GEN IV International Forum
Expertise | Collaboration | Excellence

Diamonds are a Reactor's Best Friend: Novel Sensor to Investigate High-Valence Actinides in Molten Salts

Dr. Hannah Patenaude

12 August 2026

Australian Government | ANSTO
Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens
Pacific Northwest National Laboratory
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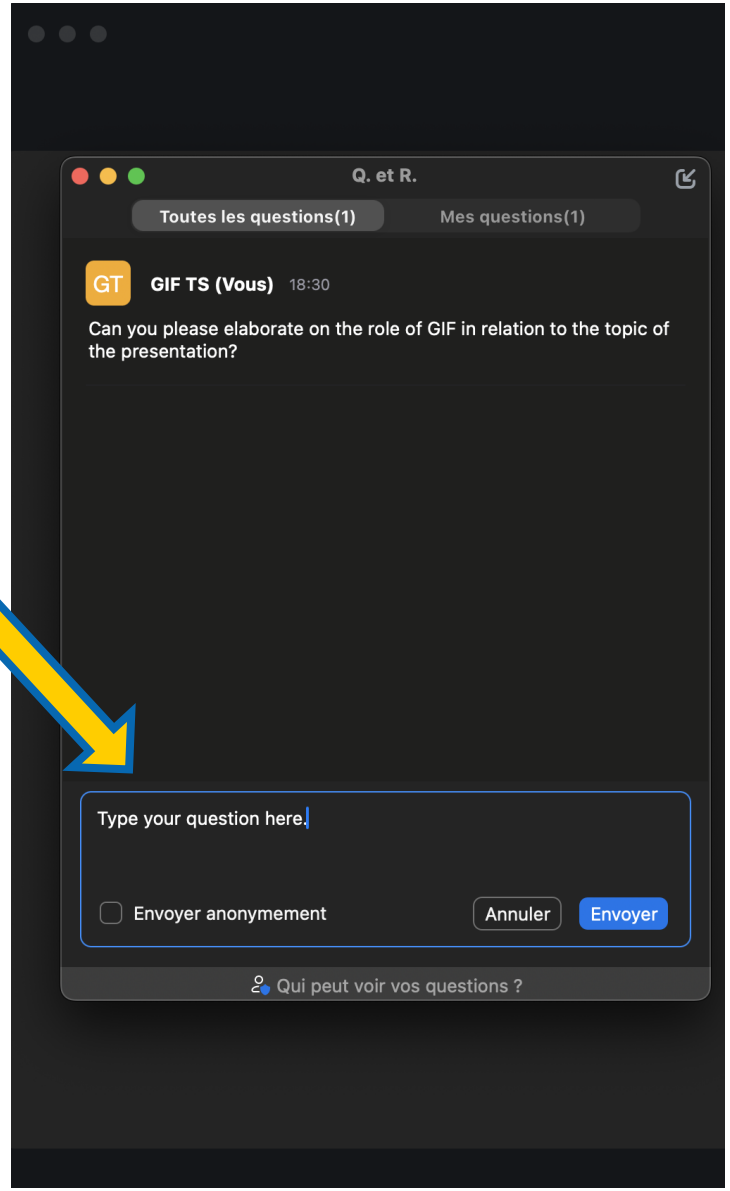

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Los Alamos NATIONAL LABORATORY

Meet the Presenter

- **Dr. Hannah Patenaude** is a Director's Postdoctoral Research Fellow in the Inorganic, Isotope, and Actinide Chemistry group at the Los Alamos National Laboratory.
- As a recent graduate of the University of Nevada, Las Vegas Radiochemistry Program, Hannah is experienced in actinide chemistry, specifically electrochemical processes, thermophysical properties measurements, and materials science techniques with an emphasis on molten salt systems to support the safe, secure deployment of Molten Salt Reactors.
- Outside of the laboratory, Hannah is involved in public policy and studies the rhetoric and public perceptions of nuclear technology. She is active in organizations like the American Nuclear Society, serving on the Executive Committee of the Fuel Cycle & Waste Management Division and as the Vice Chair for the Trinity Section. Hannah spends her free time with her dog, Clementine—named after a LANL Manhattan Project era nuclear reactor—who provided support in Hannah's 2025 Pitch Your Gen IV Research video.

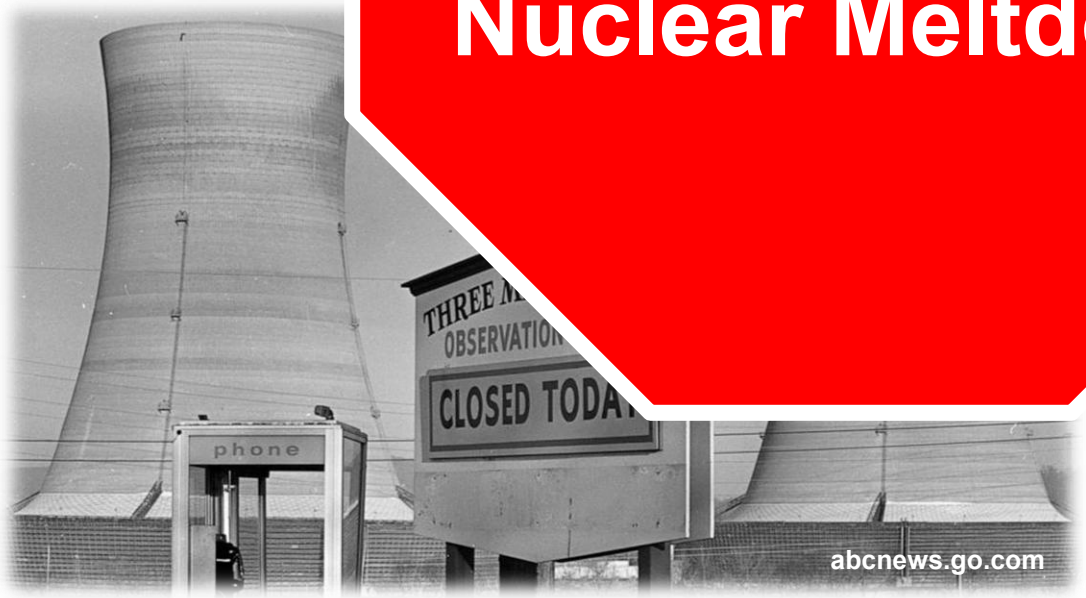
Email: hpatenaude@lanl.gov

NOAA

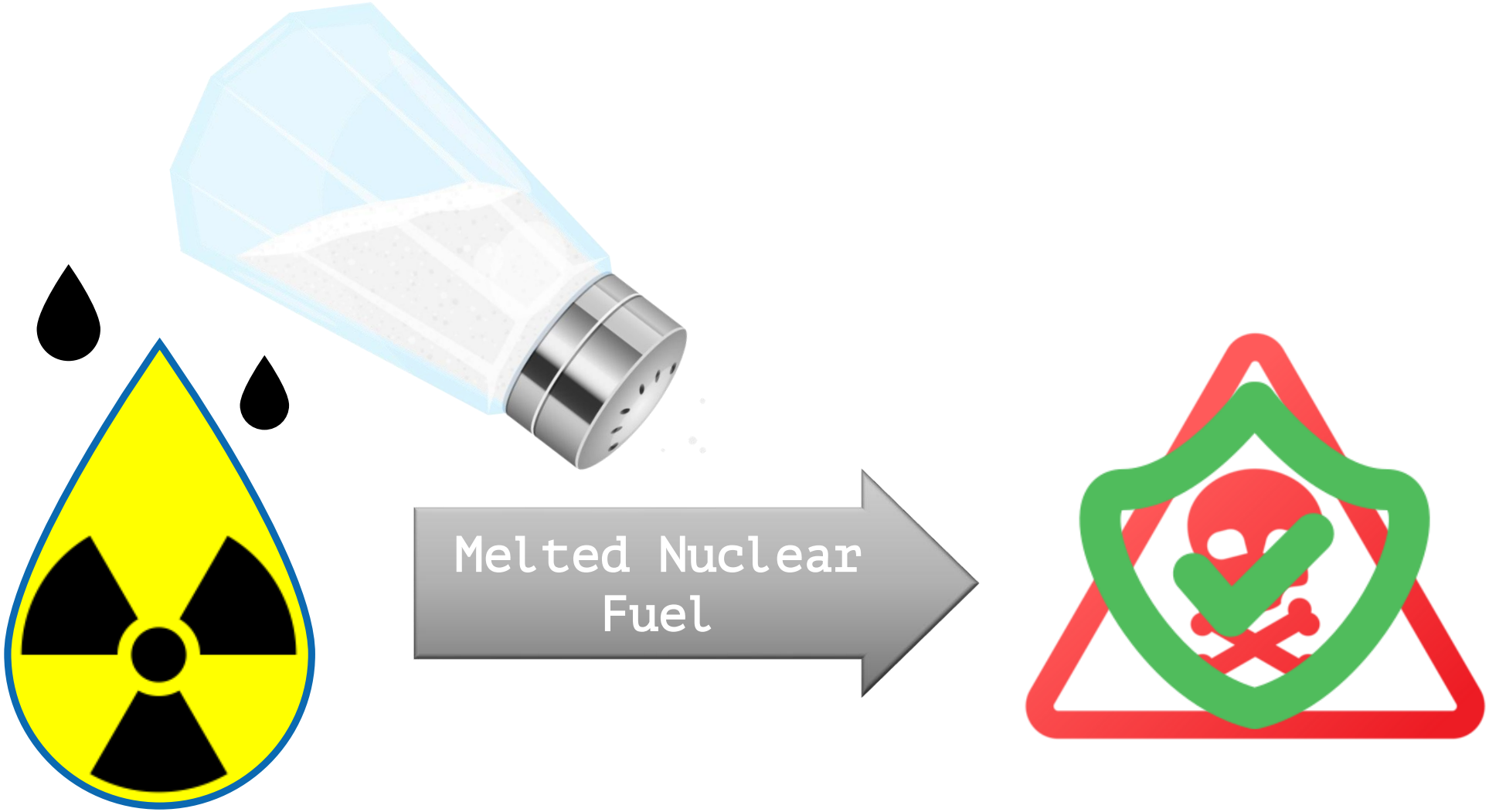
Patric Federi on Unsplash

Fukushima Daiichi
Nuclear Power Plant
Japan 2011

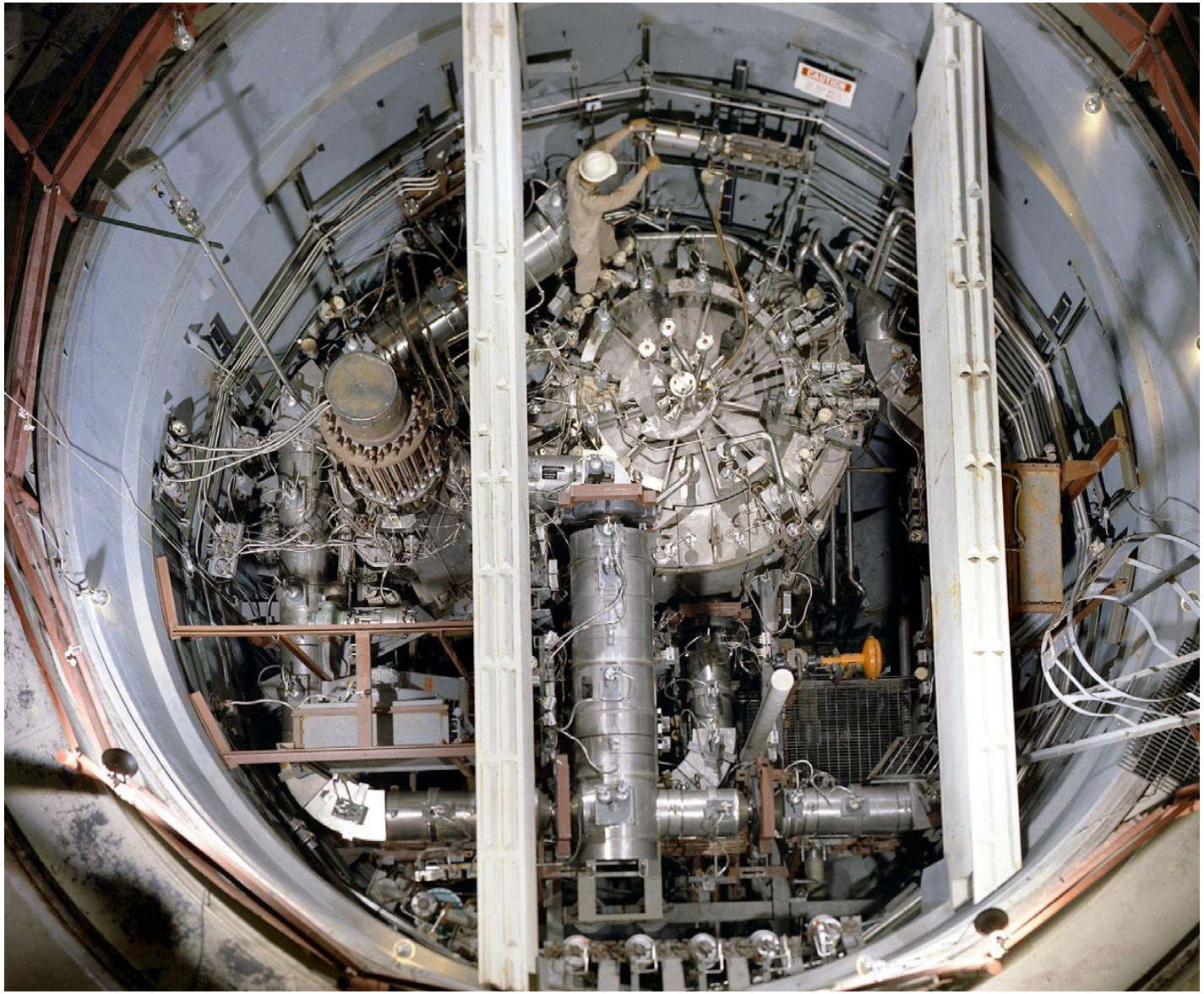
Nuclear Energy
?
Nuclear Meltdown



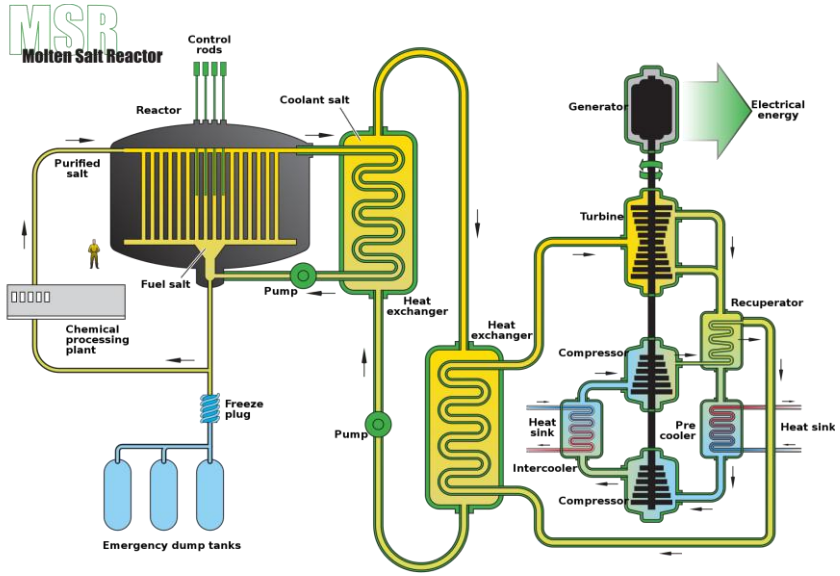
Chernobyl
Nuclear Power Plant
Ukraine SSR 1986


Melted Nuclear Fuel

Molten Salt Technology

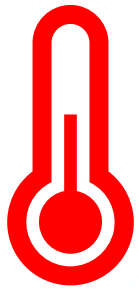


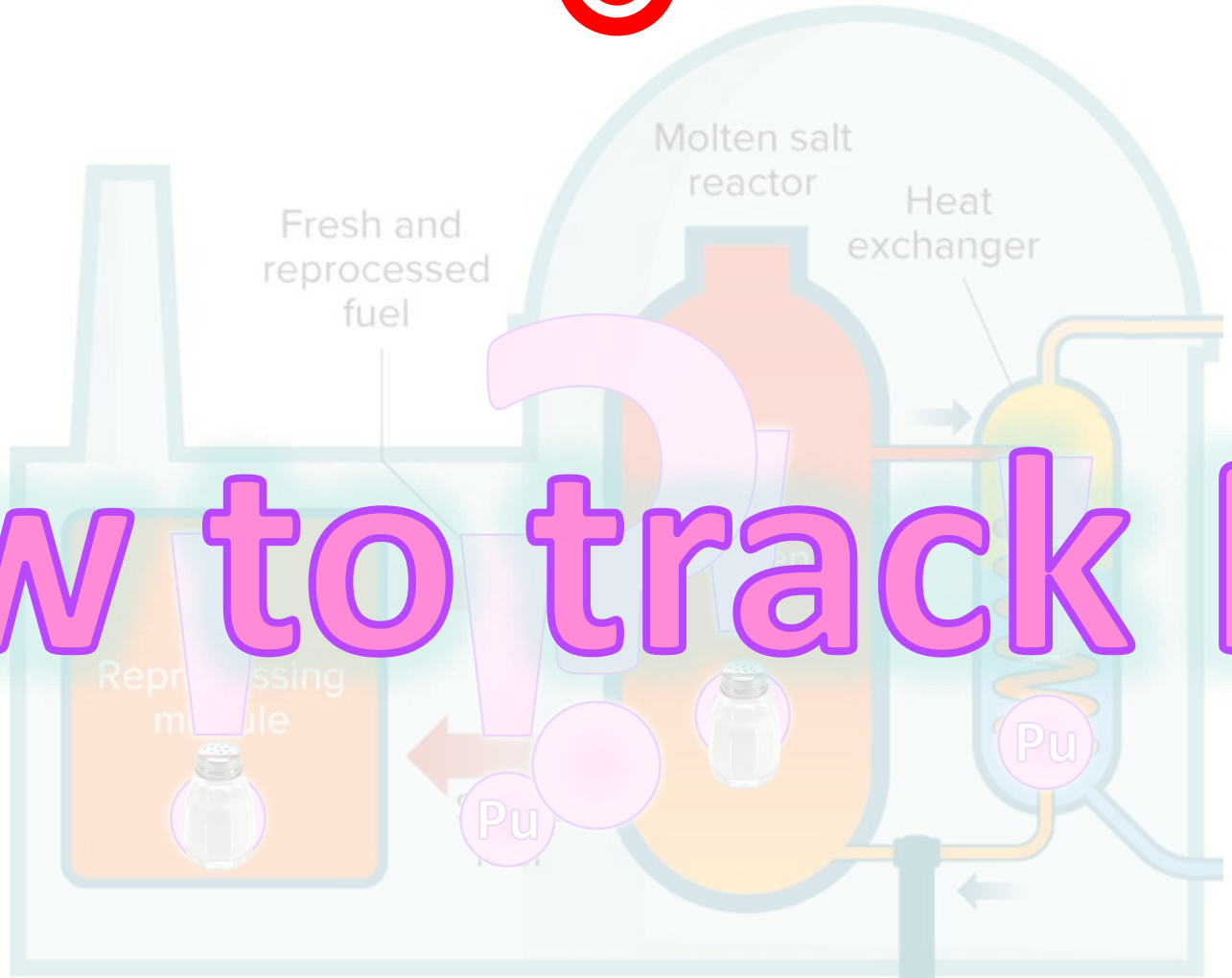
Molten Salt Reactor Experiment, Oak Ridge National Laboratory (1965-1969)
Rosenthal, ORNL/TM-2009/181, **2009**.



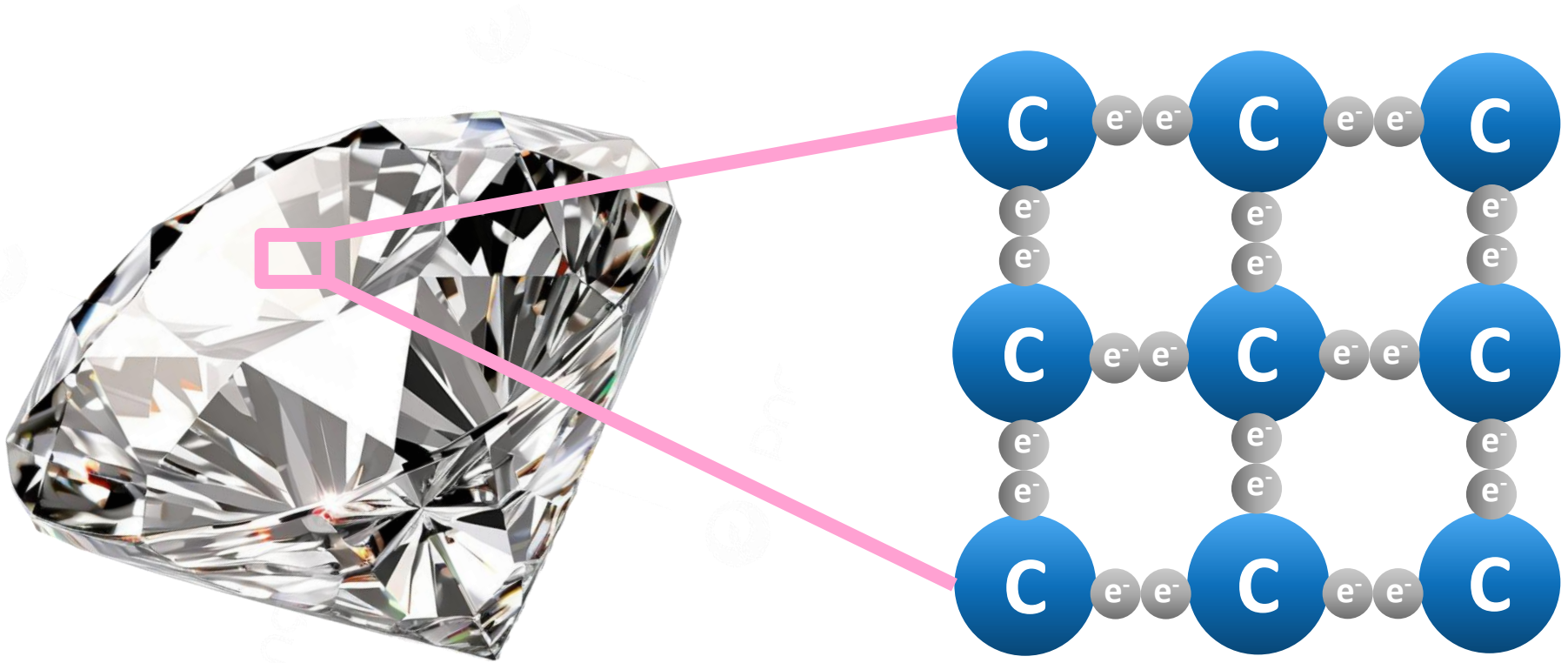
http://www.ne.doe.gov/genIV/documents/gen_iv_roadmap.pdf

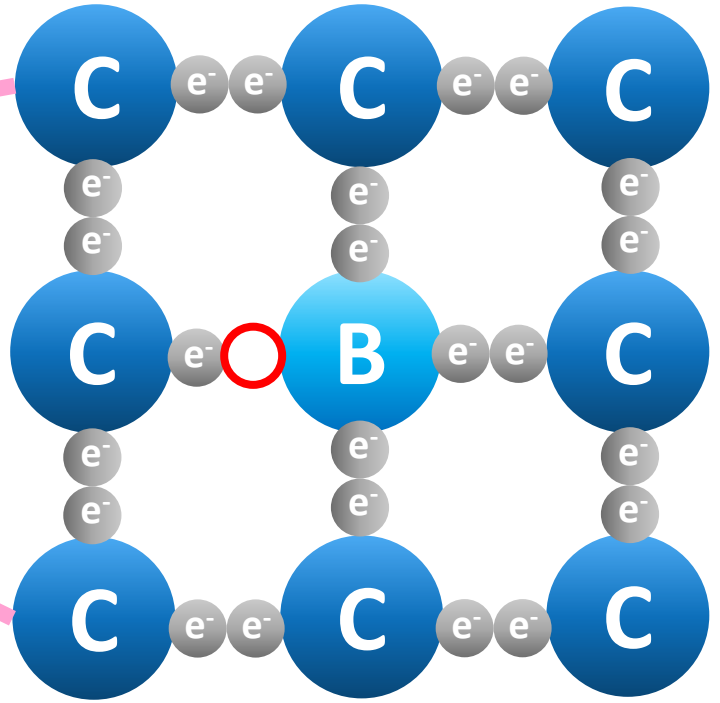
Molten Salt Reactor

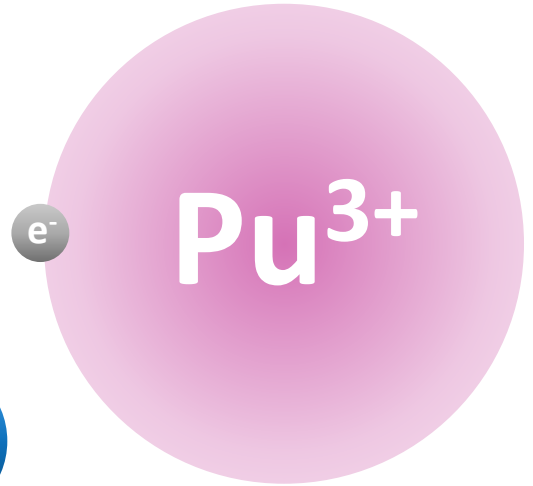


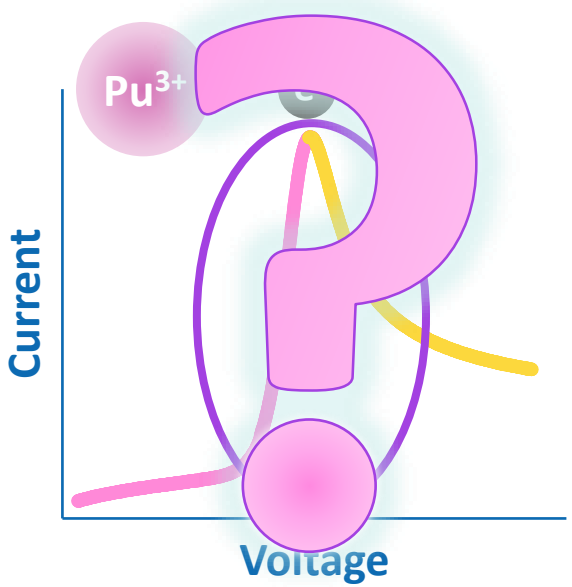


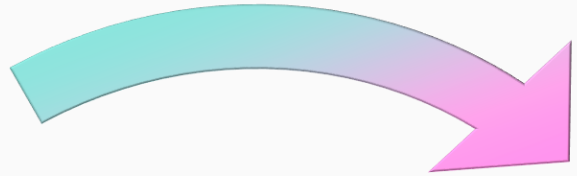
How to track Pu?

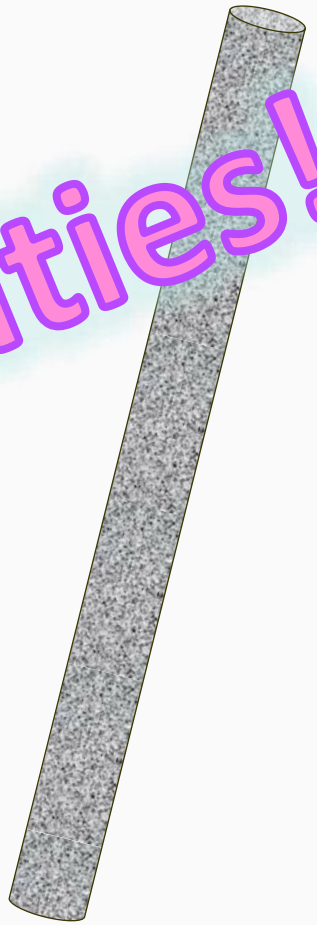

C
e-


C
e-
B

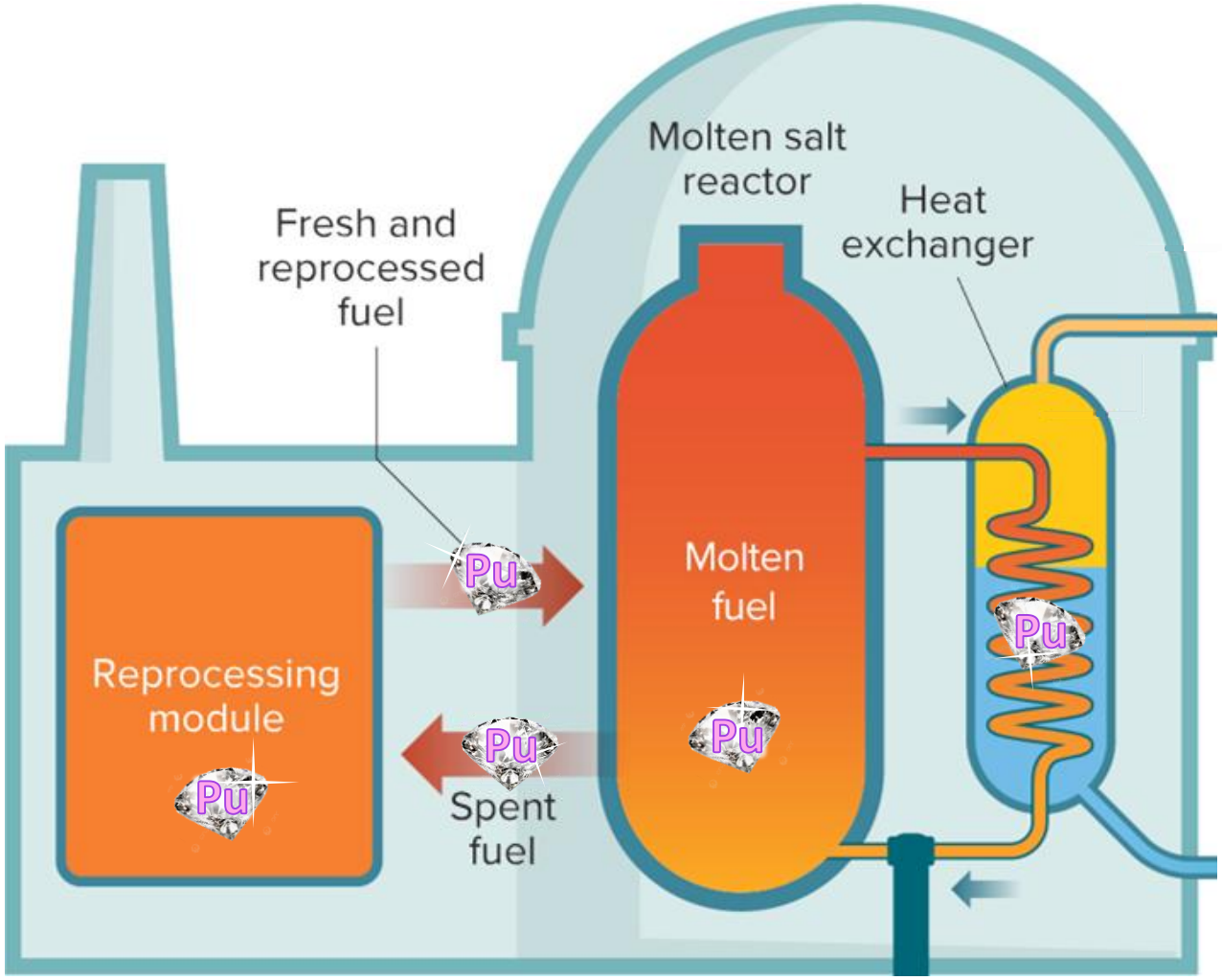

e-
Pu3+


Pu3+
Current
Voltage





Endless Possibilities!


