

Electron dynamics in magnetron sputtering discharges

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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

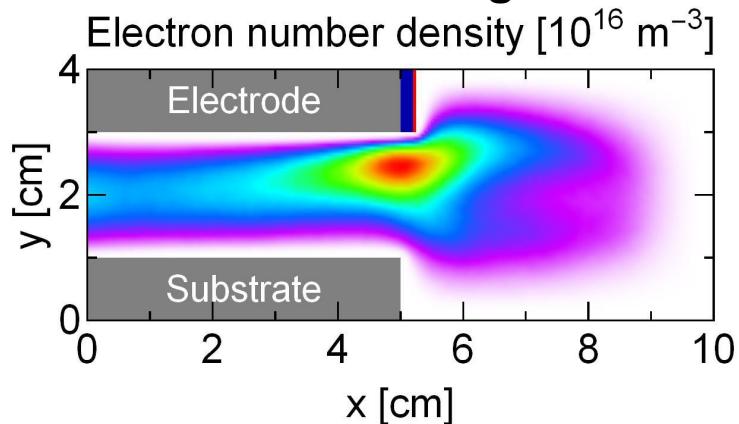
Advantages

- Self-consistent
- Complete

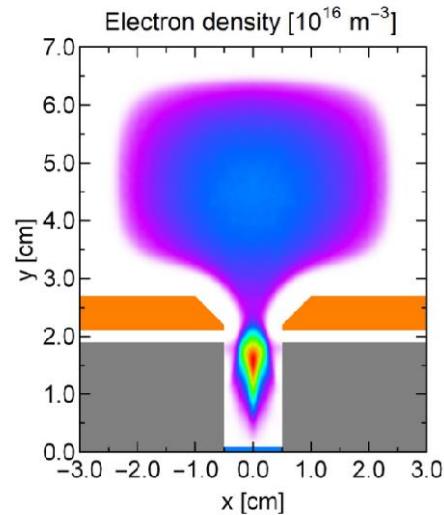
