Electron power absorption in radio-frequency magnetron discharges

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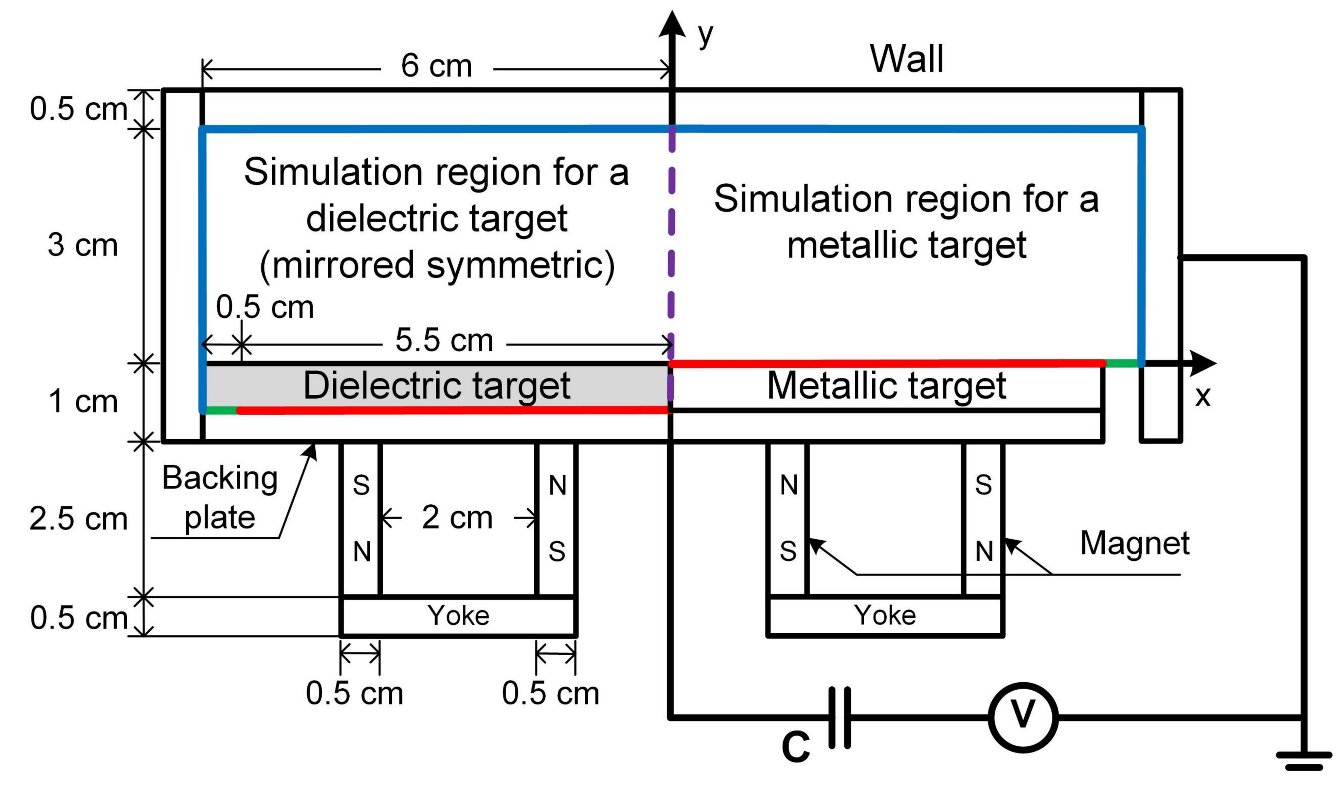
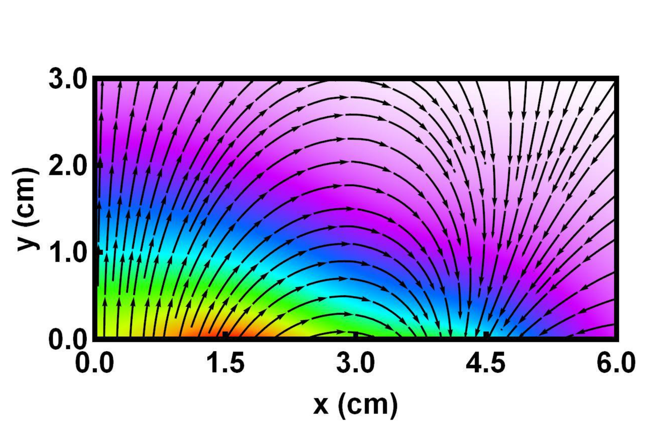
Introduction