Molten salt reactor
Heat exchanger
Fresh and reprocessed fuel
Molten fuel
Reprocessing module
Spent fuel
Pu
Pu
Pu
Pu
Pu

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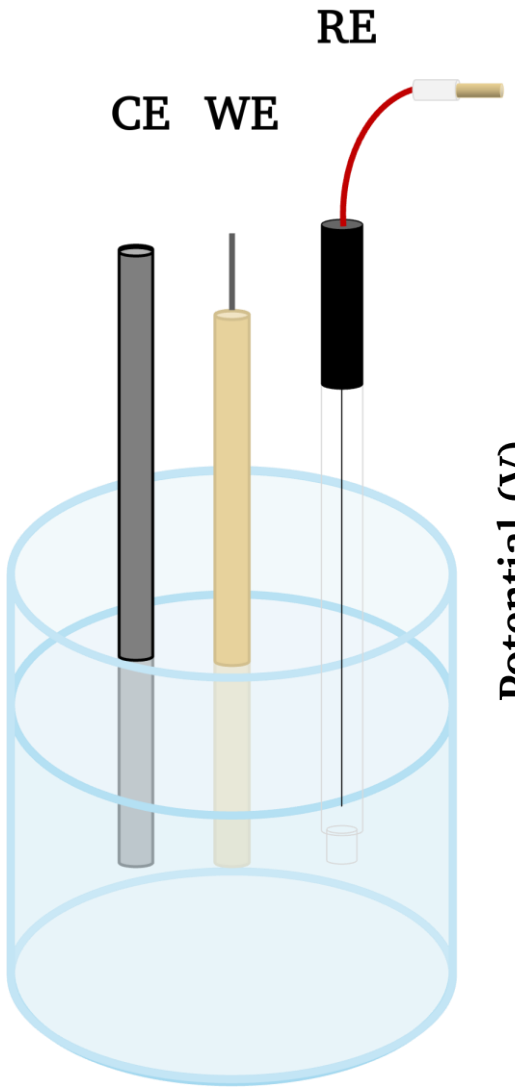
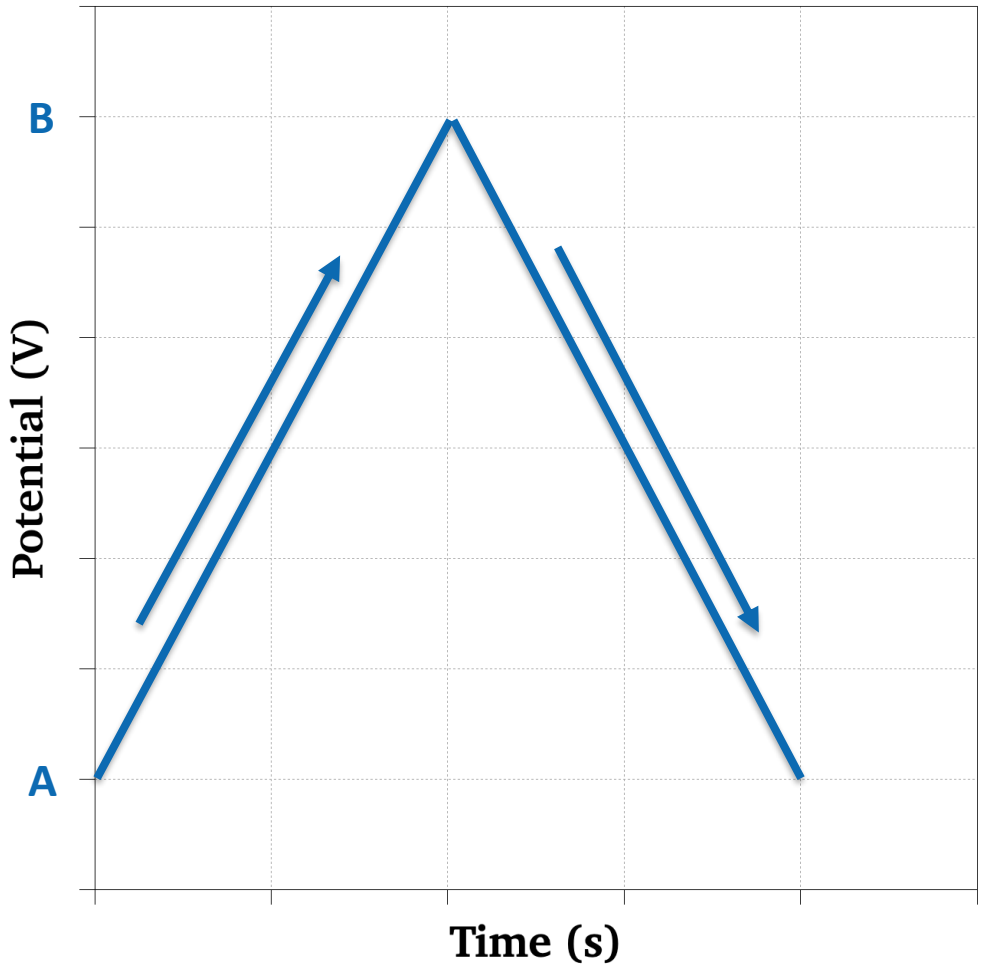
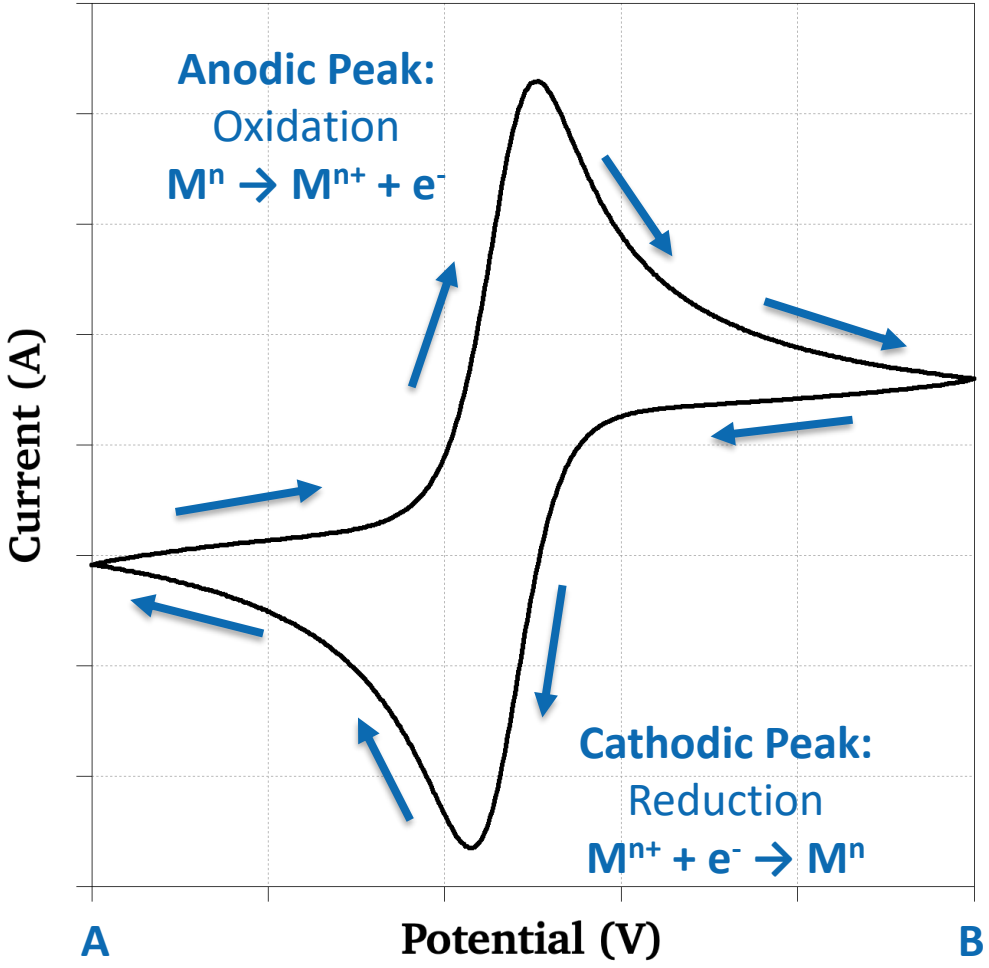
The Technique:
Electroanalysis

Electroanalytical Chemistry



Cyclic Voltammetry





Electroanalytical Chemistry

Potential & Thermodynamics:

$$E = E^o + \frac{RT}{nF} ln \frac{[Ox.]}{[Red.]}$$

$$E^o = \frac{E_p^a + E_p^c}{2} \qquad \Delta E_p = E_p^a + E_p^c$$

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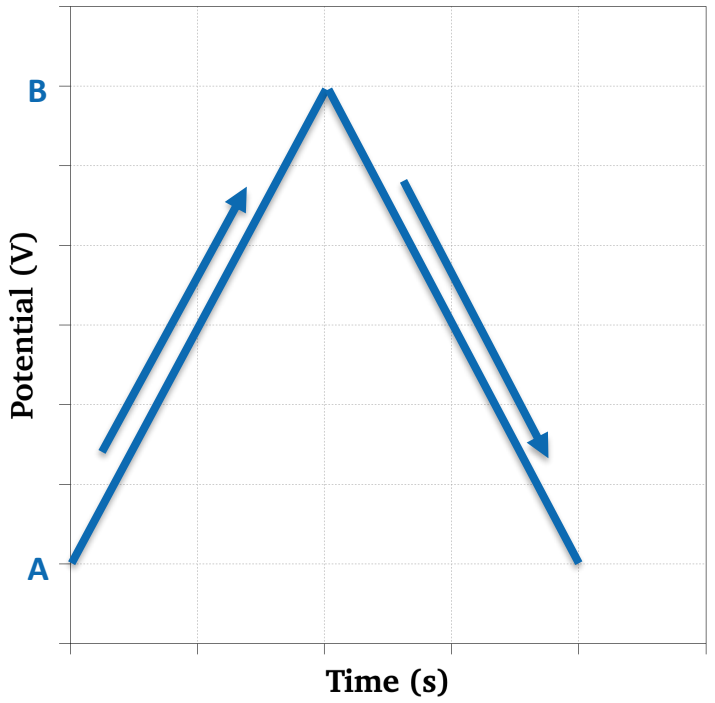

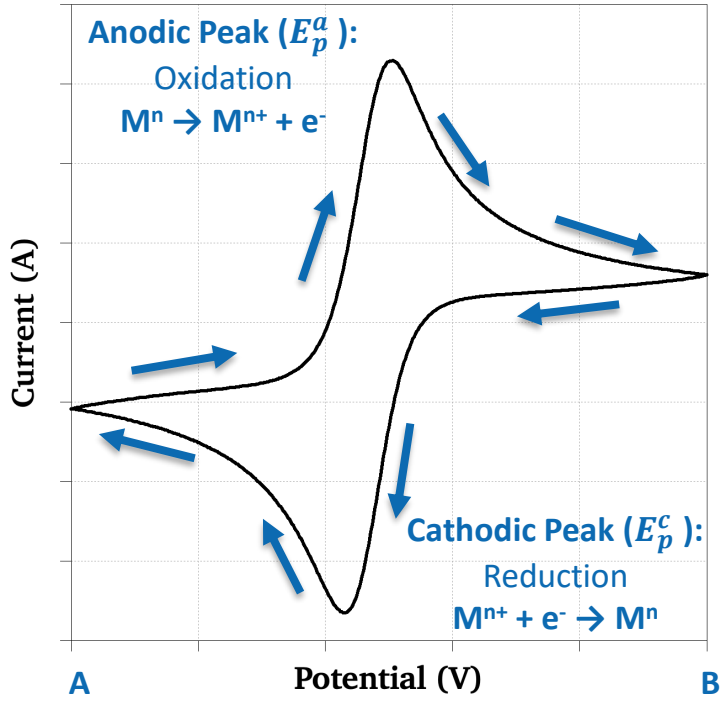

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Analyte Diffusion:

$$i_p^{a/c} = 0.496nFAC\sqrt{\frac{D_{R/O}(\alpha n_\alpha)Fv}{RT}}$$

$$i_p^{a/c} = 0.4463nFaC\sqrt{\frac{nFvD_{R/O}}{RT}}$$

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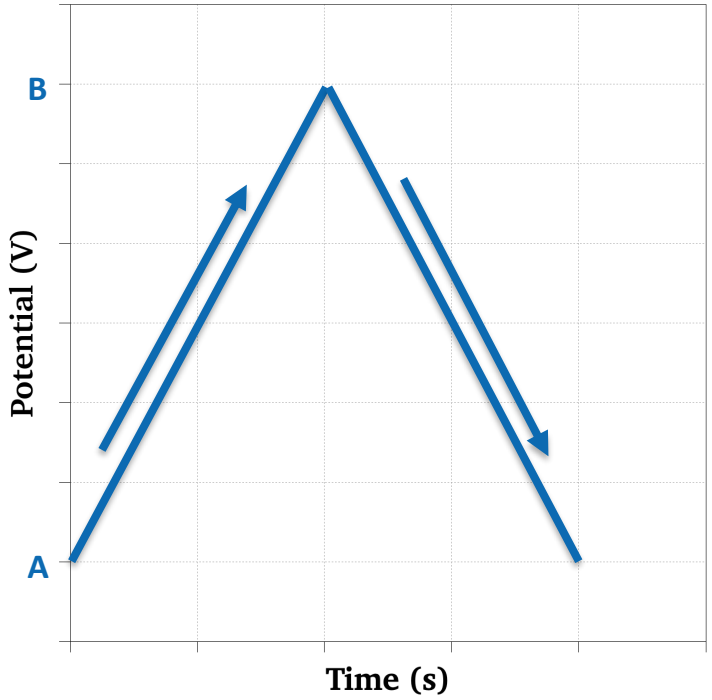

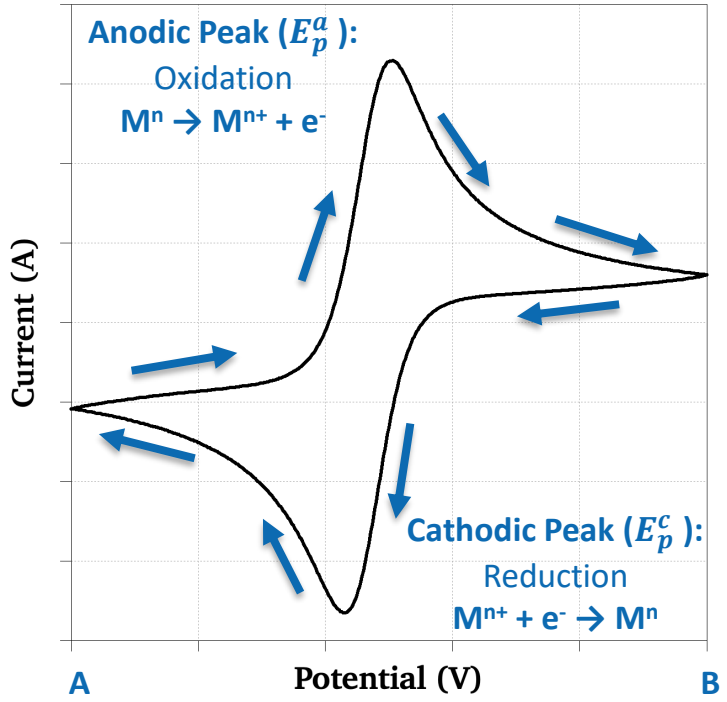

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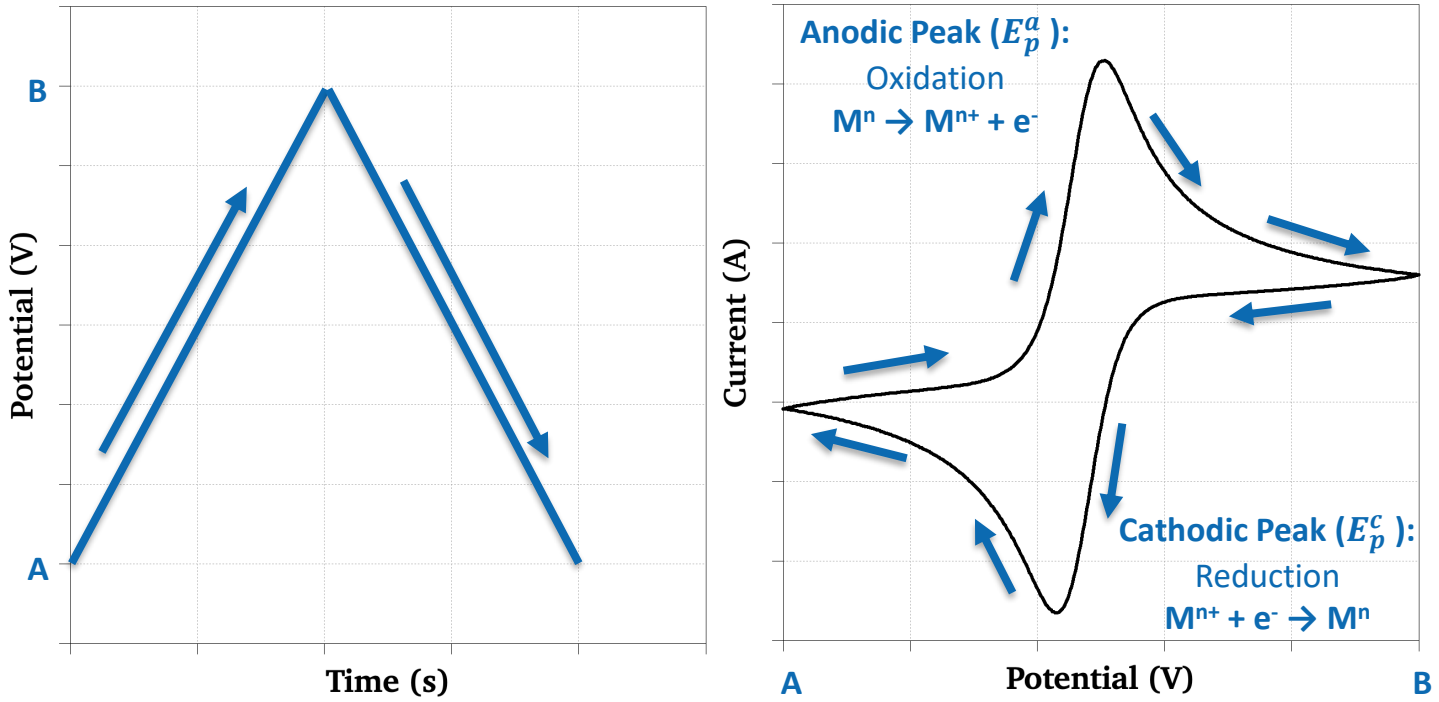

Electron Transfer Kinetics:

$$k = 2.18\sqrt{D_O(\alpha n_\alpha)\frac{\nu F}{RT}} \cdot e^{\left\{\frac{\alpha^2 nF}{RT}(E_{p,c} - E_{p,a})\right\}}$$

$$\psi = \frac{\sqrt{\frac{D_O}{D_R}}^{\alpha} k}{\sqrt{\frac{\pi D_O nFv}{RT}}}$$

$$\alpha n_\alpha = \frac{1.857RT}{\left|E_p - E_{\frac{p}{2}}\right| F}$$

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- **Benefits**
  - Fundamental Characterizations
    - E^o, D, k, ΔG^o, ΔH^o, ΔS^o
  - Elemental Analysis
  - Corrosion Kinetics
  - High Sensitivity

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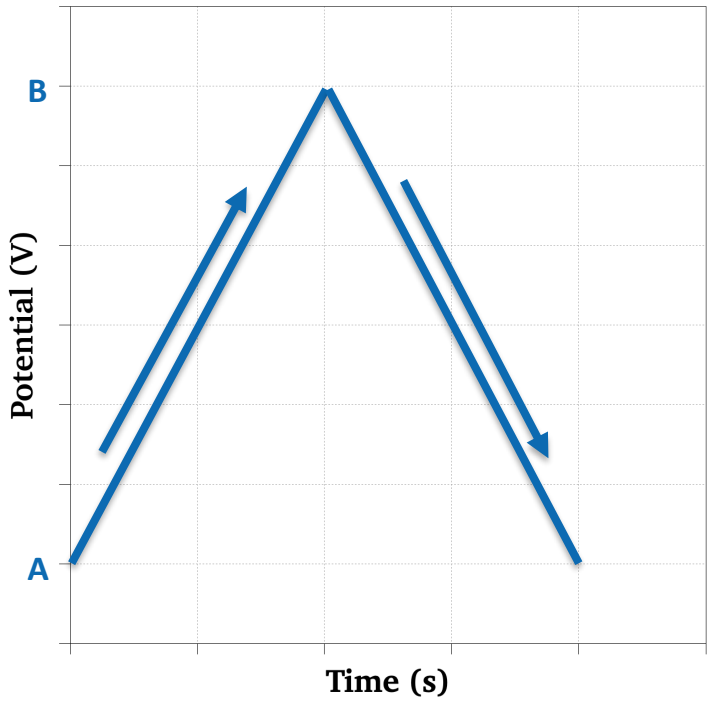

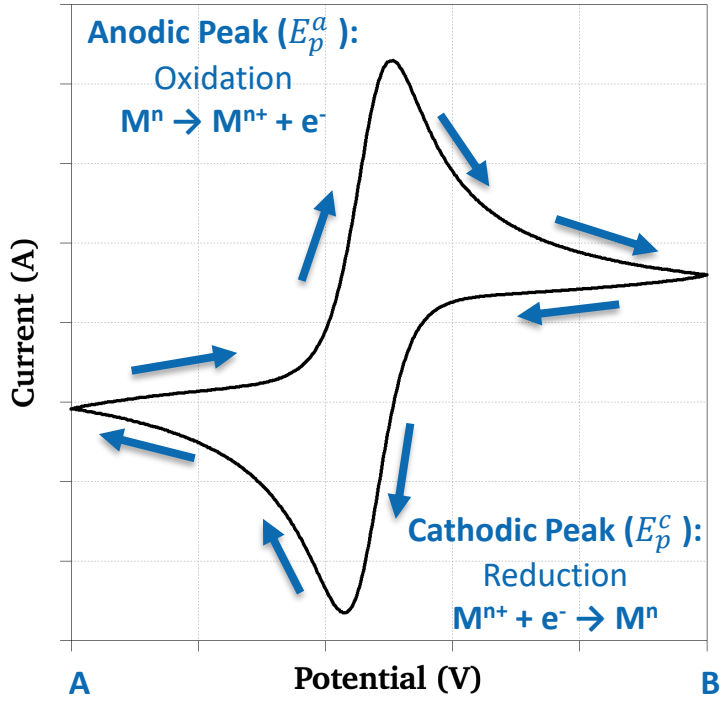

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  - Working electrode *resilience*
  - Reference electrode *stability*
  - Matrix variations and *purification*

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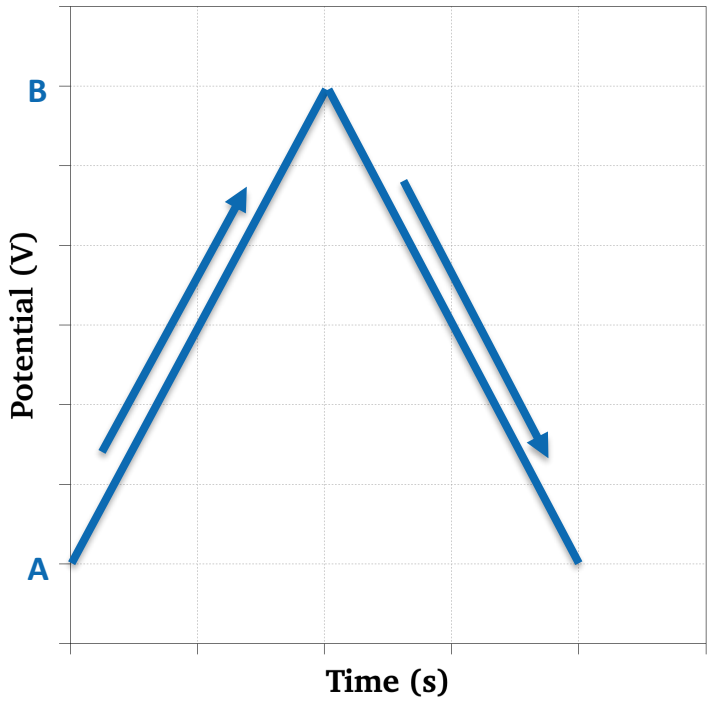

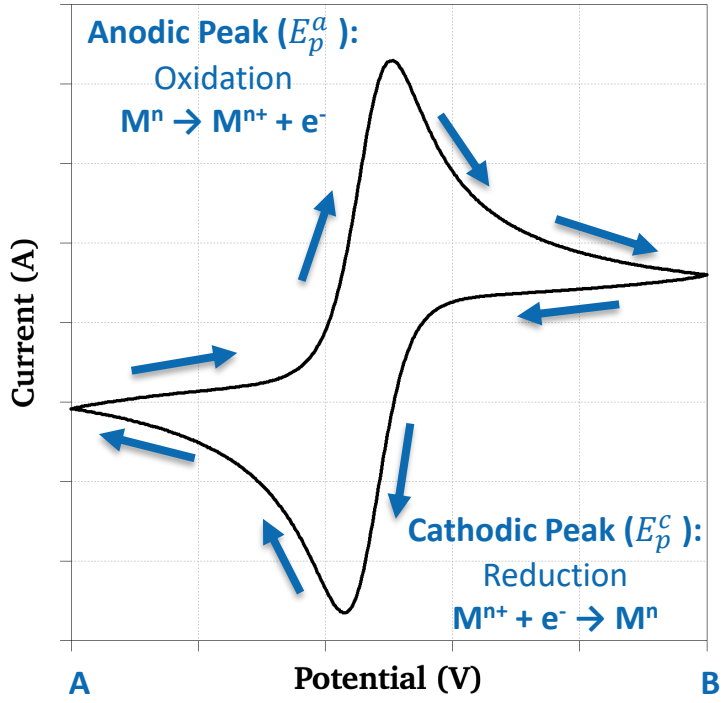

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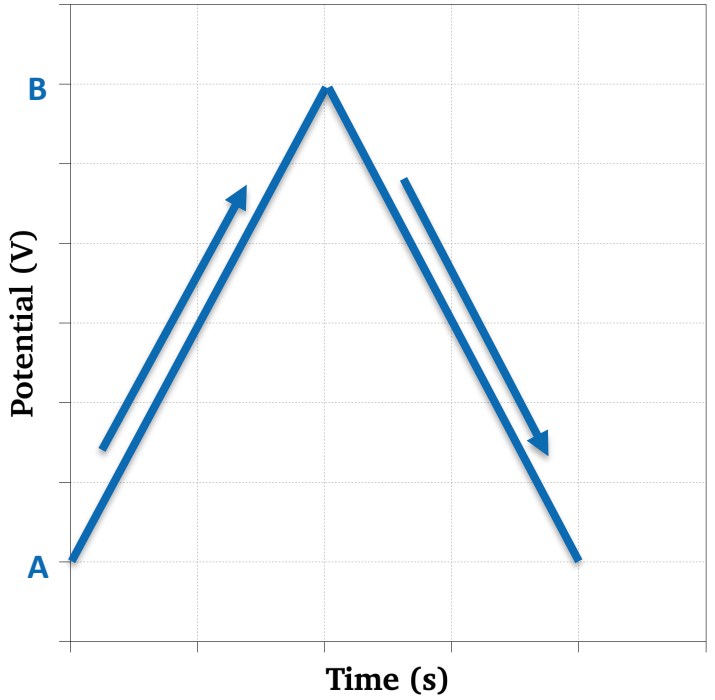

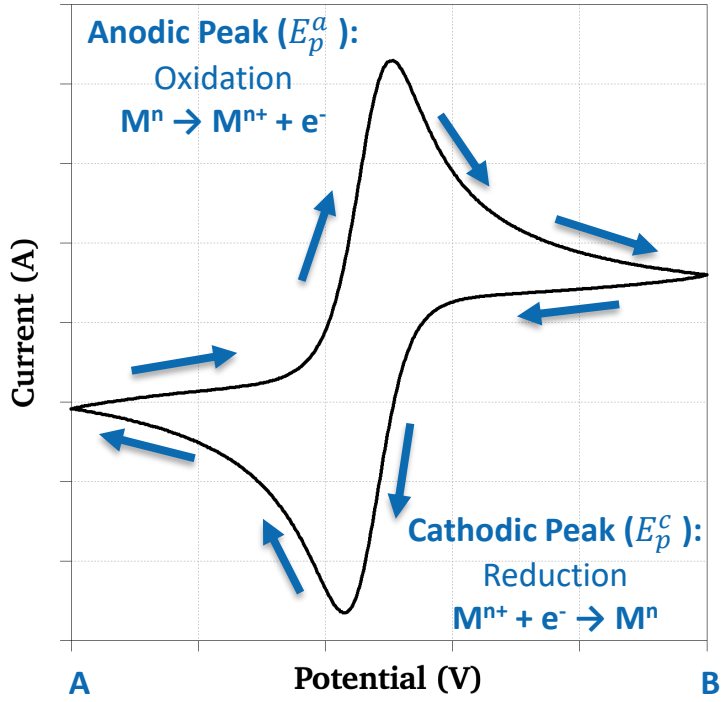

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The Mission:

Use *oxidation* to detect Pu in MSR fuels with diamond

The White Whale: $Pu^{4+/3+}$

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Does it exist?

