

Nuclear Reactor-Induced Microplasmas in Porous Metals: New Energy Frontiers

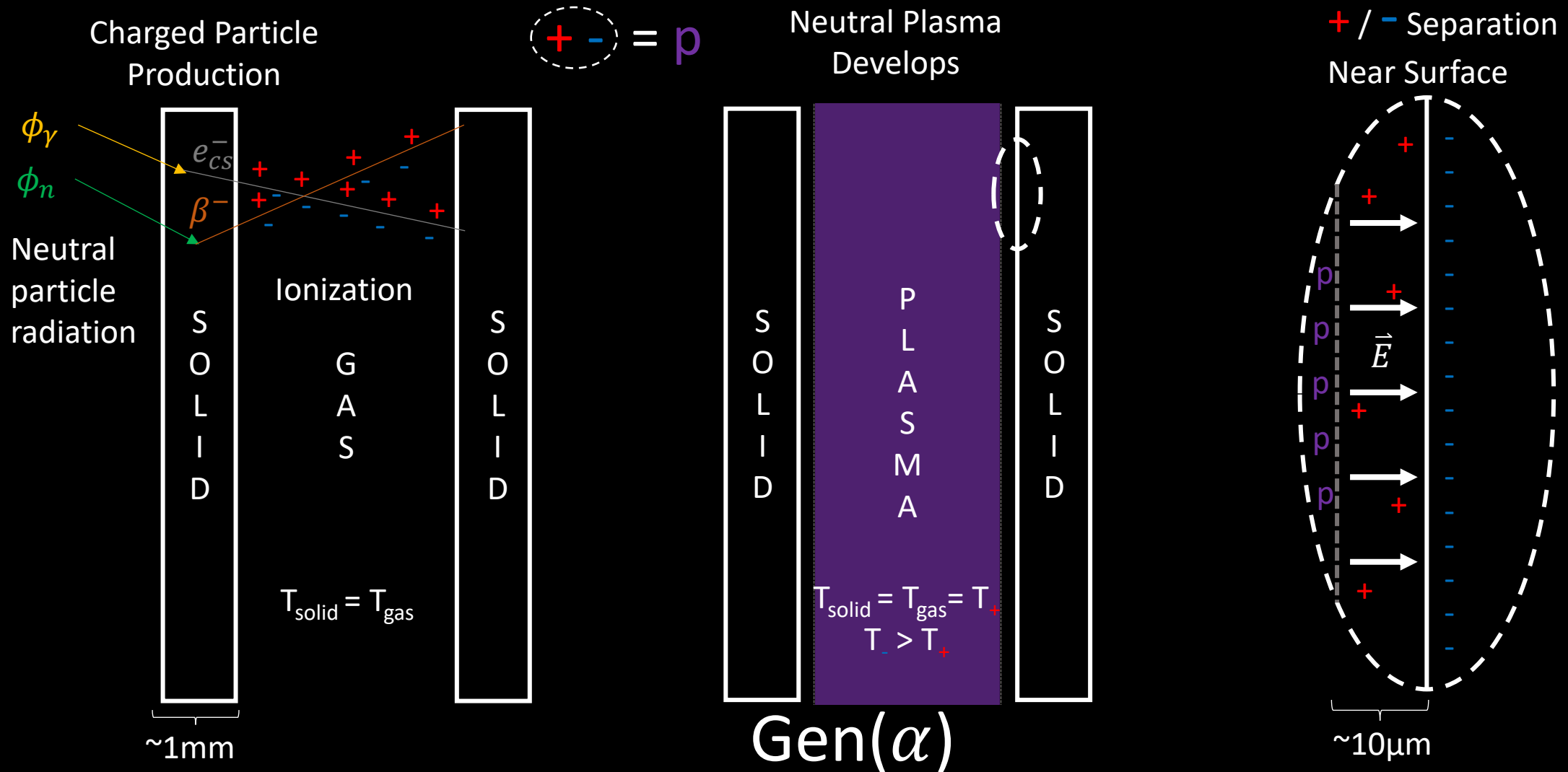
Austin Lo, PhD

Chief Research Officer

GenAlpha Nuclear Technologies LLC

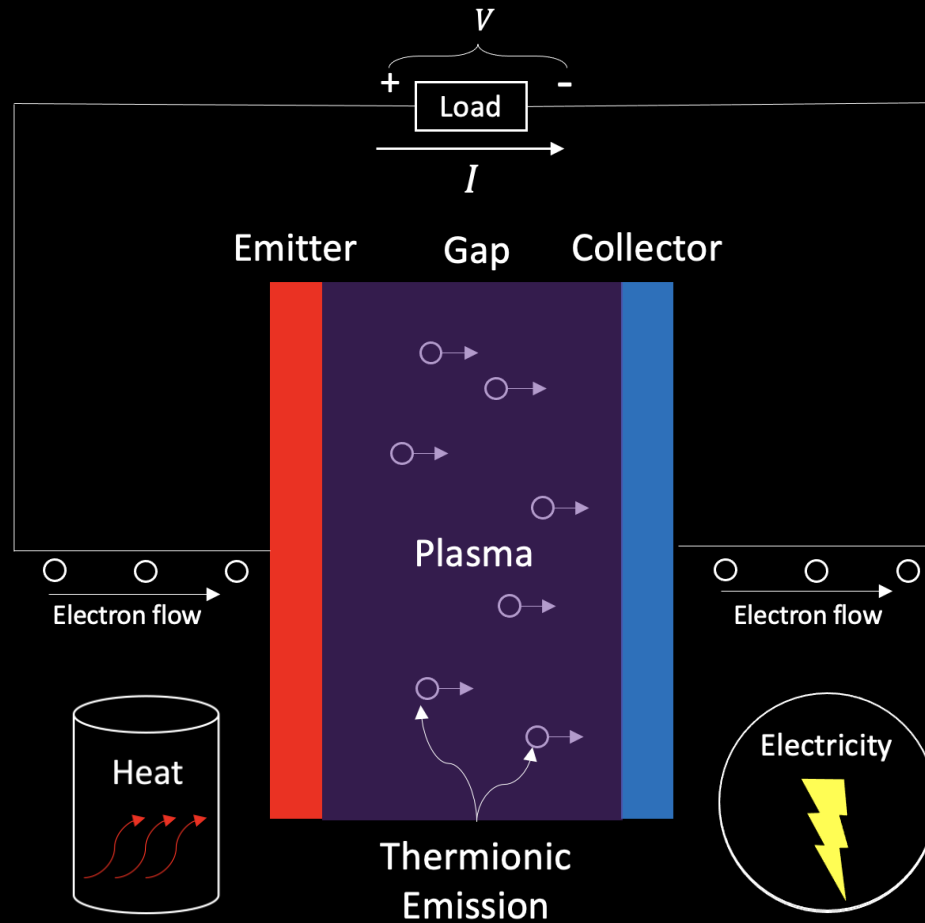
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Nuclear Low-Temperature Plasma Basics