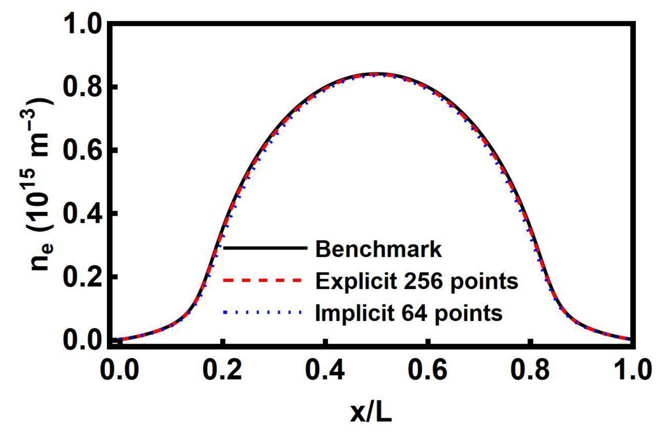
The electron heating mechanism in radio-frequency magnetron sputtering (RFMS) argon discharges is numerically investigated using a particle-in-cell (PIC) software ***ASTRA***. The code is highly flexible in allowing the user to perform 1d3v (one-dimensional in space and three-dimensional in velocity) or 2d3v (two-dimensional in space and three-dimensional in velocity) simulations, with explicit or implicit algorithm and momentum or energy conservation scheme.



Schematic of a planar RF magnetron sputtering set-up



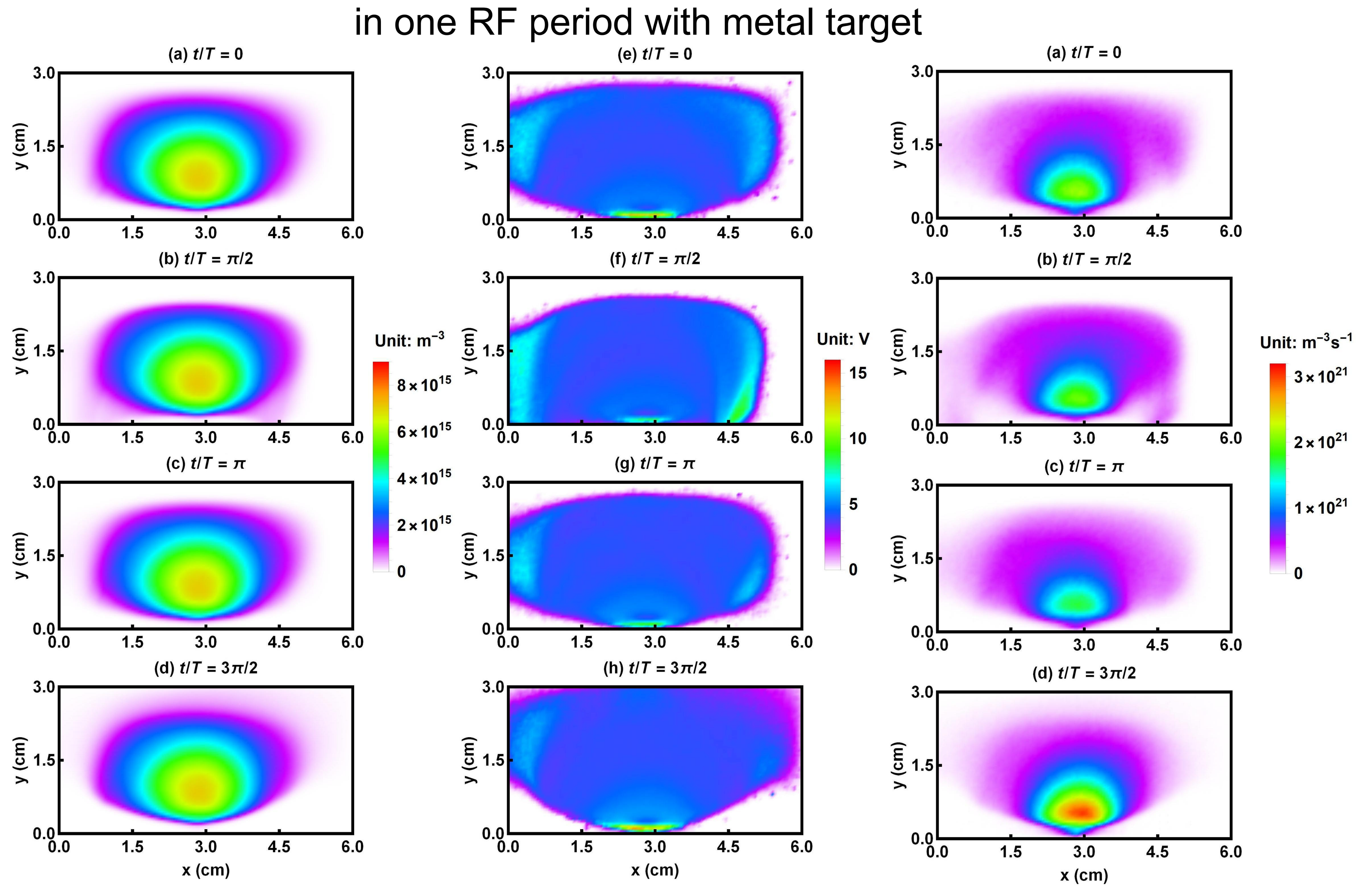
Magnetic field flux in the simulation region