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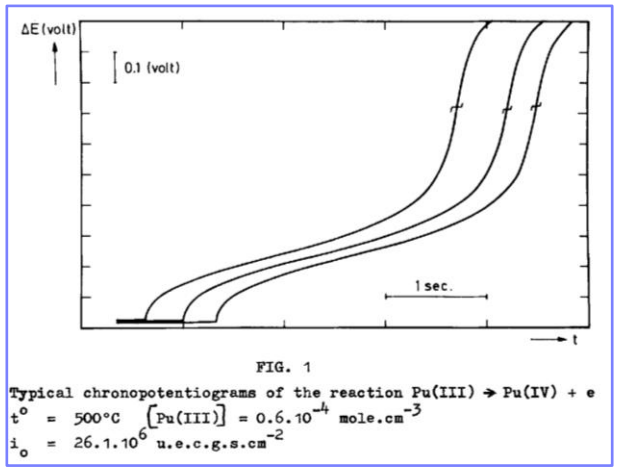

FIG. 1

Typical chronopotentiograms of the reaction Pu(III) → Pu(IV) + e

t^{o} = 500°C $[Pu(III)] = 0.6.10^{-4}$ mole.cm^{-3}

i_{o} = $26.1.10^{6}$ u.e.c.g.s.cm^{-2}

Martinot, L. & Duyckaerts, G. (1970). *Inorg. Nucl. Chem. Lett.*, *6*(6), 587.
Martinot, L. & Duyckaerts, G. (1971). *Anal. Lett.*, *4*(1), 1.
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The White Whale: $Pu^{4+/3+}$

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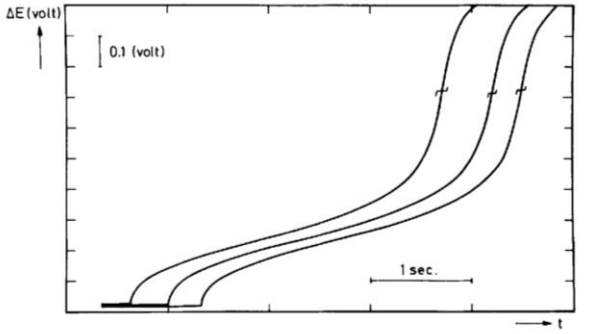

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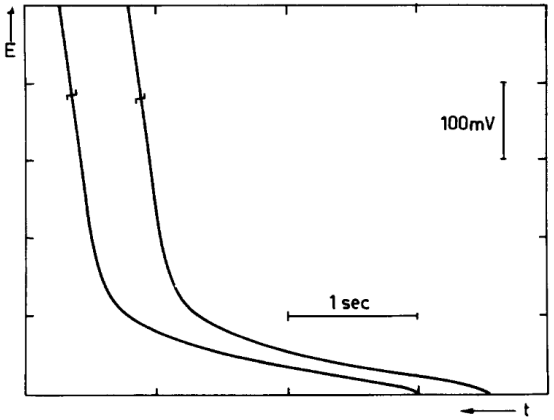

FIG. 1

Chronopotentiometric reduction of Pu(IV) in LiCl-KCl at 500°C

i_o = 1.4 mA, $[Pu(IV)] = 31.93\ 10^{-3}$ m.f.

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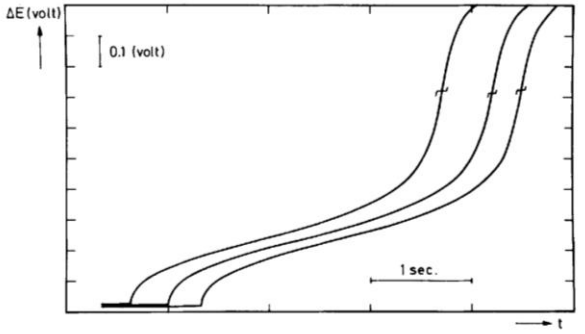

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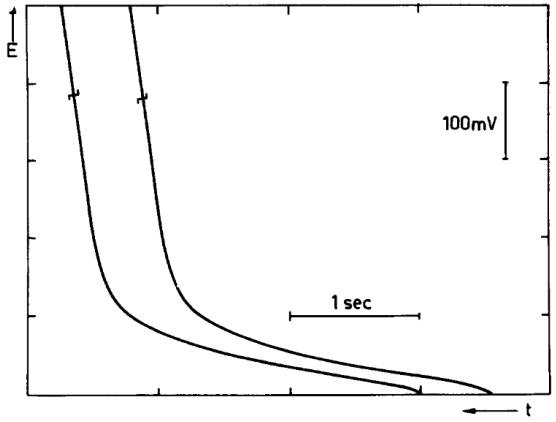

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TABLE II

Activation energy, ΔH (K.cal.mole^{-1}), for the diffusion of tetravalent actinide ions in LiCl-KCl

t(°C)	U(IV)	Np(IV)	Pu(IV)
425	11.1	11.0	10.3
475	9.4	9.5	9.7
525		7.5	9.5
575			9.2
625			9.3

TABLE I

Diffusion coefficients D.10^6 (cm^2 sec^{-1}) of tetravalent actinide ions in LiCl-KCl

t(°C)	U(IV)	Np(IV)	Pu(IV)
400	4.45 ± 0.2	4.65 ± 0.2	4.2 ± 0.2
450	8.0 ± 0.15	8.1 ± 0.1	7.2 ± 0.2
500	12.15 ± 0.2	11.7 ± 0.2	11.2 ± 0.25
550		15.75 ± 0.25	16.2 ± 0.25
600			22.4 ± 0.28
650			30.0 ± 0.5

Martinot, L. & Duyckaerts, G. (1970). *Inorg. Nucl. Chem. Lett.*, *6*(6), 587.
Martinot, L. & Duyckaerts, G. (1971). *Anal. Lett.*, *4*(1), 1.
Martinot, L. & Caligara, F. (1973). At. En. Rev., 11(1), 3.
Martinot, L. & Fuger, J. (1986). *J. Less-Common Met.*, *120*, 255

The White Whale: $Pu^{4+/3+}$

Does it exist?

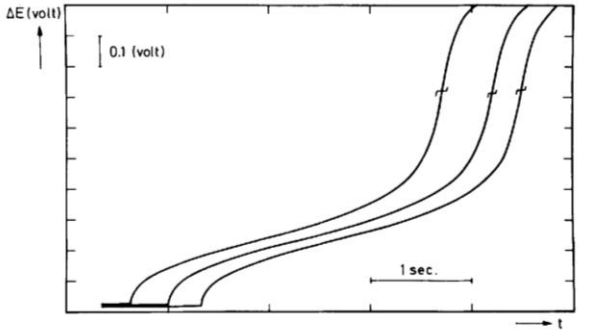

FIG. 1

Typical chronopotentiograms of the reaction Pu(III) → Pu(IV) + e
t^o = 500°C $[Pu(III)] = 0.6.10^{-4}$ mole.cm^{-3}
i_o = $26.1.10^6$ u.e.c.g.s.cm^{-2}

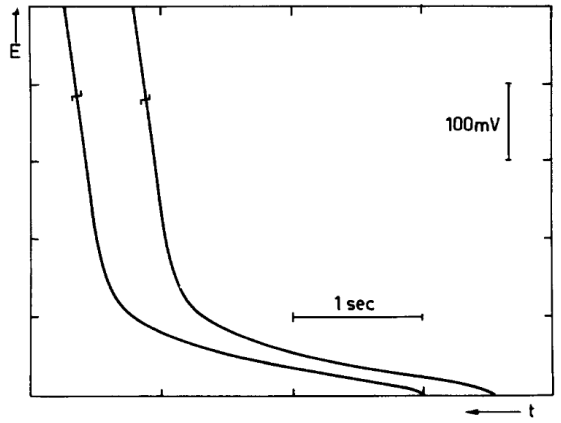

FIG. 1

Chronopotentiometric reduction of Pu(IV) in LiCl-KCl at 500°C
i_o = 1.4 mA, $[Pu(IV)] = 31.93\ 10^{-3}$ m.f.

TABLE II

Activation energy, ΔH (K.cal.mole^{-1}), for the diffusion of tetravalent actinide ions in LiCl-KCl

t(°C)	U(IV)	Np(IV)	Pu(IV)
425	11.1	11.0	10.3
475	9.4	9.5	9.7
525		7.5	9.5
575			9.2
625			9.3

TABLE I

Diffusion coefficients D.10^6 (cm^2 sec^{-1}) of tetravalent actinide ions in LiCl-KCl

t(°C)	U(IV)	Np(IV)	Pu(IV)
400	4.45 ± 0.2	4.65 ± 0.2	4.2 ± 0.2
450	8.0 ± 0.15	8.1 ± 0.1	7.2 ± 0.2
500	12.15 ± 0.2	11.7 ± 0.2	11.2 ± 0.25
550		15.75 ± 0.25	16.2 ± 0.25
600			22.4 ± 0.28
650			30.0 ± 0.5

TABLE XXII. STANDARD POTENTIAL FOR Pu(IV)|Pu(III) IN LiCl-KCl

t (°C)	$E^0_{Pu(IV)\,|\,t\,Pu(III)} - E^0_{Cl_2\,|\,2Cl^-}$ (V)
400	1.024
450	0.994
500	0.967

The standard potential for Pu(IV)|Pu(III) in LiCl - KCl has been recently measured by Martinot and Duyckaerts (Table XXII) and the thermodynamic quantities for the reaction $AgCl + PuCl_3 \rightarrow Ag^0 + PuCl_4$ were calculated:

	400°C	450°C	500°C
$-\Delta F^0$ (kcal/mole)	16.5	15.9	15.3
$-\Delta H^0$ (kcal/mole)	24.4	24.4	24.4
$-\Delta S^0$ (e.u.)	11.5	11.5	11.5

Martinot, L. & Duyckaerts, G. (1970). *Inorg. Nucl. Chem. Lett.*, *6*(6), 587.
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Martinot, L. & Fuger, J. (1986). *J. Less-Common Met.*, *120*, 255

The White Whale: $Pu^{4+/3+}$

Does it exist?

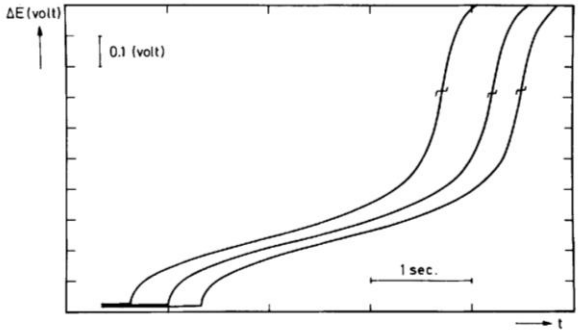

FIG. 1

Typical chronopotentiograms of the reaction Pu(III) → Pu(IV) + e
t° = 500°C [Pu(III)] = $0.6.10^{-4}$ mole.cm^{-3}
i_o = $26.1.10^6$ u.e.c.g.s.cm^{-2}

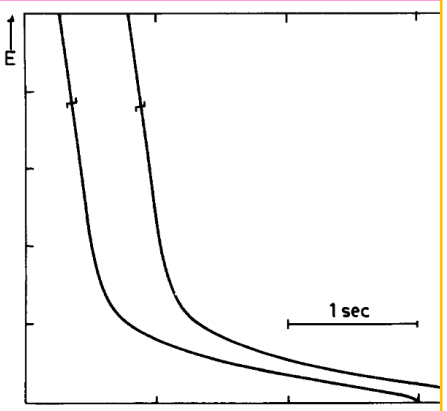

FIG. 1

Chronopotentiometric reduction of Pu(IV) in L
i_o = 1.4 mA, [Pu(IV)] = 31.93 10^{-}

TABLE XXII. STANDARD POTENTIAL FOR Pu(IV)|Pu(III) IN LiCl-KCl

t (°C)	$E^0_{Pu(IV)\,|\,t\,Pu(III)} - E^0_{Cl_2\,|\,2Cl^-}$ (V)

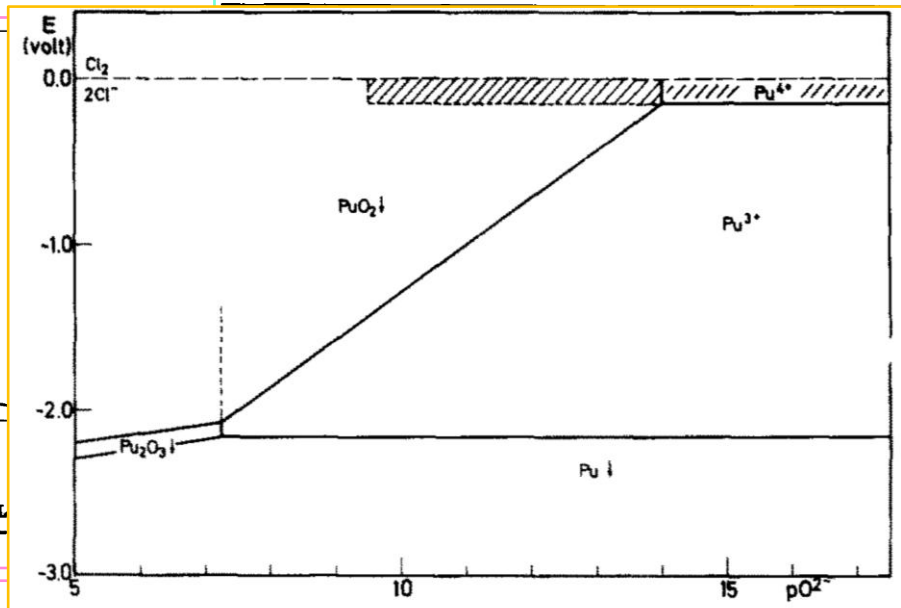

Fig. 4. Potential–pO^{2-} diagram of plutonium in (Li–K)Cl at 450 °C: $[Pu^{3+}] = [Pu^{4+}] = 10^{-2}$ mol l^{-1}.

This diagram must be considered only as tentative because a large error is involved in the value of $L(PuO_2)$.

TABLE II

Activation energy, ΔH (K.cal.mole^{-1}), for the diffusion of tetravalent actinide ions in LiCl-KCl

t(°C)	U(IV)	Np(IV)	Pu(IV)
425	11.1	11.0	10.3
475	9.4	9.5	9.7
525		7.5	9.5
575			9.2
625			9.3

TABLE I

Diffusion coefficients D.10^6 (cm^2 sec^{-1}) of tetravalent actinide ions in LiCl-KCl

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450	8.0 ± 0.15	8.1 ± 0.1	7.2 ± 0.2
500	12.15 ± 0.2	11.7 ± 0.2	11.2 ± 0.25
550		15.75 ± 0.25	16.2 ± 0.25
600			22.4 ± 0.28
650			30.0 ± 0.5

our equilibrium diagram (Fig. 4). The standard potential of the couple Pu^{3+}–Pu^0 is equal to −2.86 V *versus* Cl_2–$2Cl^-$ at 450 °C [20]. The only acceptable value for $E^\circ_{Pu^{4+}-Pu^{3+}}$ has been deduced from spectroscopic investigations [6] and found equal to −0.050 V *versus* Cl_2–$2Cl^-$ at 400 °C; our determination by cyclic voltammetry gives $E^\circ_{Pu^{4+}-Pu^{3+}}$ = −0.15 V at 450 °C. We use the latter value in Fig. 4.

Martinot, L. & Duyckaerts, G. (1970). *Inorg. Nucl. Chem. Lett.*, *6*(6), 587.
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Martinot, L. & Fuger, J. (1986). *J. Less-Common Met.*, *120*, 255

The White Whale: $Pu^{4+/3+}$

Does it exist?

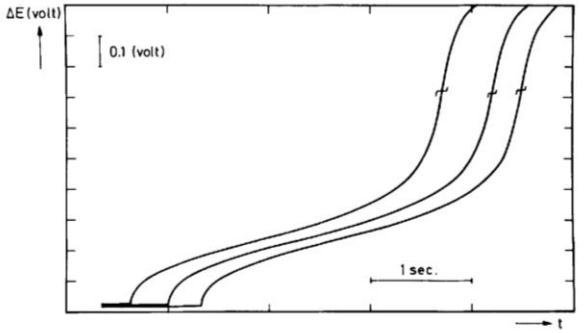


FIG. 1

Typical chronopotentiograms of the reaction Pu(III) → Pu(IV) + e
t° = 500°C [Pu(III)] = $0.6.10^{-4}$ mole.cm^{-3}
i_o = $26.1.10^6$ u.e.c.g.s.cm^{-2}

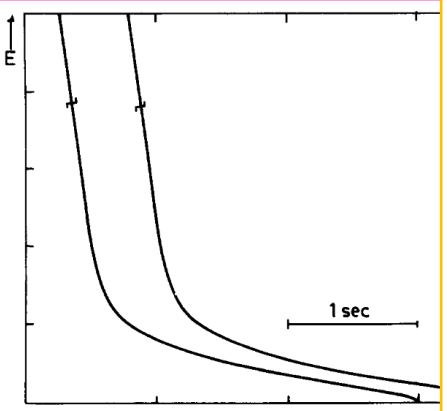
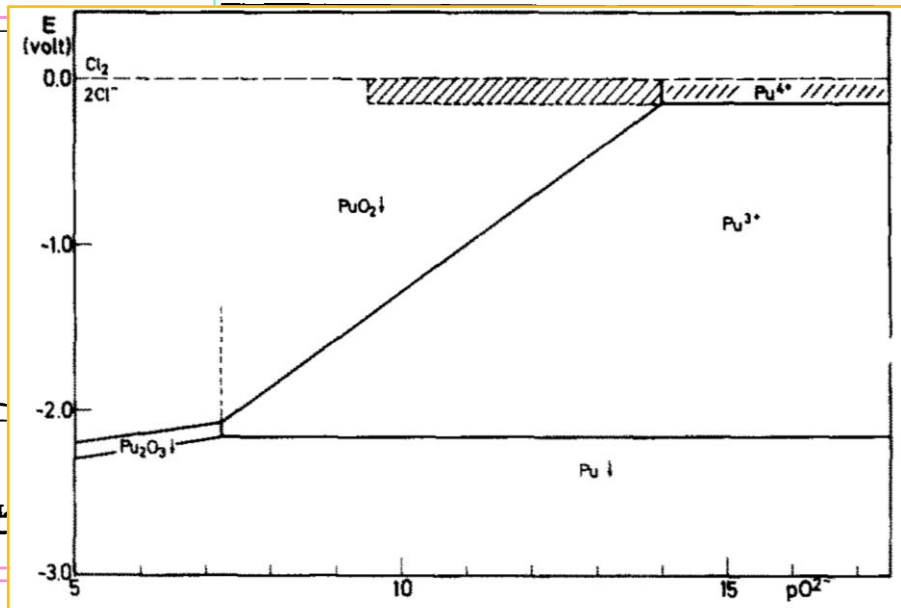


FIG. 1

Chronopotentiometric reduction of Pu(IV) in L
i_o = 1.4 mA, [Pu(IV)] = 31.93 10^{-}

TABLE XXII. STANDARD POTENTIAL FOR Pu(IV)|Pu(III) IN LiCl-KCl

t (°C)	$E^0_{Pu(IV)\,|\,t\,Pu(III)} - E^0_{Cl_2\,|\,2Cl^-}$ (V)



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Activation energy, ΔH (K.cal.mole^{-1}), for the diffusion of tetravalent actinide ions in LiCl-KCl

t(°C)	U(IV)	Np(IV)	Pu(IV)
425	11.1	11.0	10.3
475	9.4	9.5	9.7
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Martinot, L. & Fuger, J. (1986). *J. Less-Common Met.*, *120*, 255

The White Whale: $Pu^{4+/3+}$

Does it exist?

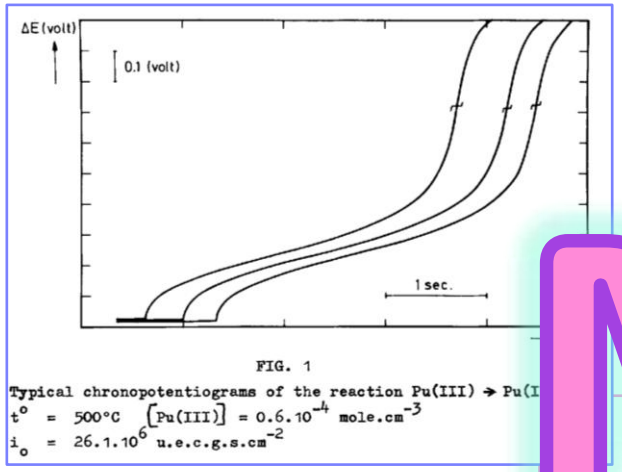

FIG. 1

Typical chronopotentiograms of the reaction Pu(III) → Pu(I
t° = 500°C [Pu(III)] = $0.6.10^{-4}$ mole.cm^{-3}
i_o = $26.1.10^6$ u.e.c.g.s.cm^{-2}

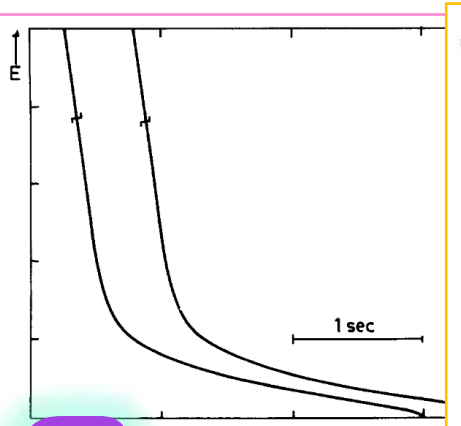

FIG. 1

Chro tric
.4 m
L E
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ole
ent
e ion
-KCl

(°C)	U(IV)	Np	Pu(IV)
425	11.1	11.0	10.3
475	9.4	9.5	9.7
525		7.5	9.5
575			9.2
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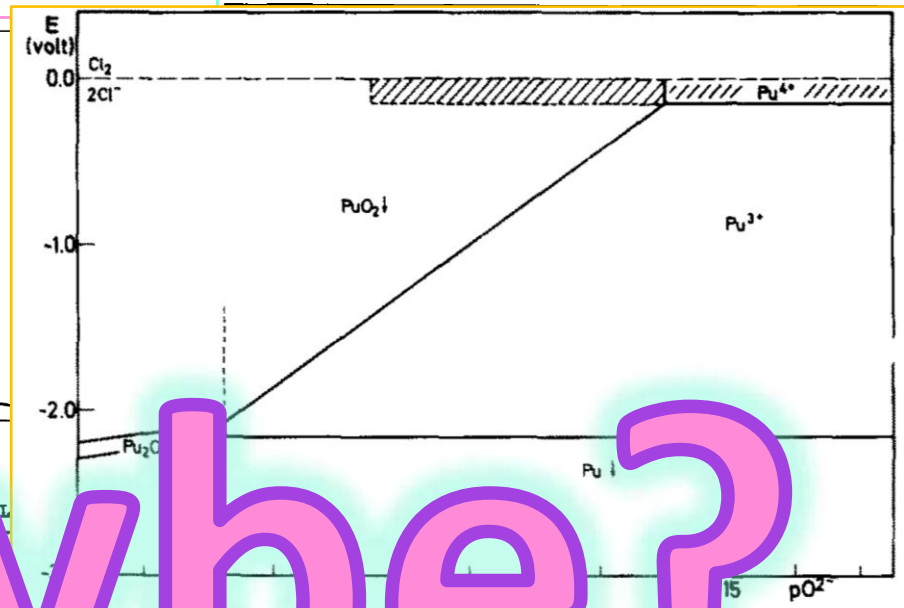
t (°C)	$E^0_{Pu(IV)\,|\,t\,Pu(III)} - E^0_{Cl_2\,|\,2Cl^-}$ (V)



4. P ial-p d m of plutonium in (Li–K)Cl at 450 °C: $[Pu^{3+}] = [Pu^{4+}] =$ mol

This diagram must be considered only as tentative because a large error is involved in the value of $L(PuO_2)$.

TABLE I

Diffusion coefficients $D.10^6$ ($cm^2\ sec^{-1}$) of tetravalent actinide ions in LiCl-KCl

t(°C)	U(IV)	Np(IV)	Pu(IV)
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600			22.4 ± 0.28
650			30.0 ± 0.5

Maybe?