ASTRA

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

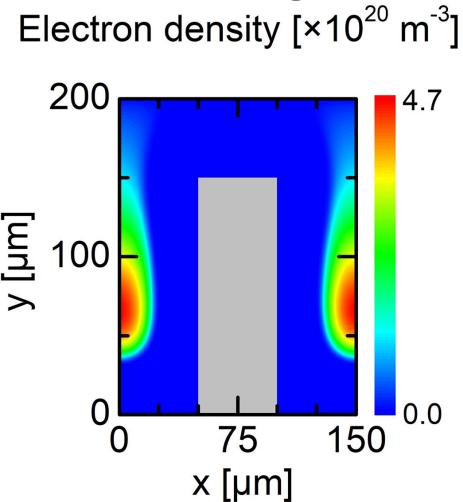
CCP discharges



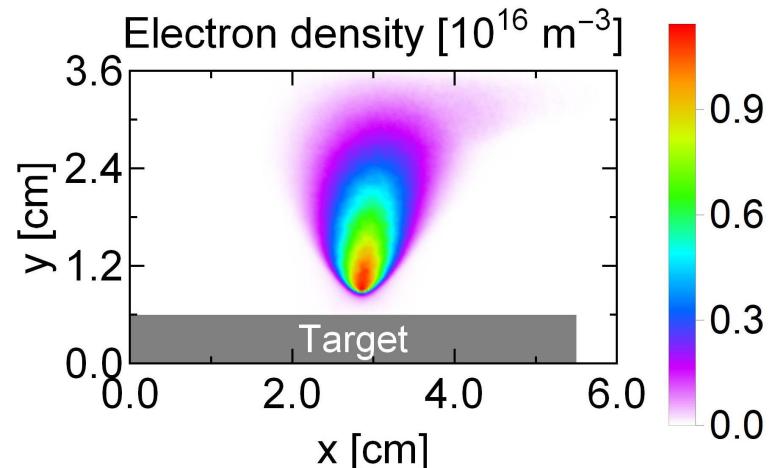
Ion sources



microhollow cathode discharges

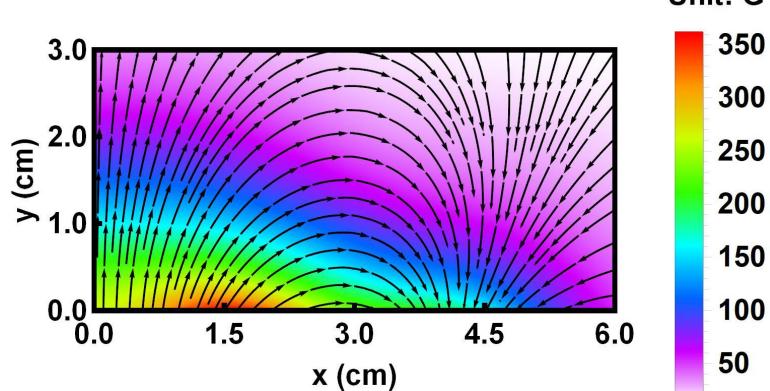
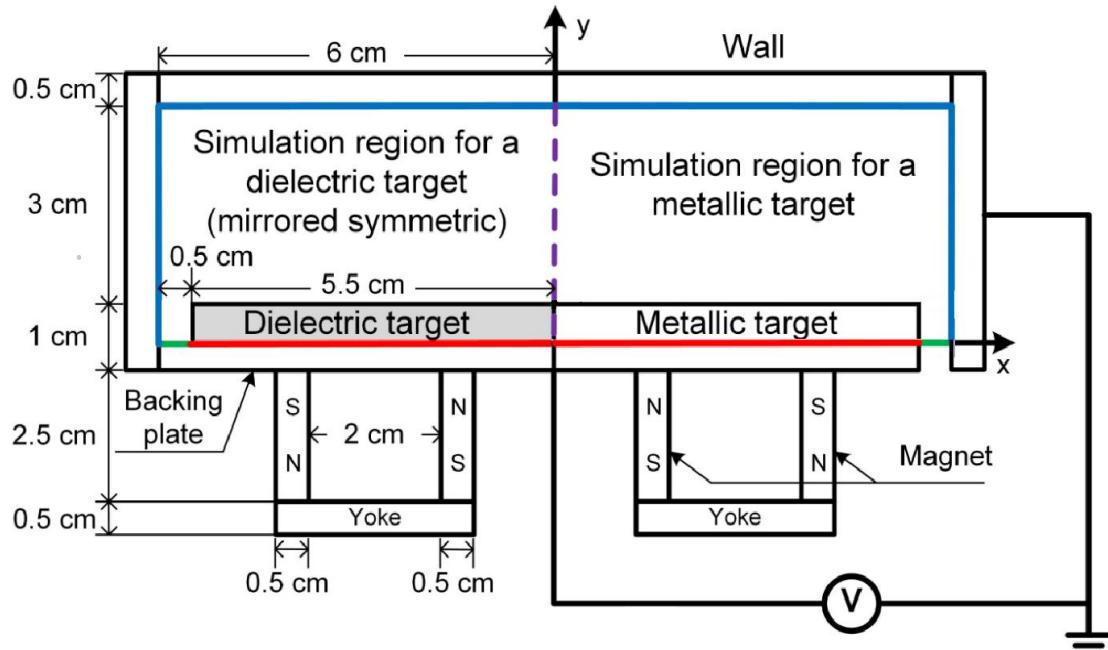


