

Electron dynamics in magnetron sputtering discharges

Bocong Zheng¹, Yangyang Fu², Keliang Wang¹,
Thomas Schuelke^{1,2}, and Qi Hua Fan^{1,2}

¹ Fraunhofer Center for Coatings and Diamond Technologies
Michigan State University

² Department of Electrical and Computer Engineering
Michigan State University
Email: bzheng@fraunhofer.org

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Outline

- Particle-In-Cell/Monte Carlo Collision (PIC/MCC)
- Radio Frequency Magnetron Sputtering (RFMS)
- Direct Current Magnetron Sputtering (DCMS)
- Pulsed DCMS
- High Power Impulse Magnetron Sputtering (HiPIMS)

PIC/MCC simulation

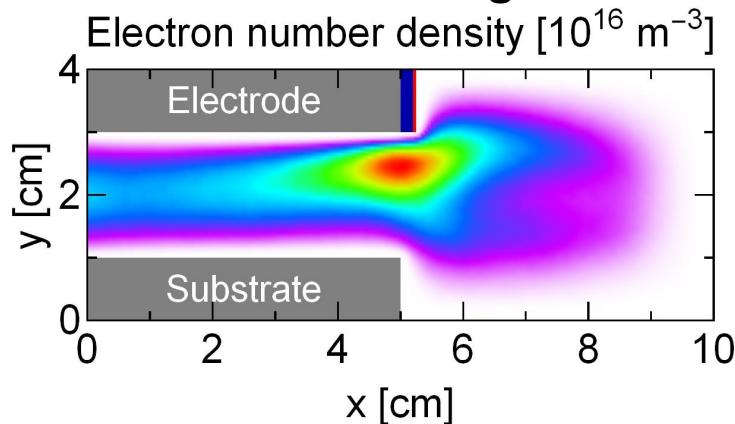
Advantages

- Self-consistent
- Complete

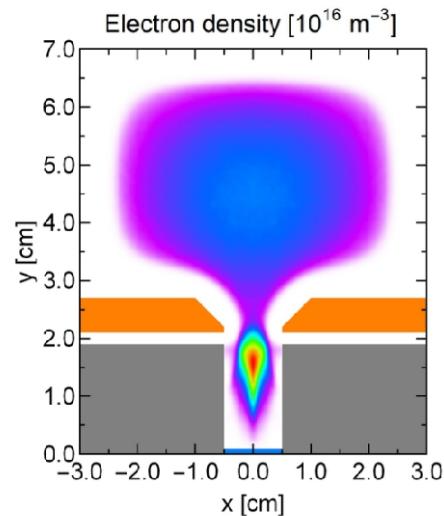
ASTRA

- Efficient PIC software
- Applications in
 - Ion sources
 - Microplasmas
 - RF plasmas
 - Magnetized plasmas
 - etc.

