

One-dimensional PIC/MCC simulation of HiPIMS discharges

Bocong Zheng¹, Yangyang Fu², Keliang Wang¹,
Thomas Schuelke^{1,3}, and Qi Hua Fan^{1,3}

¹ Fraunhofer USA Center Midwest, Michigan State University,
East Lansing, Michigan 48824, USA

² Department of Electrical Engineering, Tsinghua University,
Beijing, 10084, China

³ Department of Electrical and Computer Engineering, Michigan State University,
East Lansing, Michigan 48824, USA
Email: bzheng@fraunhofer.org

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Outline

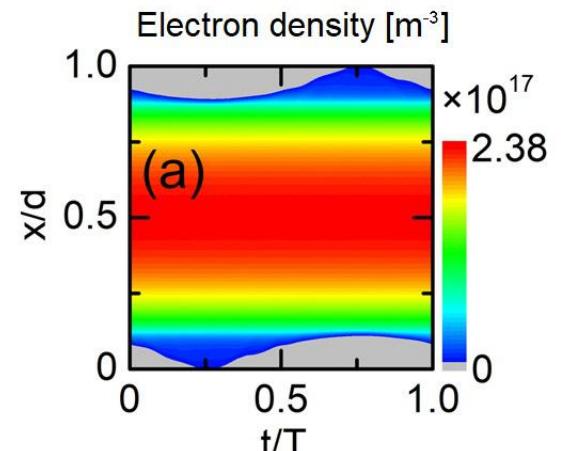
- Particle-In-Cell/Monte Carlo Collision (PIC/MCC)
- Particle simulation of magnetron discharges: 1D vs 2D
- HiPIMS discharge characteristics
 - Discharge characteristics
 - Electron kinetics
 - Gas rarefaction

PIC/MCC simulation

- Advantages
 - Self-consistent
 - Complete

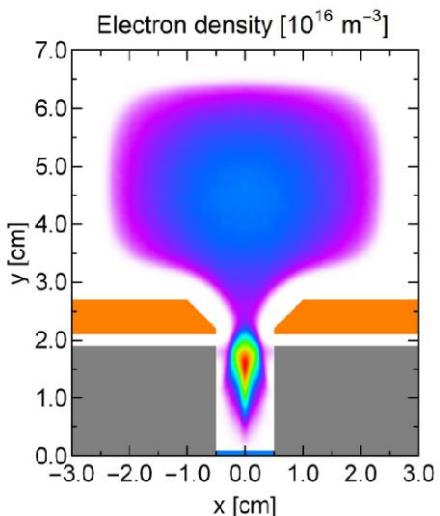
- Developed by *Bocong Zheng*
- **ASTRA**
 - Efficient PIC software
 - Applications in
 - Ion sources
 - Microplasmas
 - RF plasmas
 - Magnetized plasmas
 - etc.

CCP discharges



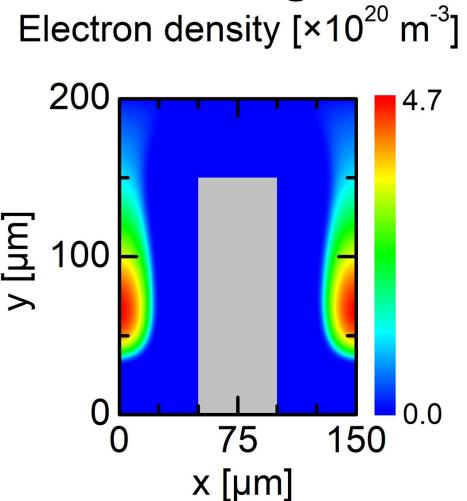
Y. Fu, B. Zheng et al., APL 117, 204101 (2020)