Magnetron discharges



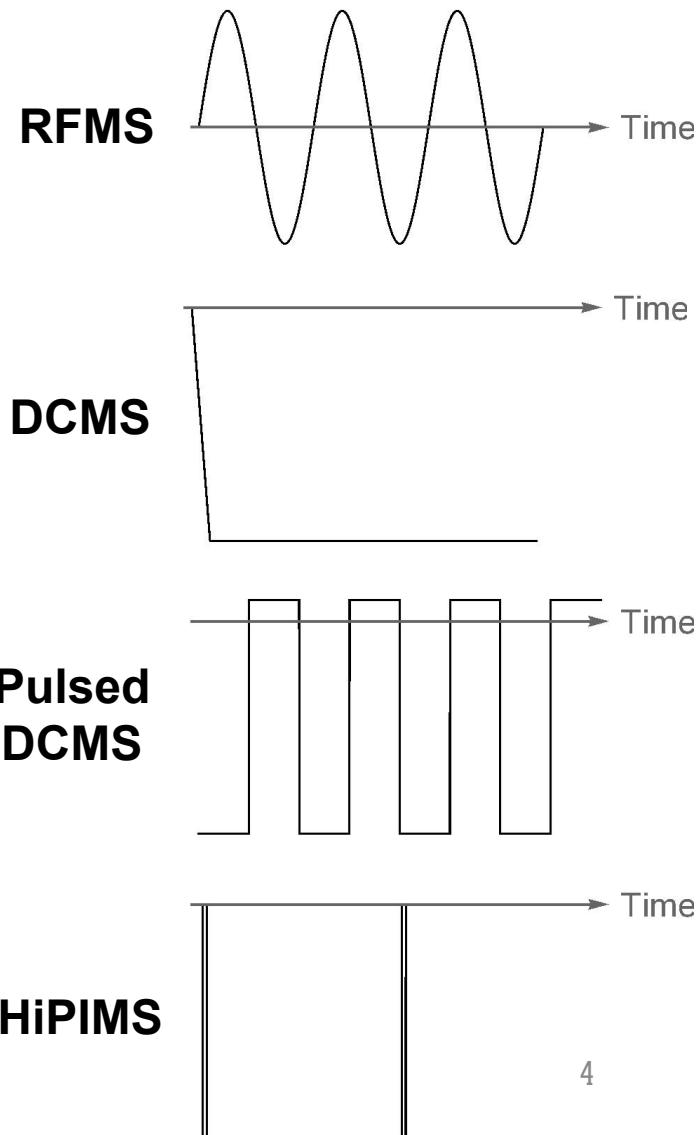
Magnetron sputtering discharges

Schematic of a magnetron sputtering set-up

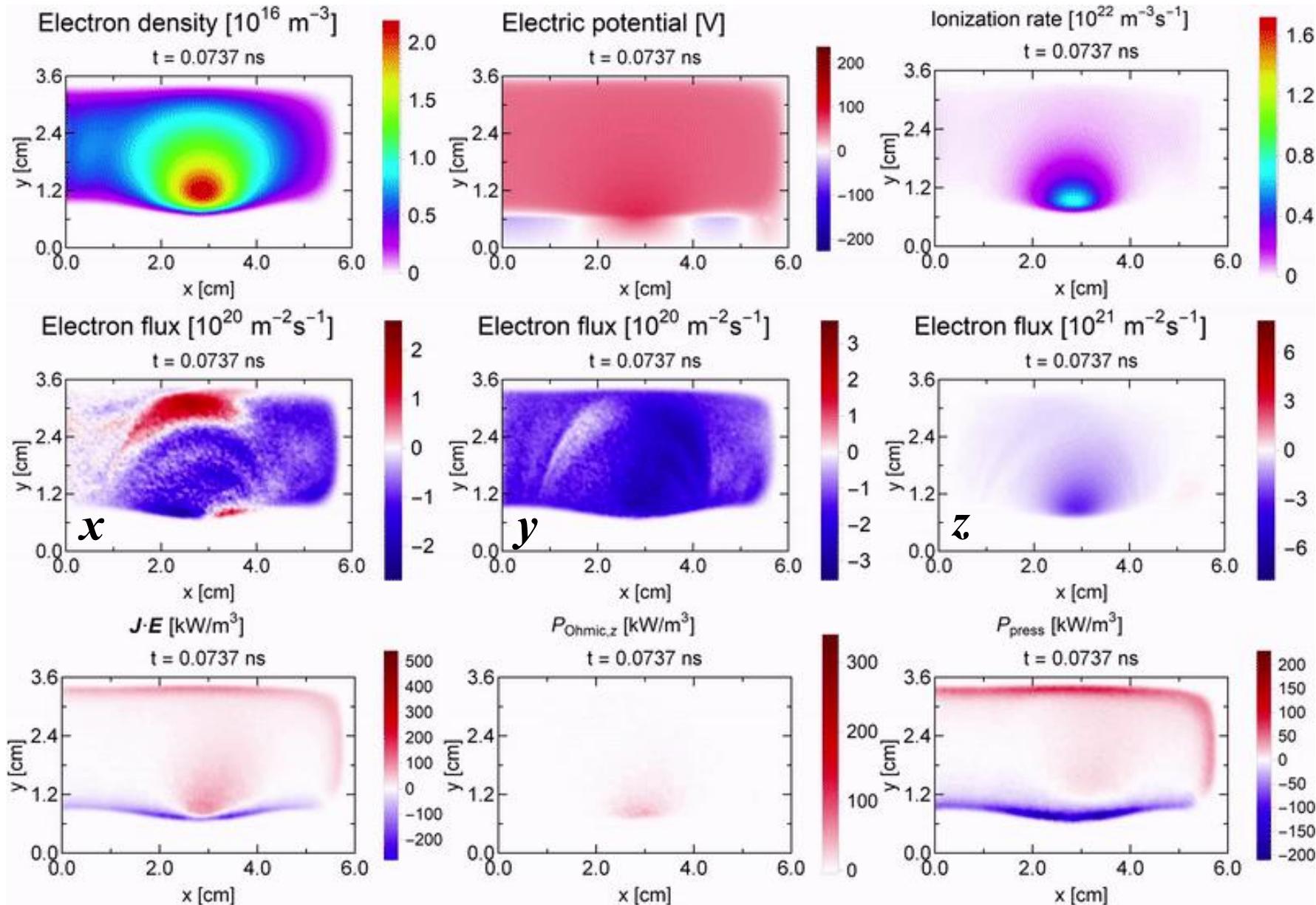


Magnetic field

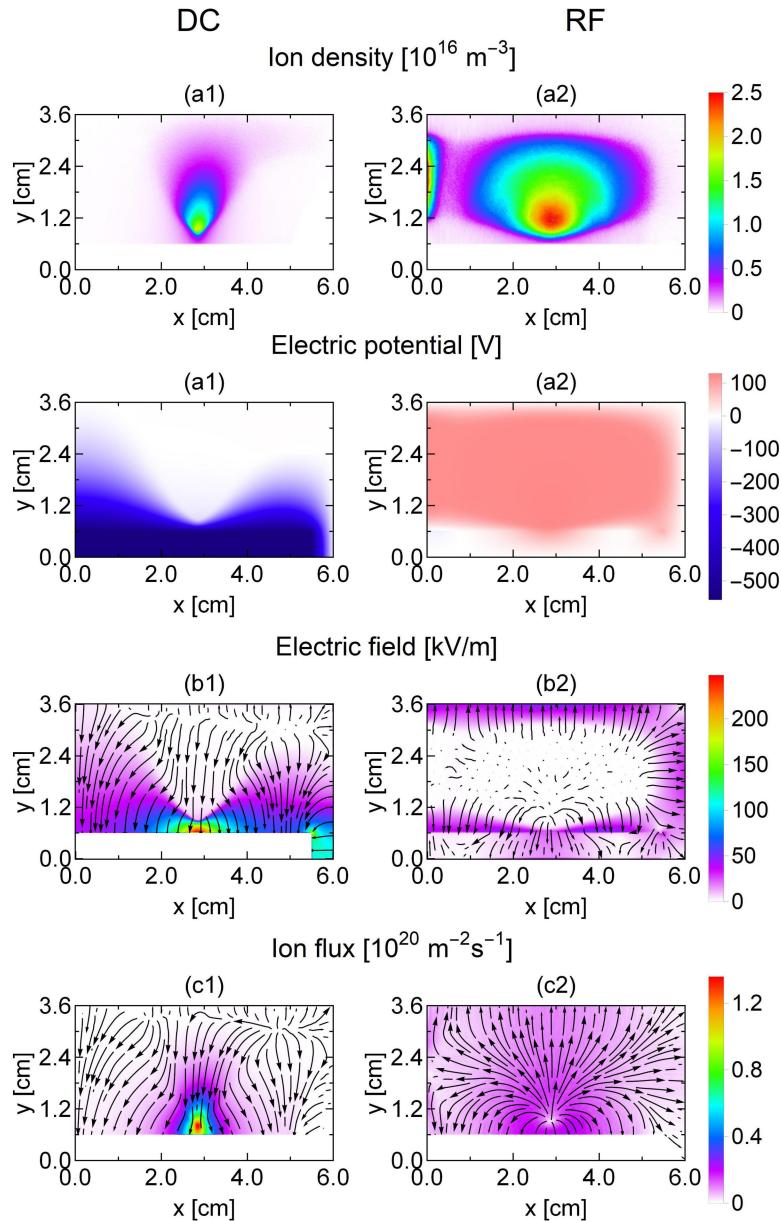
Voltage waveforms



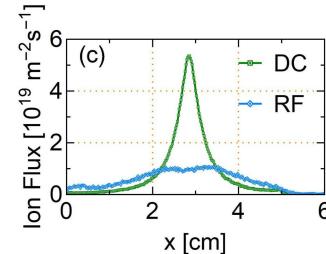