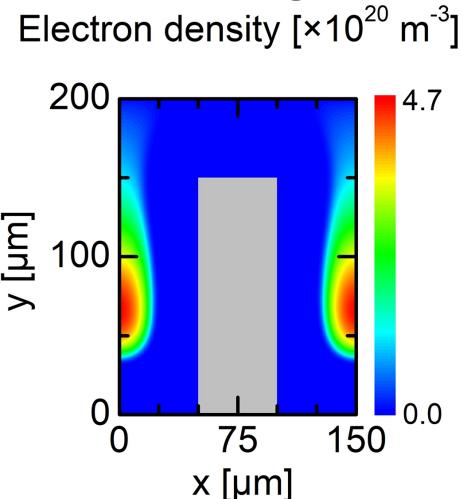
CCP discharges



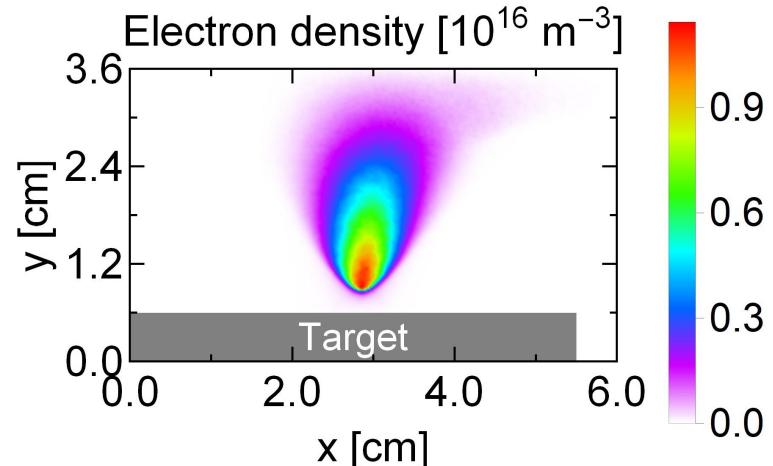
Ion sources



microhollow cathode discharges

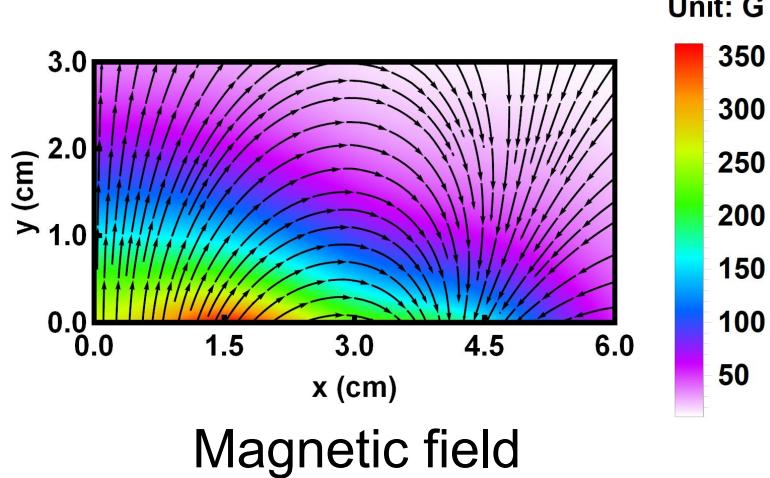
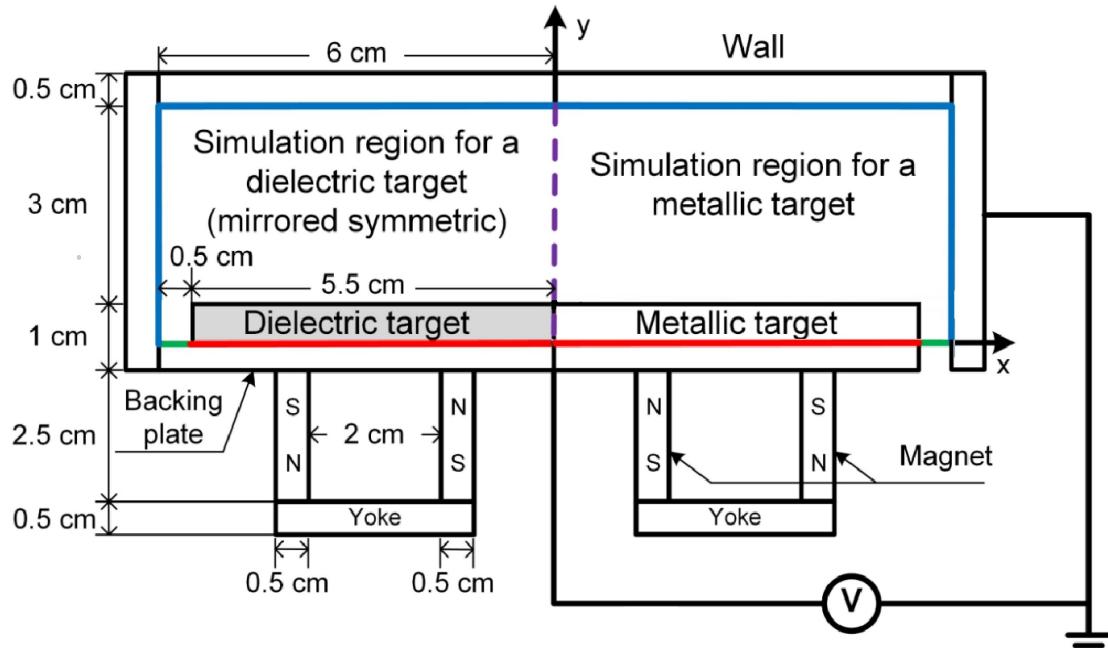