Ion sources



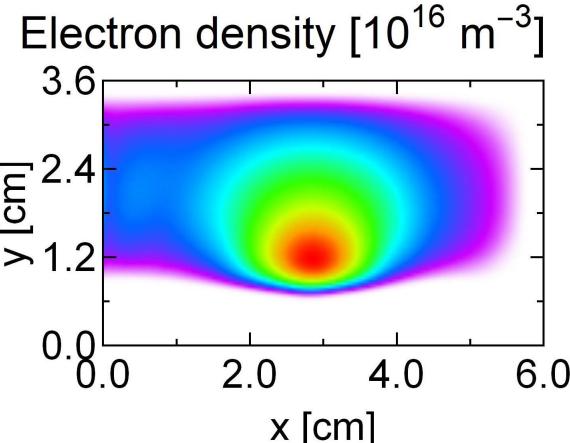
B. Zheng et al., In preparation

microhollow cathode discharges



Y. Fu, B. Zheng et al., JAP 129, 023302 (2021)

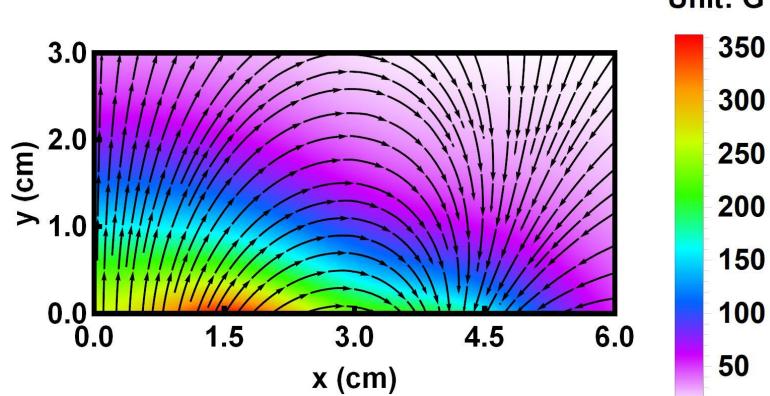
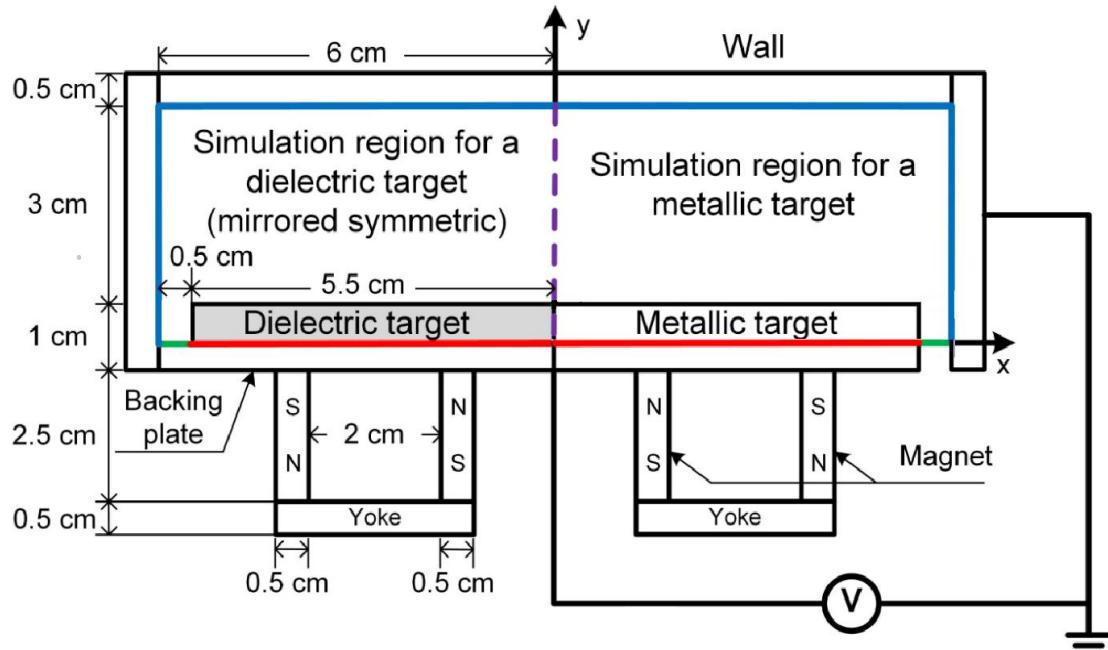
Magnetron discharges