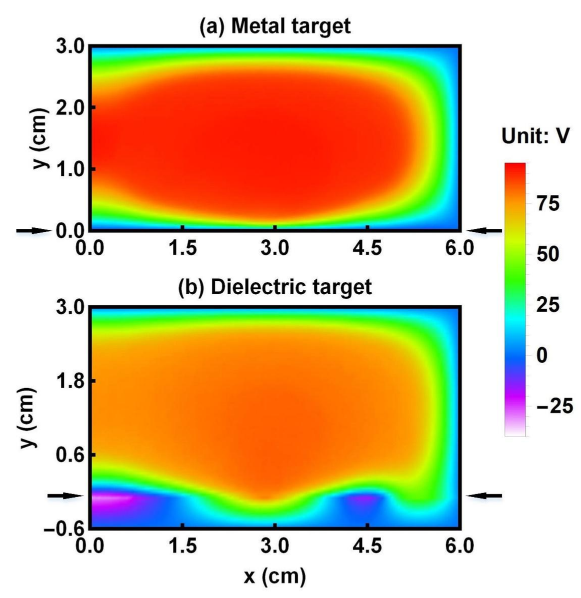


Comparison of the present PIC code with the benchmark solutions from Turner, et al., Physics of Plasmas, 20(1), 013507 (2013).

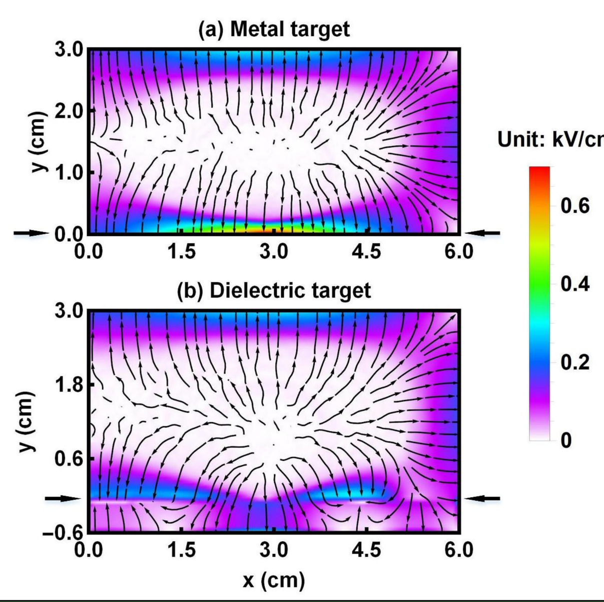
RFMS discharges with metal and dielectric targets