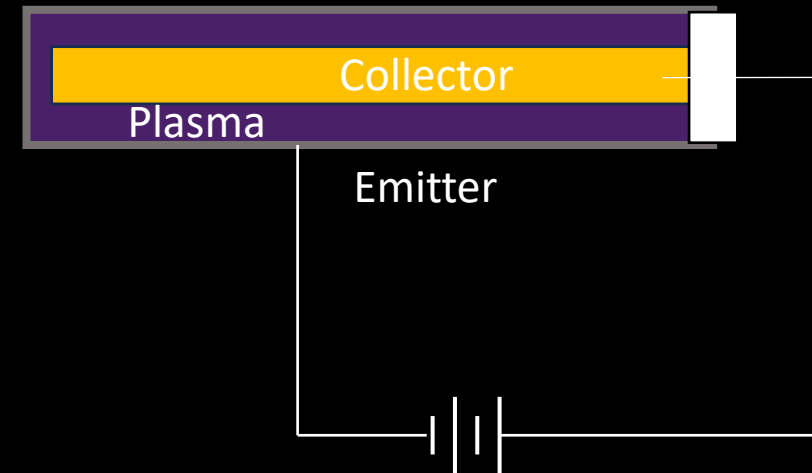
Applications

Thermionic Energy Conversion

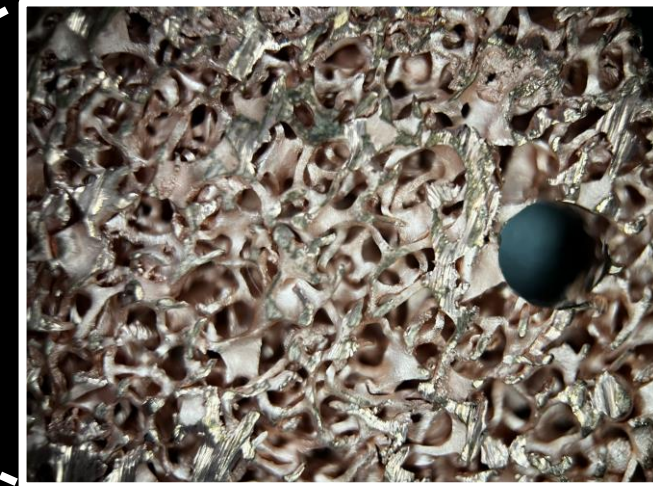
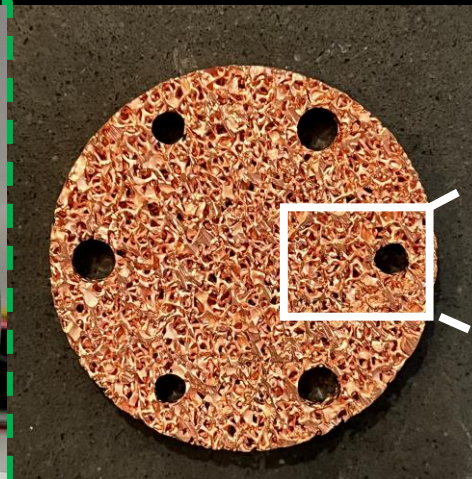
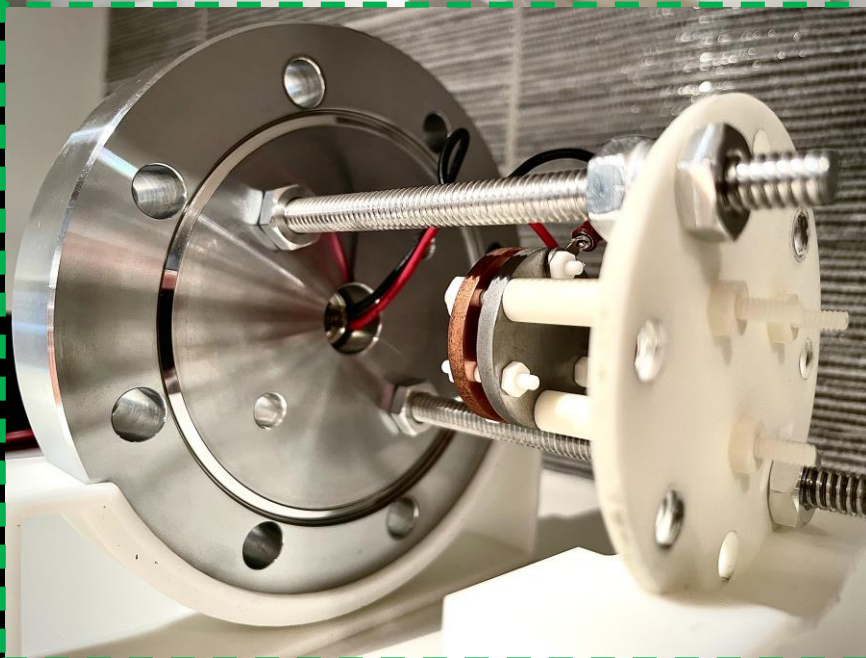
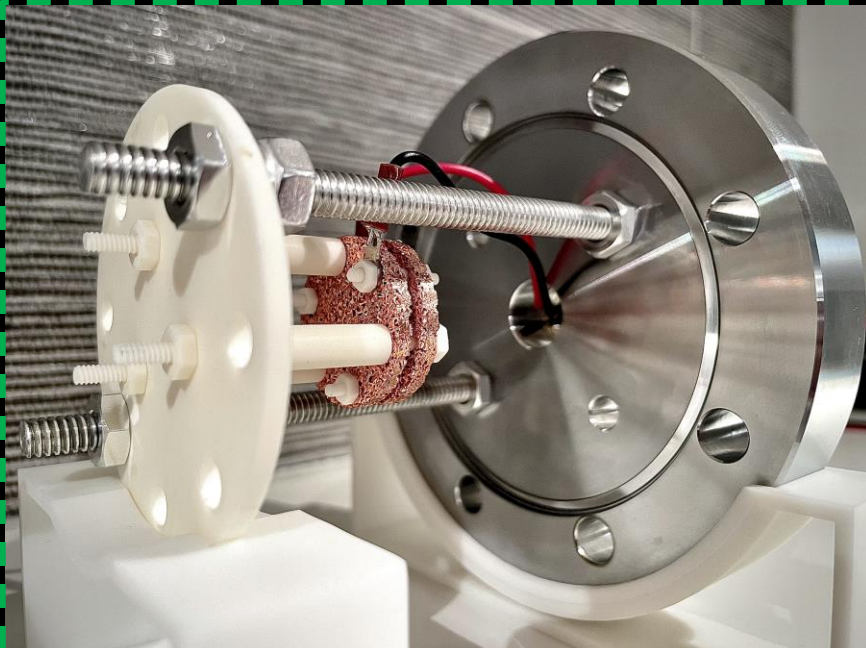


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In-core reactor instrumentation (ionization chambers)



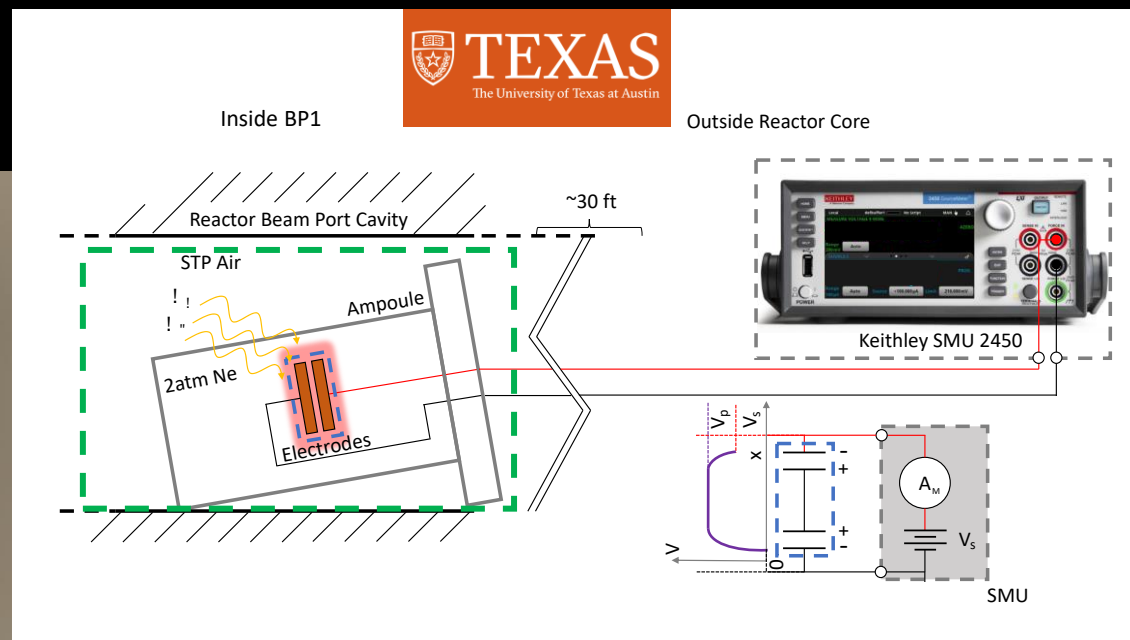
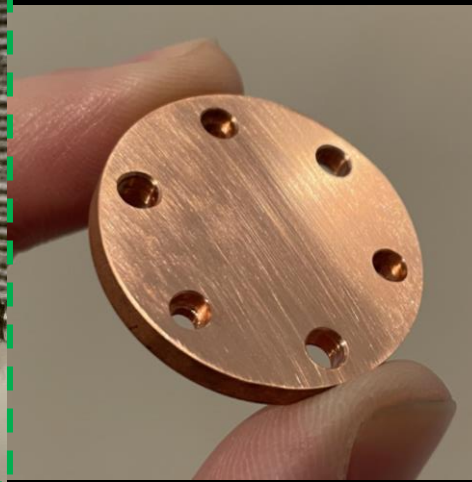
Others?