*B. Zheng et al., PSST (2021)
doi:10.1088/1361-6595/abe9f9*

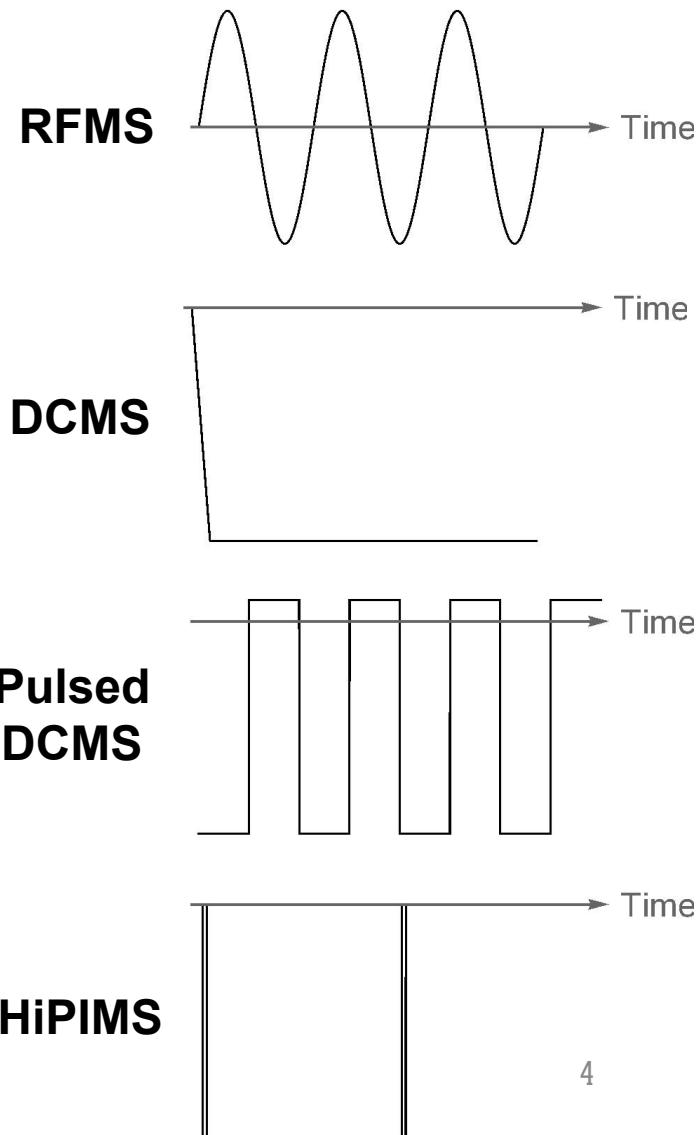
Magnetron sputtering discharges

Schematic of a magnetron sputtering set-up