Electron densities, electron temperatures and ionization rates in one RF period with metal target



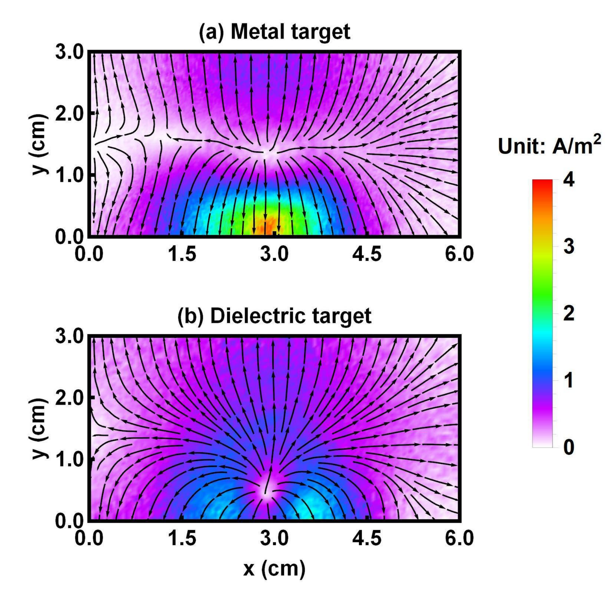


Time-averaged electric potentials

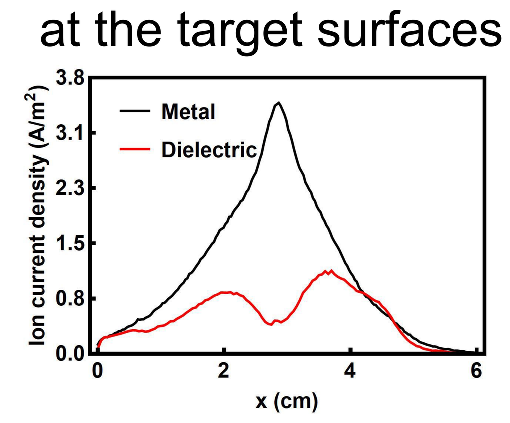