Electron dynamics in RFMS discharges



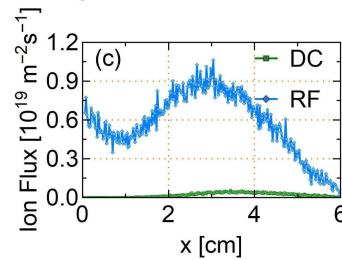
RFMS vs DCMS



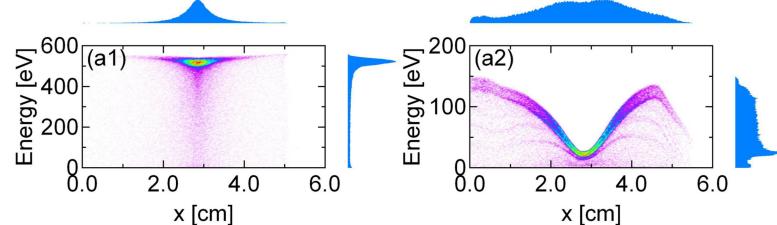
Ion flux along the surface of the target



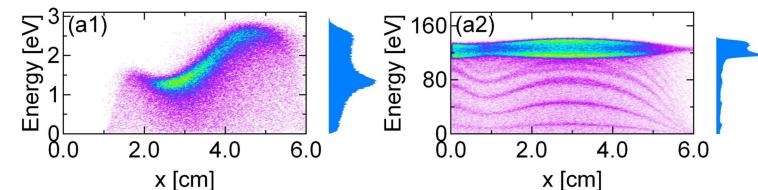
Ion flux along the surface of the substrate