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Martinot, L. & Fuger, J. (1986). *J. Less-Common Met.*, *120*, 255

GEN IV International Forum
Expertise | Collaboration | Excellence

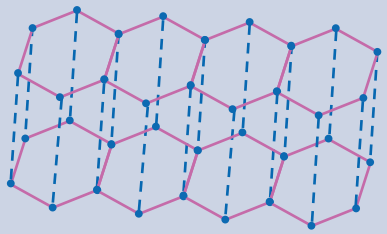
The Key:

Boron Doped Diamond

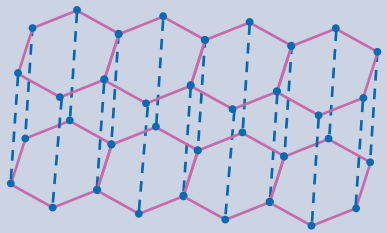
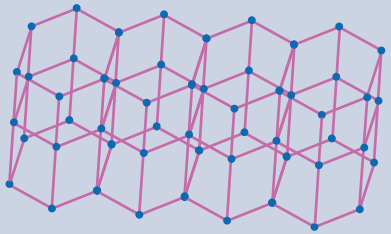
Diamond & Carbon Hybridization

sp
C≡C
1 σ, 2 π
H-C≡C-H

Diamond & Carbon Hybridization

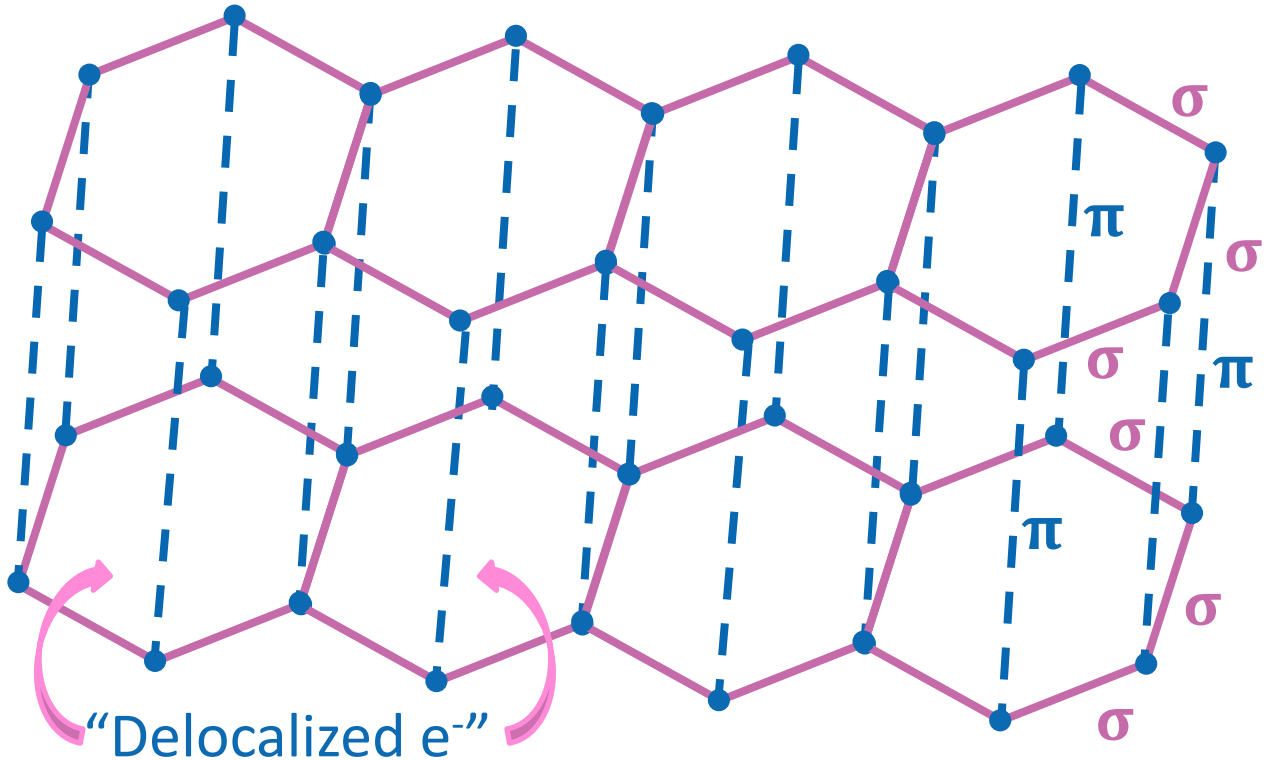
sp	sp^2	
C≡C	C=C	C-C C-C
1 σ, 2 π	1 σ, 1 π	1 σ, π plane
H-C≡C-H		

Diamond & Carbon Hybridization

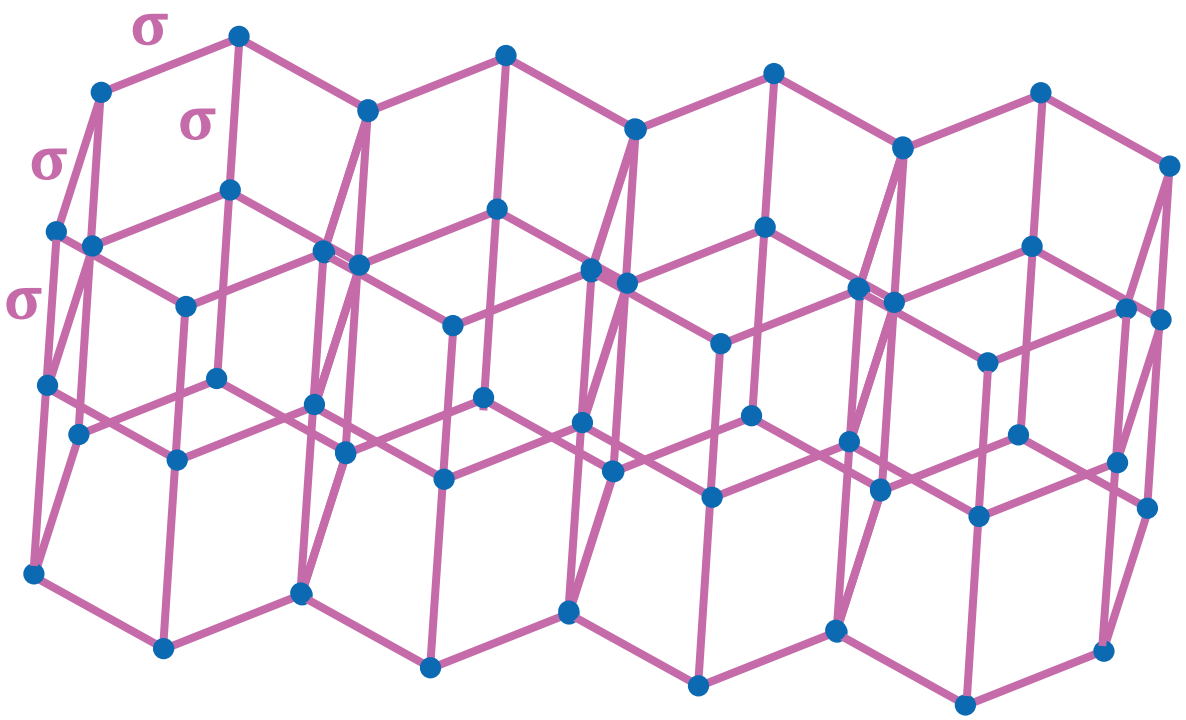
sp	sp^2		sp^3	
C≡C	C=C	C-C C-C	C-C	
1 σ, 2 π	1 σ, 1 π	1 σ, π plane	1 σ	
H-C≡C-H			**H H** **H-C-C-H** **H H**	

Diamond & Carbon Hybridization

Graphite Sheets



Diamond Crystal



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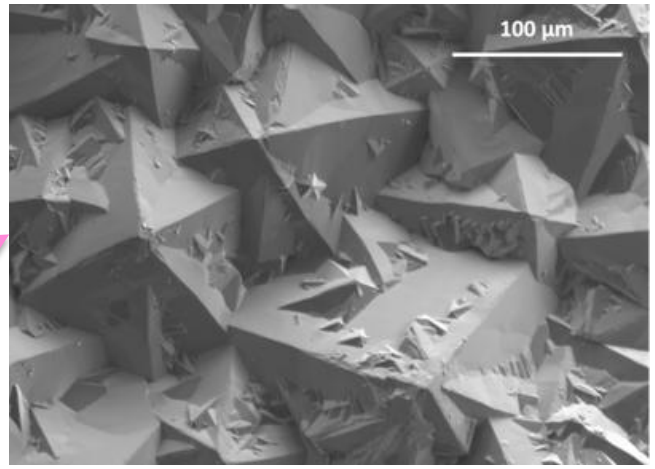
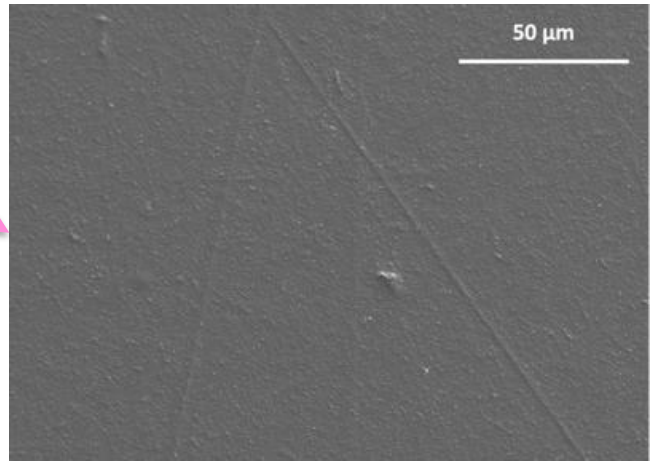
• Carbon atom – – – – Pi Bond ——— Sigma Bond

Boron Doped Diamond

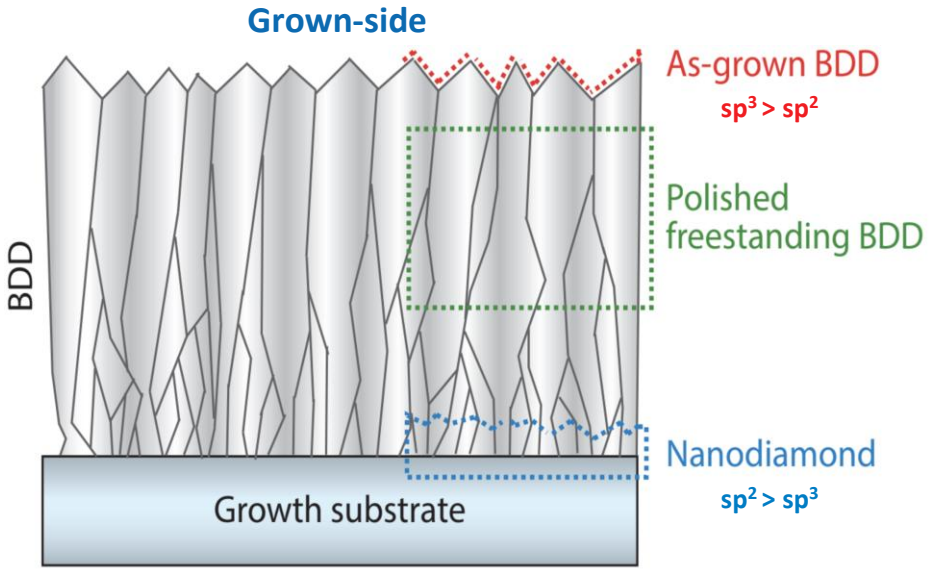
Free-Standing BDD



Grown-side



Nucleation-side



Cobb et al., *Annu. Rev. Anal. Chem.*, **2018**.

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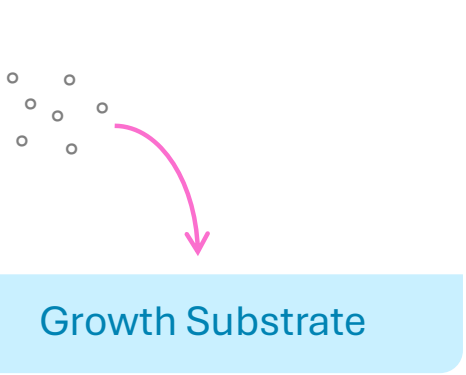
Boron Doped Diamond (BDD): Chemical Vapor Deposition

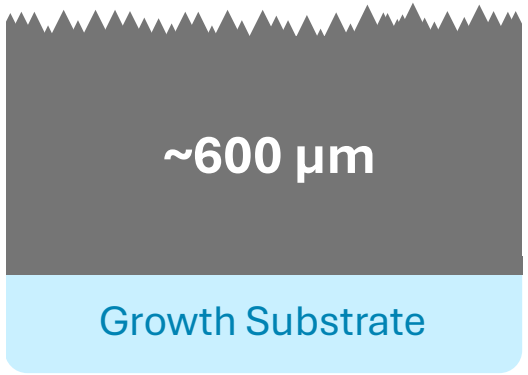
CVD Growth of Polycrystalline BDD

A) Free-Standing BDD

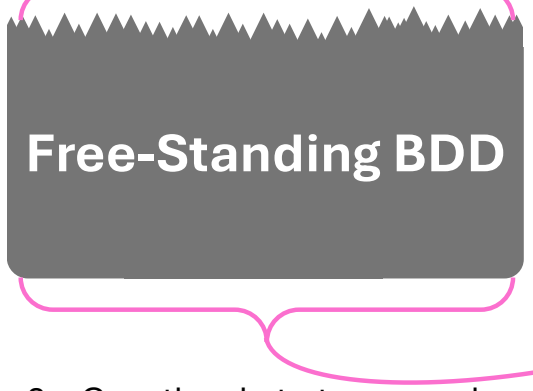
Thick polycrystalline layer with growth substrate removal.



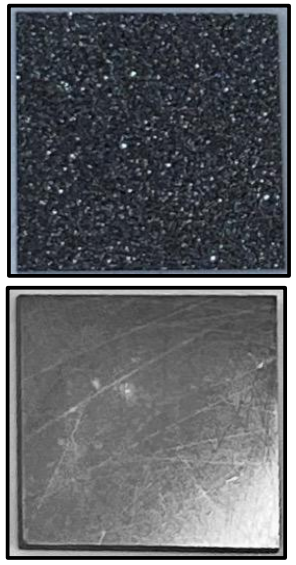
1. Diamond nano-particle scratched into growth substrate.



2. CVD Polycrystalline BBD growth via plasma decomp. of H_2, CH_4, and B_2H_6.

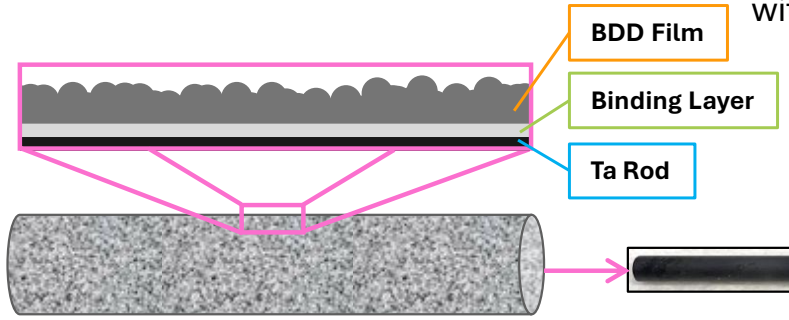


3. Growth substrate removal via etching or polishing to leave free-standing BDD with two distinct sides.



B) Thin-Film BDD

Thin polycrystalline layer that remains on the original growth substrate with adherence supported by a binding layer (e.g., Cr).



Roughness & sp^3/sp^2:

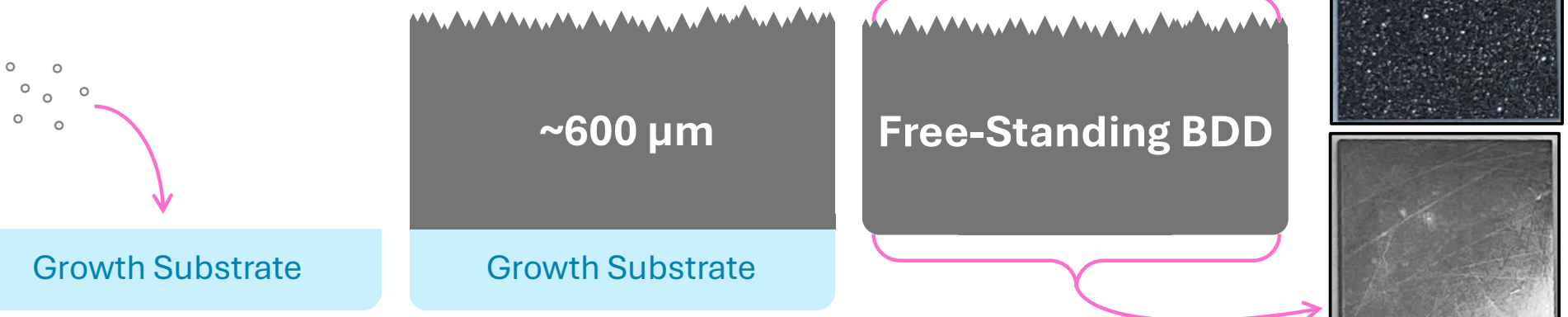
FSBDD-g >> TFBDD > FSBDD-n

Boron Doped Diamond (BDD): Chemical Vapor Deposition

CVD Growth of Polycrystalline BDD

A) Free-Standing BDD

Thick polycrystalline layer with growth substrate removal.



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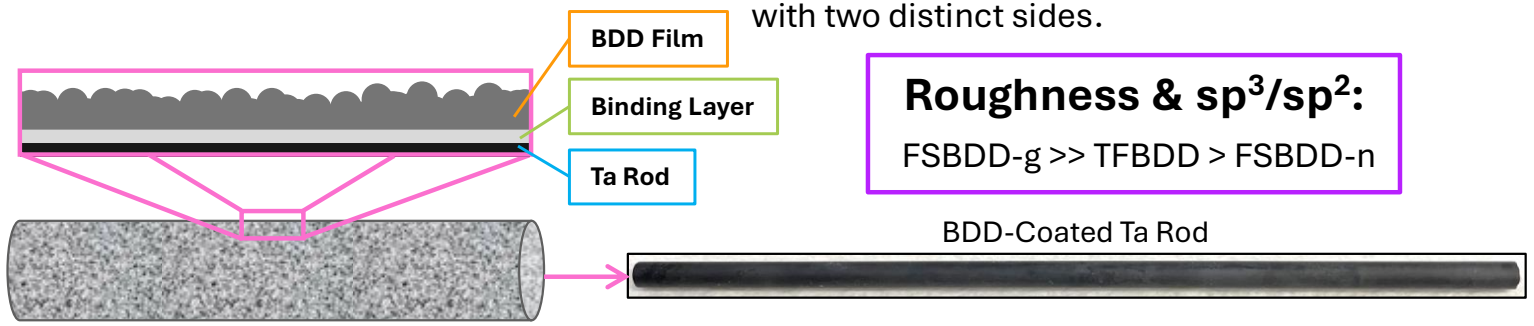
2. CVD Polycrystalline BBD growth via plasma decomp. of H_2, CH_4, and B_2H_6.
3. Growth substrate removal via etching or polishing to leave free-standing BDD with two distinct sides.

B) Thin-Film BDD

Thin polycrystalline layer that remains on the original growth substrate with adherence supported by a binding layer (e.g., Cr).



Roughness & sp^3/sp^2:

FSBDD-g >> TFBDD > FSBDD-n

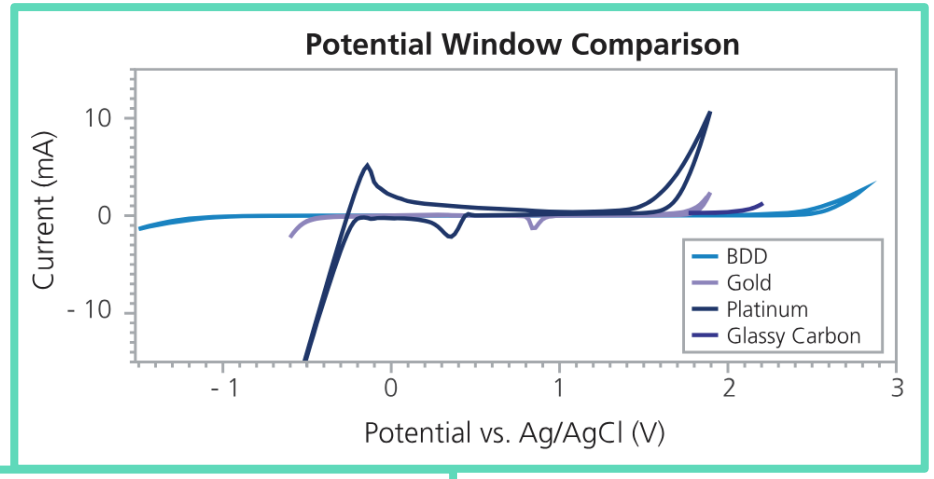
FSBDD: grown + nucleation

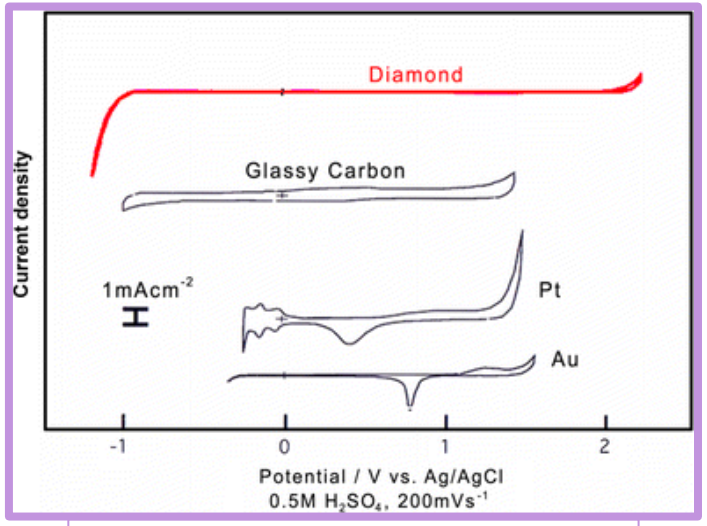
FSBDD-g: grown

FSBDD-n: nucleation

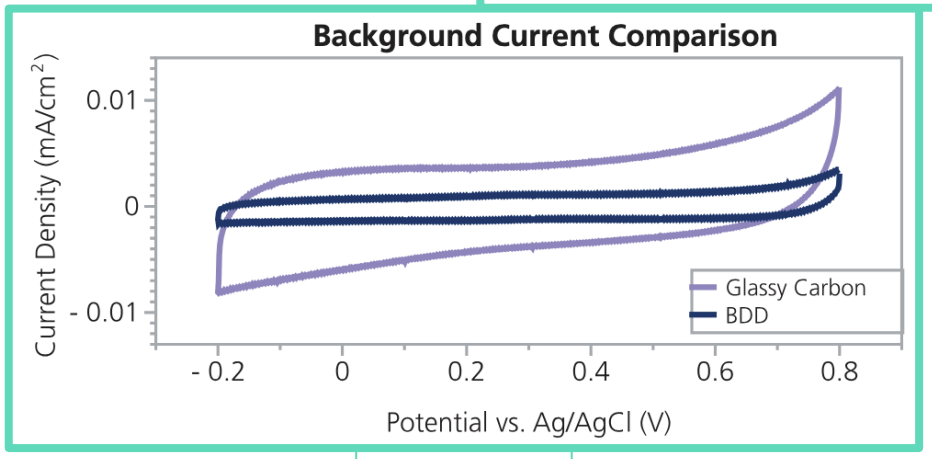
TFBDD: thin-film

Boron Doped Diamond (BDD): Comparative Performance

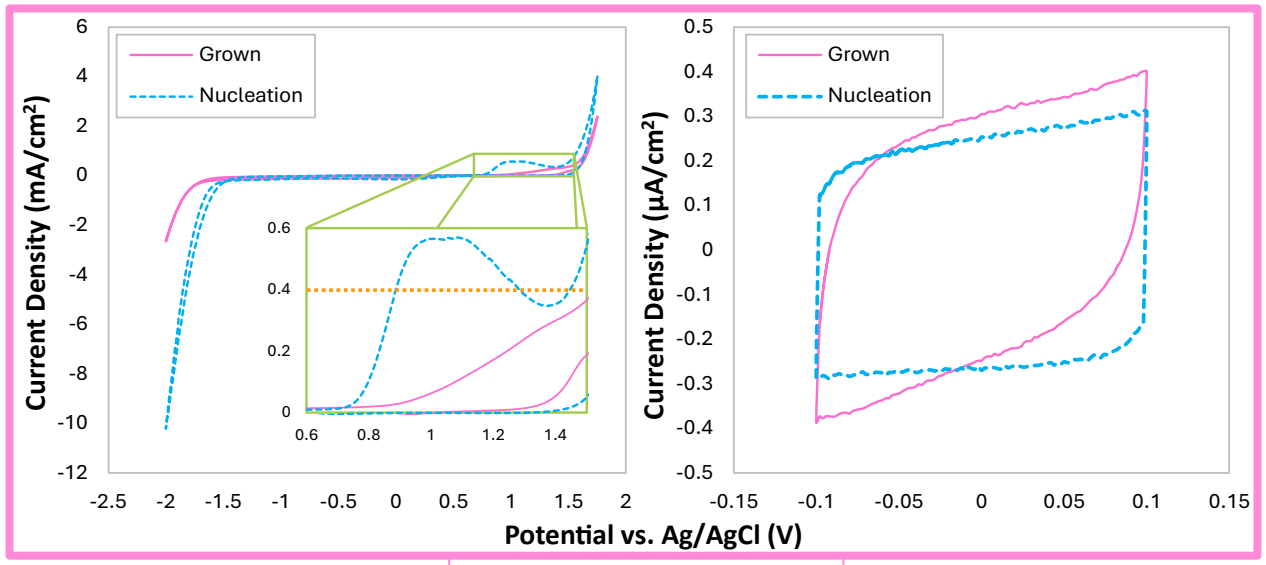




Einaga, Y. *J. App. Electrochem.*, *40*, 1807 (2010).



Fraunhofer USA



Patenaude et al., *in preparation*

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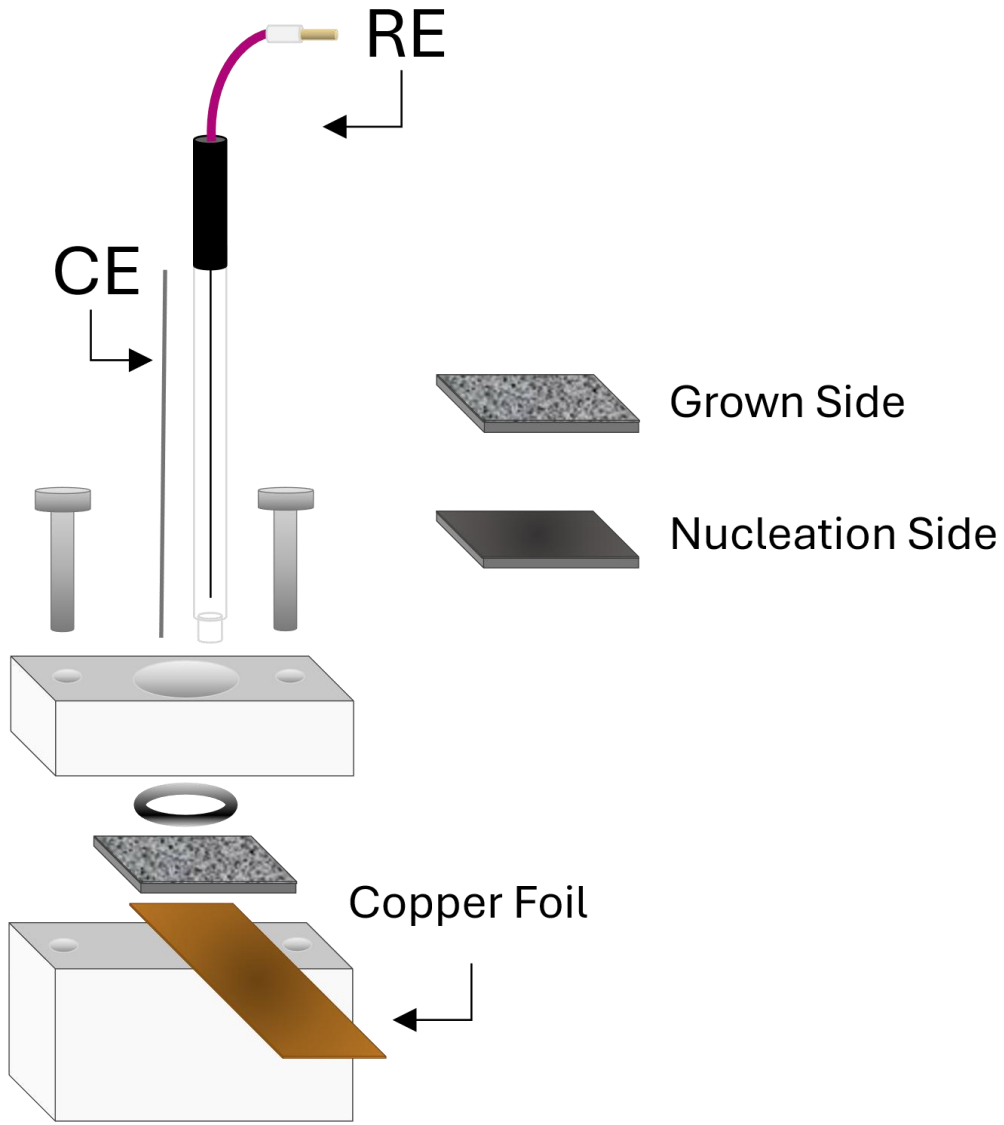
Aqueous Cyclic Voltammetry

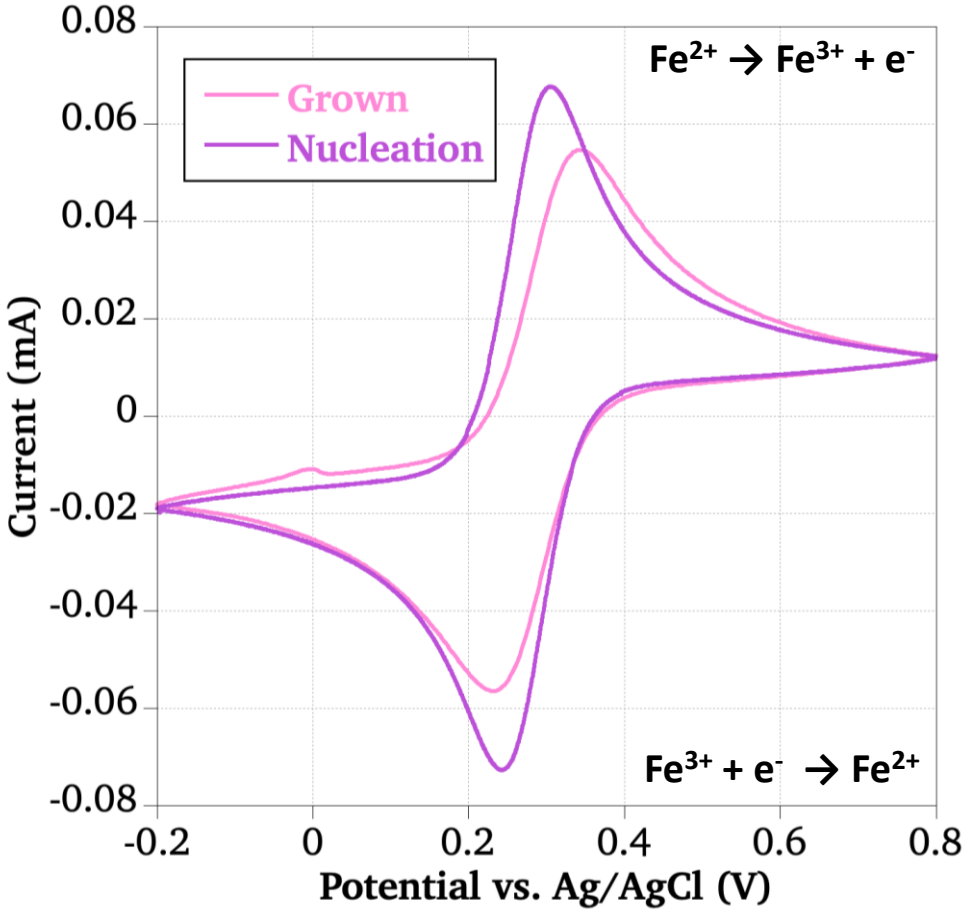
- **Side-Isolating Cell**
- **WE:** Grown or Nucleation Side, BDD
- **RE:** Ag/AgCl (3.5 M KCl)
- **CE:** Pt Wire
- **Sample Solutions**
  - 1 mM $K_3Fe(CN)_6$ (1 M KCl)
  - 1 mM $Cl_3Ru(NH_3)_6$ (1 M KCl)
- **Scan Rate Studies**
  - 10, 25, 50, 75, 100 mV/s