Magnetron discharges

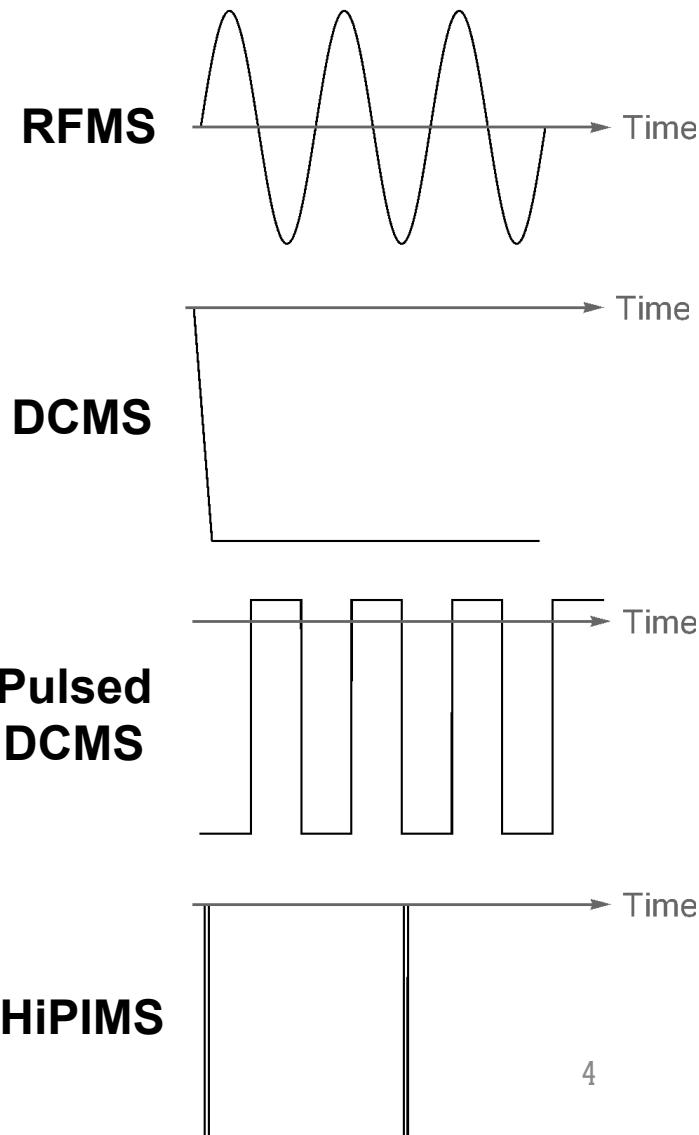


Magnetron sputtering discharges

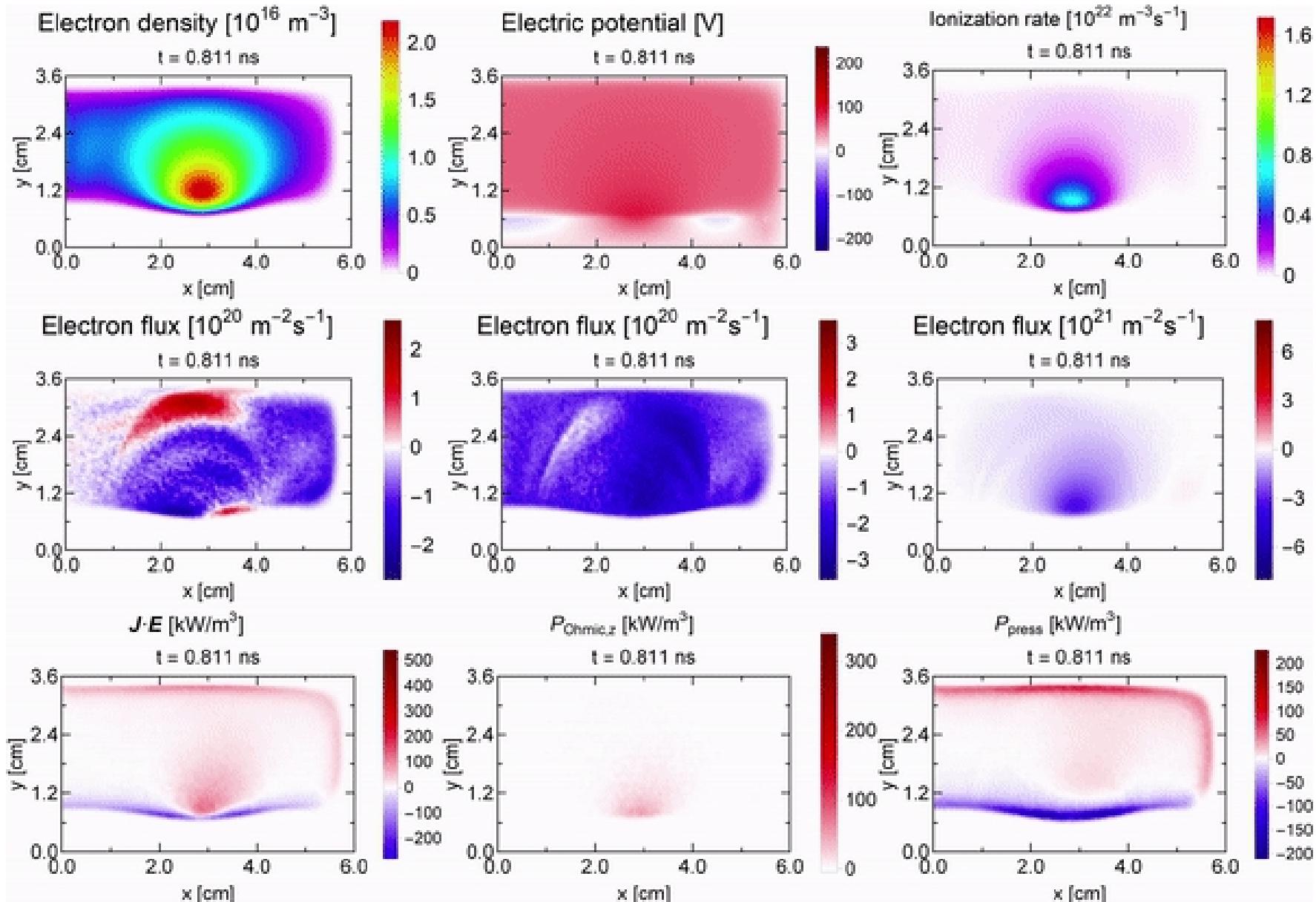
Schematic of a magnetron sputtering set-up