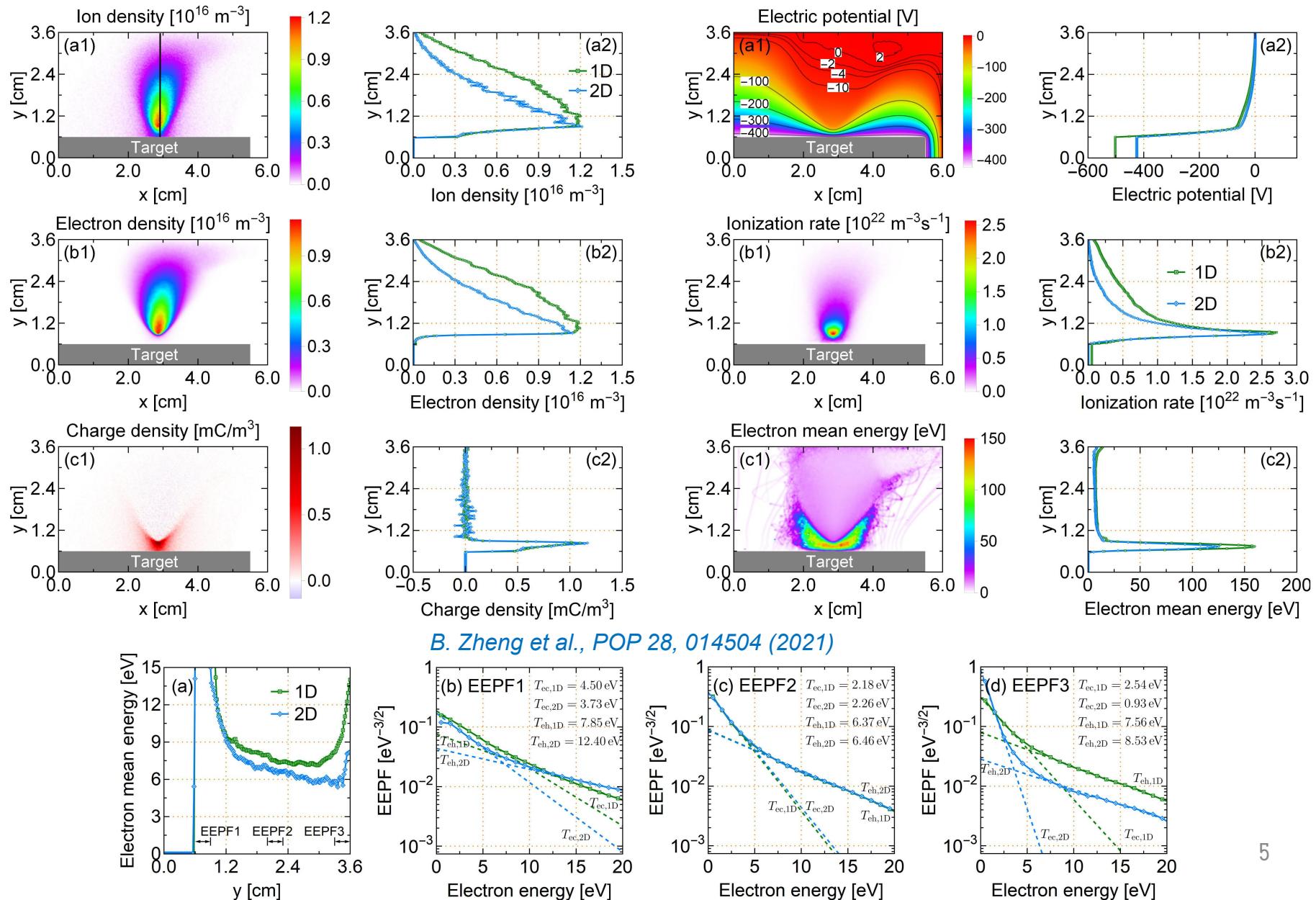


Magnetic field

Voltage waveforms

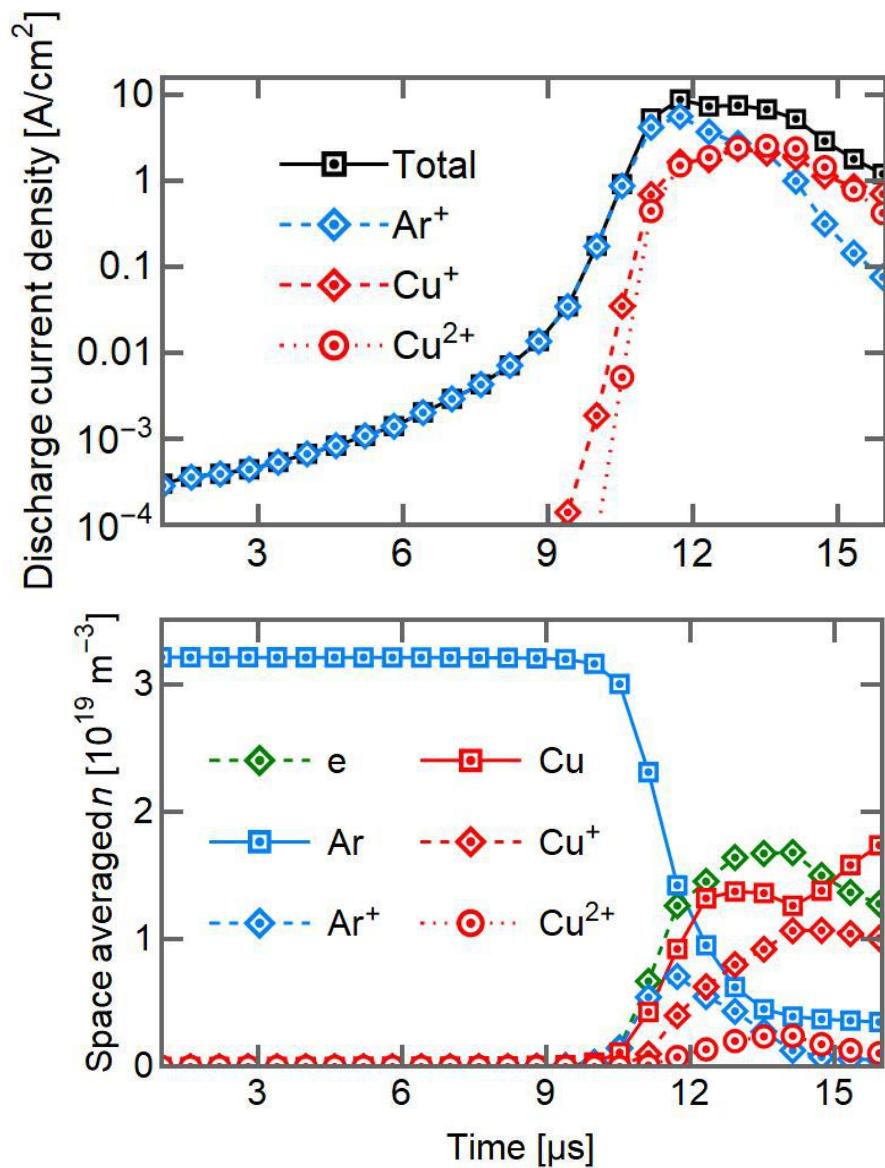