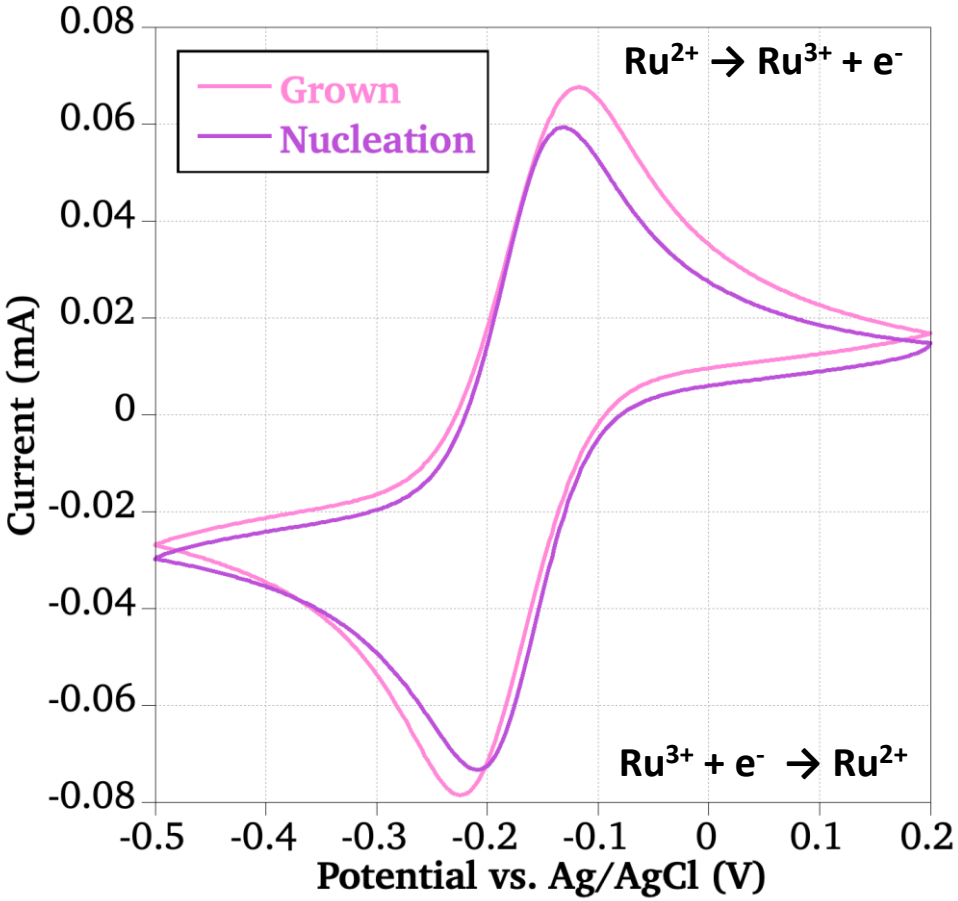


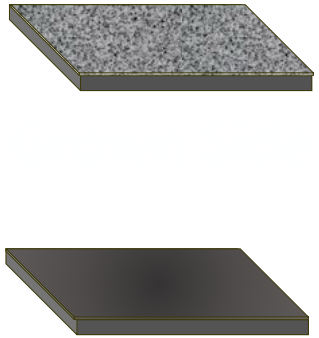
Aqueous Cyclic Voltammetry

$$Fe(CN)_6^{3-} + e^- \rightleftharpoons Fe(CN)_6^{4-}$$

$$Ru(NH_3)_6^{3+} + e^- \rightleftharpoons Ru(NH_3)_6^{2+}$$







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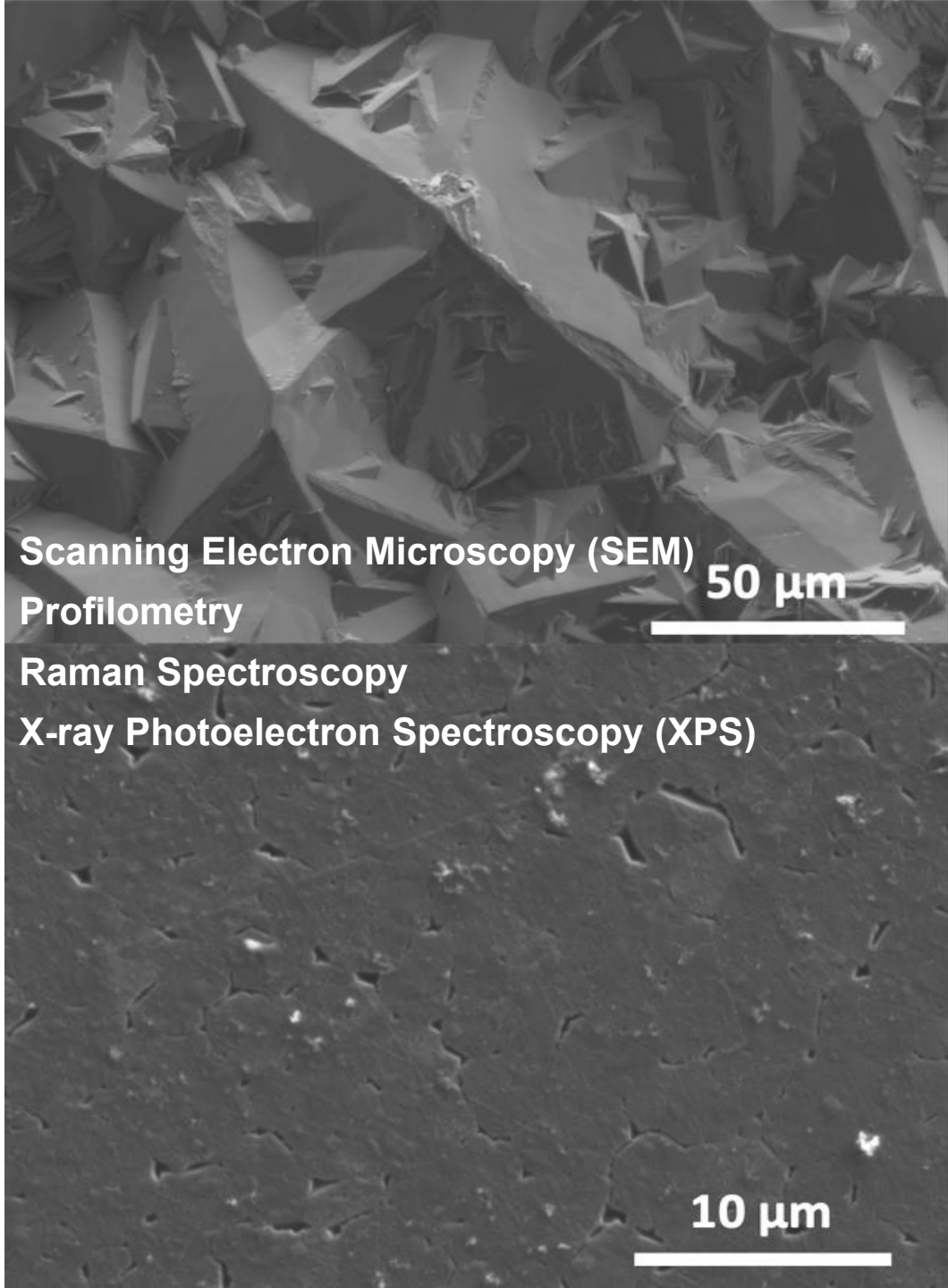
Exposure Studies:
Does BDD Survive Molten Salts?

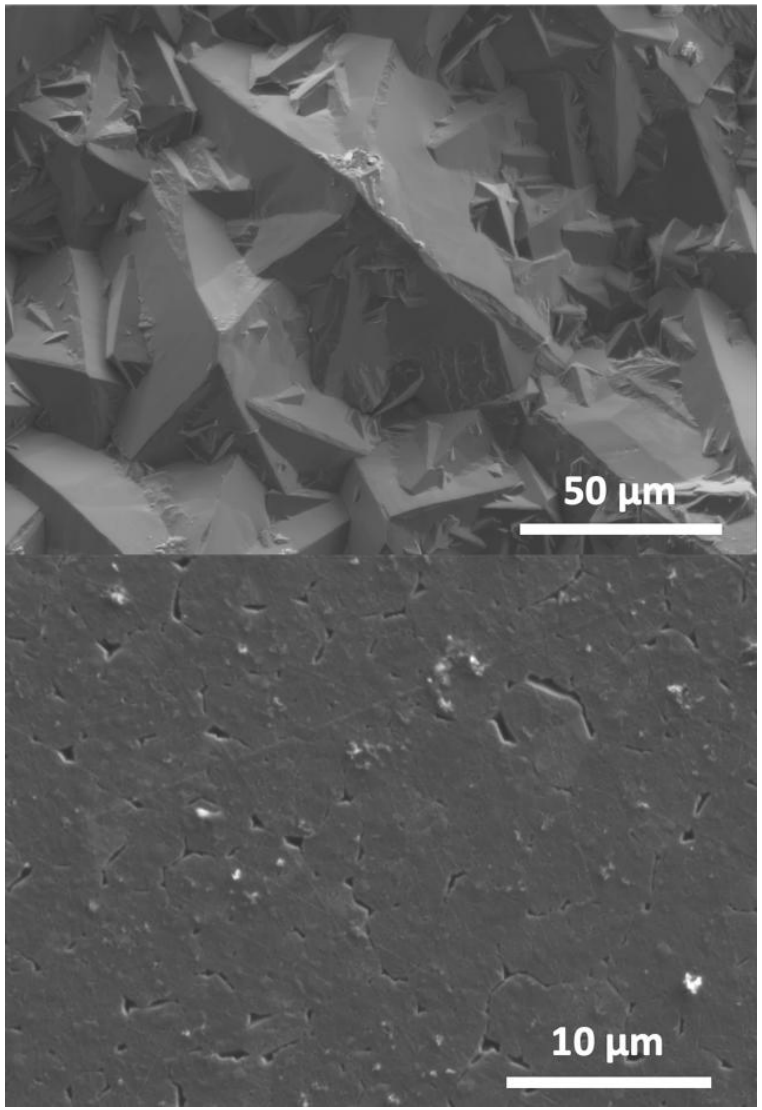
Salt Exposure

NaCl-KCl	FLiNaK
50-50 mol%	46.5-11.5-42 mol% LiF-NaF-KF
700 °C	500 °C

- 10 Day Hold
- 'As received' salt:
  - Furnace in fume hood
- Thermally dried salt
  - Vacuum oven antechamber
  - Furnace in glovebox
  - Ar(*g*), <0.5 ppm O_2, <0.5 ppm H_2O

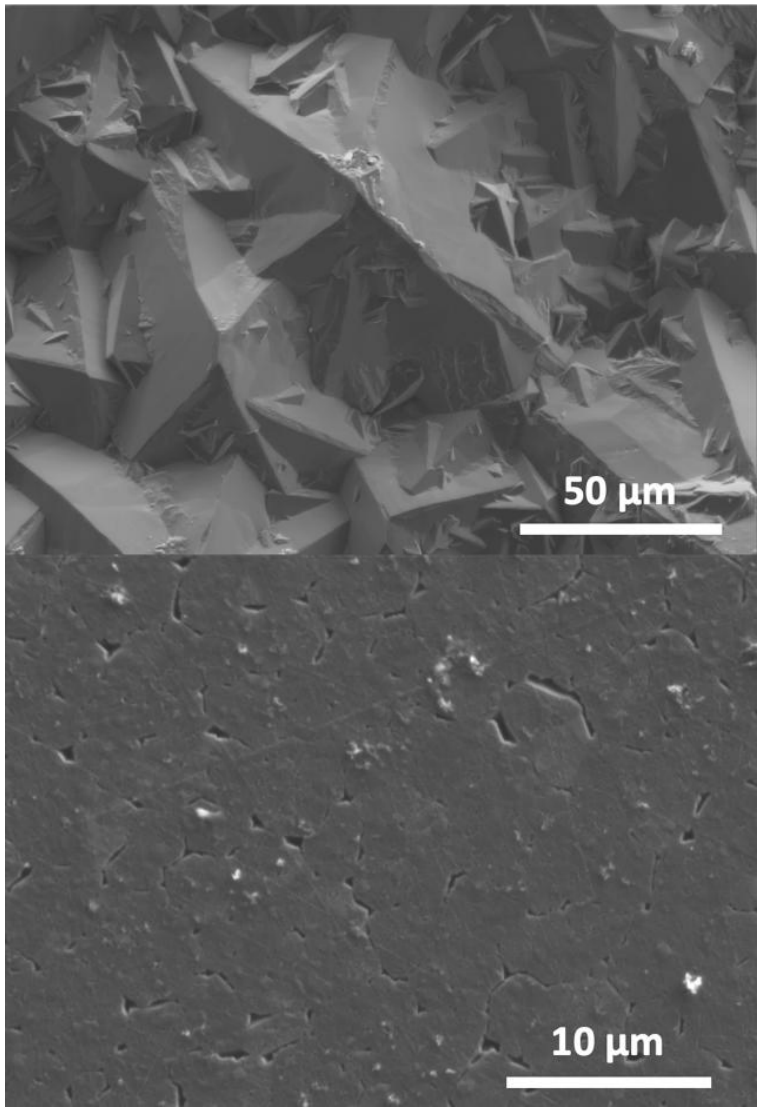


Scanning Electron Microscopy (SEM): NaCl-KCl Exposure



New

Scanning Electron Microscopy (SEM): NaCl-KCl Exposure



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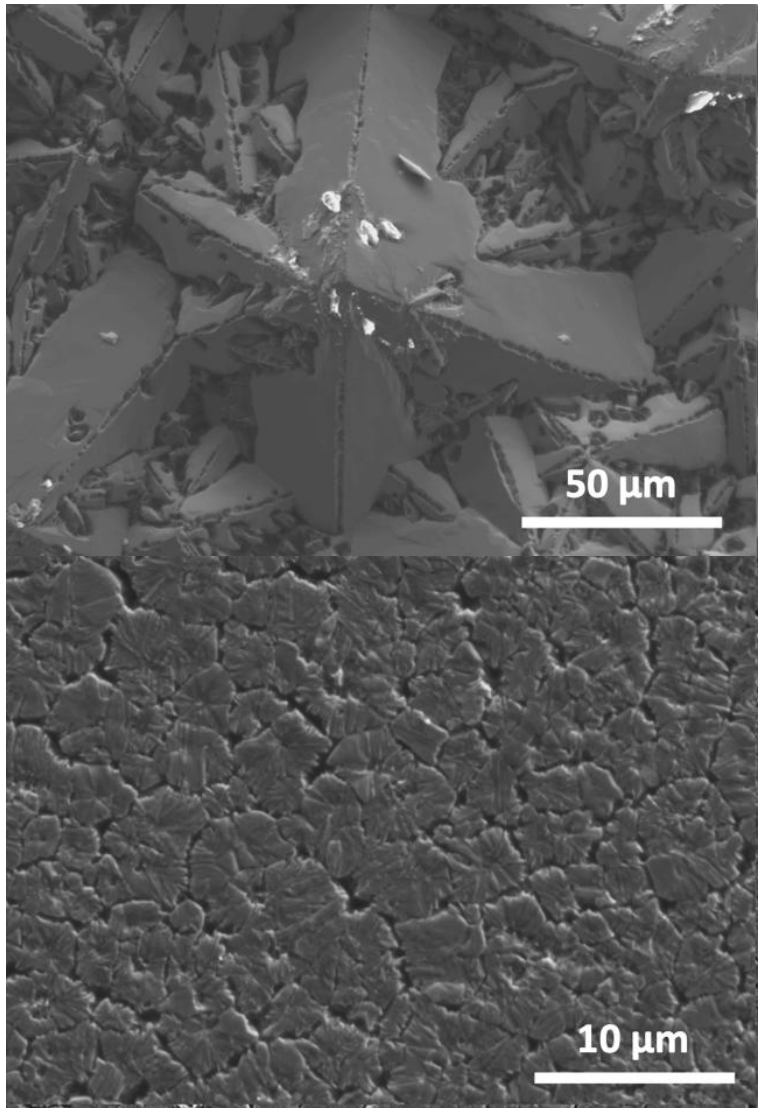
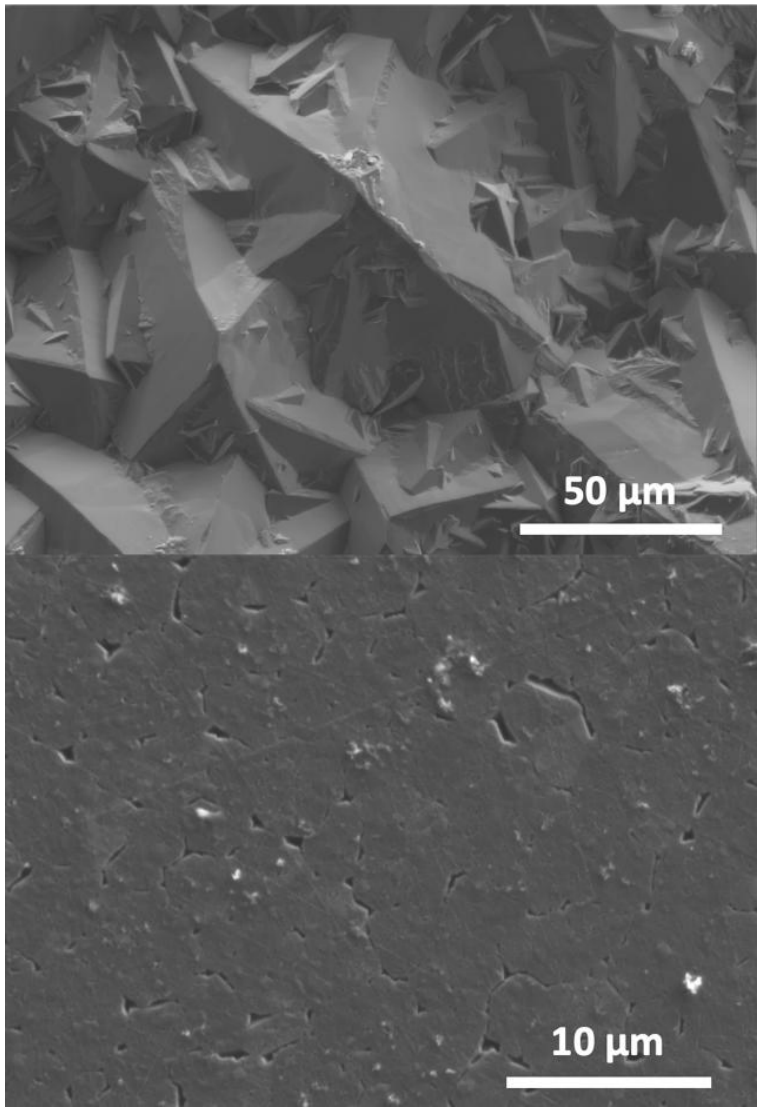


Not Dried | Fume Hood

Scanning Electron Microscopy (SEM): NaCl-KCl Exposure



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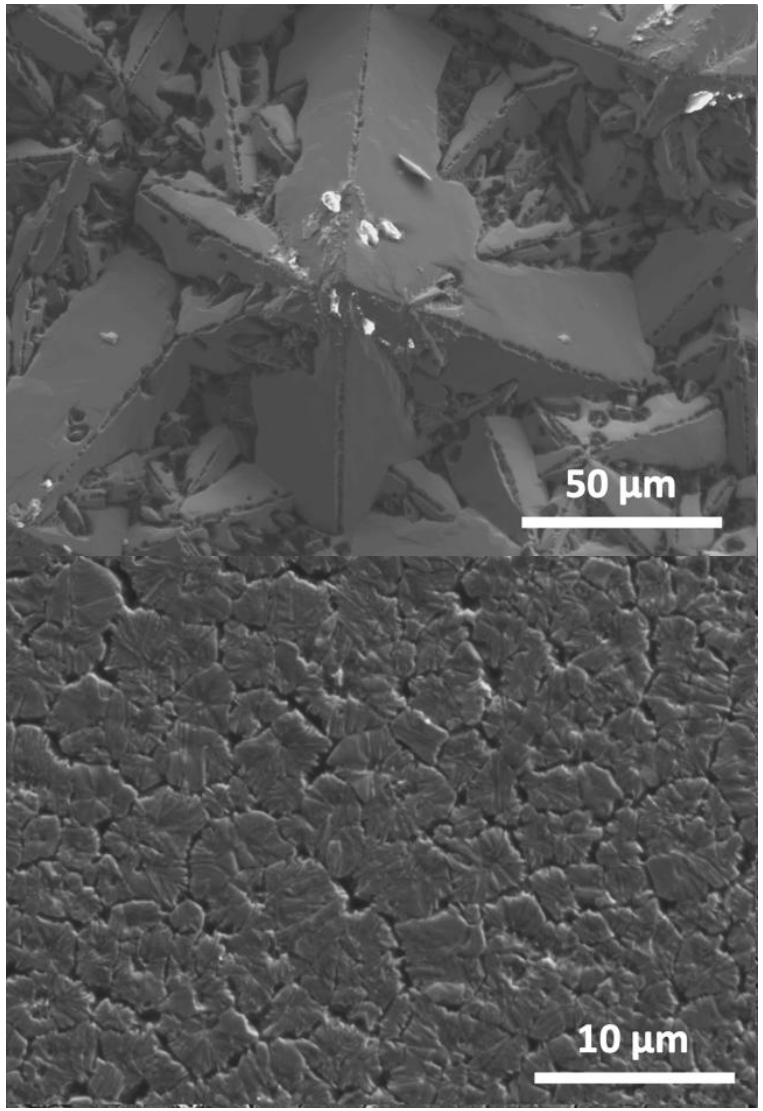
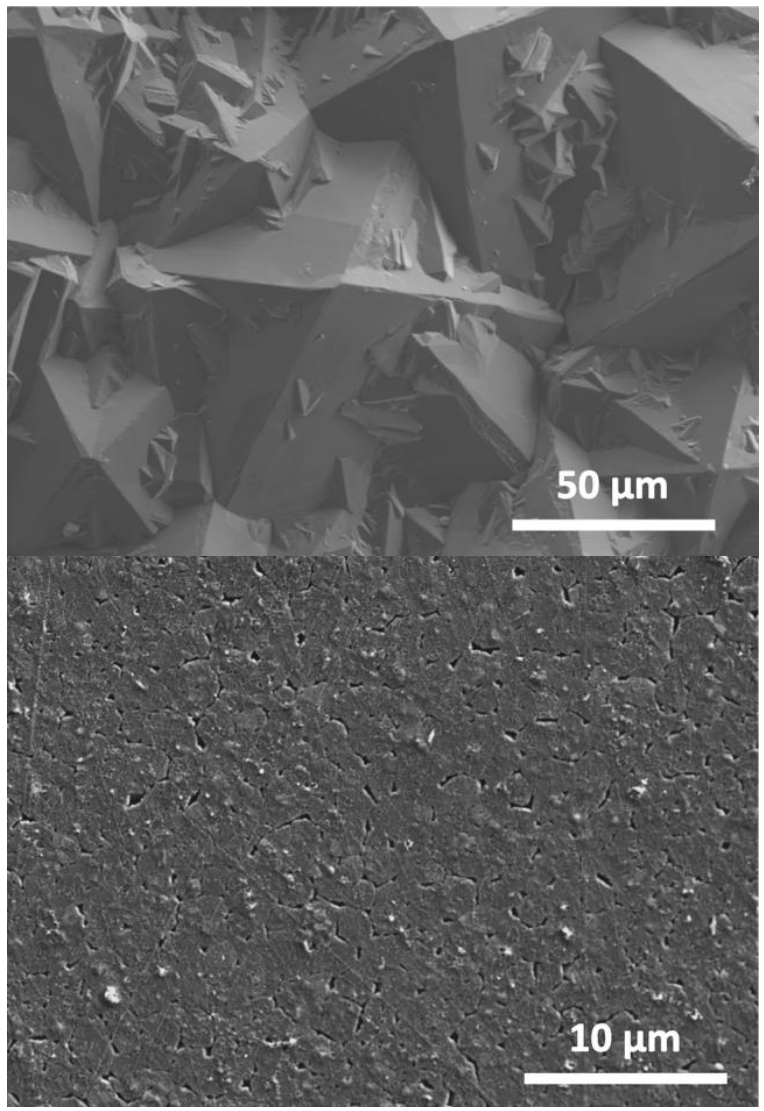
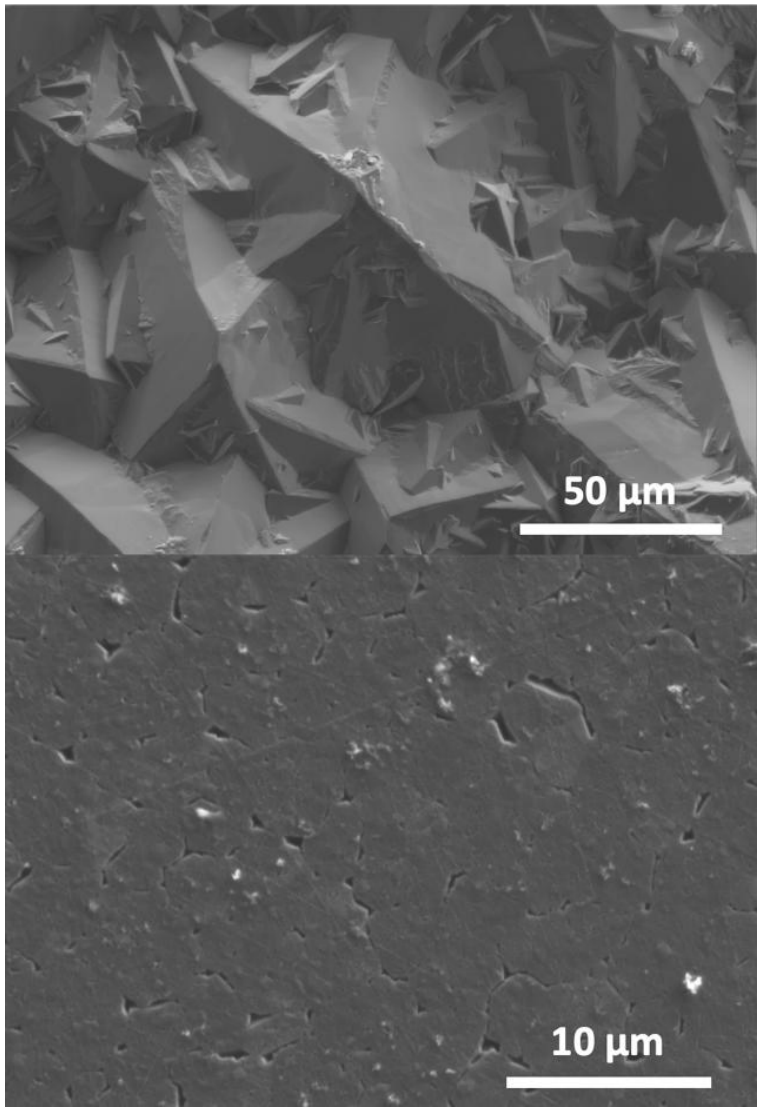