1mm

I-V curves for:

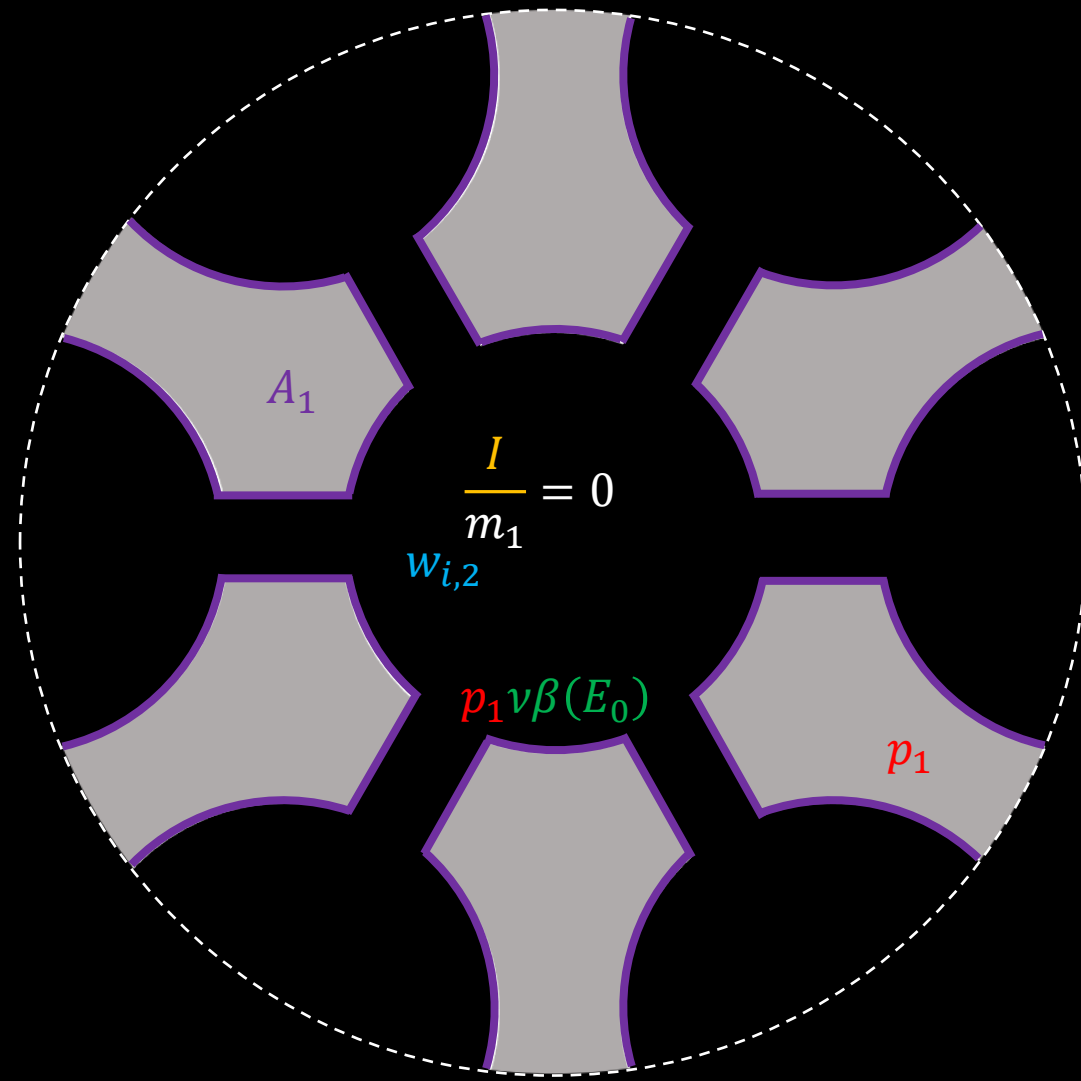
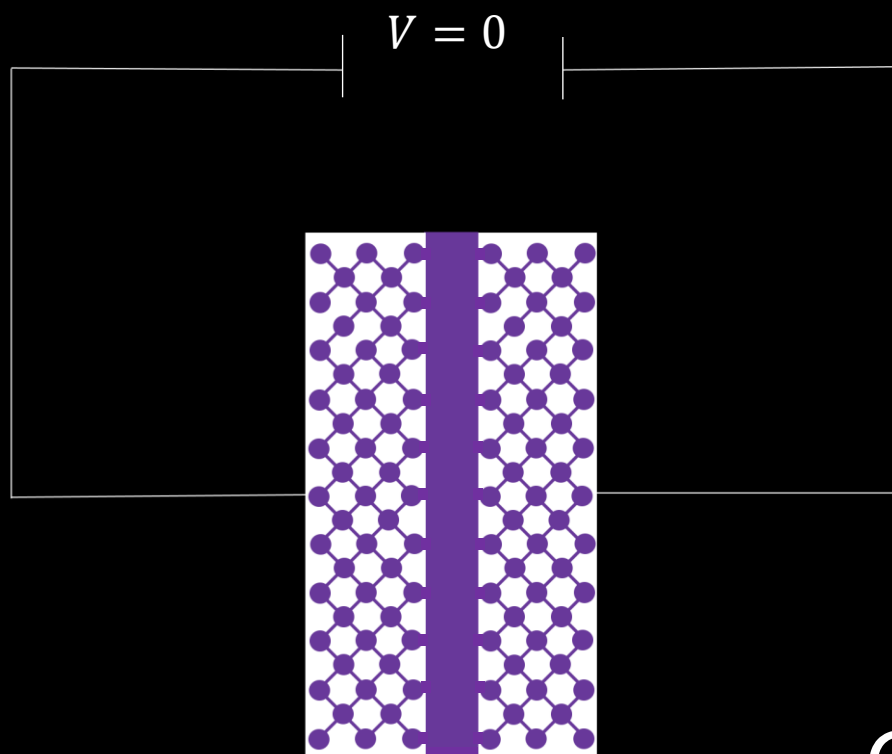
- Solid electrode
- Foam electrode