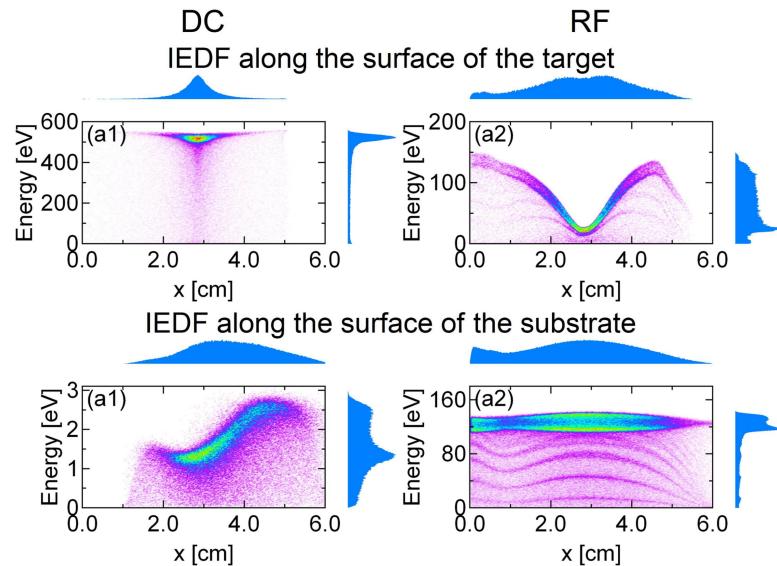
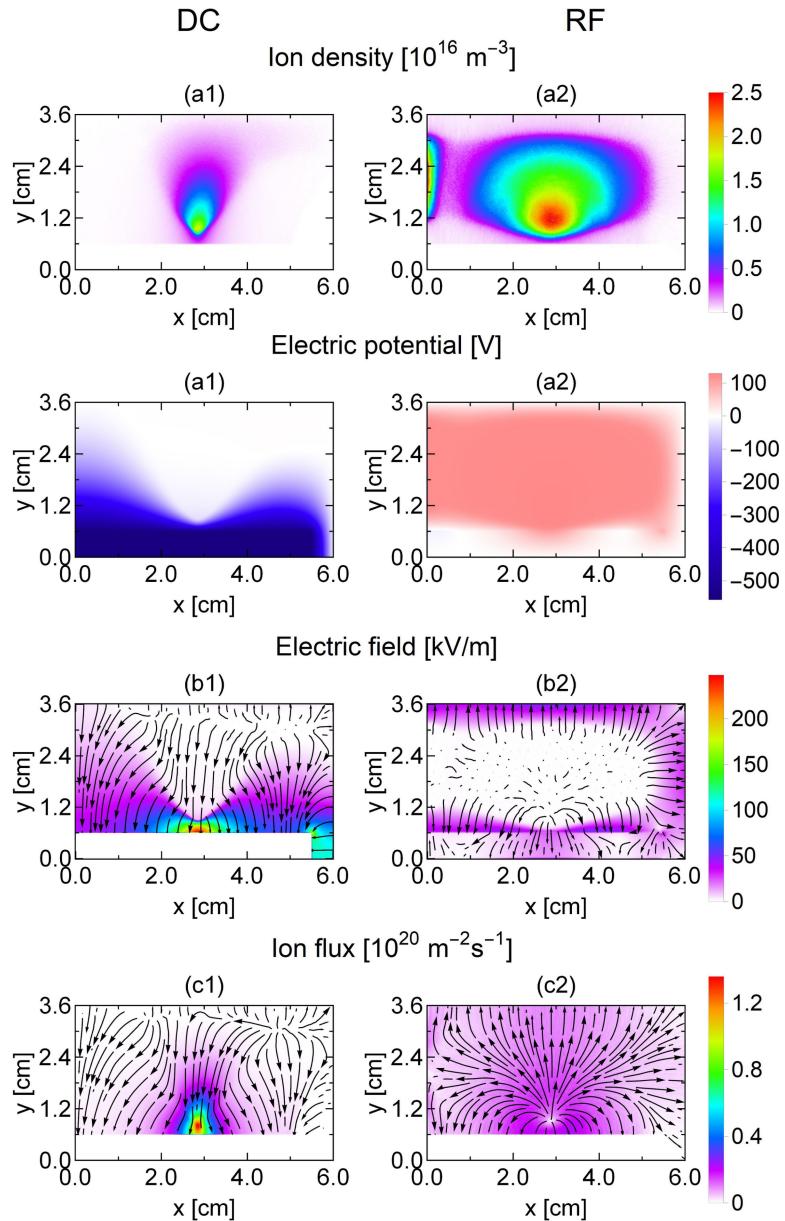
Voltage waveforms