PIC simulation of DC magnetron discharges: 1D vs 2D

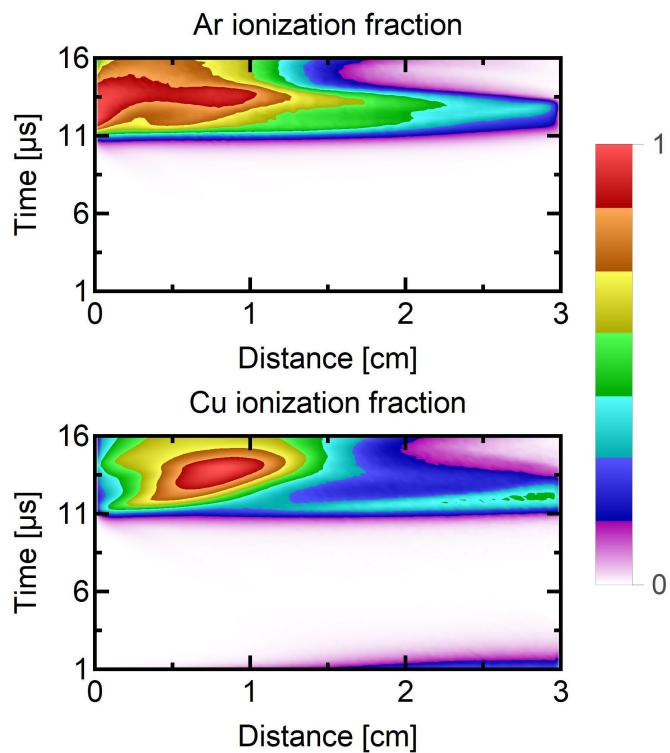
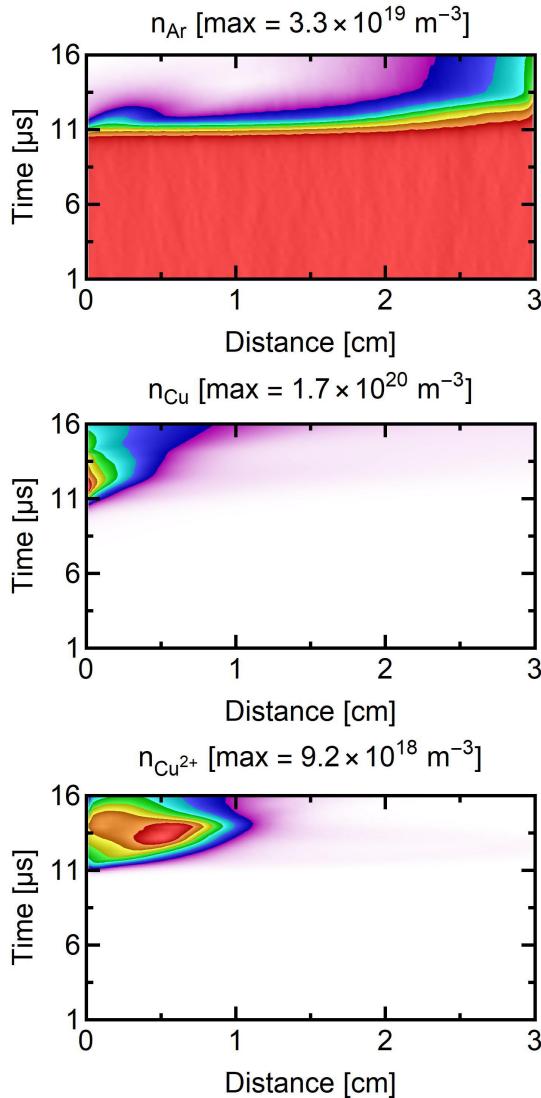
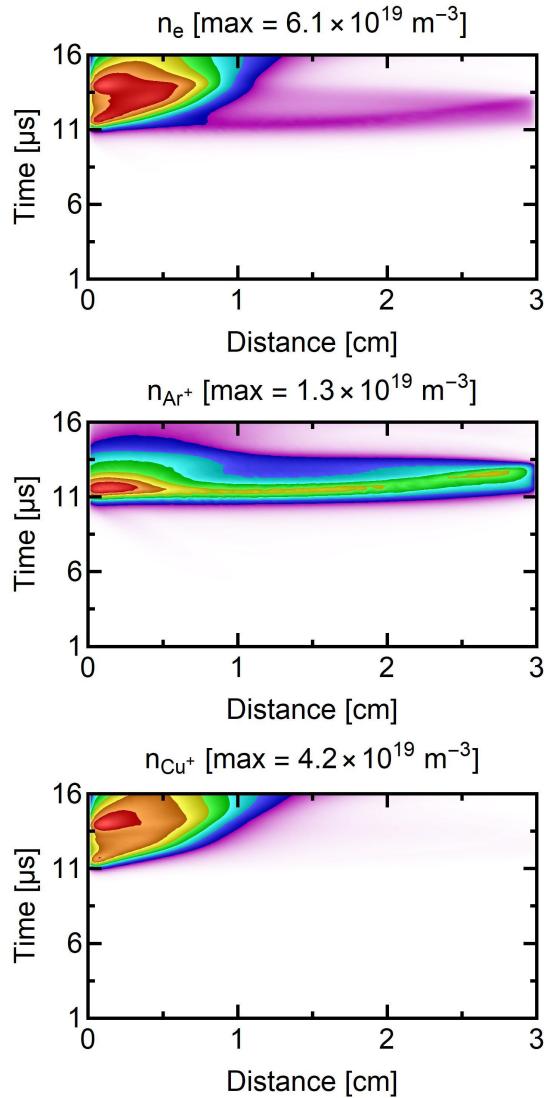