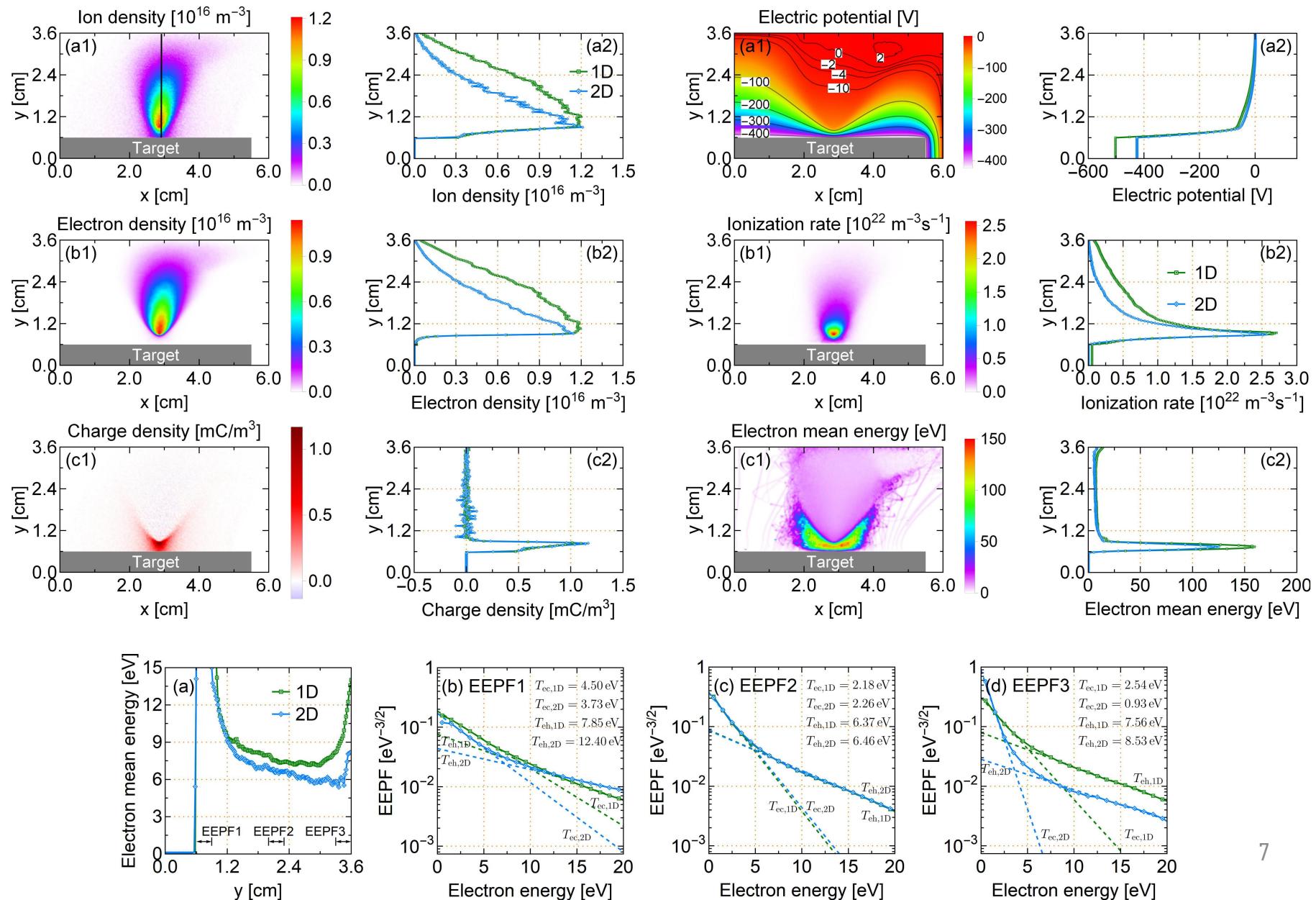
DC RF
IEDF along the surface of the target