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I-V Analysis

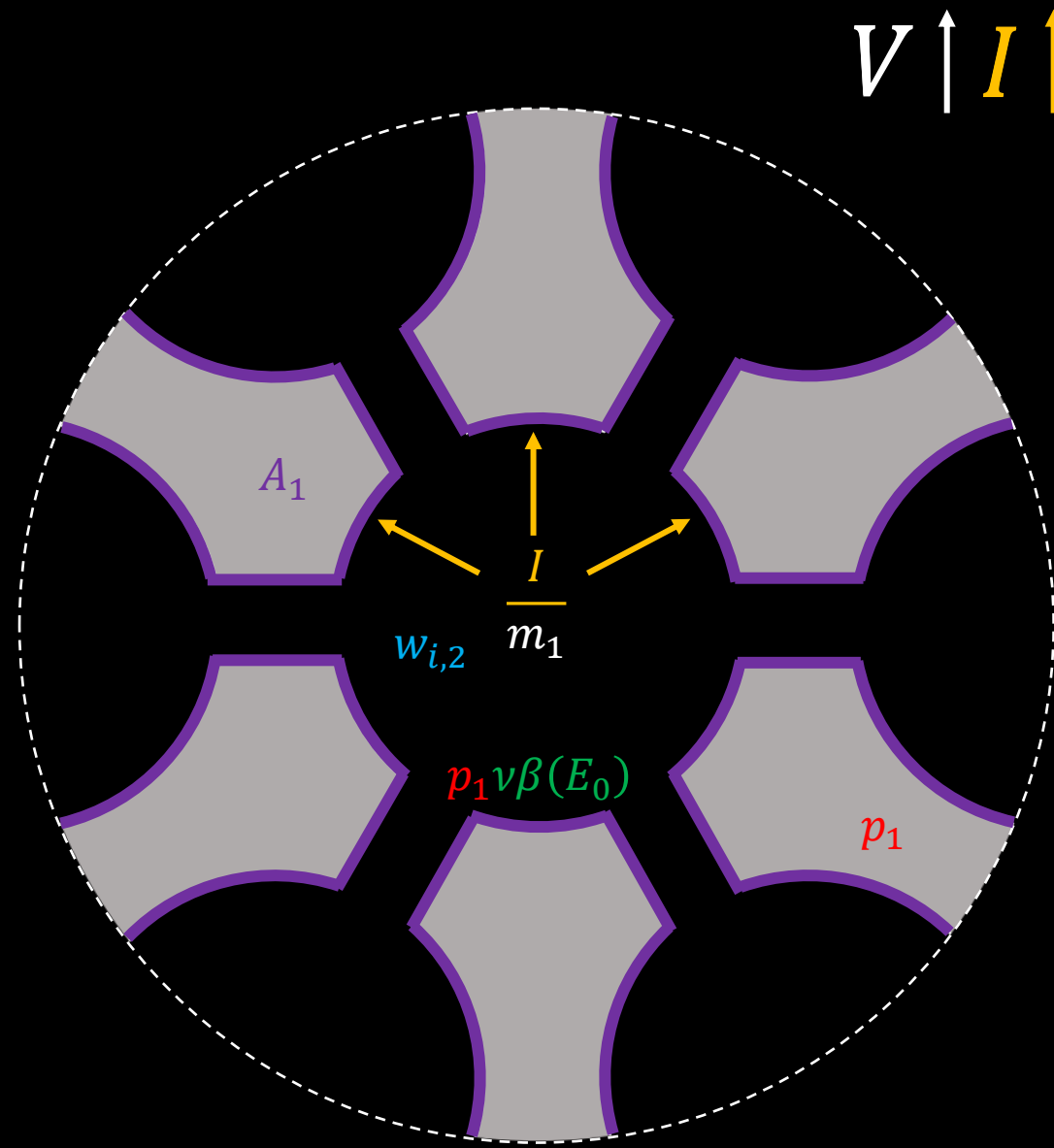
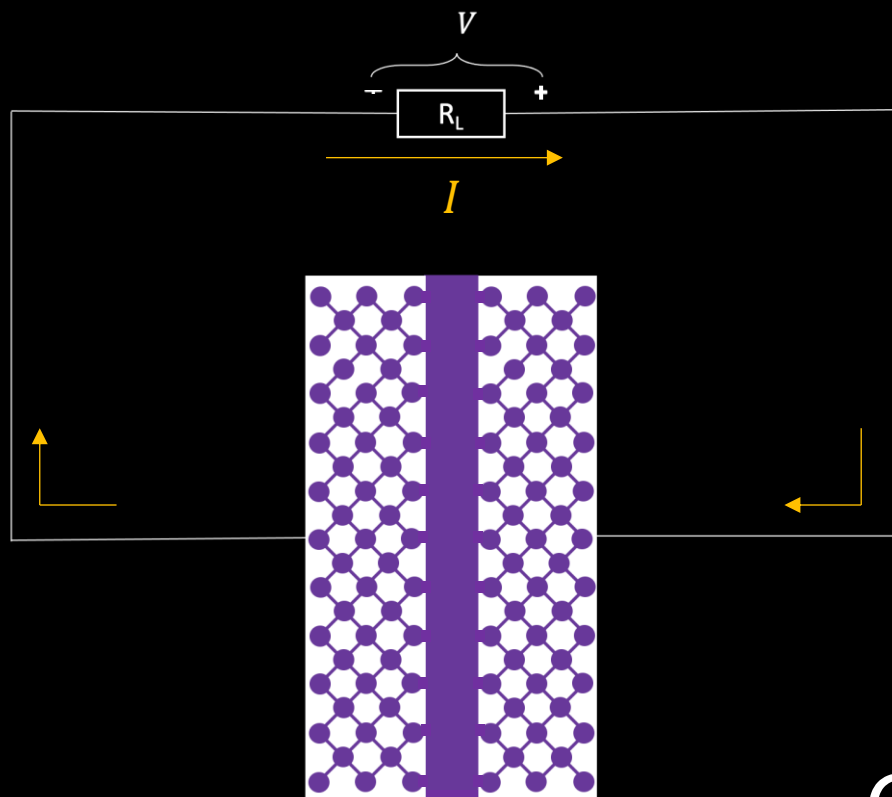
$$\frac{I}{m_1} = \frac{CA_1}{m_1} \left(p_1 \frac{v\beta(E_0)}{ew_{i,2}} \right)^{3/4} V^{1/2} \quad \frac{\left[\frac{v\beta}{m} \right]_f}{\left[\frac{v\beta}{m} \right]_s} = \left(\frac{I_{i,f}A_s}{I_{i,s}A_f} \right)^{4/3} \left(\frac{m_s}{m_f} \right)^2$$