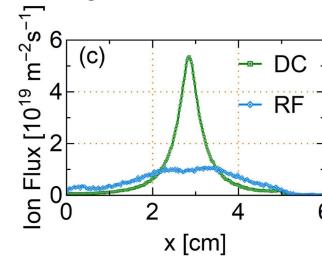
Electron dynamics in RFMS discharges



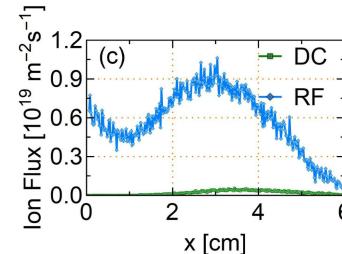
RFMS vs DCMS



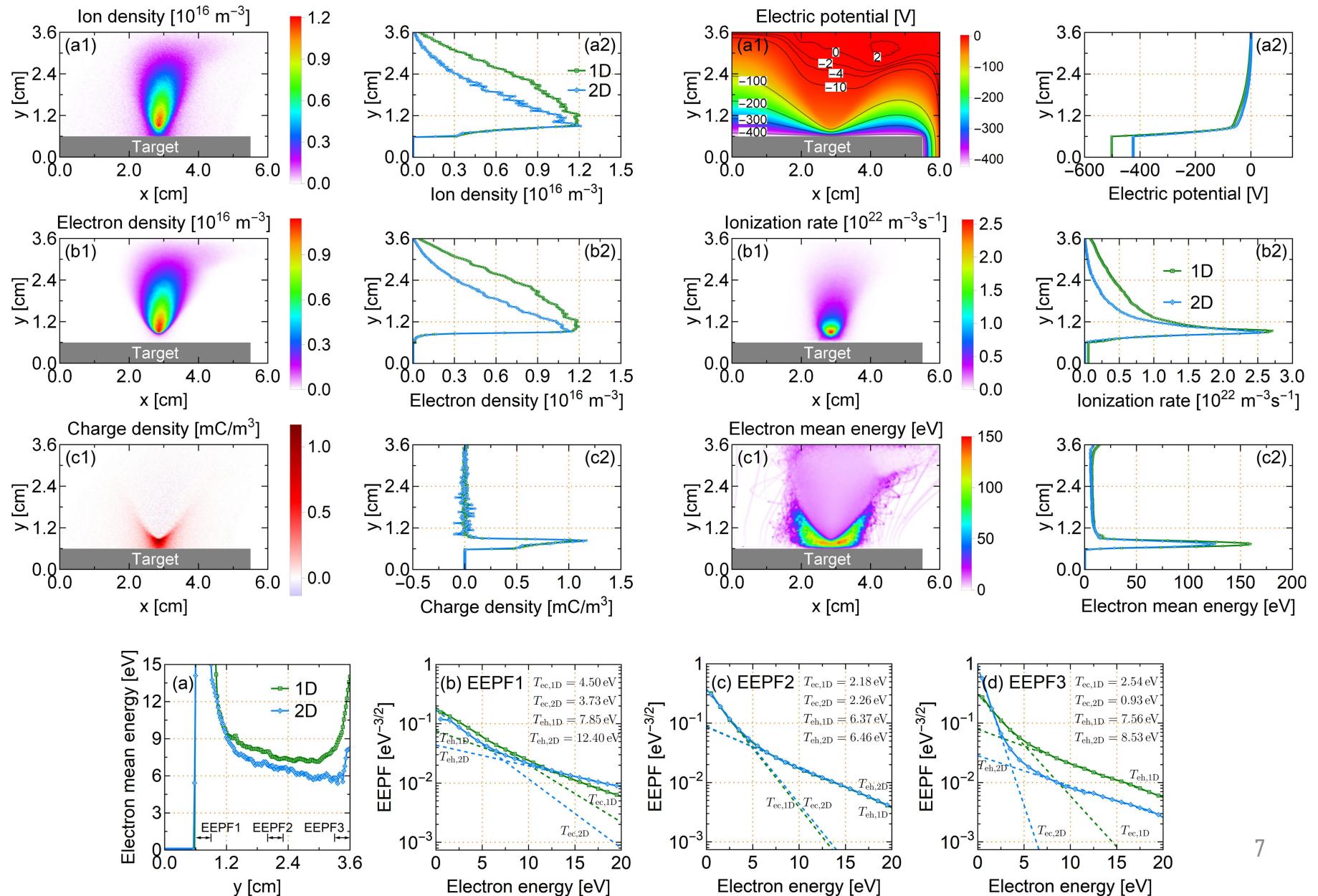
Ion flux along the surface of the target