Not Dried | Fume Hood

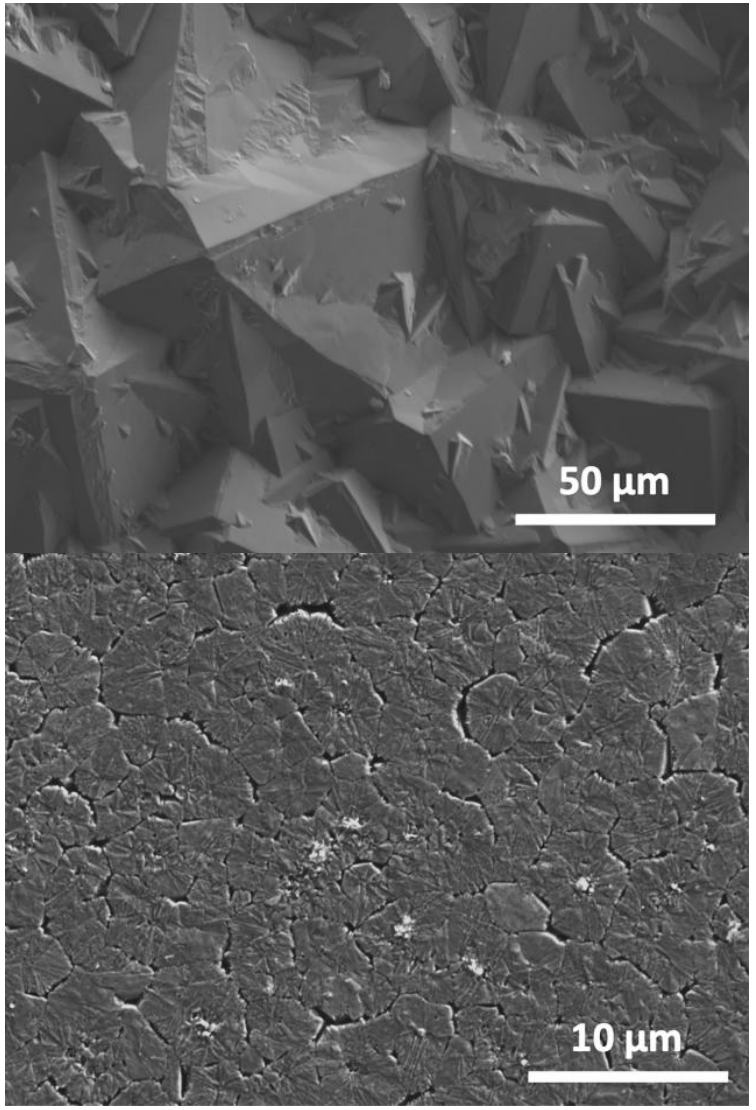


Dried | Glovebox

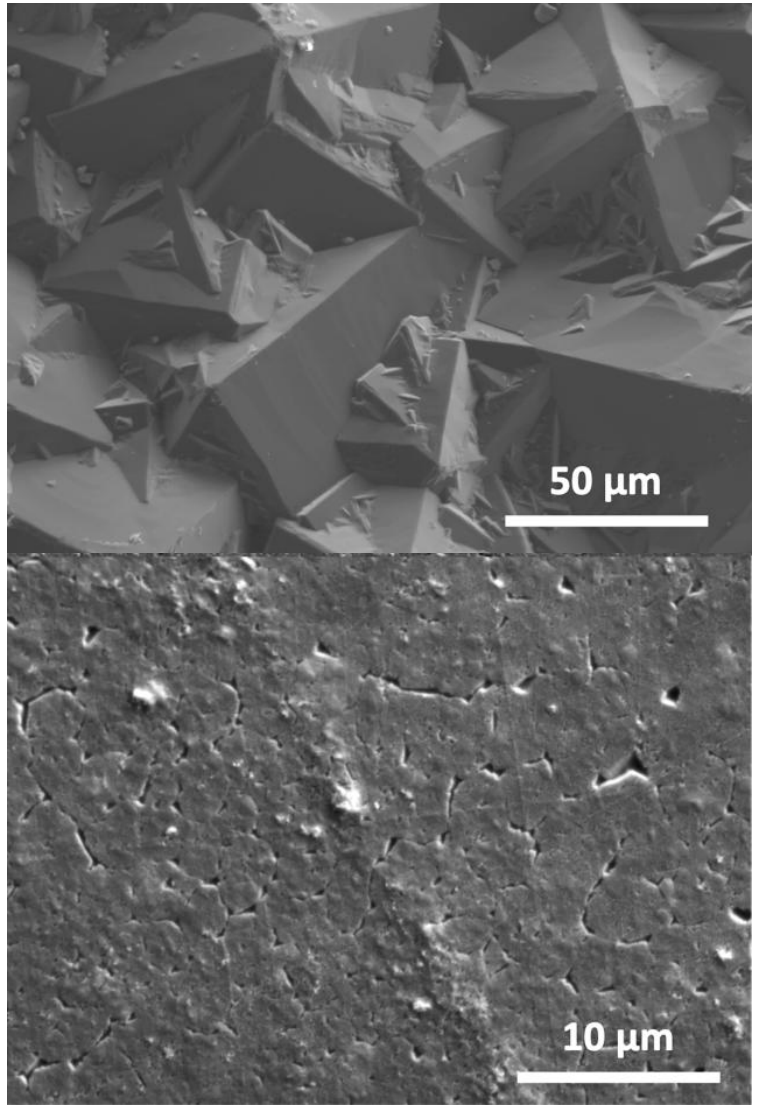
Scanning Electron Microscopy (SEM): FLiNaK Exposure



New



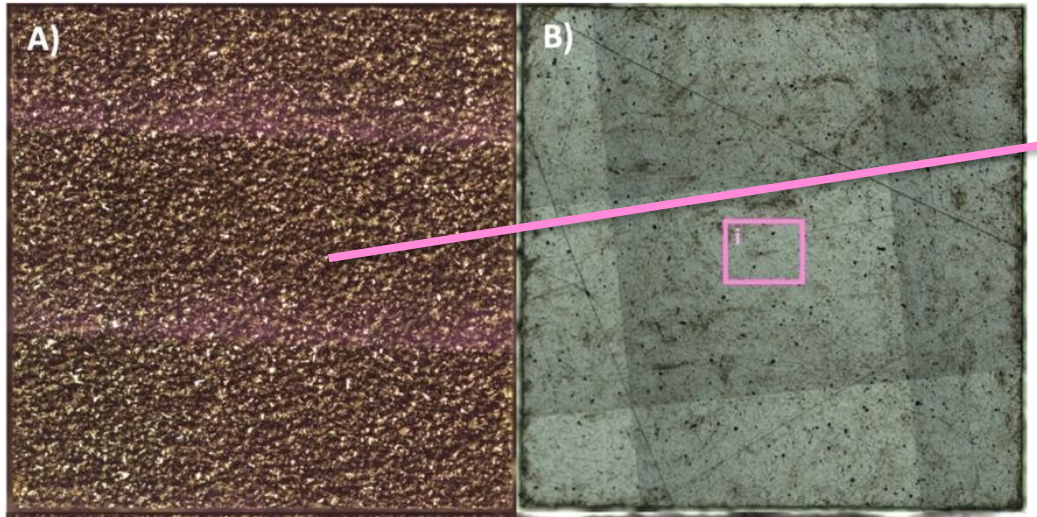
Not Dried | Fume Hood

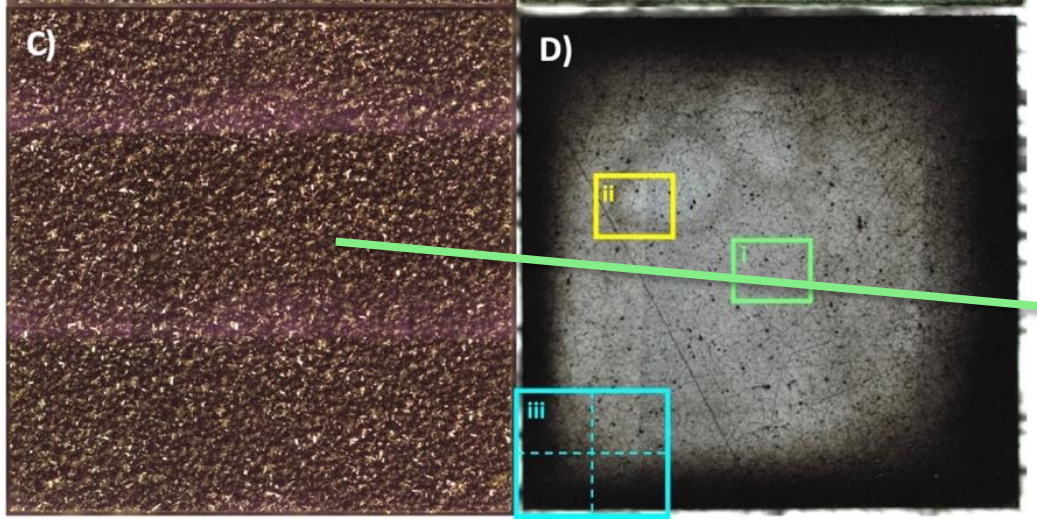


Dried | Glovebox

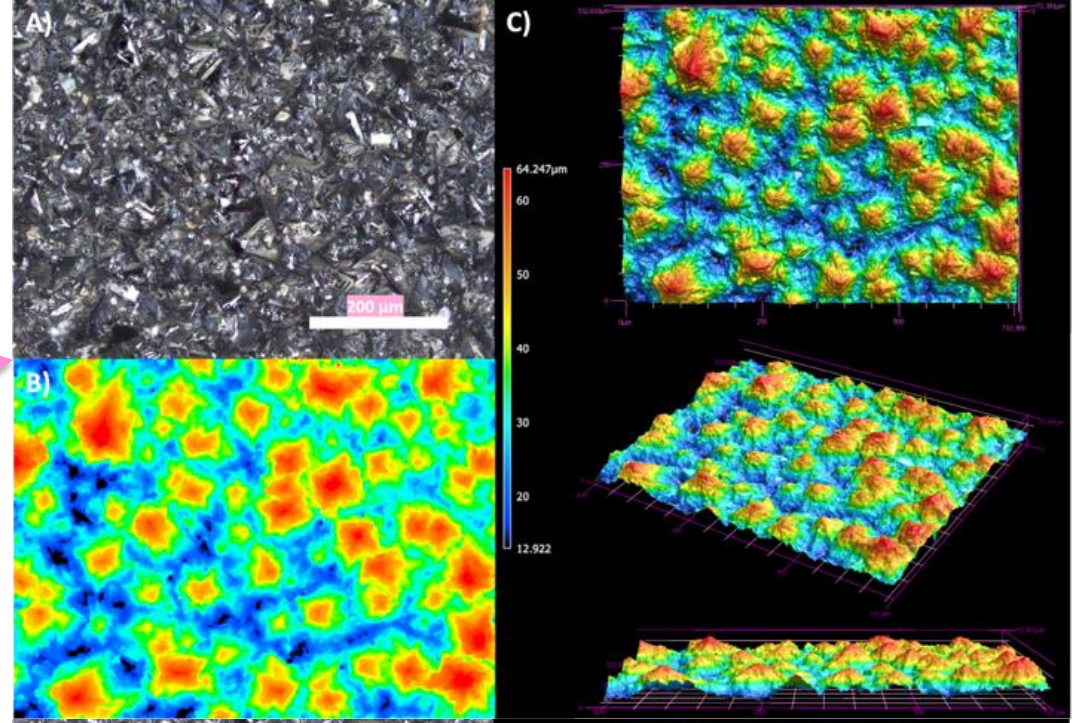
Profilometry

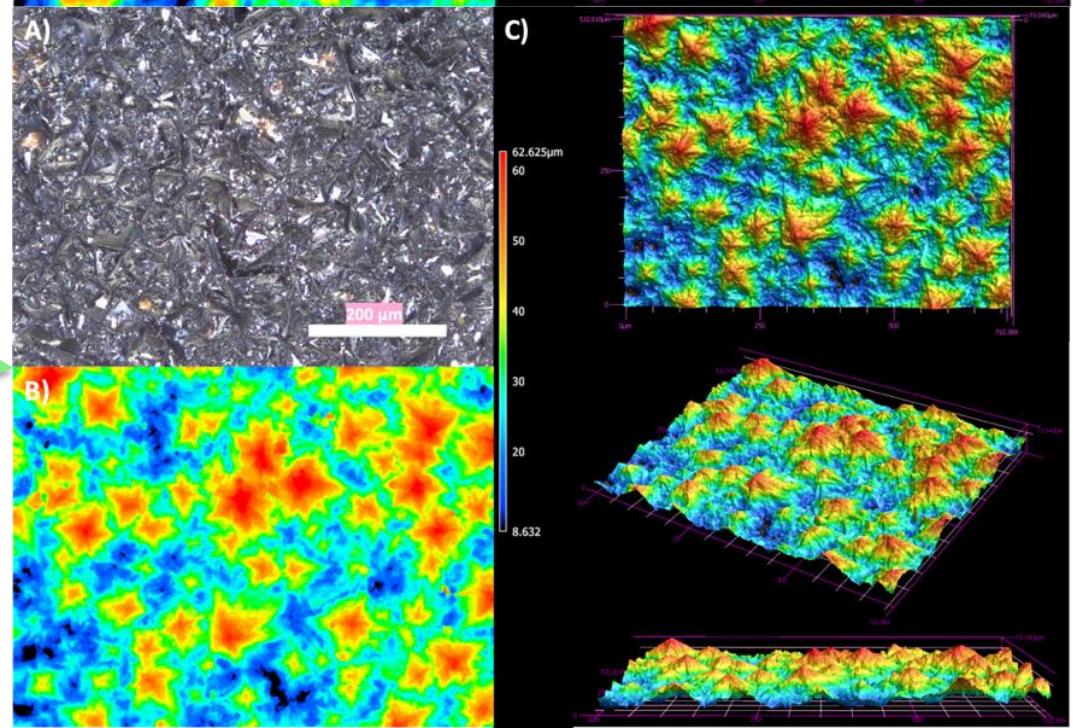
New BDD





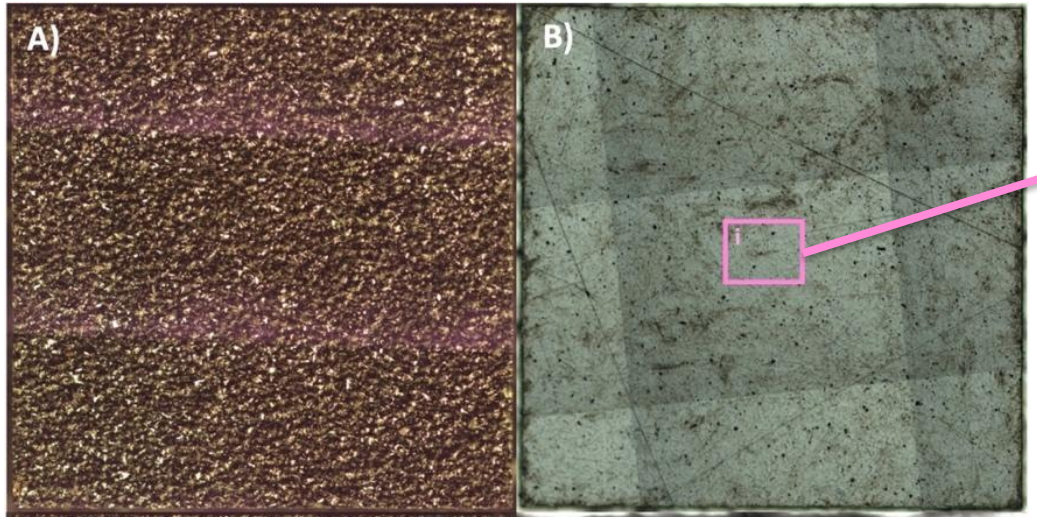
NaCl-KCl (Corroded) BDD

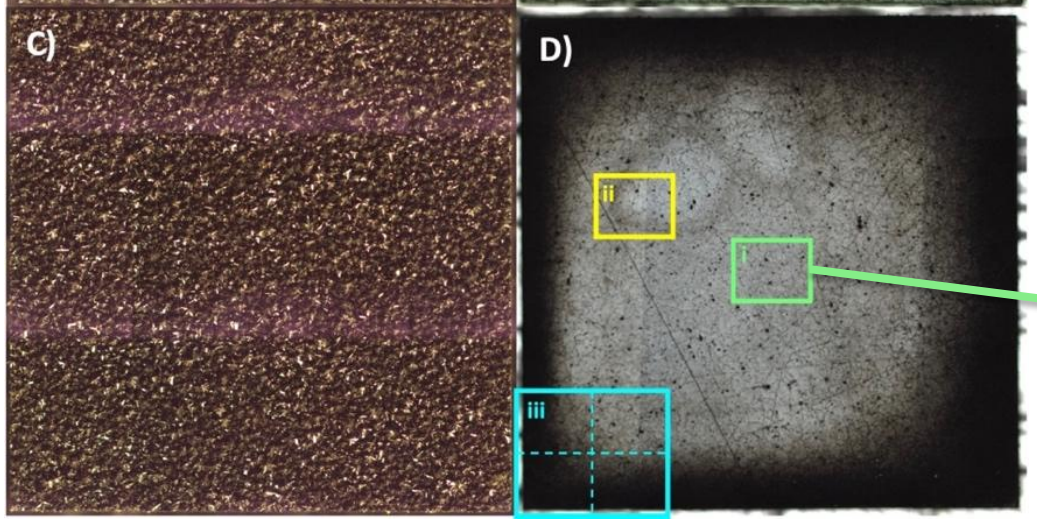




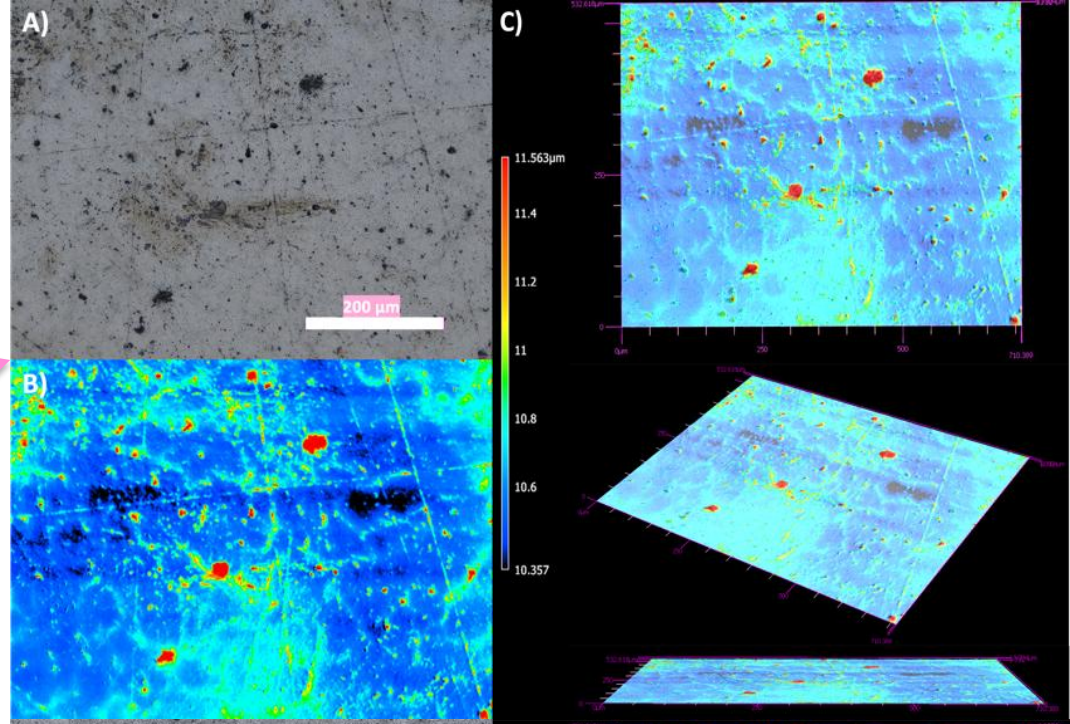
Profilometry

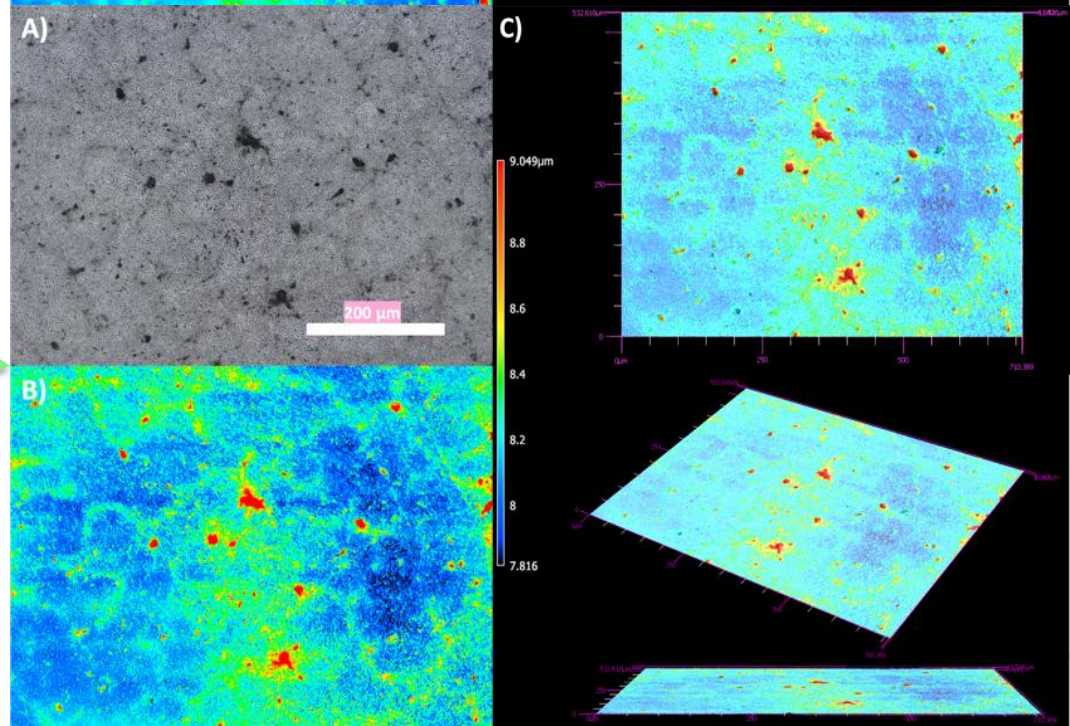
New BDD





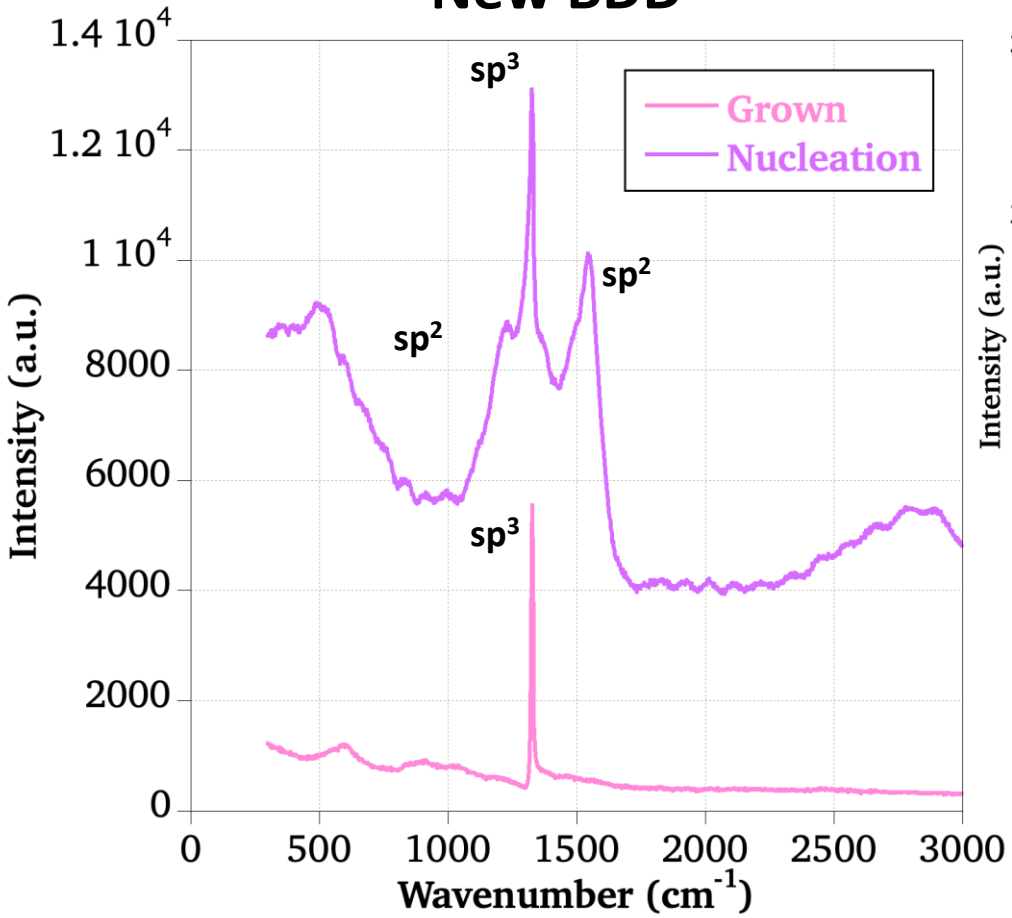
NaCl-KCl (Corroded) BDD



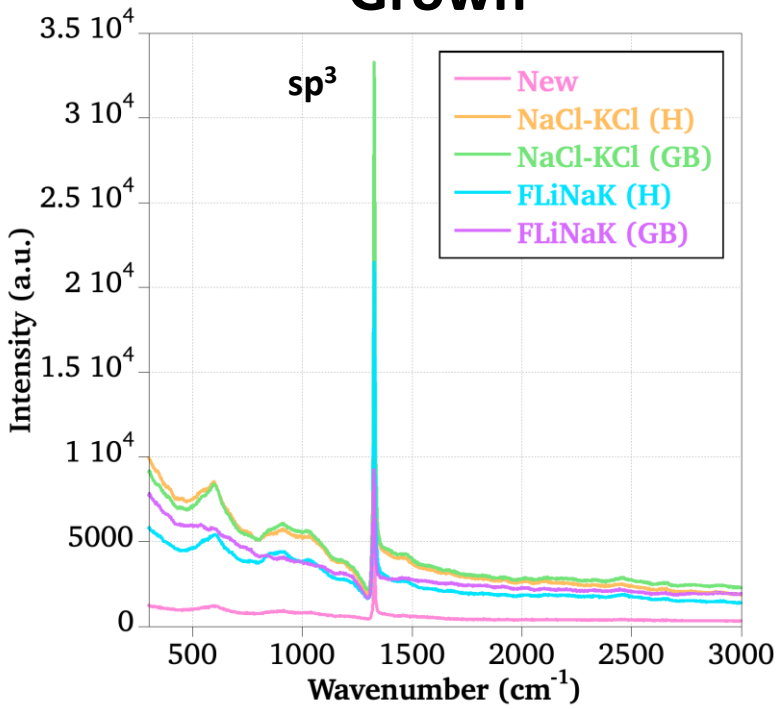


Raman Spectroscopy

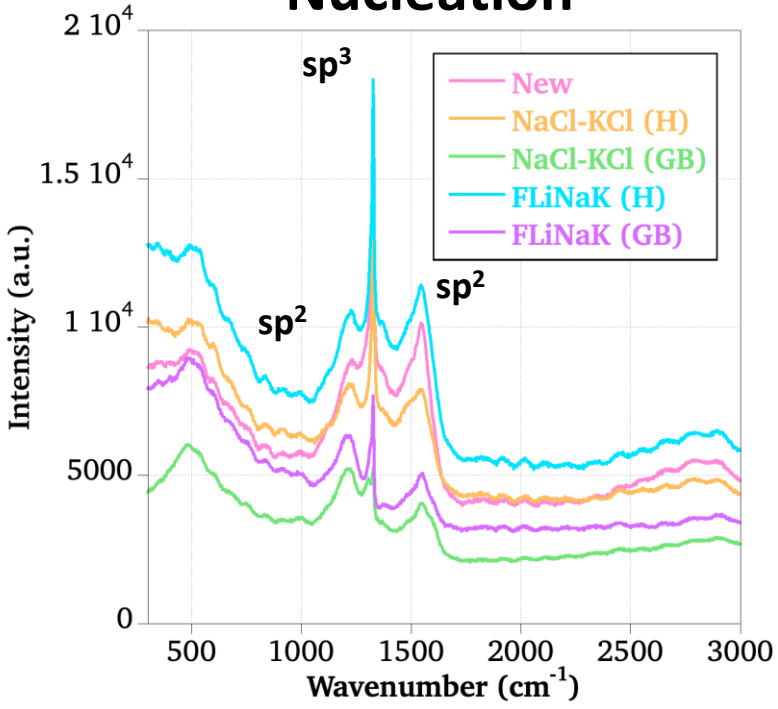
New BDD



Grown



Nucleation

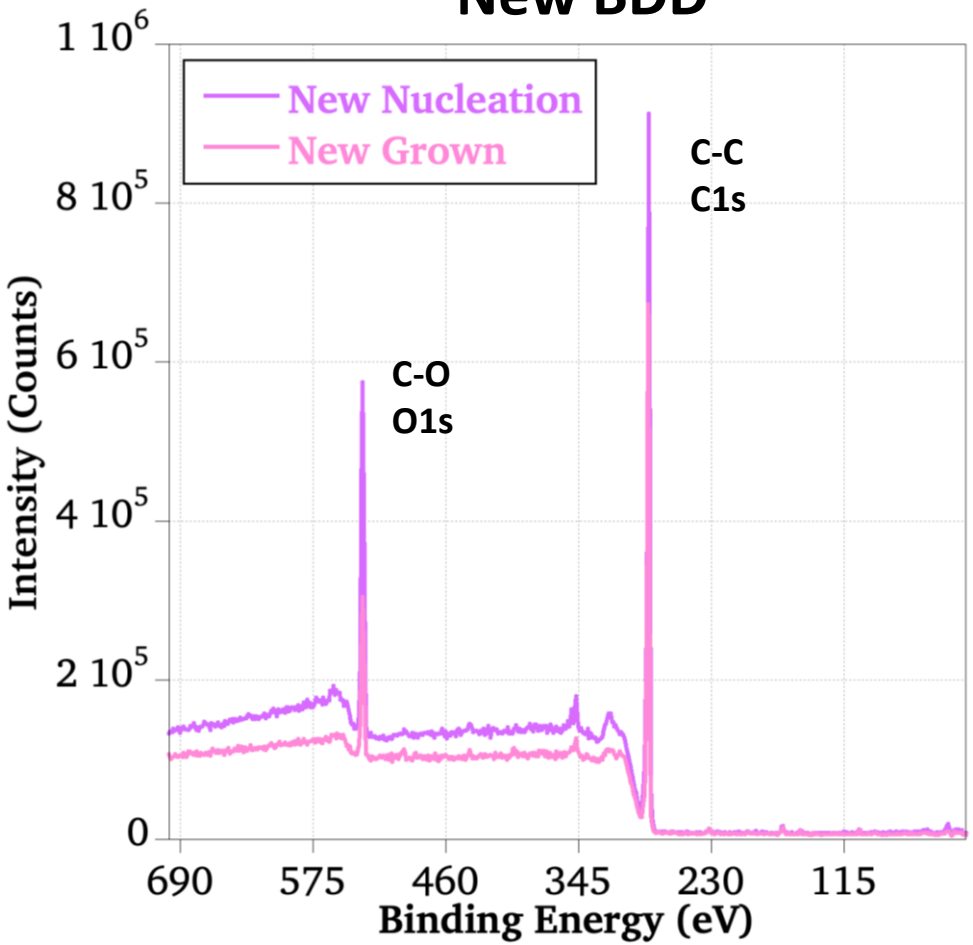


- ★ Only sp^3 & sp^2 C
- ★ No evidence of F or Cl
- ★ No impact from inert vs. non-inert

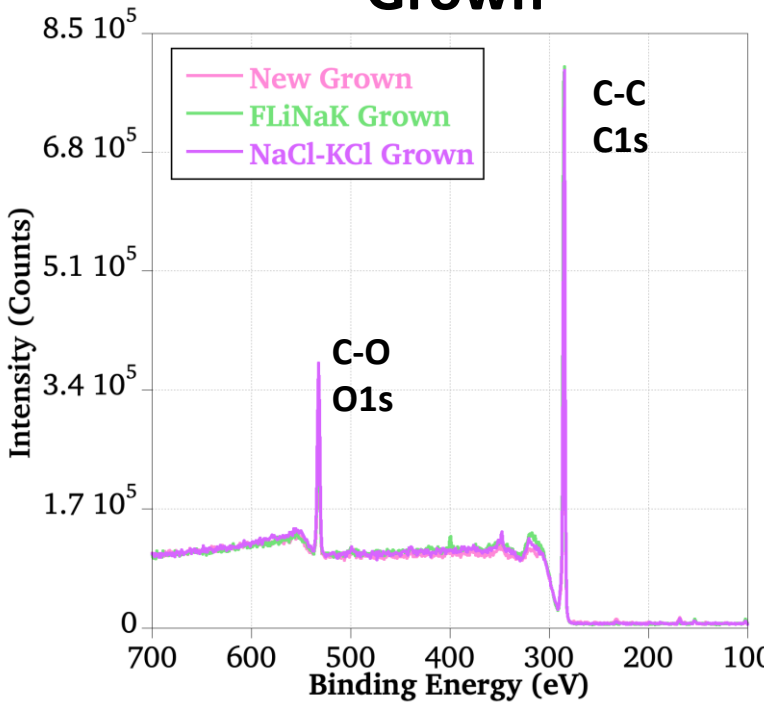
Okino et al., *J. Fluor. Chem.*, *125*, **2004**.
Kuo et al., *ESL.*, *2*(6), **1999**.