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I-V Analysis

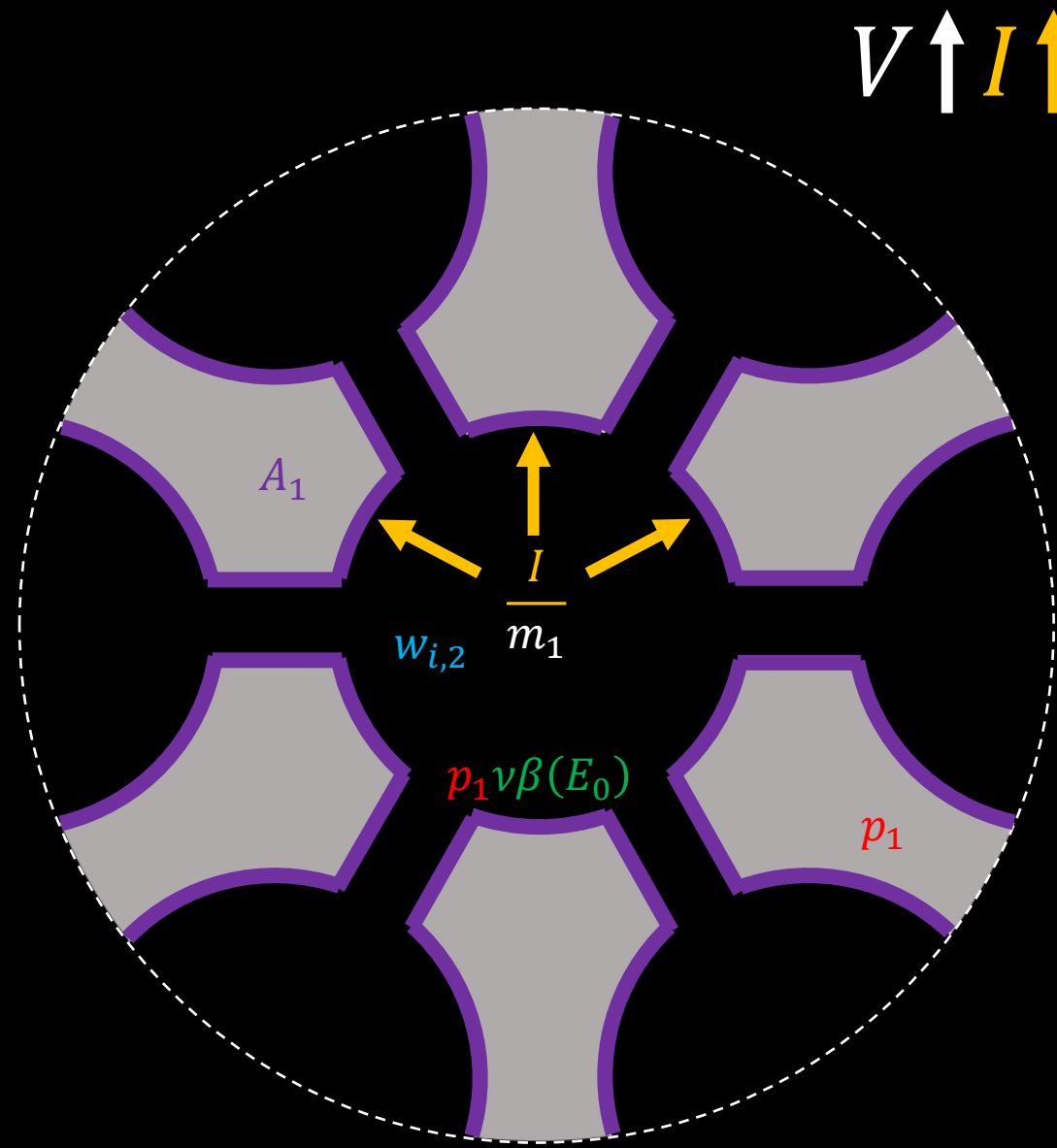
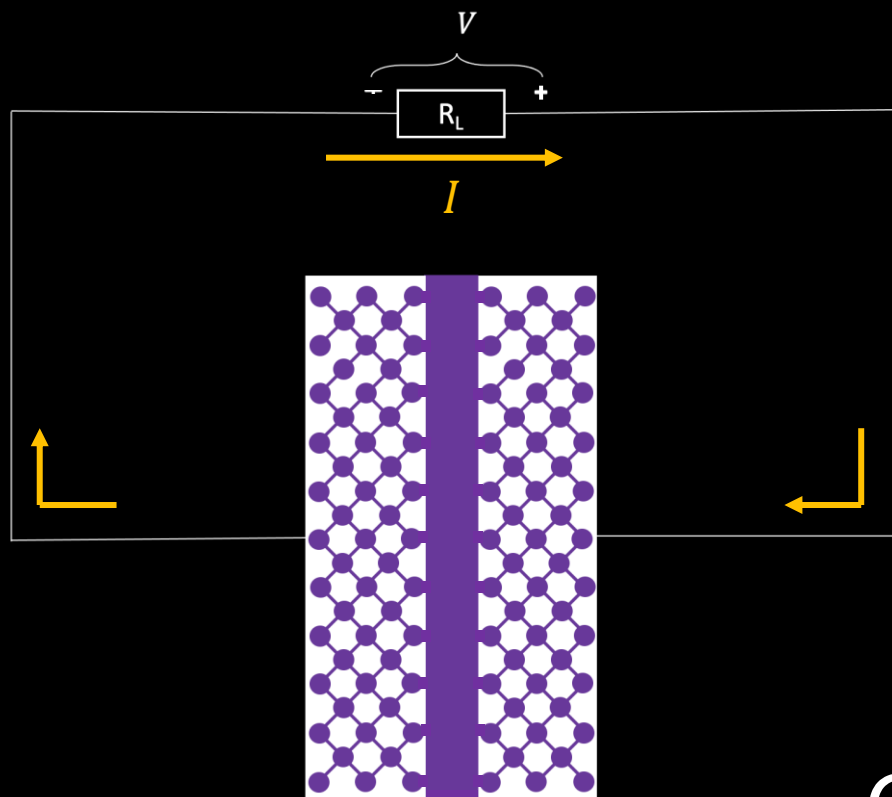
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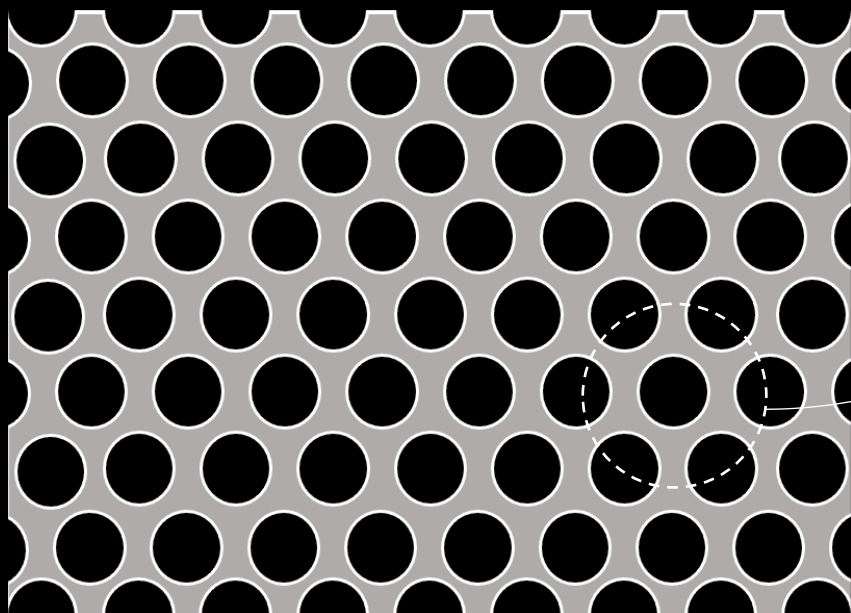
I-V Analysis

$$\frac{I}{m_1} = \frac{CA_1}{m_1} \left(p_1 \frac{v\beta(E_0)}{ew_{i,2}} \right)^{3/4} V^{1/2} \frac{\left[\frac{v\beta}{m} \right]_f}{\left[\frac{v\beta}{m} \right]_s} = \left(\frac{I_{i,f}A_s}{I_{i,s}A_f} \right)^{4/3} \left(\frac{m_s}{m_f} \right)^2$$



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M&S Methods



$$R_{ijl} = \phi_{ij} \sigma_{ijl} n_j \quad \text{Reaction Rate}$$

$$p_{tot} = \sum_{ijkl} \left(R_{ijl} E(E_0)_{l,j \rightarrow k} \frac{V_j}{V_k} \right) \quad \text{Power Density}$$