Time-averaged electric fields

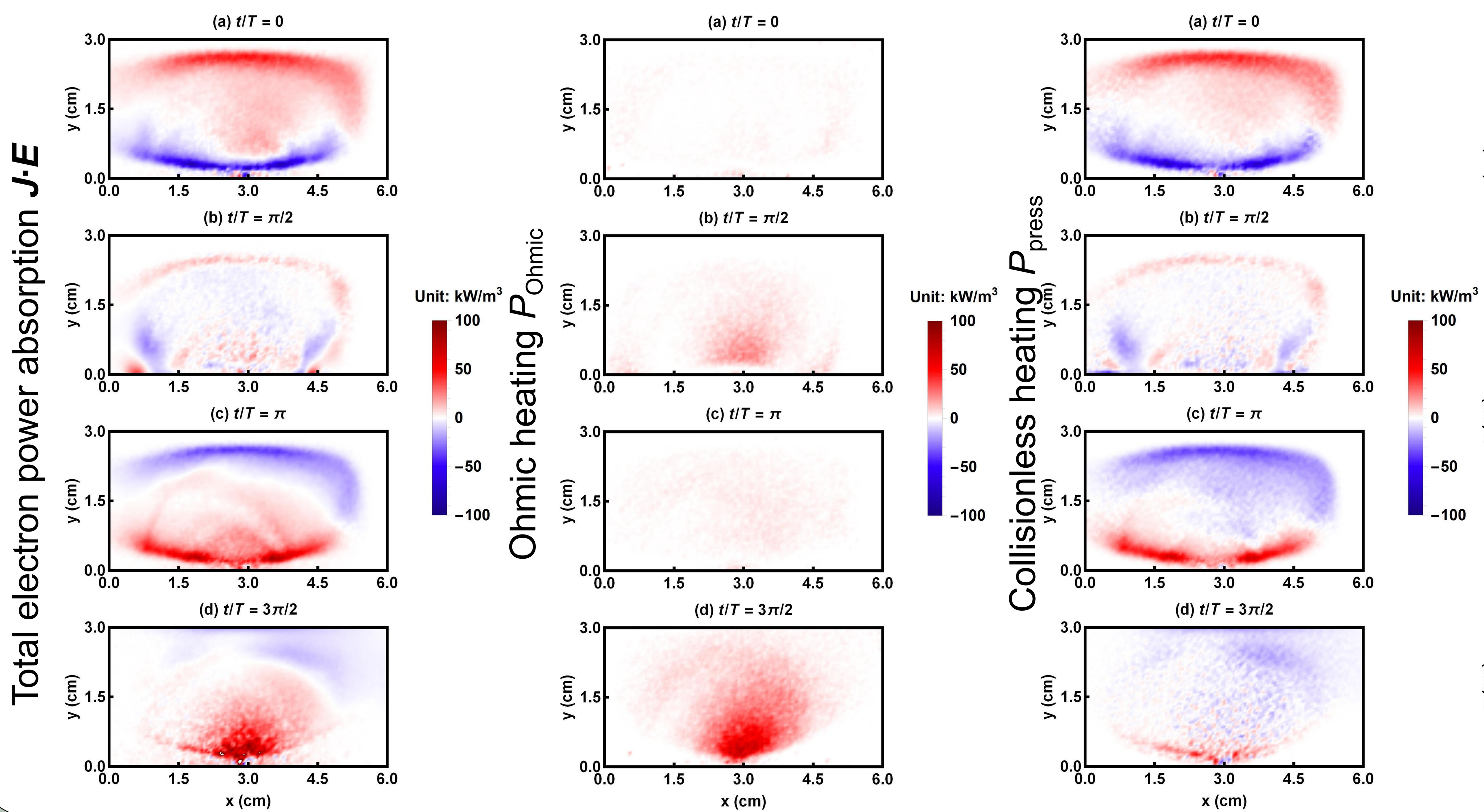
Time-averaged ion current densities



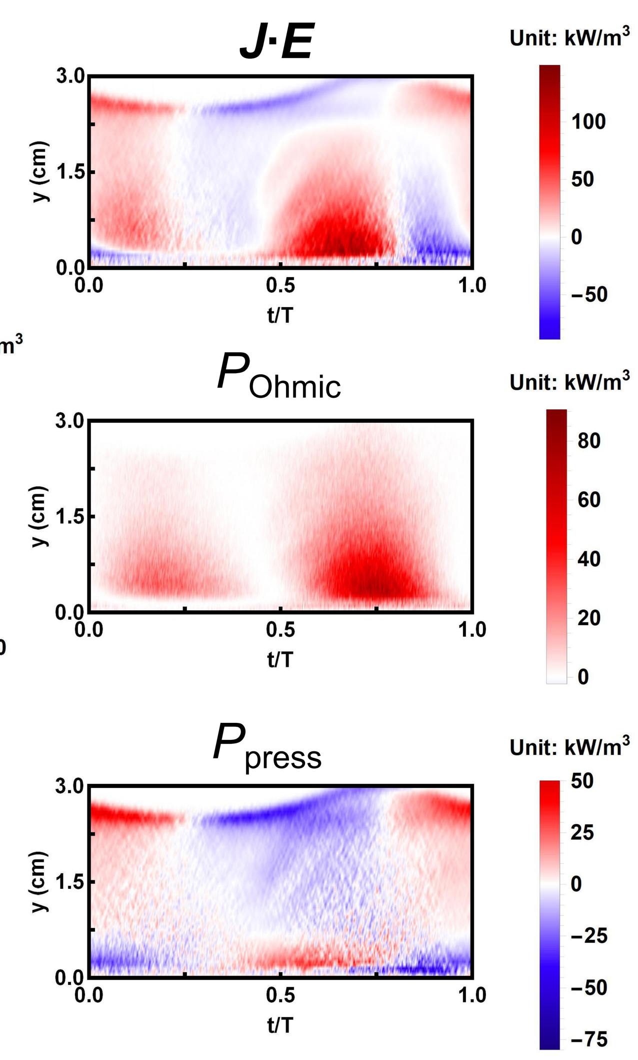
Ion current densities at the target surfaces