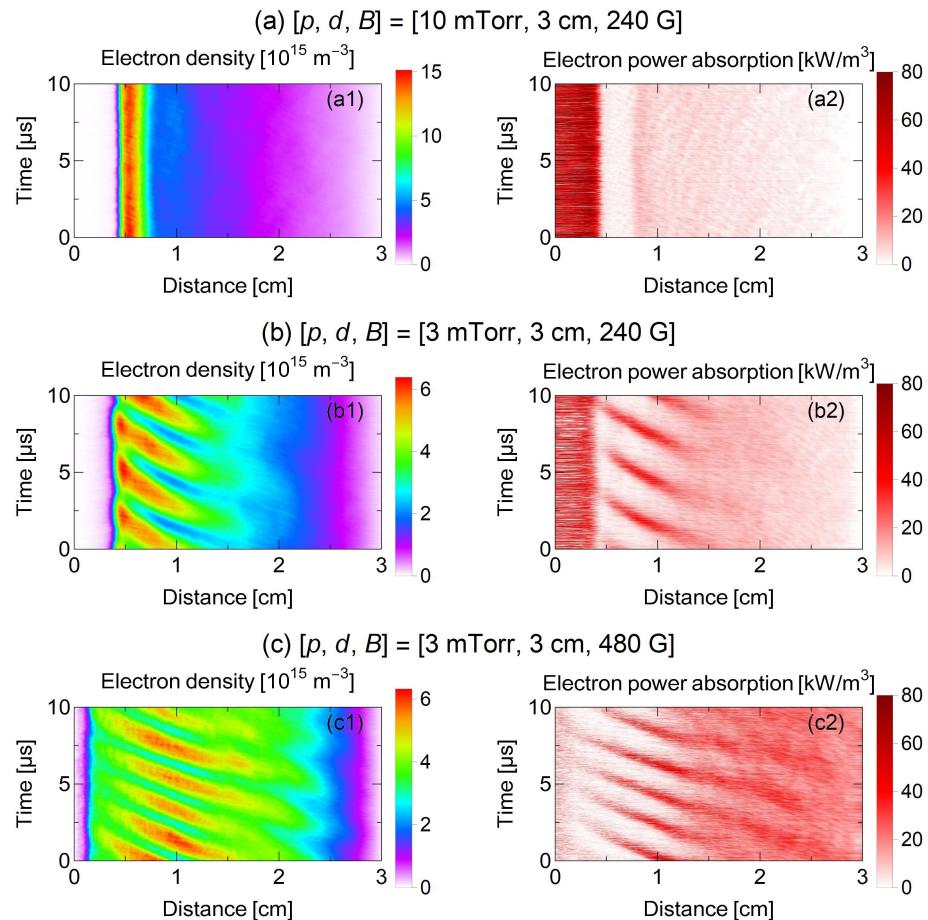
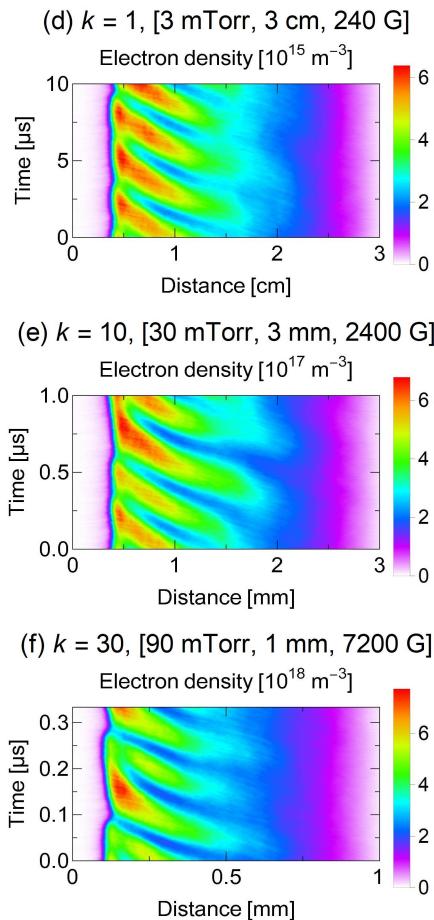
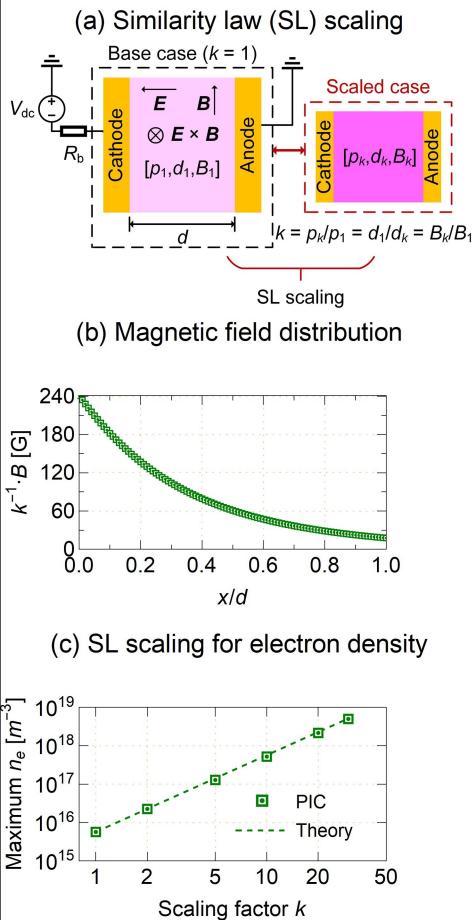
Ion flux along the surface of the substrate