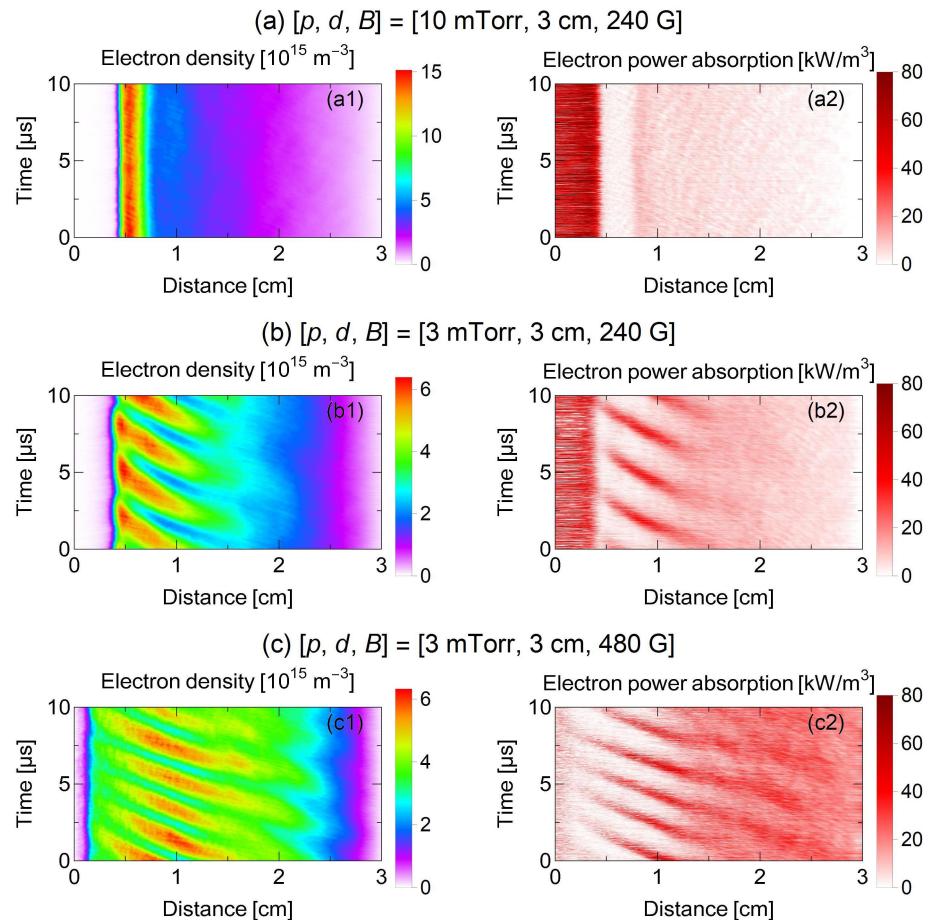
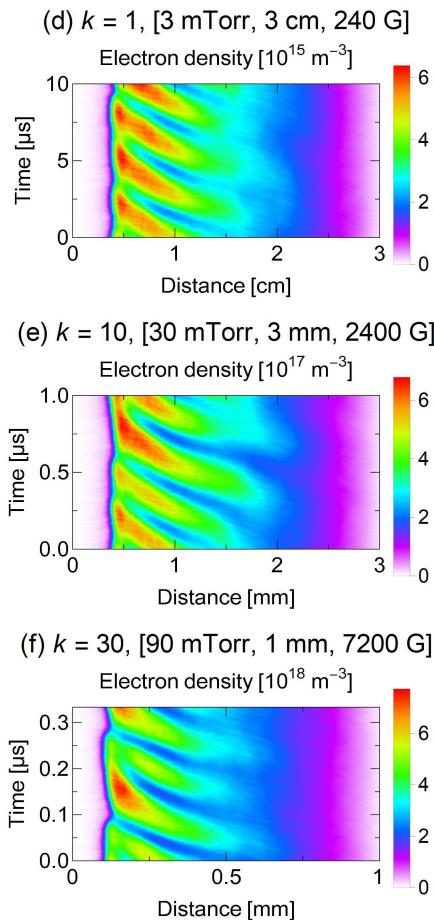
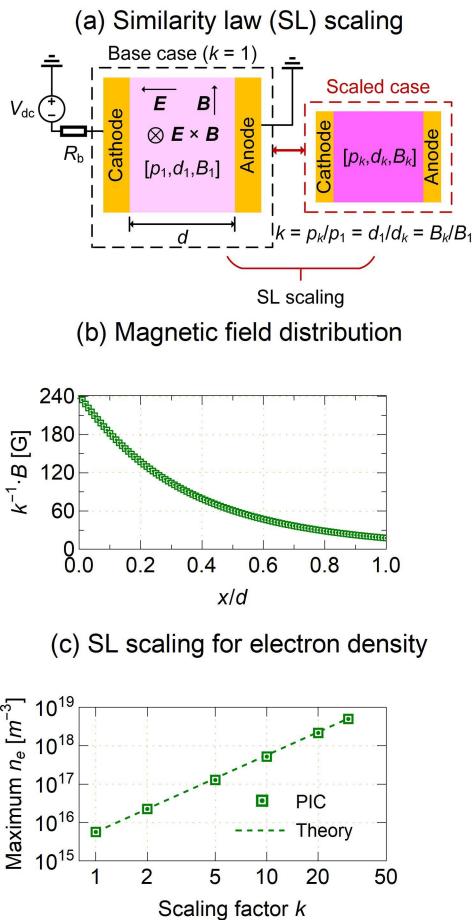
IEDF along the surface of the substrate