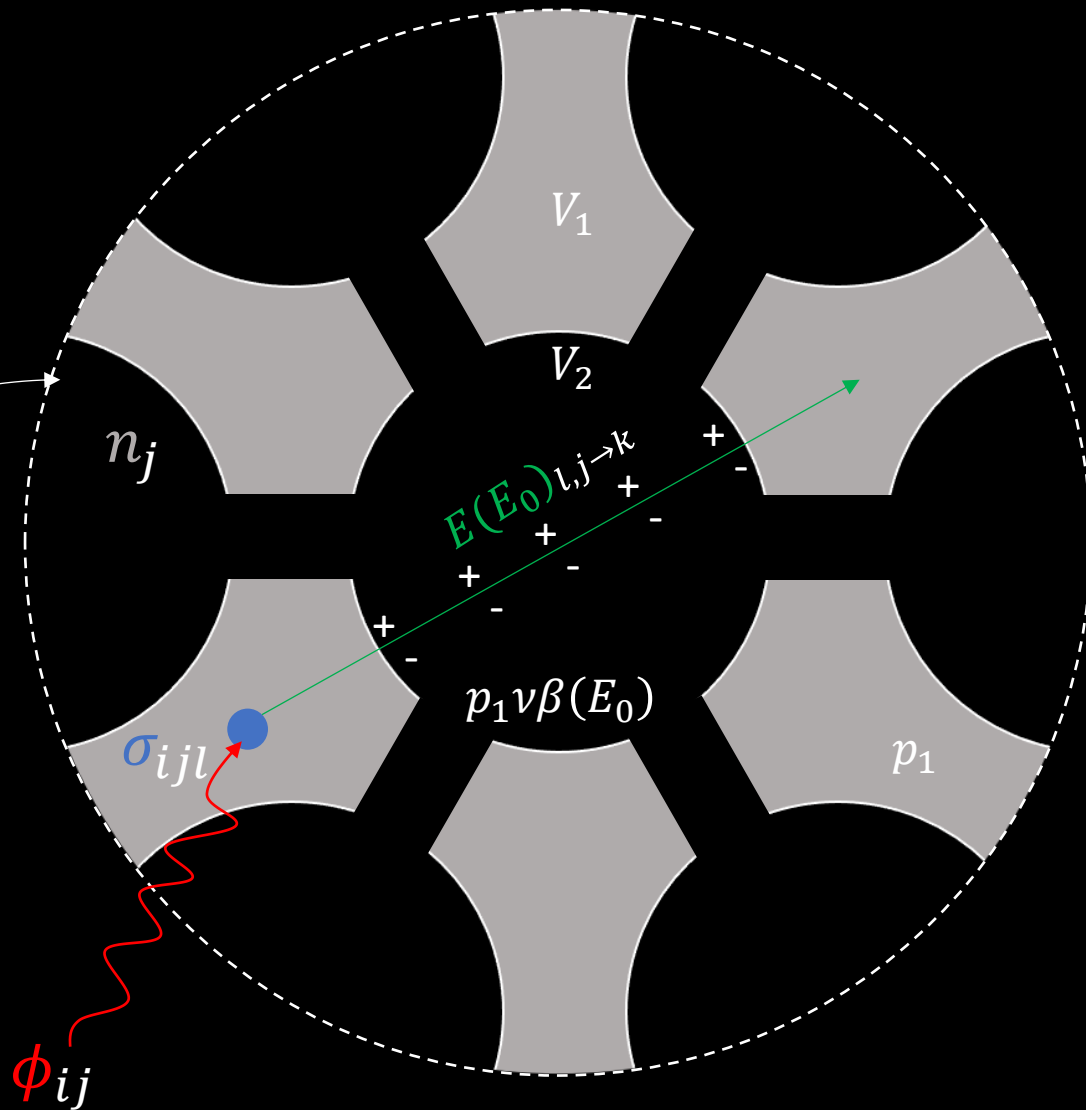
$$p_{tot} = p_1 [1 + \nu \beta(E_0)]$$

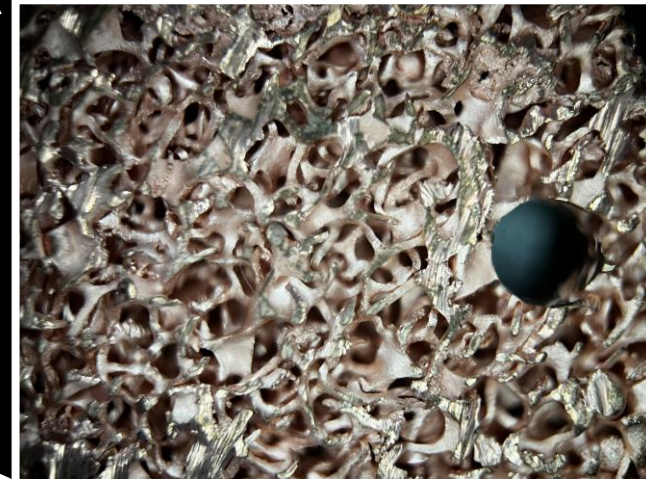
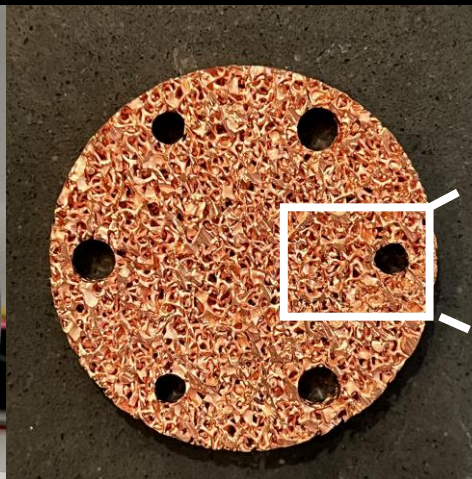
$$\frac{V_1}{V_2}$$

$$\frac{E(E_0)_{e,1 \rightarrow 2}}{E(E_0)_{e,1 \rightarrow 1}}$$

MCNP calculates this!