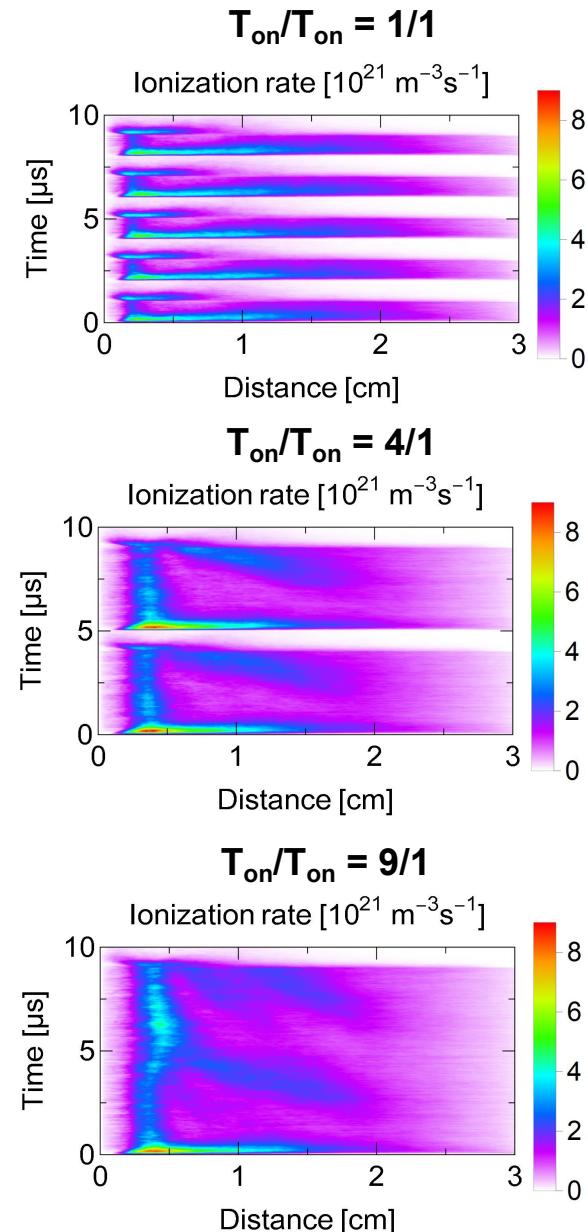
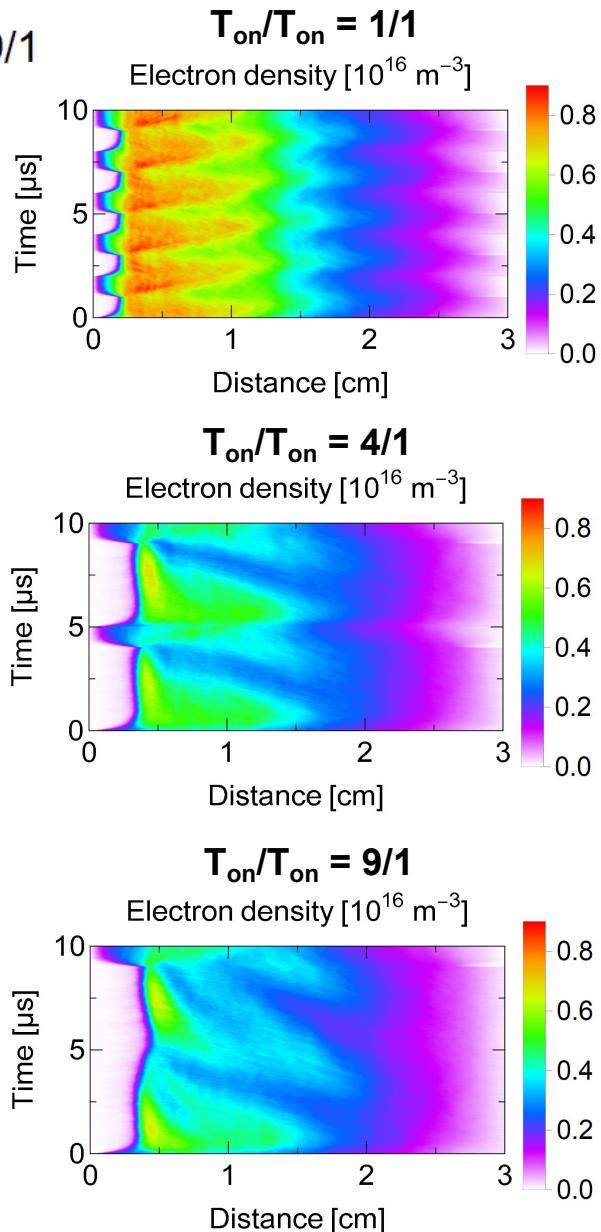
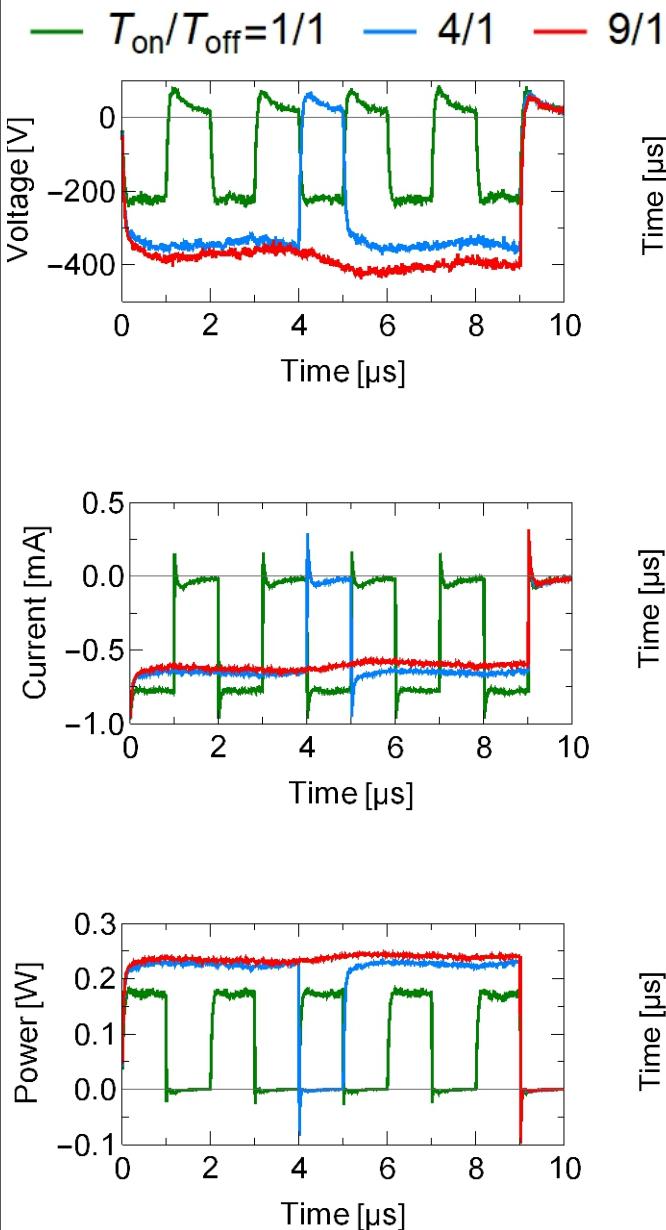
Simulation: 1D vs 2D