Electron power absorption

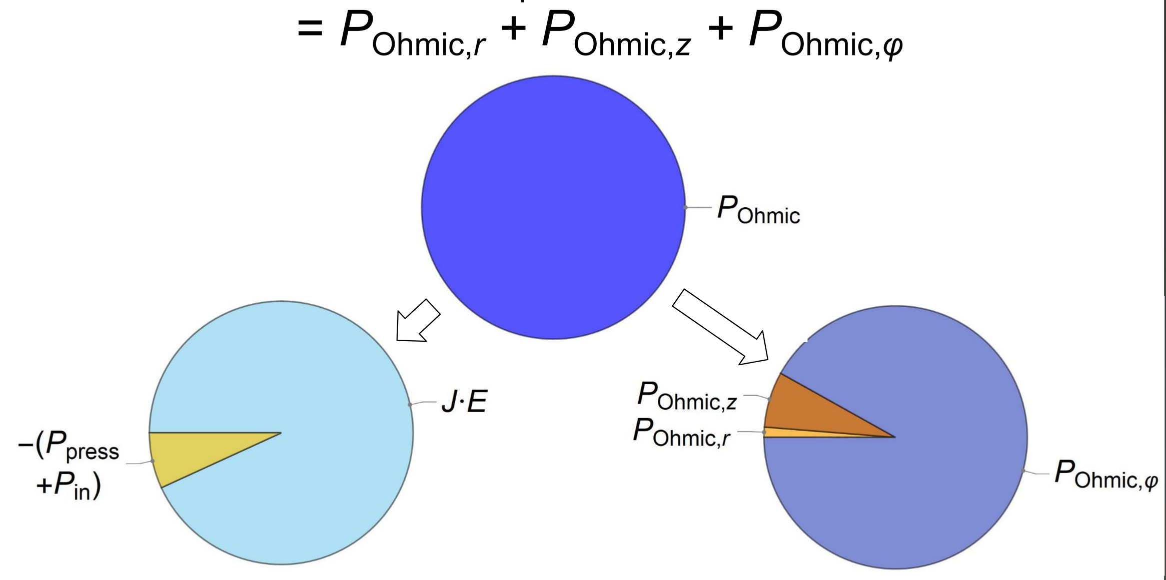


Spatiotemporal distribution of electron power deposition at x = 3 cm

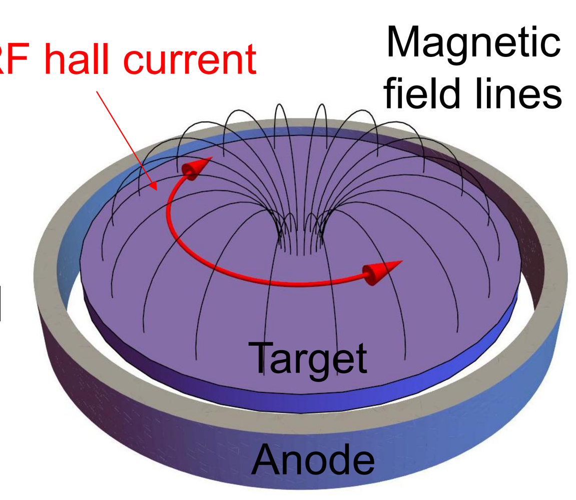


$$P_{abs} = \boldsymbol{J}\cdot\boldsymbol{E} = P_{Ohmic} + P_{press} + P_{in}$$

$$P_{Ohmic} = \boldsymbol{J}\cdot\boldsymbol{E} - (P_{press} + P_{in}) = P_{Ohmic,r} + P_{Ohmic,z} + P_{Ohmic,\varphi}$$



The primary heating component in RFMS discharges is the Ohmic heating induced by the RF Hall current in the $E \times B$ direction!



Conclusions

- An abnormal erosion profile in RFMS discharges with a dielectric target is predicted;
- The spatiotemporal variations of electron power deposition in RFMS discharges are investigated in detail;
- The Ohmic heating induced by the RF Hall current in the $E \times B$ direction is identified as the primary heating component in RFMS discharges.

Acknowledgement

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WHERE DISCOVERIES BEGIN

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