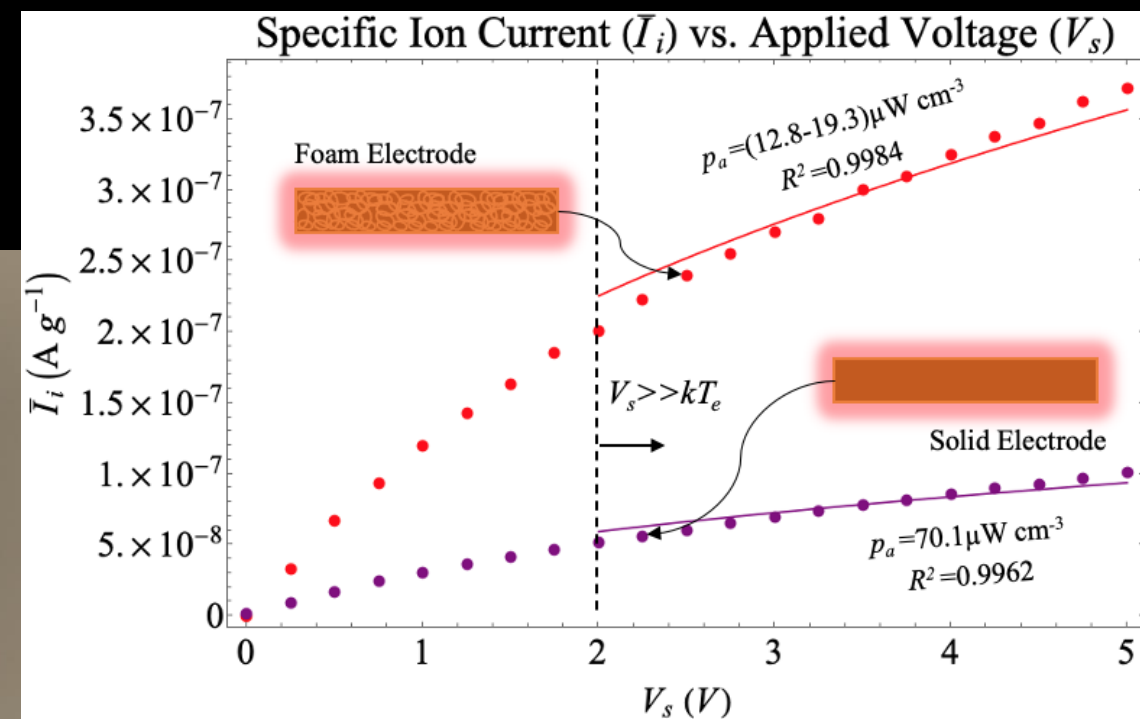
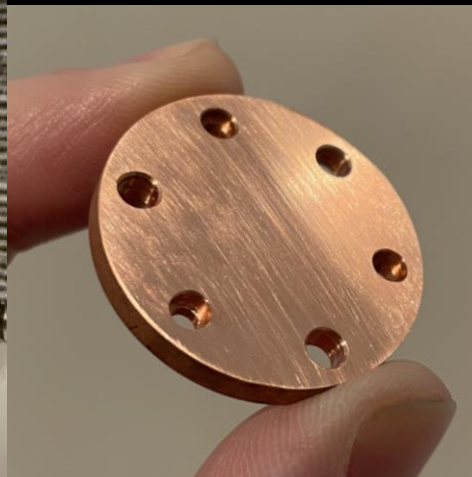
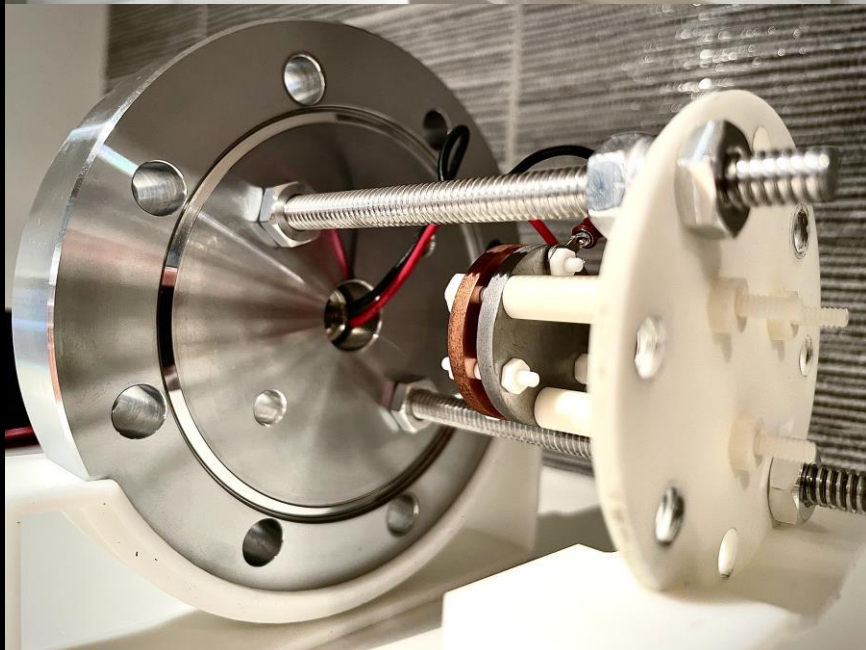
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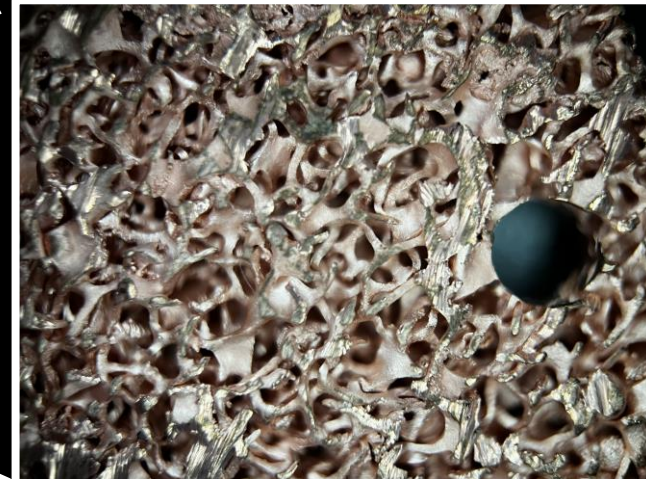
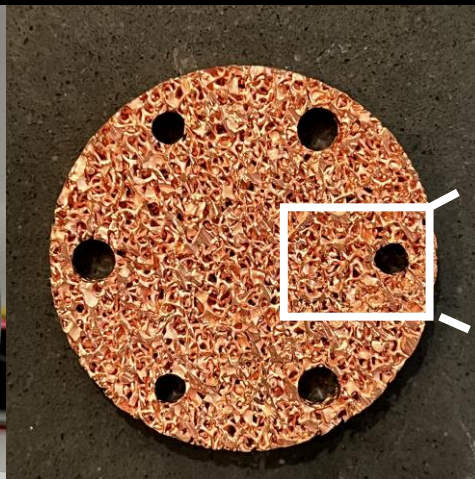


1mm

Observation 1:
Higher specific
current observed for
foam electrode

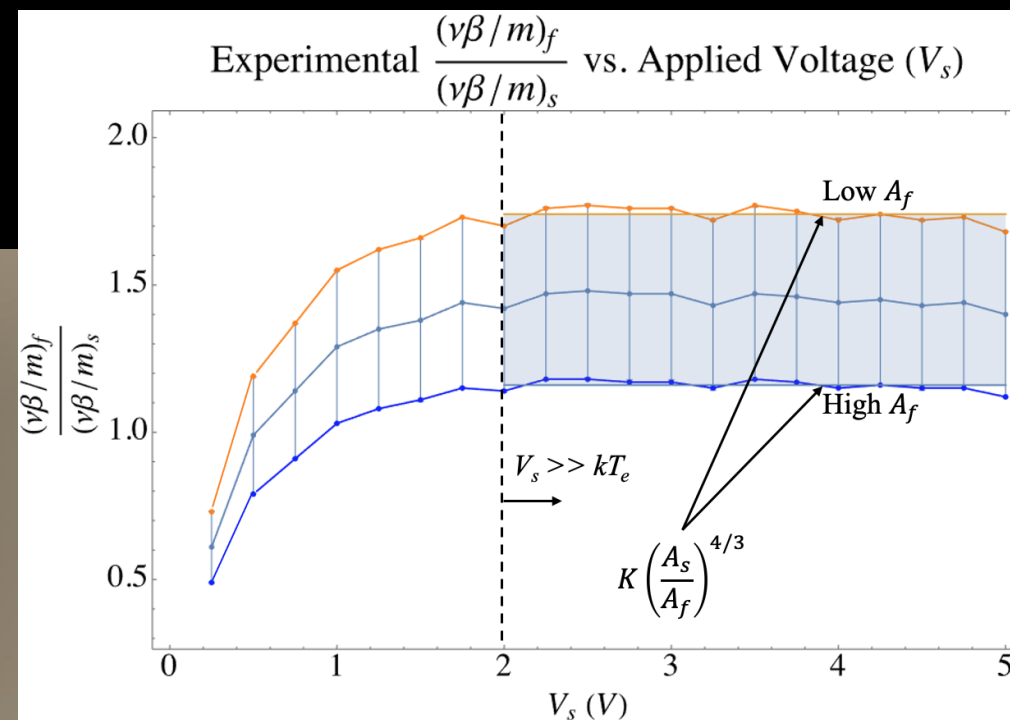
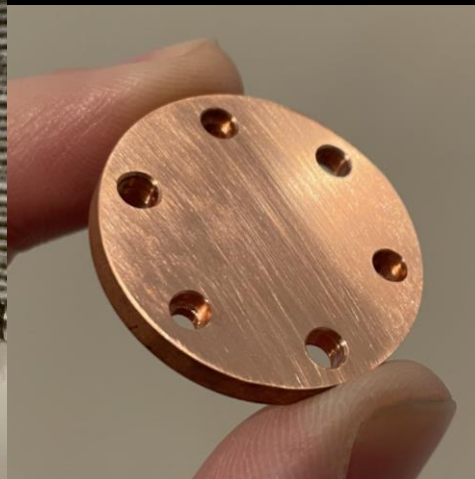
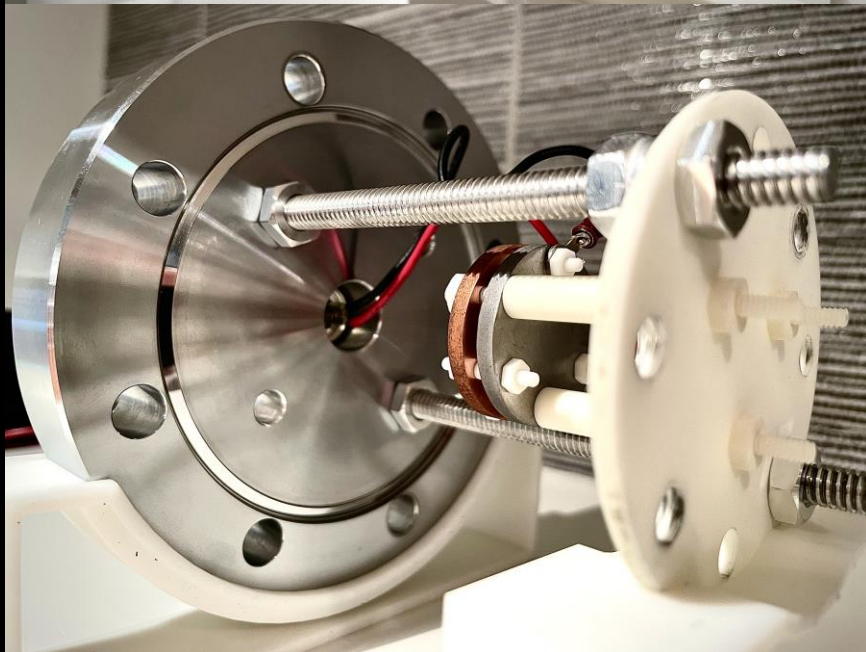


