Ion resonance causes striations in electronegative rf glow discharges

With the support by the National Natural Science Foundation of China, Dr Liu Yongxin (刘永新) and his coworkers at the Key Laboratory of Materials Modification by Laser, Ion, and Electron Beams (Ministry of Education), School of Physics and Optoelectronic Technology, Dalian University of Technology, observed, for the first time, the self-organized striated structures of the plasma emission in electronegative capacitively coupled radio-frequency (CCRF) plasmas. This work was published in *Physical Review Letters* (2016, 116: 255002).

Striations in glow discharges, appearing as alternating bright and dark regions, are well-known spontaneously forming patterns and have been attracting great attention for more than 100 years. In electropositive discharges ion-acoustic or ionization waves can be responsible for their appearance. Here, we discover a new mechanism that leads to the formation of striations in electronegative CCRF plasmas operated in CF_4. Striations will show up, if the ion density in such an ion-ion plasma is large enough (i. e., exceeds a critical value) to allow positive and negative ions to respond to and to provide a feedback to the rf electric field. This phenomenon is observed experimentally for the first time and is reproduced to a great accuracy by particle-based kinetic simulations. The numerical analysis confirms the universal nature of the physical mechanisms involved. Thus, striated structures are expected to occur in other ion-ion plasma systems that are immersed in rf electric fields, too.

This novel effect substantially changes the discharge structure of electronegative CCRF plasmas and could drastically affect various process relevant plasma parameters, e. g., the flux-energy distribution functions of different charged species. Therefore, it is expected that these structures can play an important role in various plasma-based applications, such as plasma enhanced chemical vapor deposition, usually performed at relatively high pressures, low driving frequencies, and in electronegative gases.

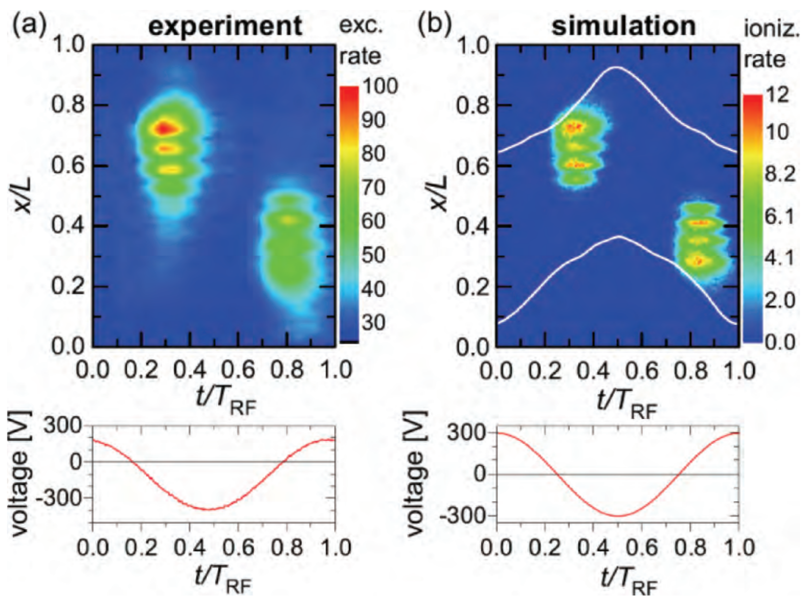

Figure (a) Measured electron-impact excitation rate and (b) simulated spatiotemporal ionization rate (with white lines showing the sheath edges). The powered electrode is at $x/L=0$, and the grounded electrode is at $x/L=1$. The panels at the bottom show the discharge voltage in the experiment and in the simulation.