X-ray Photoelectron Spectroscopy (XPS)

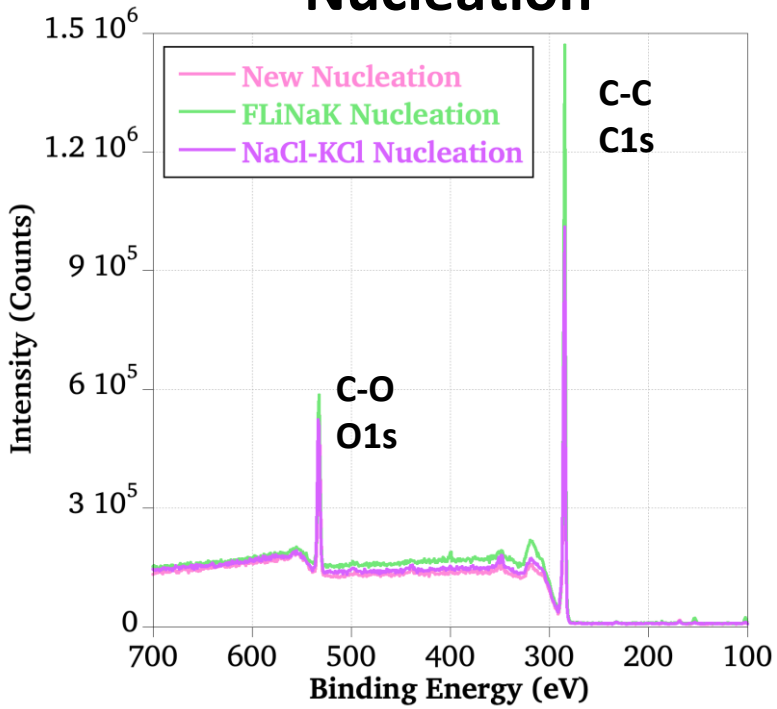
New BDD



Grown



Nucleation



- ★ Only C1s and O1s
- ★ No evidence of F1s or Cl2p
- ★ Only measured inert exposure samples
- ★ No difference between grown and nucleation

Kuo et al., *ESL.*, *2*(6), **1999**.
Kondo et al., *Electrochim. Act.*, *52*, **2007**.
Goeting et al., *Diam. Relat. Mater.*, *9*, **2000**.

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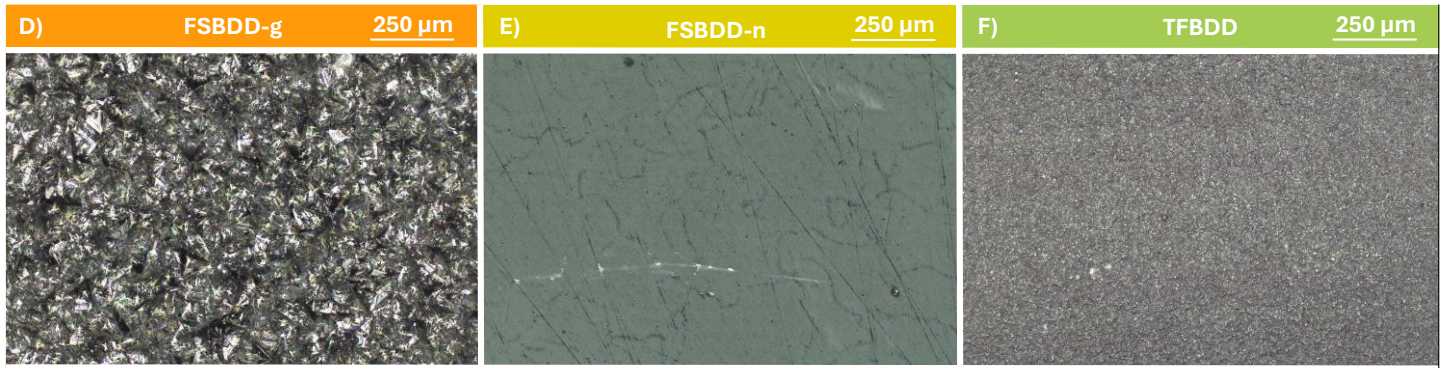
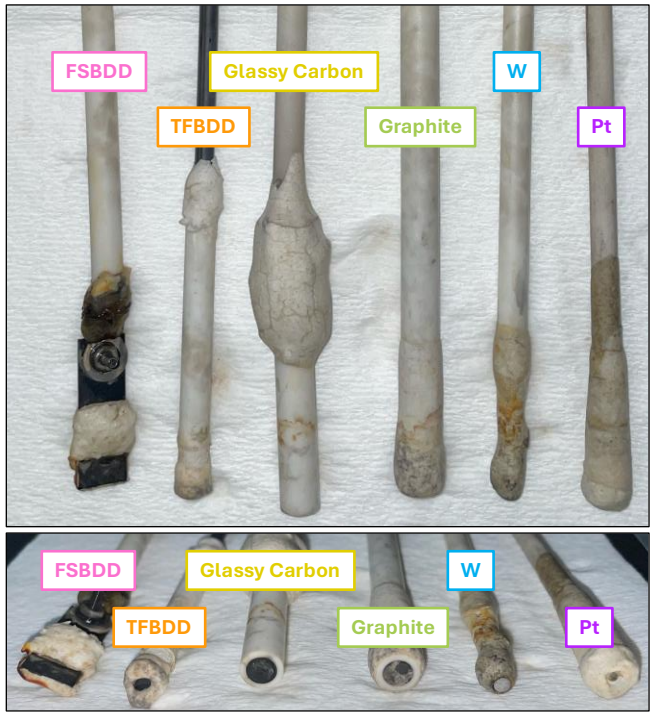
BDD Performance:
Molten Salt Environments

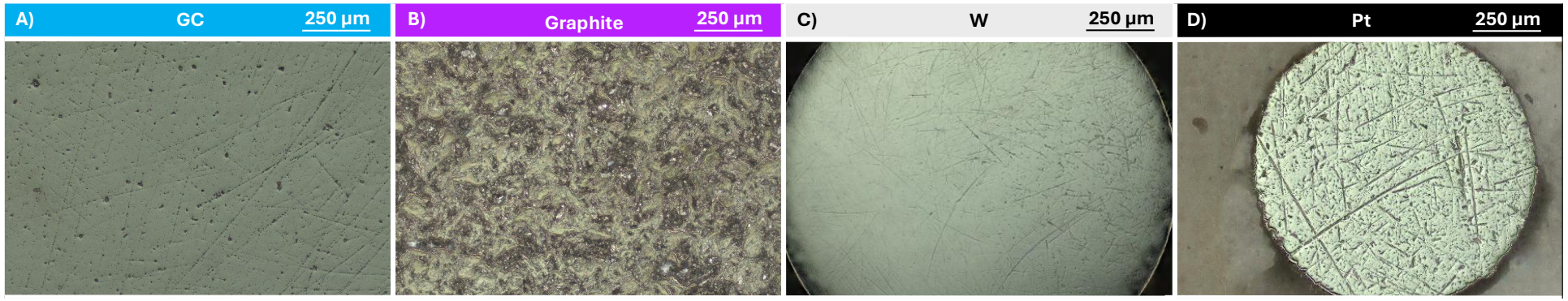
Comparing a Series of Electrodes

Various BDD Morphologies



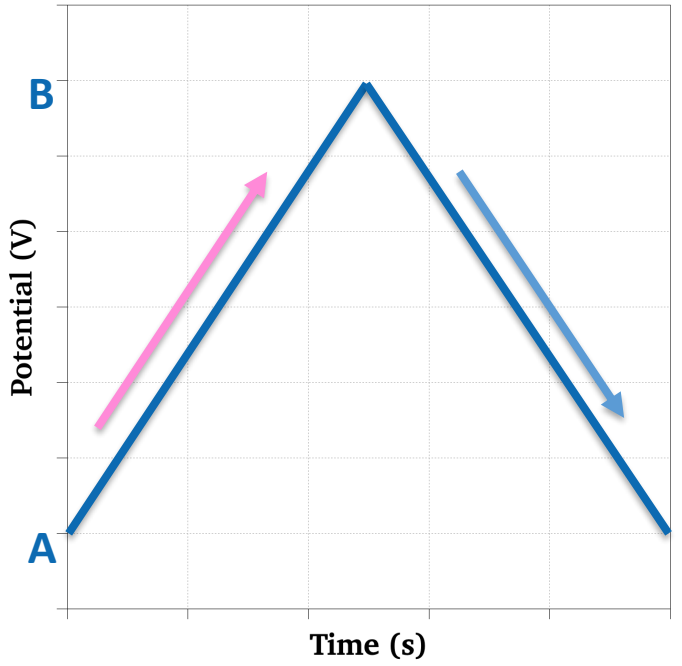


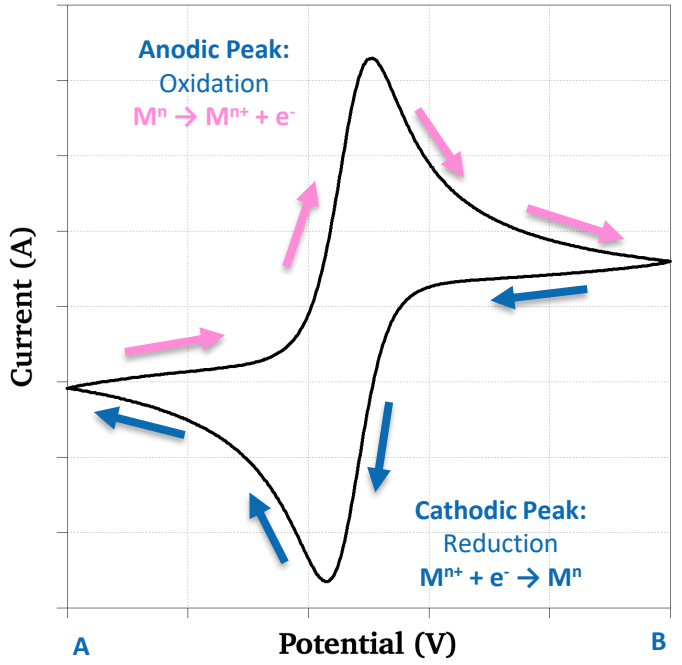
Common Molten Salt Electrodes



Experimental Design

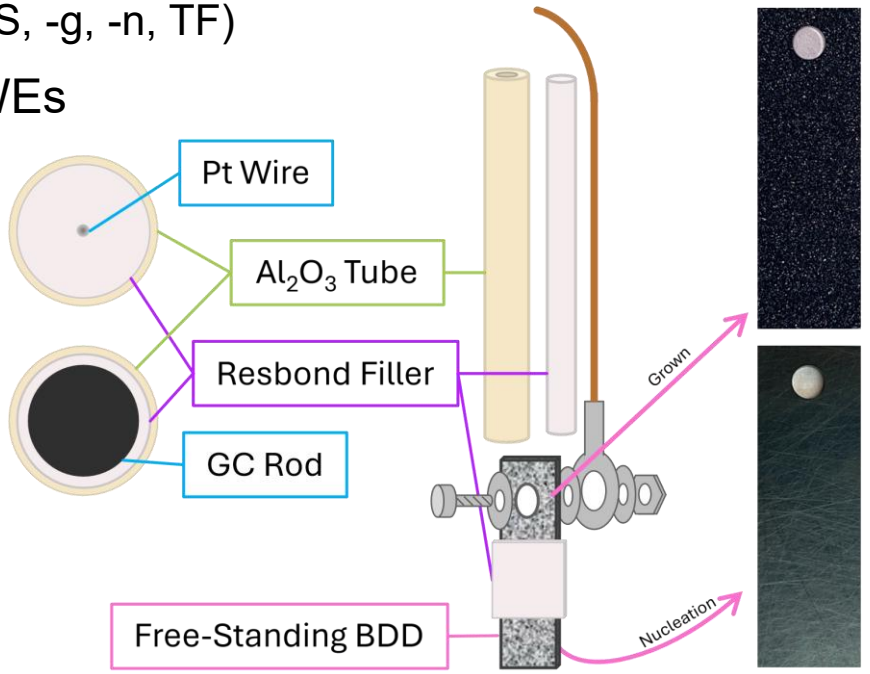
- **Simple:**
  - Different Electrodes
    - ✓ Same Electrolyte
    - ✓ Same Analyte Concentration
    - ✓ Same Temperature
    - ✓ Same techniques
    - ✓ Same Scan Rates
    - ✓ All in One Run
- **Cyclic Voltammetry**
  - NOT ideal for reporting novel information about an analyte
  - Valuable for rapid, relative comparison within the same system

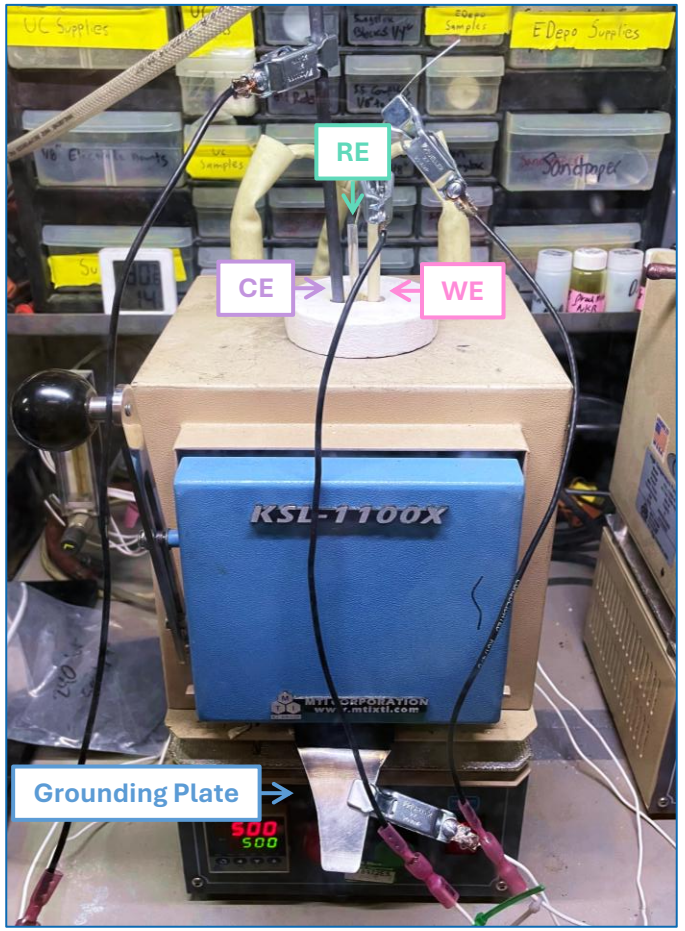




Electrode Comparisons

- **8 WE Materials:**
  - Boron-Doped Diamond (BDD)
    - Four different morphologies (FS, -g, -n, TF)
  - Four “common” molten salt WEs
    - Glassy Carbon (GC)
    - Graphite
    - Tungsten (W)
    - Platinum (Pt)
- **Surface Area**
  - Controlled
  - Minimized
  - Measured (via profilometry)
- **Ceramic Epoxy & Insulation**

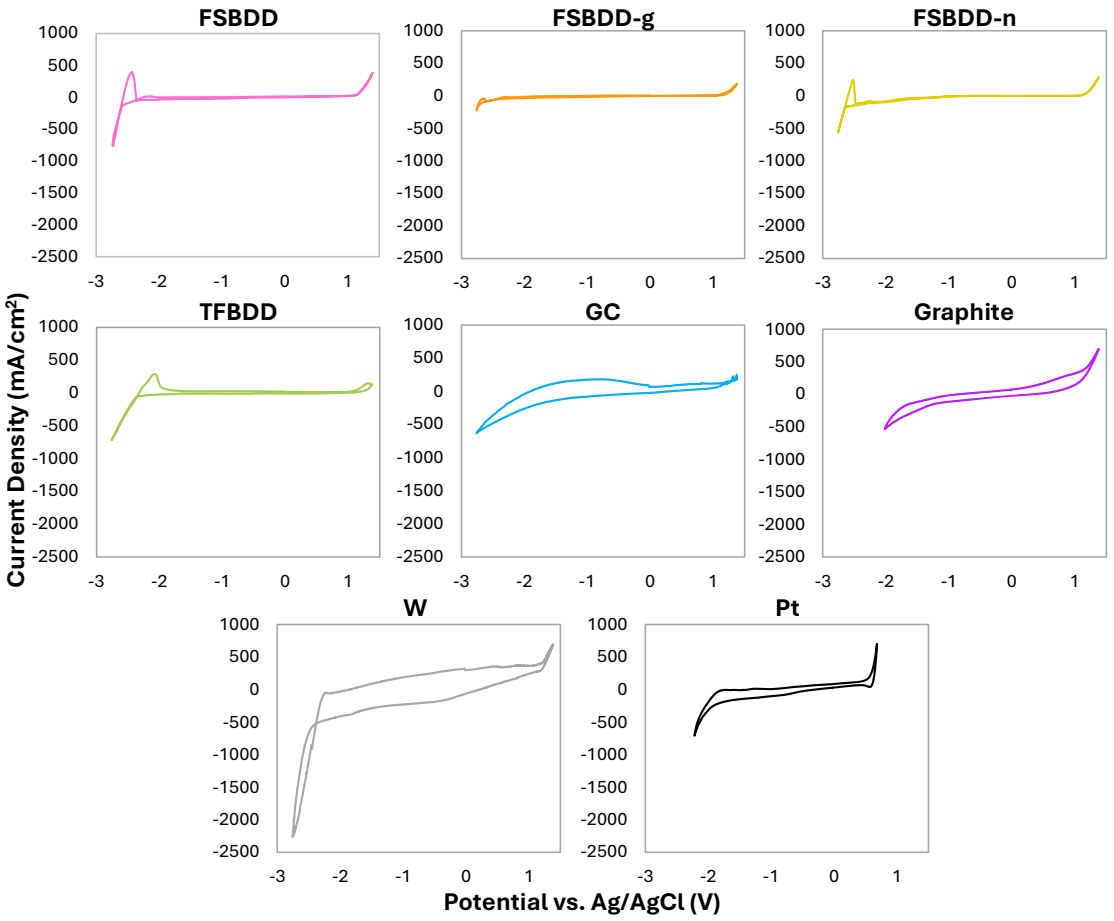




LiCl-KCl | 454 ºC

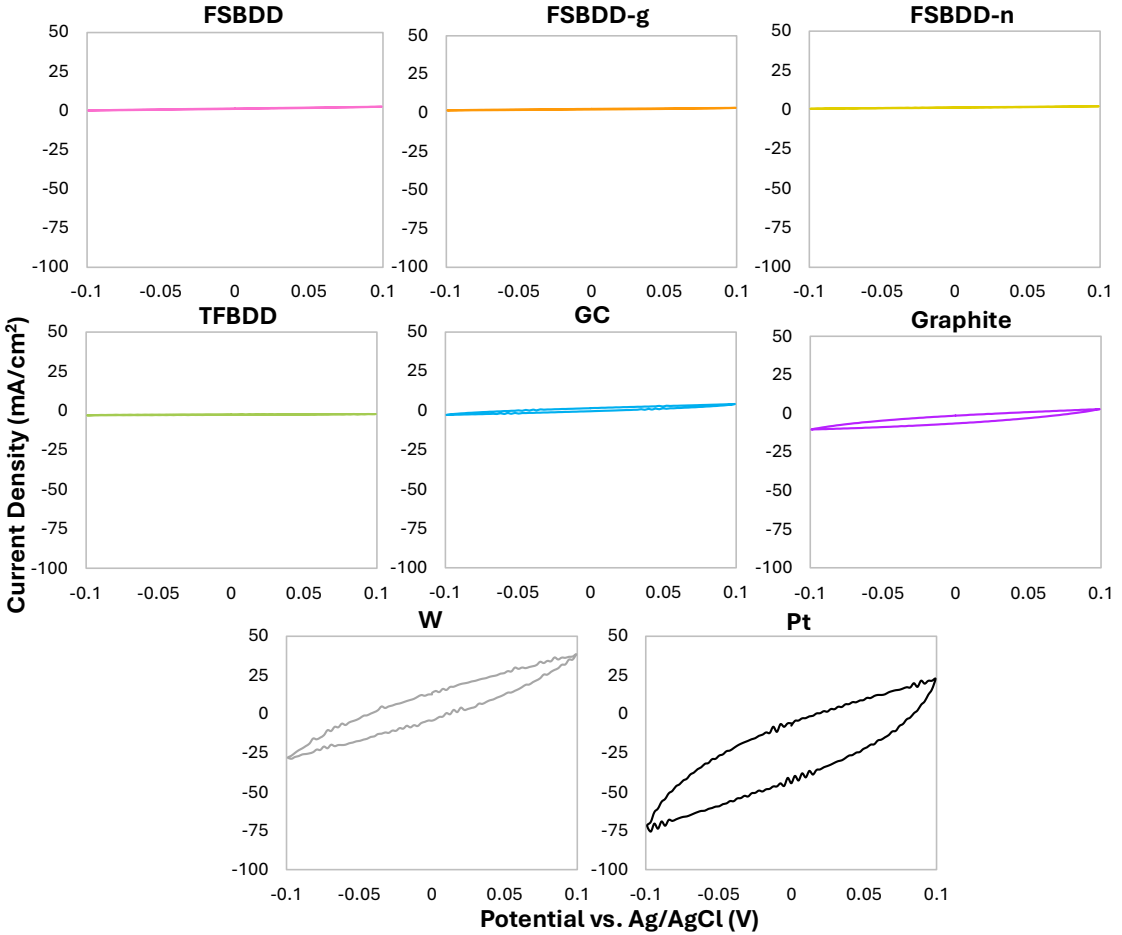
Potential ("Solvent") Window:

Width of Usable Potential

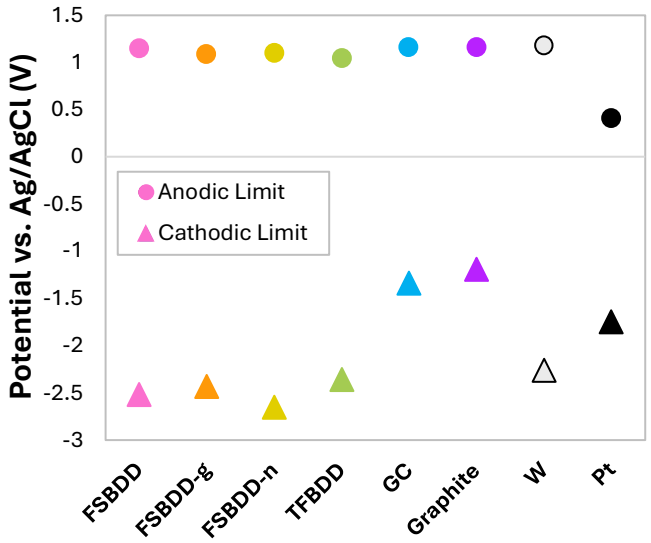


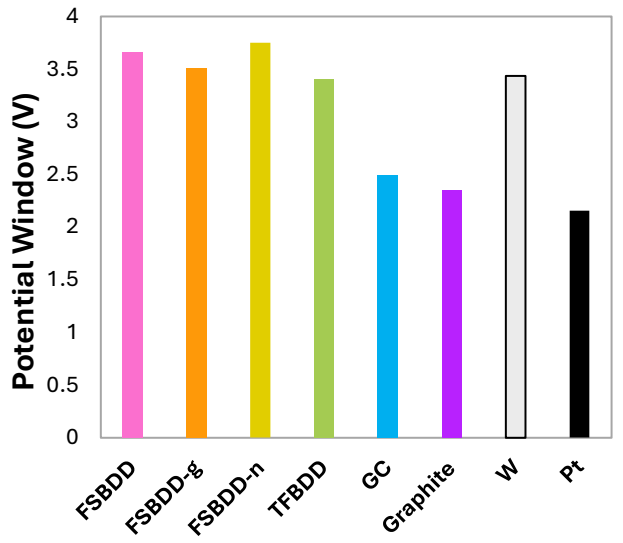
Capacitance:

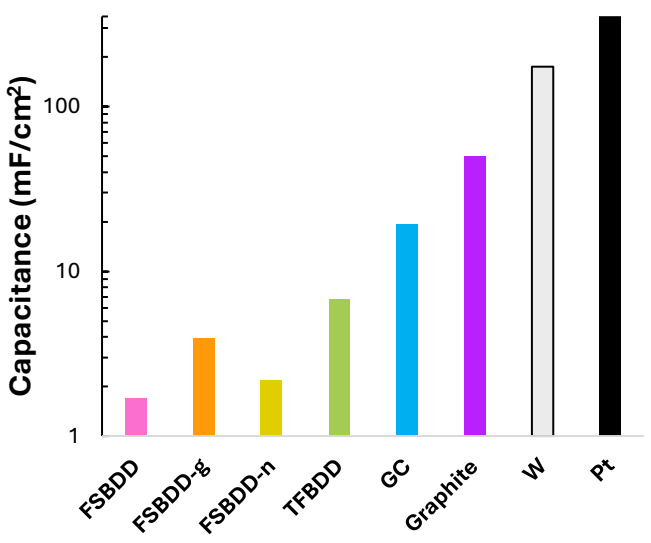
"Background" Current or Charge Stored at the Surface