Discharge characteristics

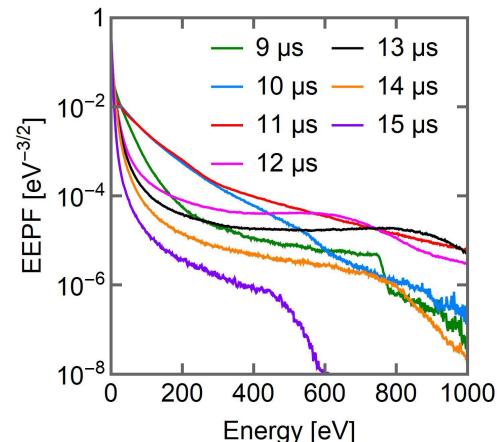
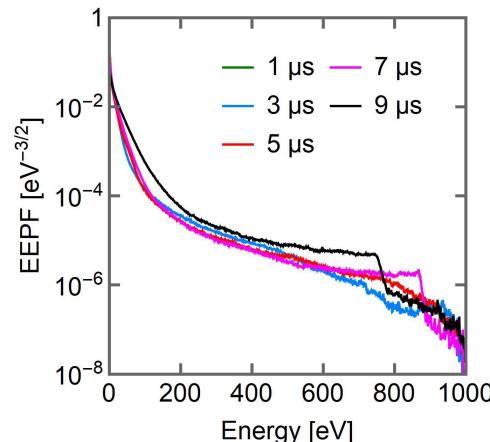
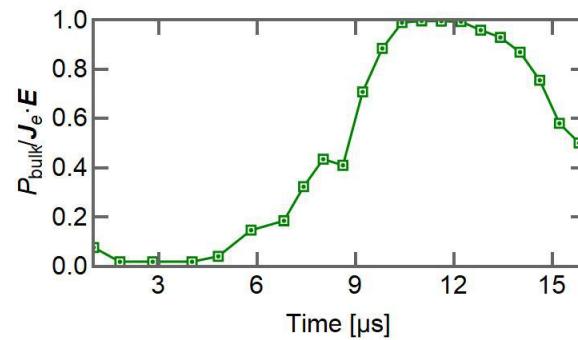
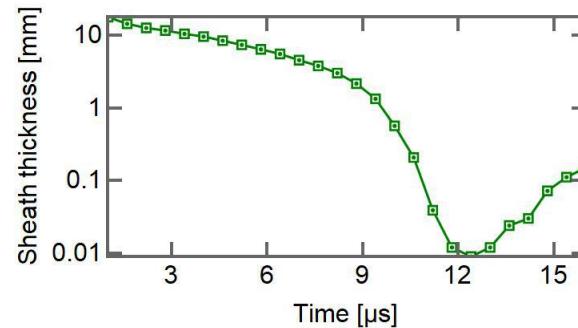
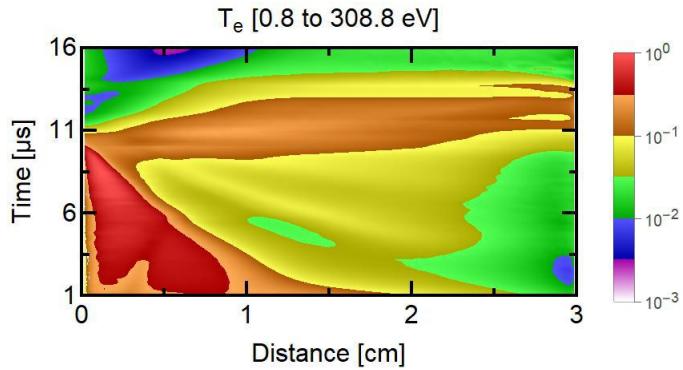
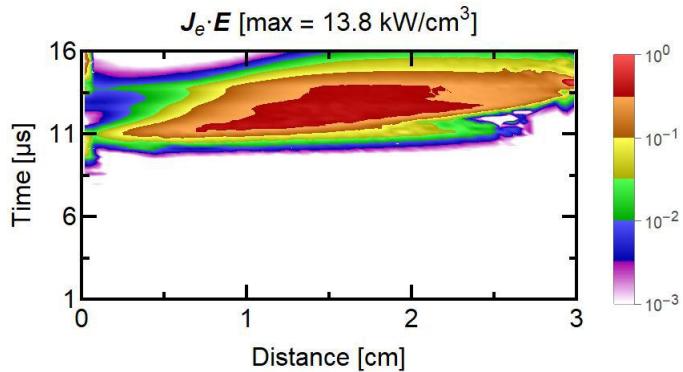
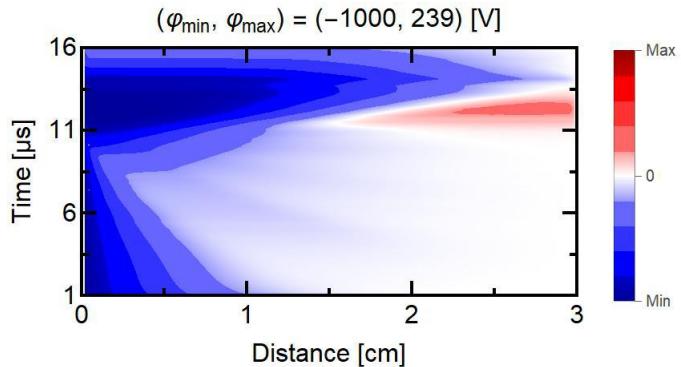
- Additional physical processes
 - Coulomb collisions
 - Sputtering wind
 - Metal ions
 - SEE induced by metal ions
- Discharge parameters
 - Voltage: -1 kV
 - Pressure: 1 mTorr
 - Gas: Ar
 - Target: Cu
 - Gap length: 3 cm