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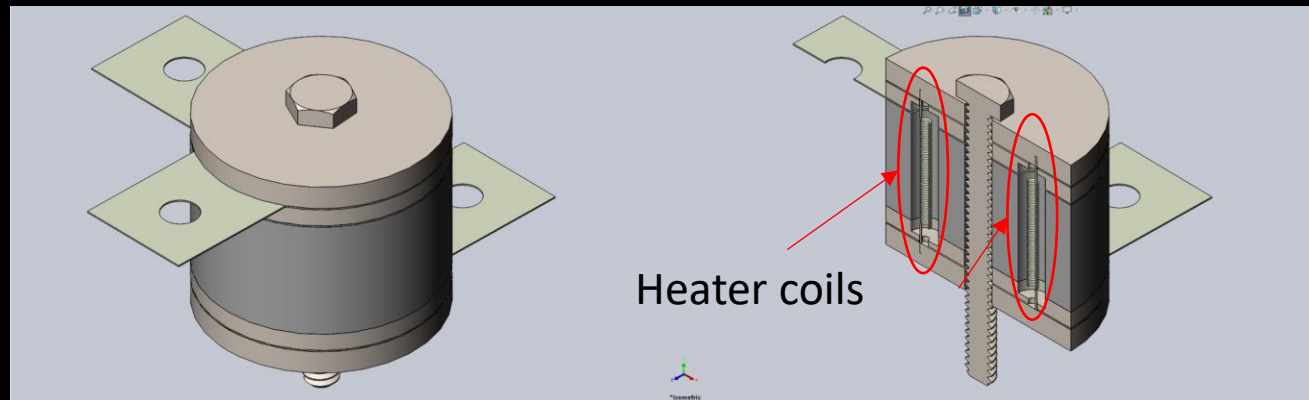
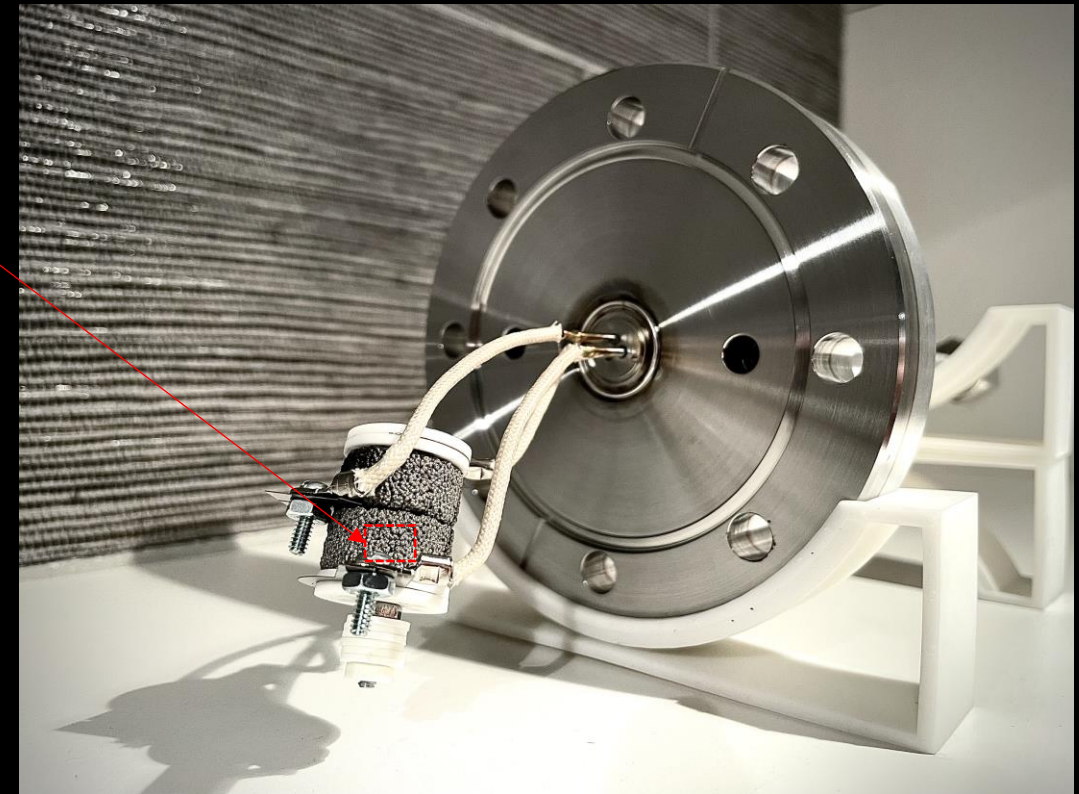
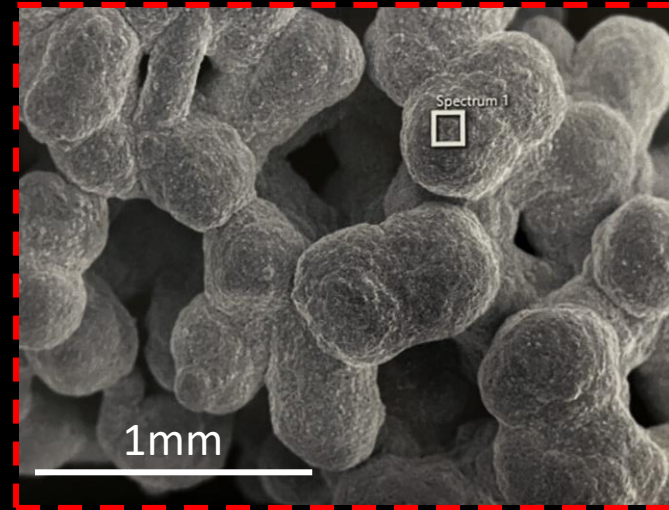
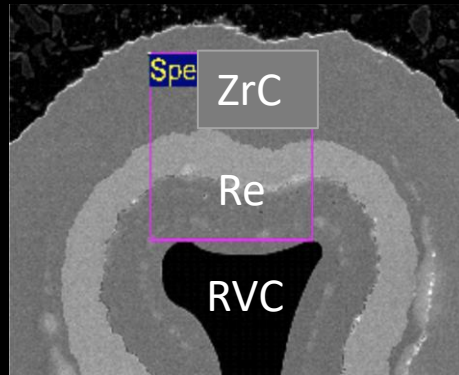
1mm

Observation 2:
Constant $v\beta/m$ ratio
observed for low
voltages



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Higher Temperatures with Refractory Foams



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Open Questions

- What are the best heating methods/facilities for devices:
 - $<1000\text{K}$
 - $>1000\text{K}$
- Methods
 - Electric heaters ($\sim 50\text{-}100\text{W}$)?
 - Radiation absorbers (W, B_4C , etc.)
- Facilities
 - Beam ports
 - In-core
- Other useful methods for assessing NLTPs?
 - Emissive probe (one electrode emits thermionically)
 - RC resonance circuit

Questions



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