties of self-organized patterns with simple experimental setup[1-2]. These plasma patterns generally exhibit high symmetries in appearance, but show complex spatial-temporal dynamics in microscopic. These intriguing phenomena pose deep questions on the underlying physics of DBDs.

Here we present both numerically and experimentally the formation of filamentary structure in dielectric barrier discharge. By using a special designed DBD system with two water electrodes, a rich variety of filamentary patterns have been obtained by self-organization (Fig. 1). The spatio-temporal dynamics of these patterns are studied by optical method, and the microstructures of the discharge are demonstrated. Furthermore, a two-dimensional particle-in-cell simulation with Monte Carlo collisions included is performed[3-4]. The formation of filamentary structure in DBD and the involved electric fields, electric potentials, plasma densities, and kinetic energies are studied (Fig. 2). The 'dark discharges' which produce ion densities lower by one order of magnitude than the normal discharge is suggested. The transition of the electron energy probability function from a bi-Maxwellian profile during the discharge to the Maxwellian distribution when the discharge terminates is observed. Moreover, the evolution of two successive filamentary discharge between two half cycles have been investigated. The results reveal details of the behavior of the barrier discharge and can be taken as a basis for barrier charge applications.

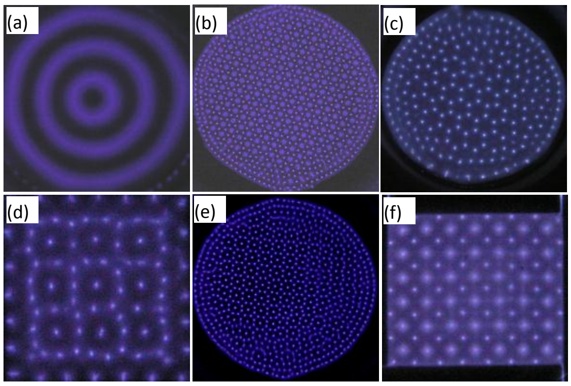


Fig.1 A rich variety of patterns in dielectric barrier discharge.

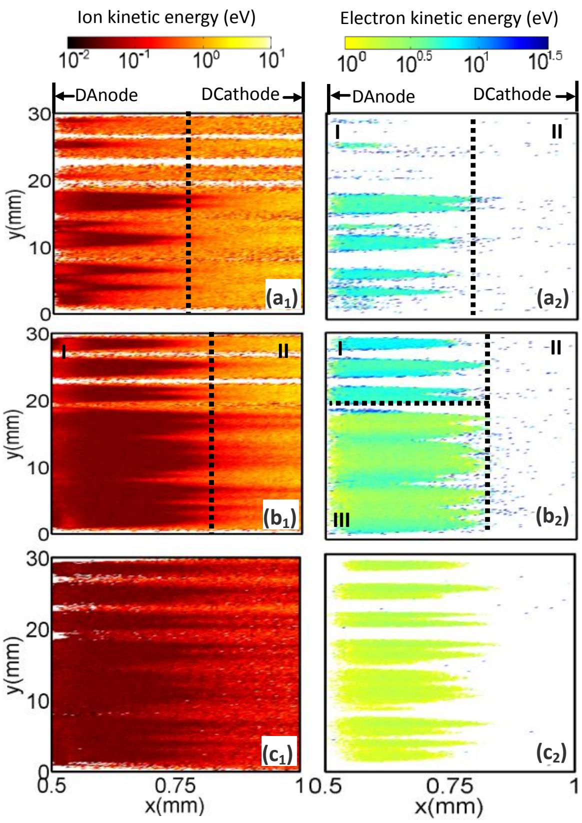


Fig. 2 Kinetic energy distributions of the $He^+$ ions and electrons in the gas gap with development of the discharge.

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