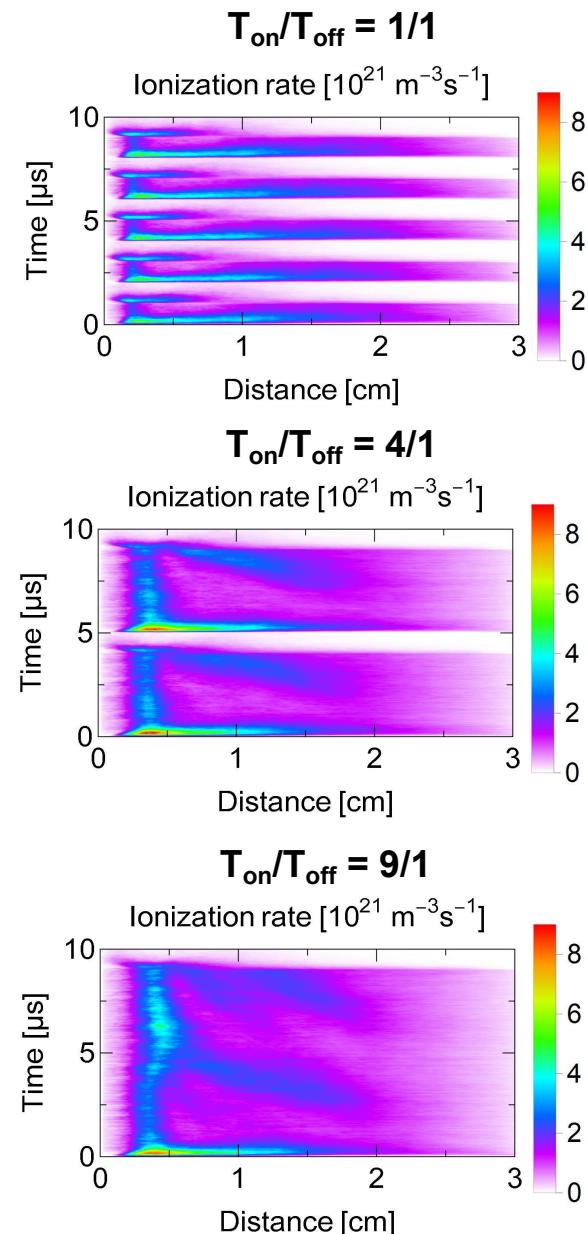
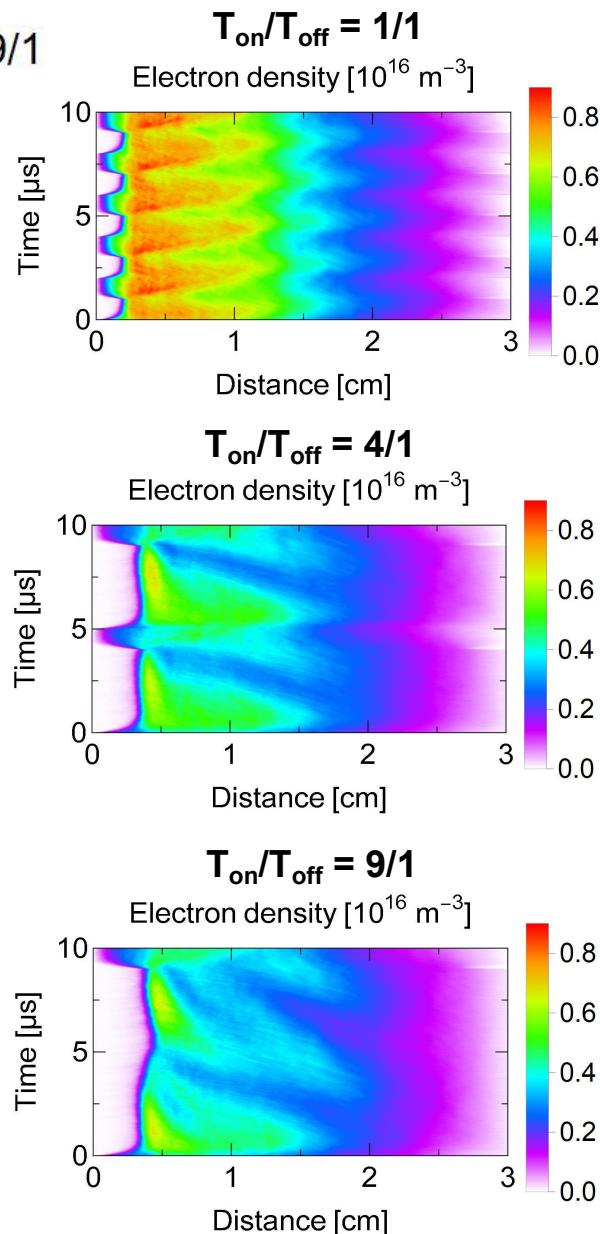
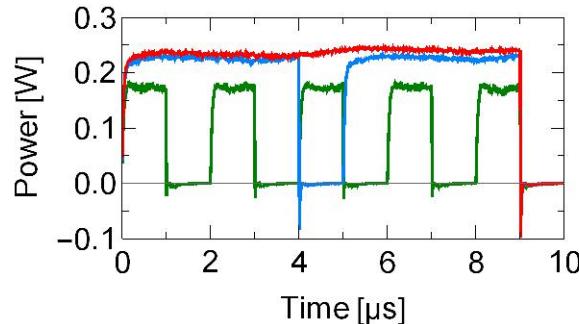
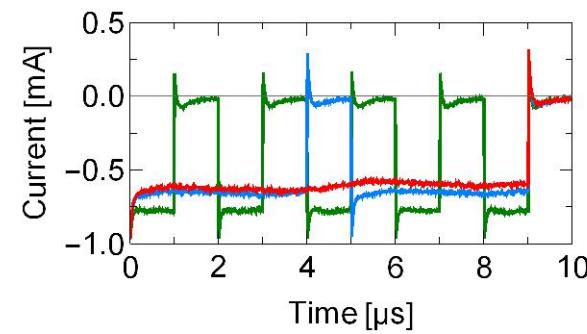
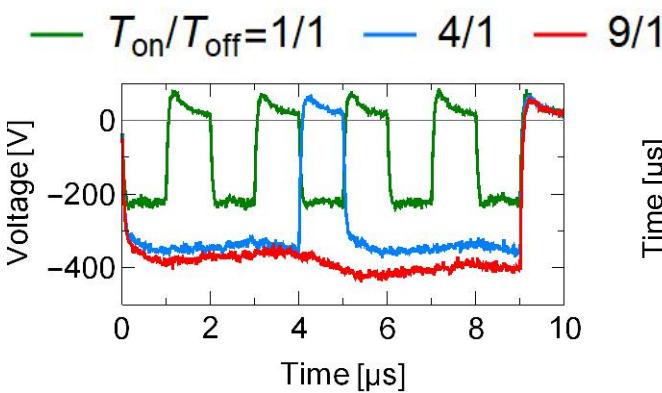
Simulation: 1D vs 2D