DCMS: breathing oscillations and electron energization

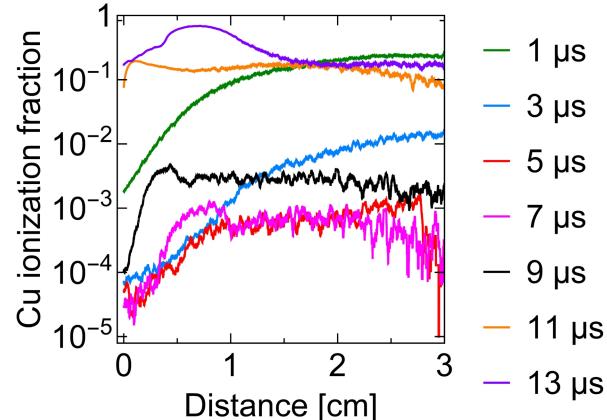
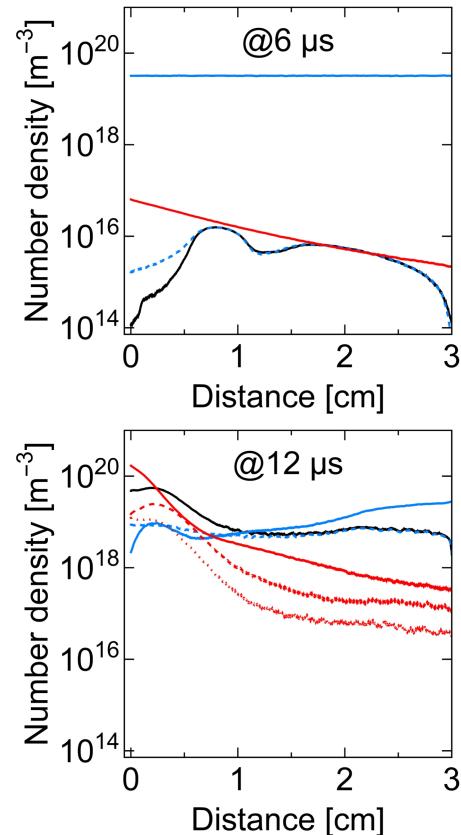
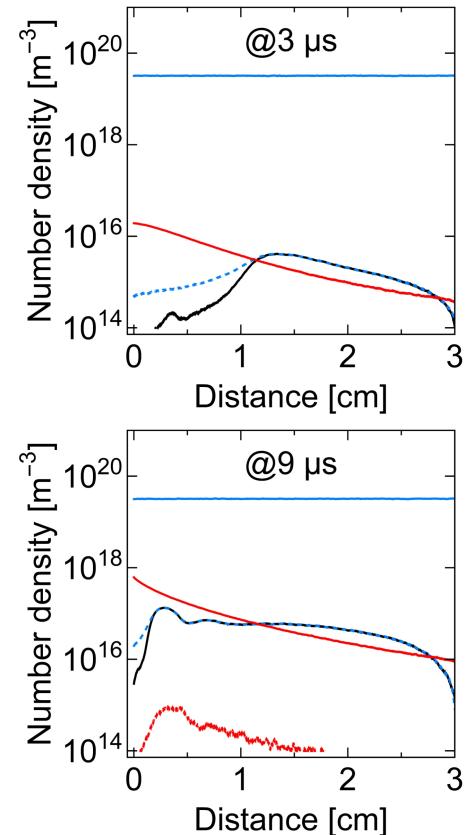
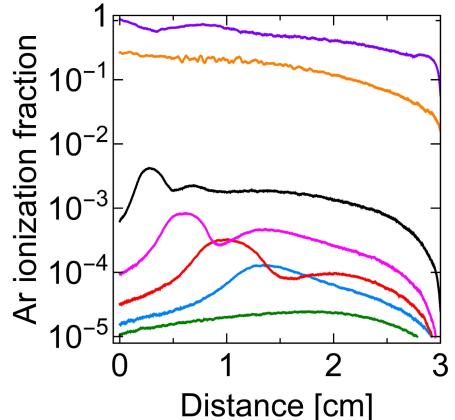
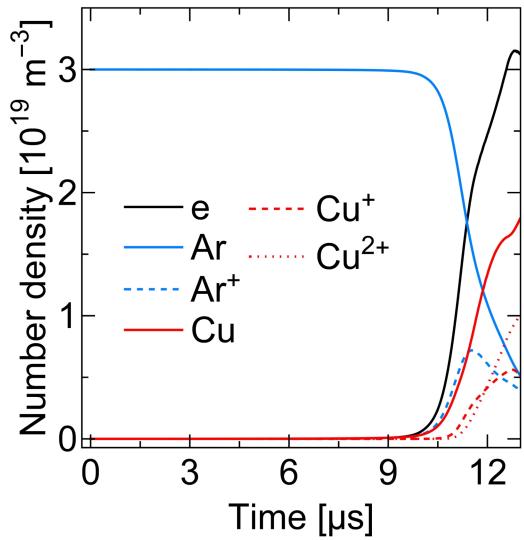


Pulsed DCMS



HiPIMS

- Additional physical processes
 - Coulomb collisions
 - Sputtering wind
 - Metal ions
 - SEE induced by metal ions



Thank you

- The slides can be downloaded at
bczheng.com/conferences/zheng21_icmap.pdf
- Email: bzheng@fraunhofer.org
- Website: bczheng.com