Spatiotemporal dynamics of species

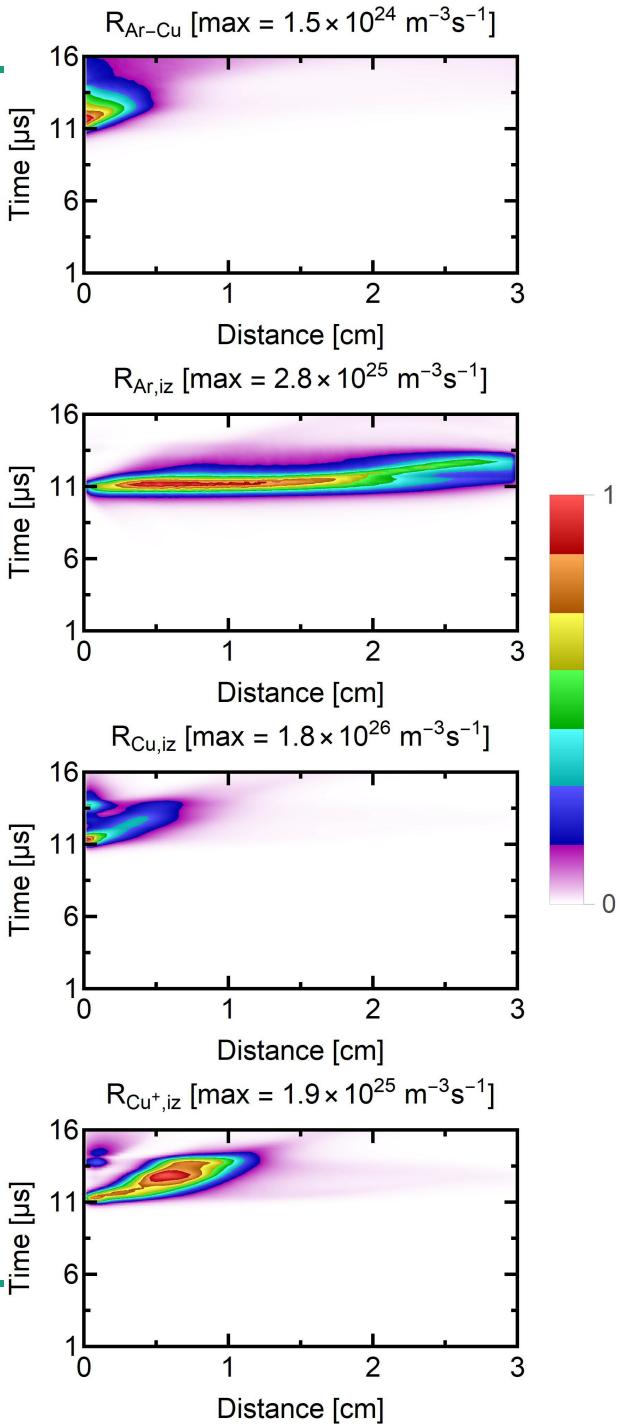
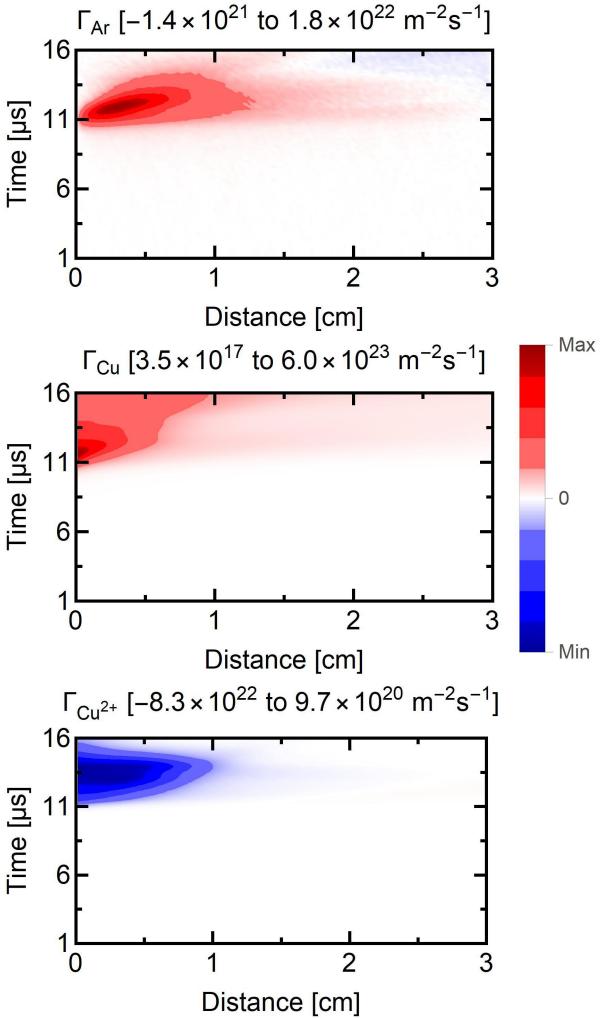
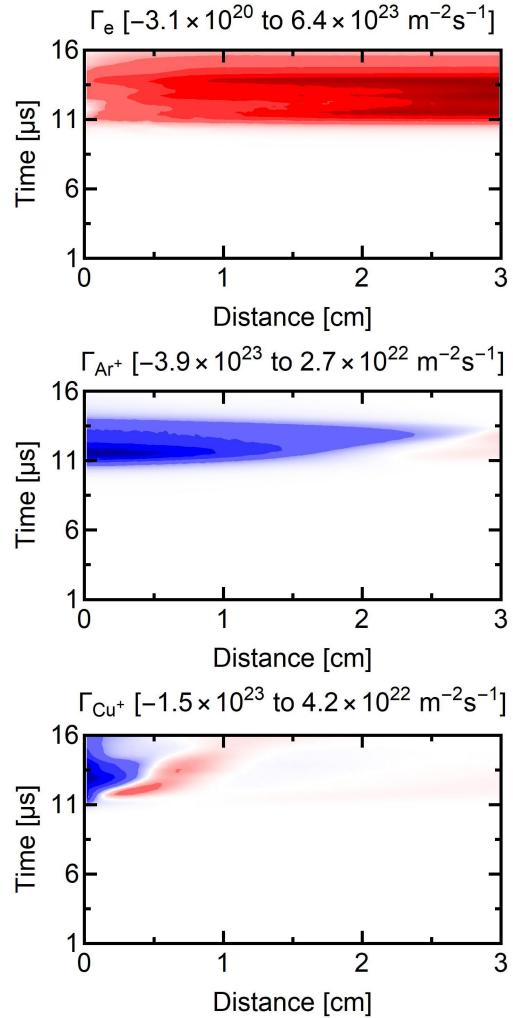


Electron kinetics



Gas rarefaction

Sputtering wind vs ionization



Thank you

- The slides can be downloaded at
bczheng.com/talks/zheng21_SVC.pdf
- Emails: bzheng@fraunhofer.org;
bcong.zheng@gmail.com
- Website: bczheng.com