DCMS: breathing oscillations and electron energization



Pulsed DCMS



HiPIMS

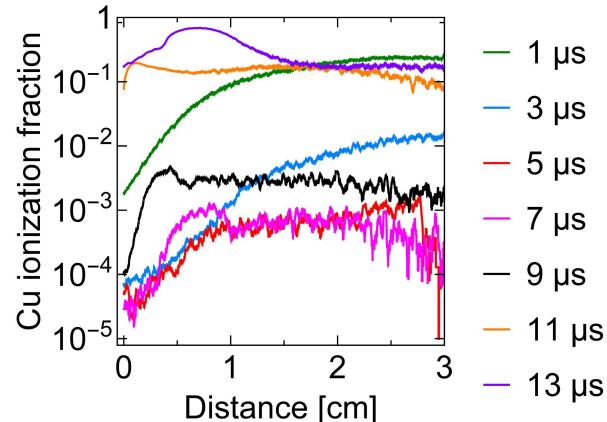
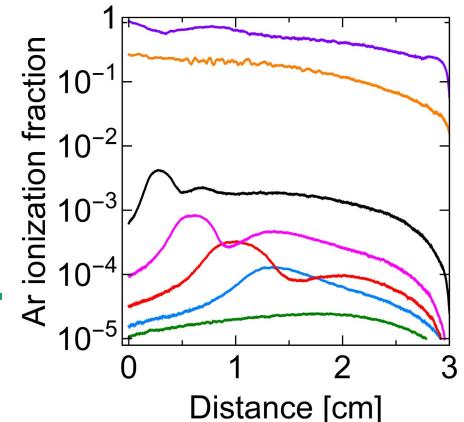
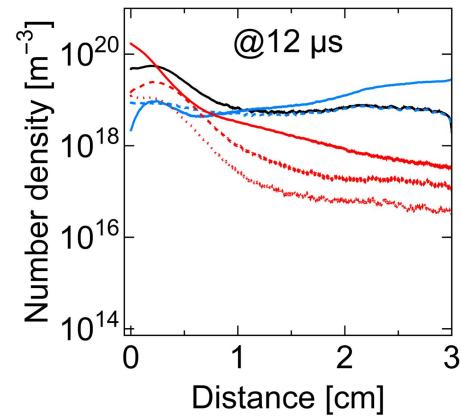
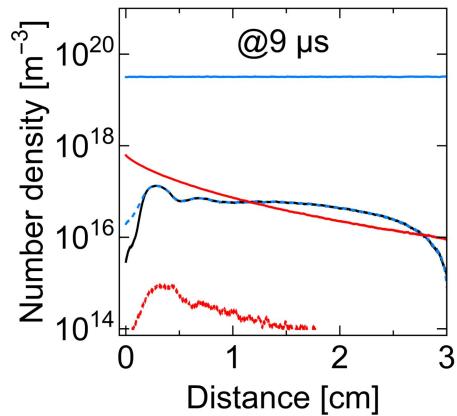
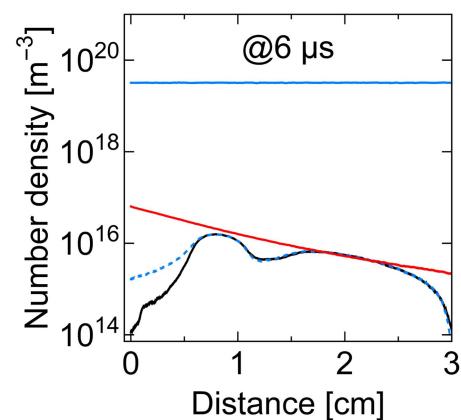
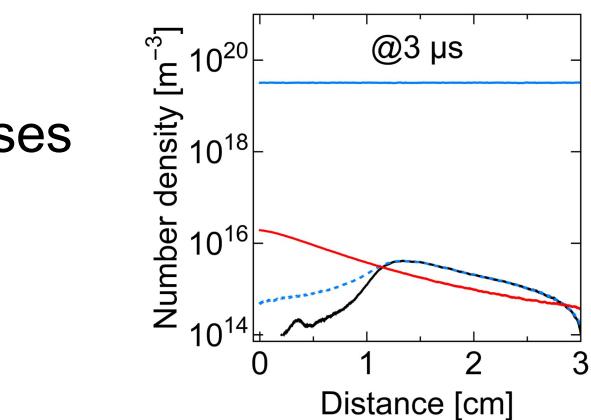
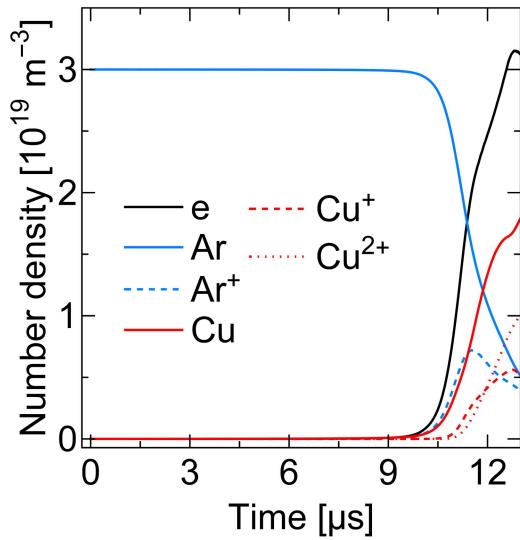
Additional physical processes

Coulomb collisions

Sputtering wind

Metal ions

SEE induced by metal ions



Thank you

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