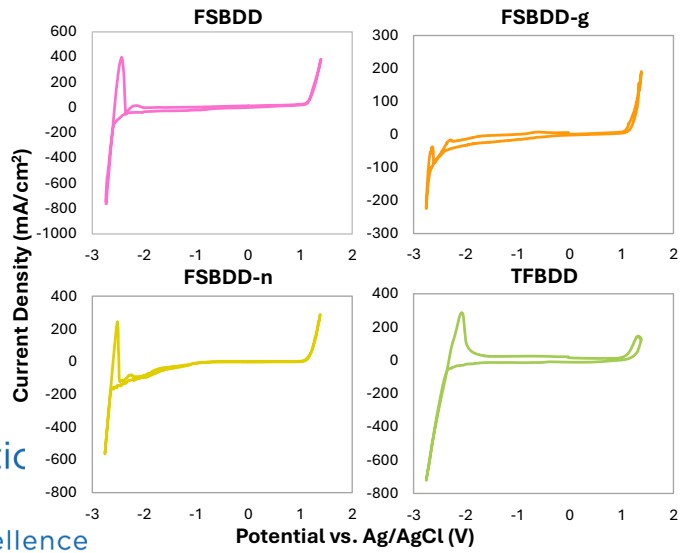


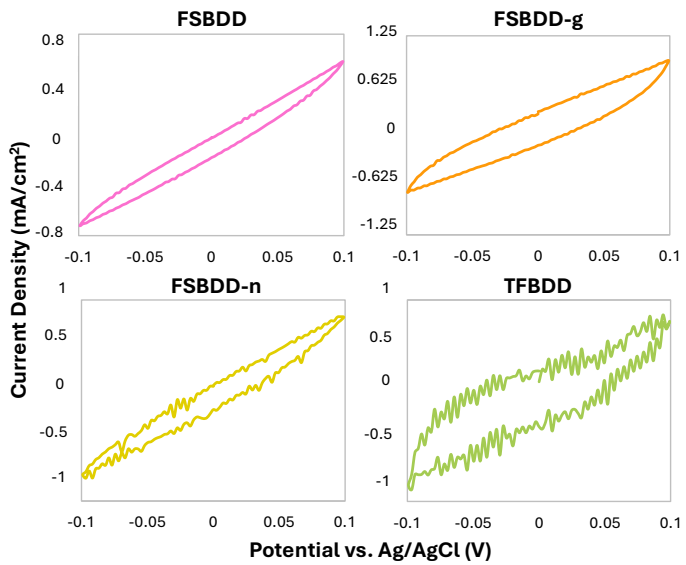
LiCl-KCl | 454 ºC











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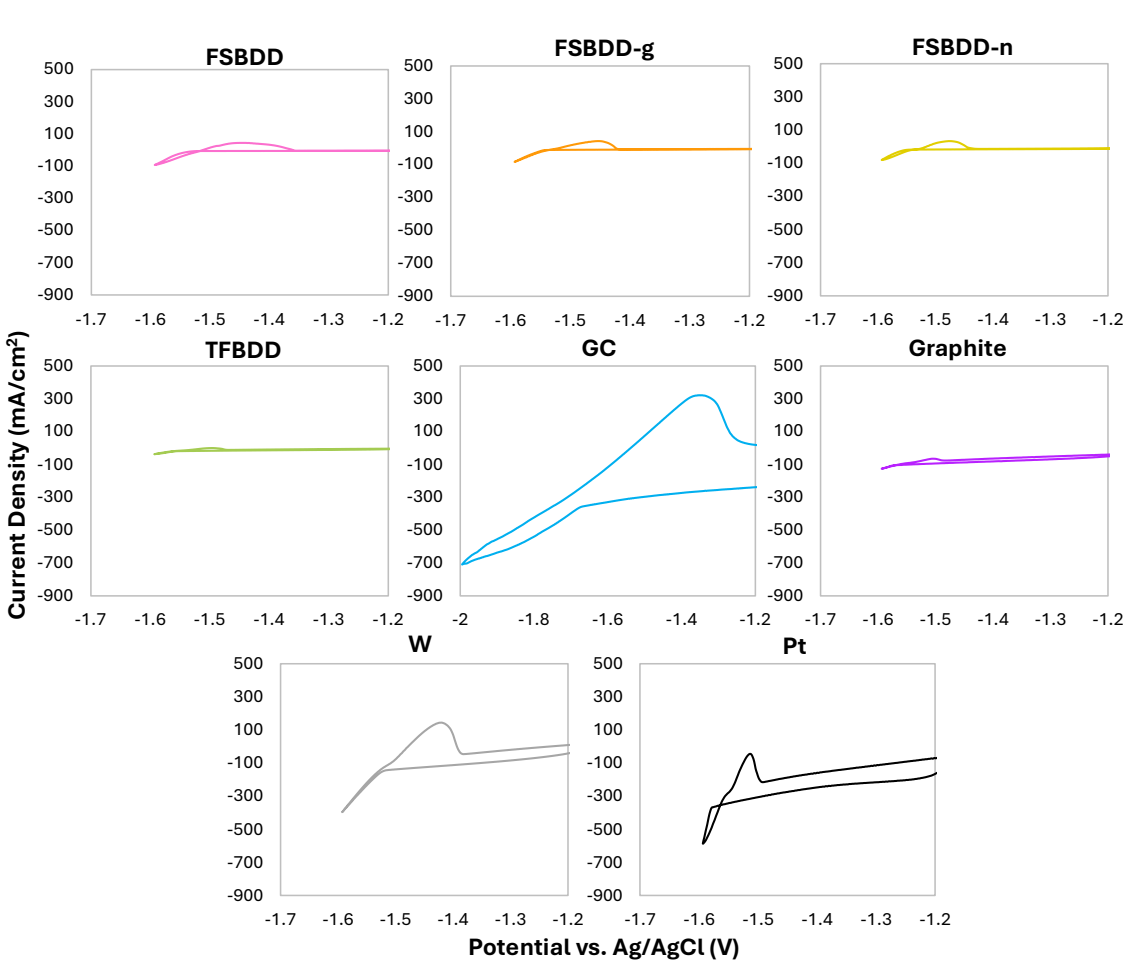
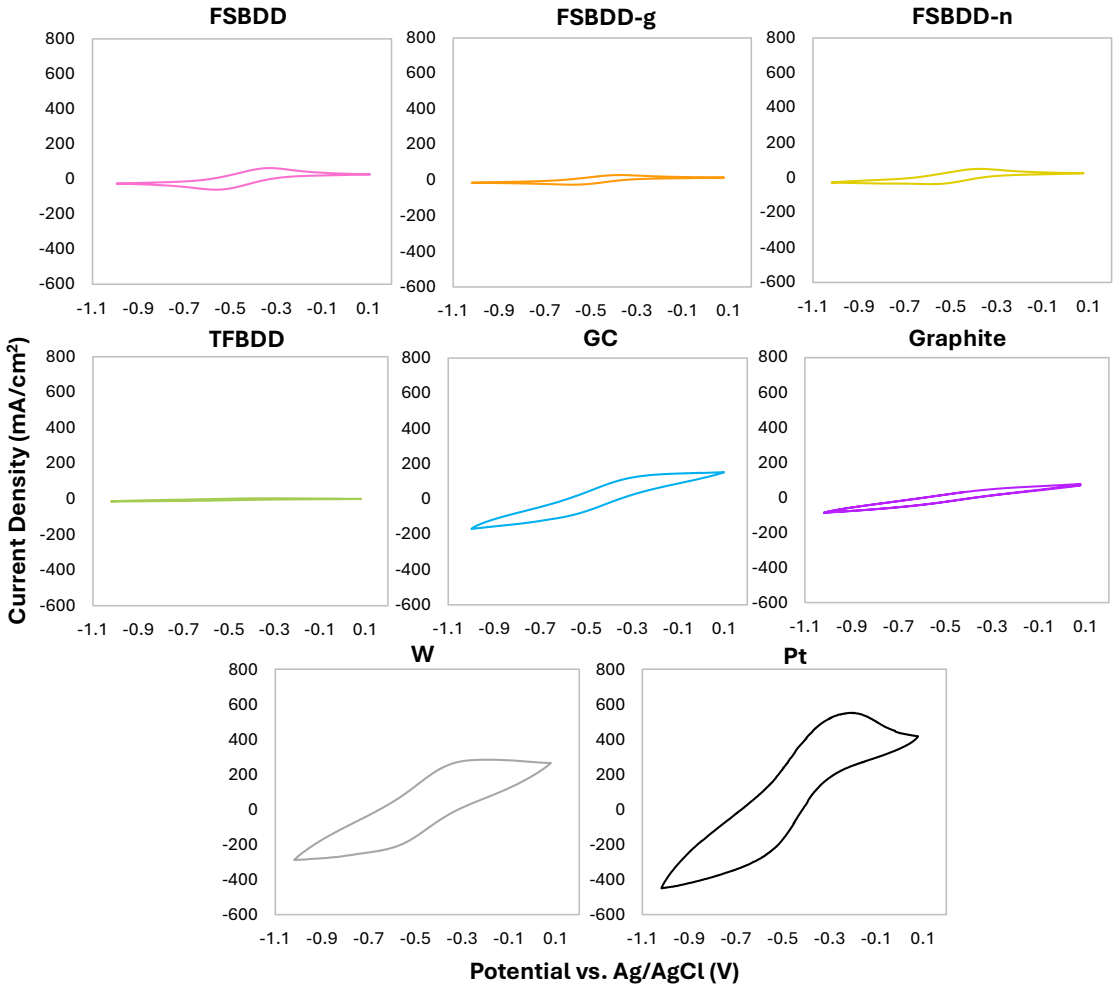
$U^{3+/0}$ & $U^{4+/3+}$:

1.47 mol% UCl_3 | LiCl-KCl | 446 °C





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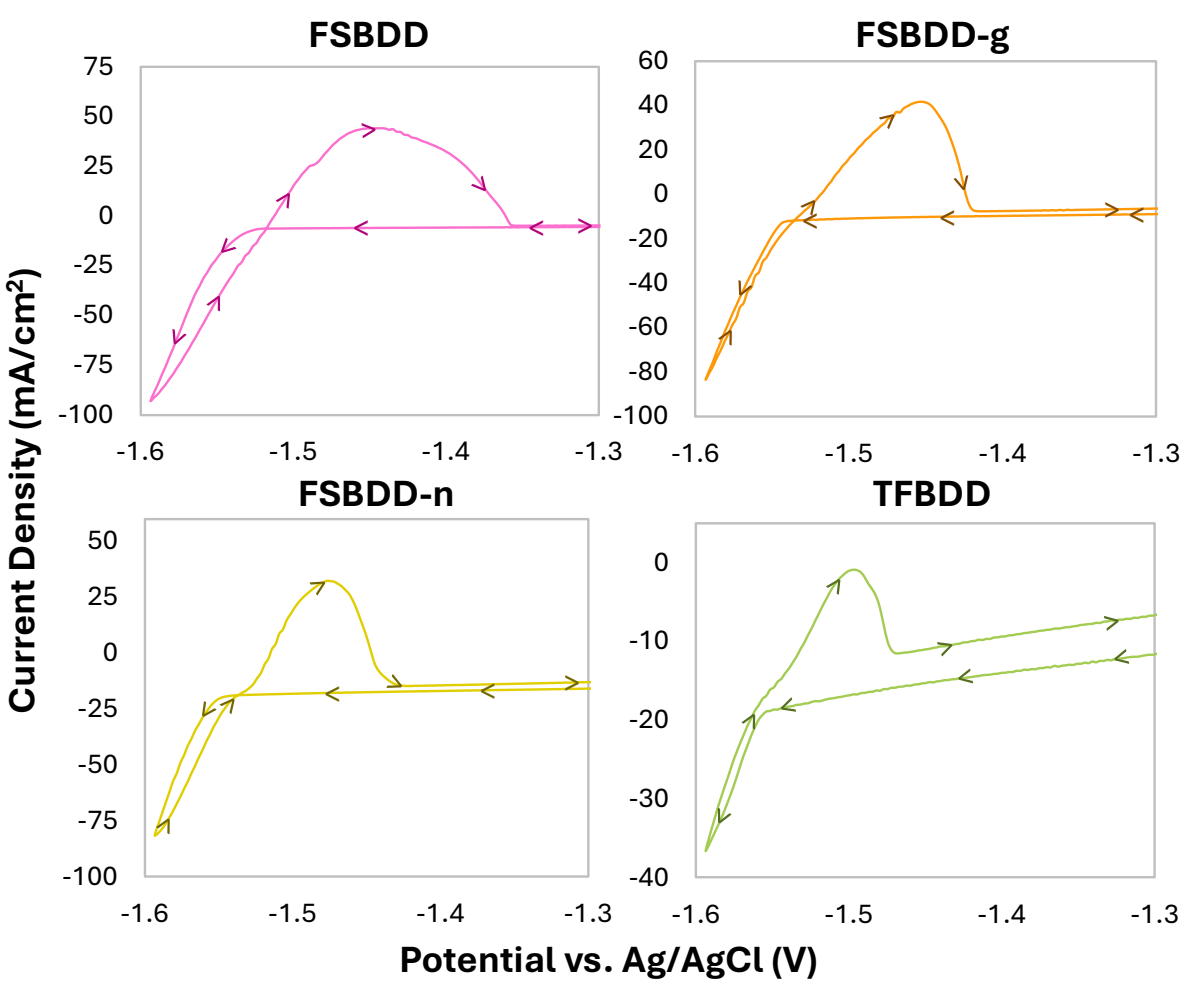
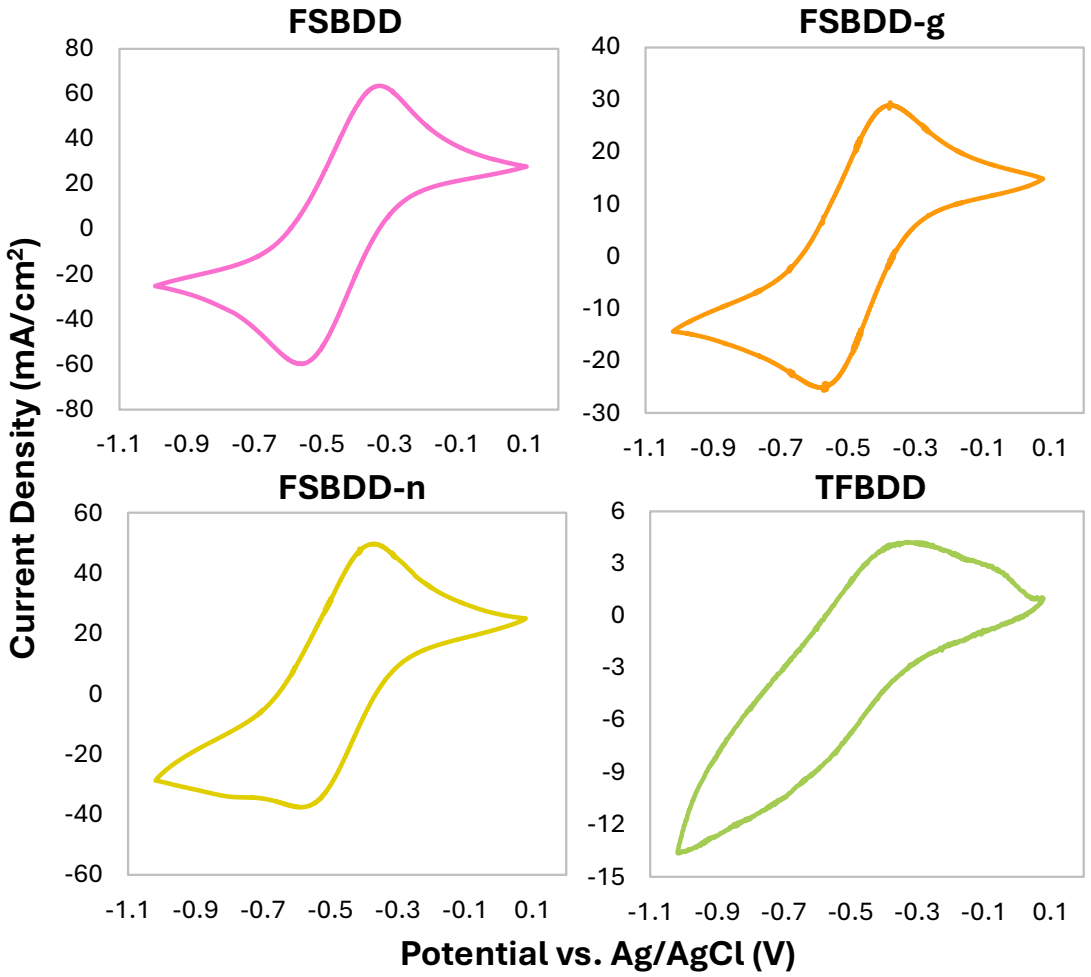
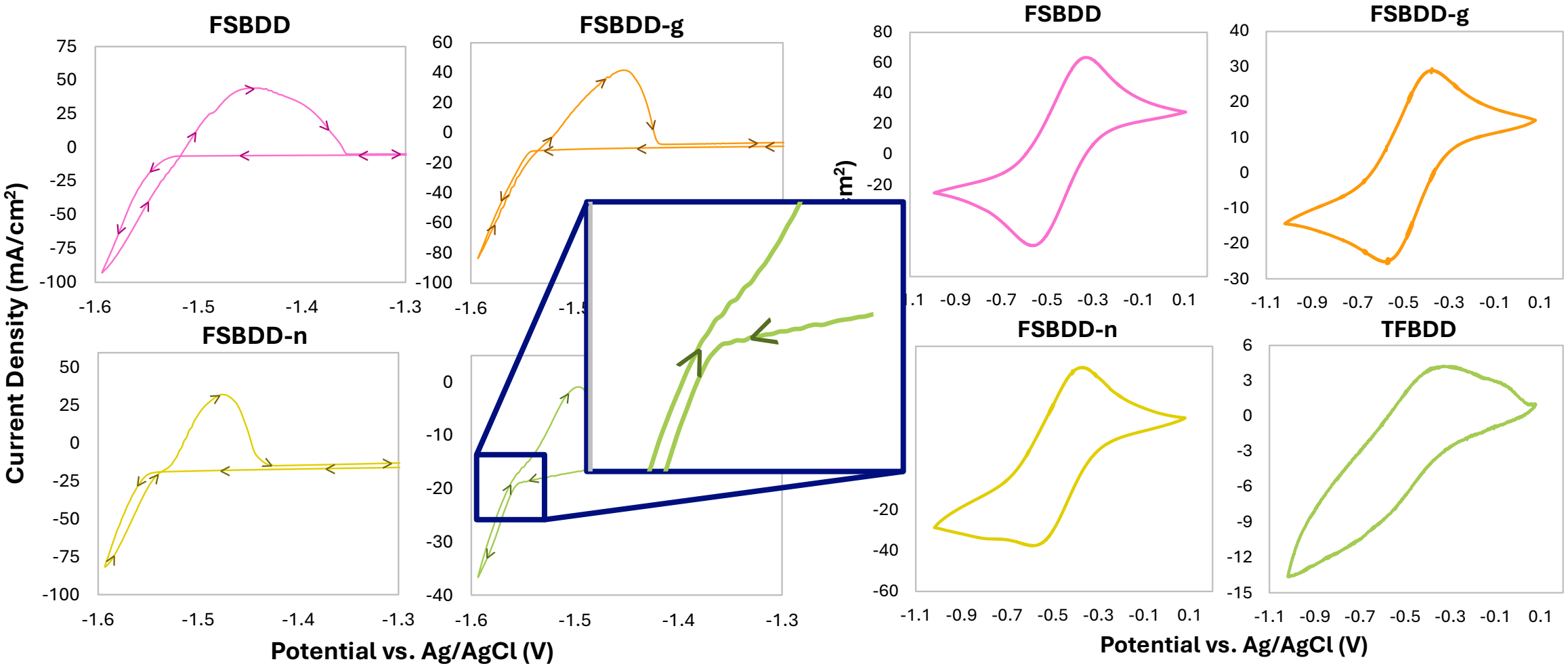




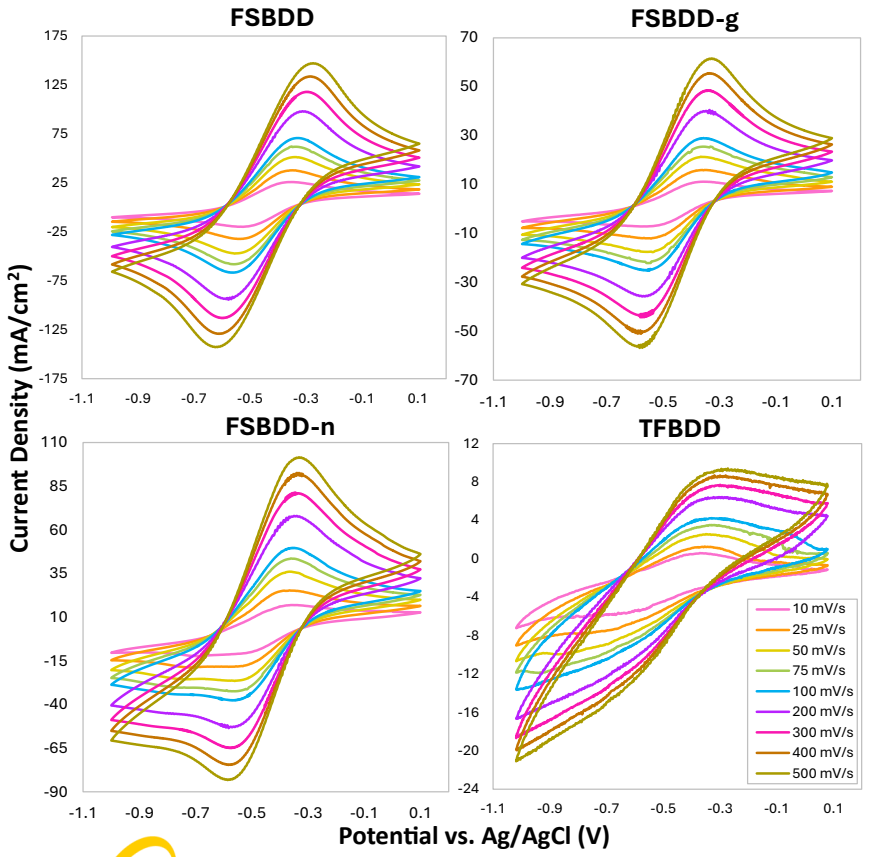
$U^{3+/0}$ & $U^{4+/3+}$:

1.47 mol% UCl_3 | LiCl-KCl | 446 °C



$U^{3+/0}$ & $U^{4+/3+}$

1.47 mol% UCl_3 | LiCl-KCl | 446 °C



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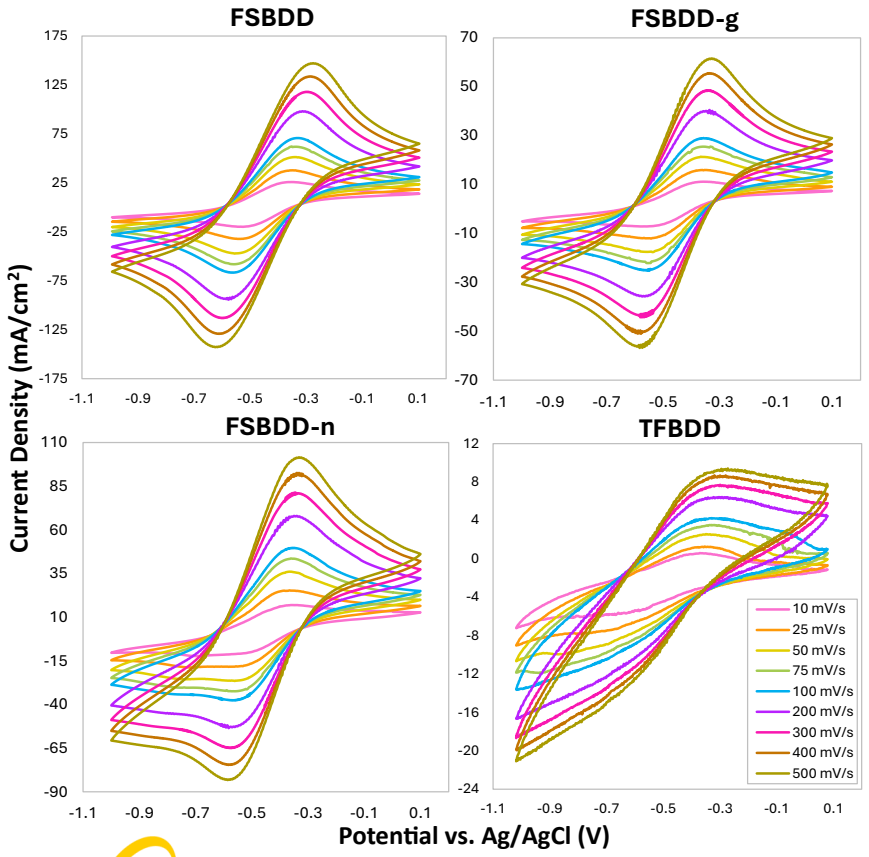
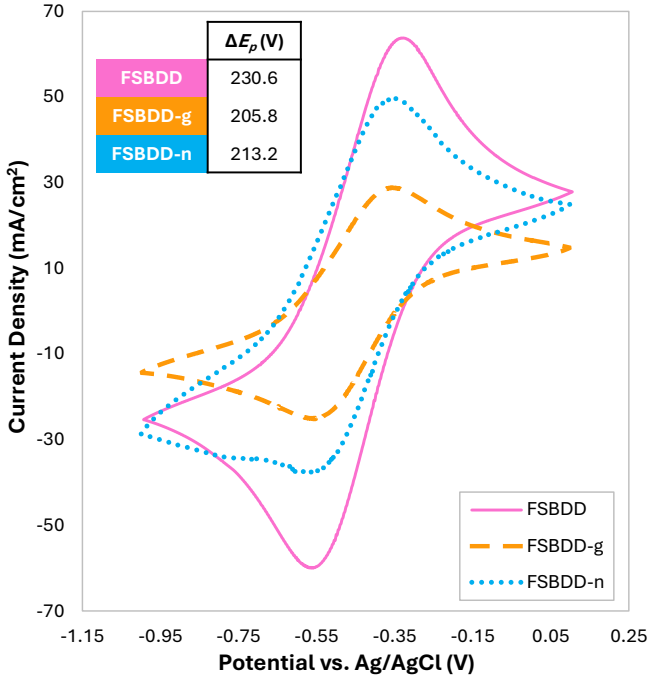
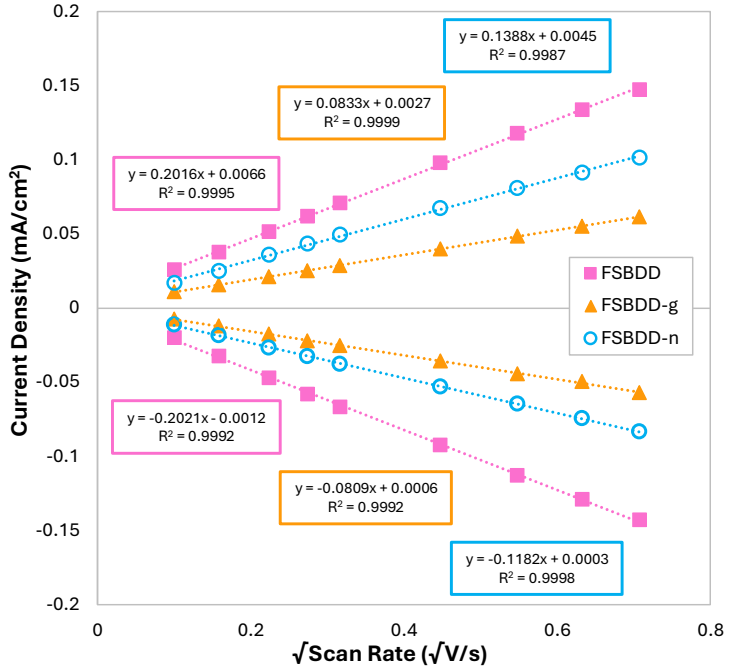
$U^{3+/0}$ & $U^{4+/3+}$

1.47 mol% UCl_3 | LiCl-KCl | 446 °C







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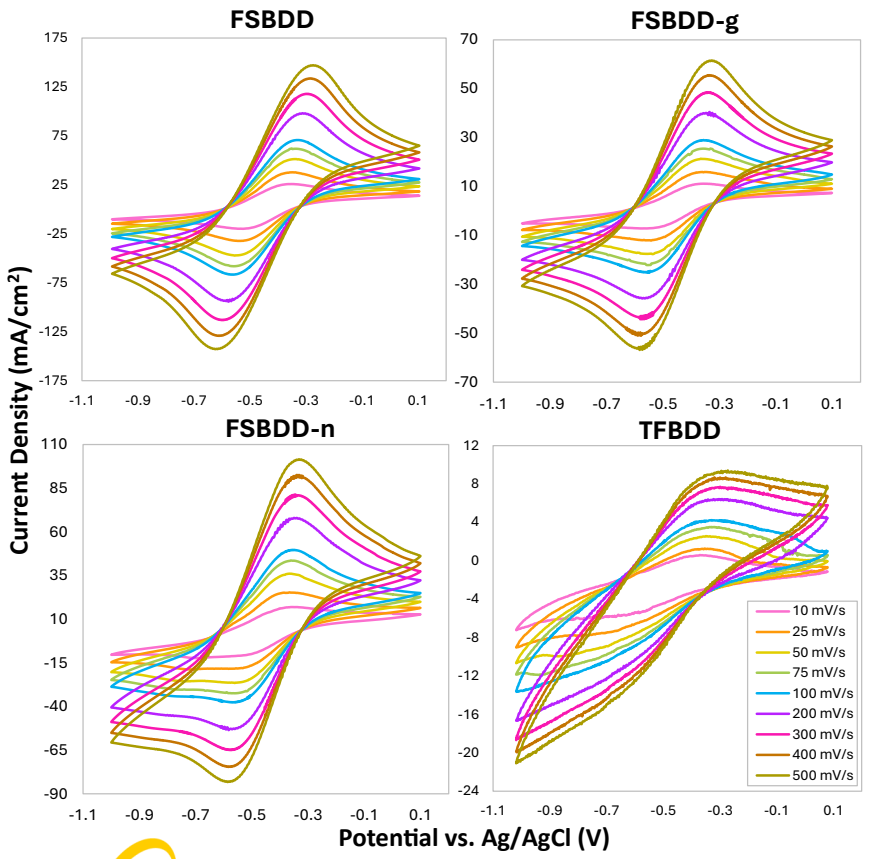
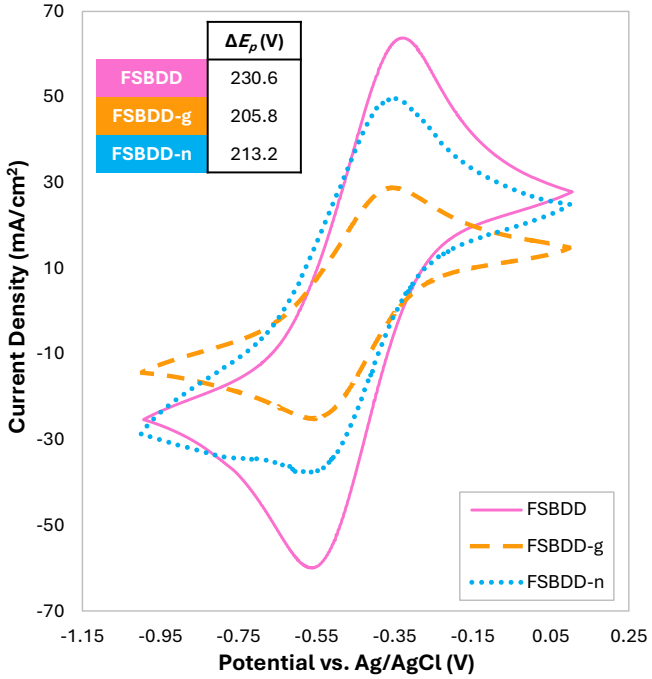
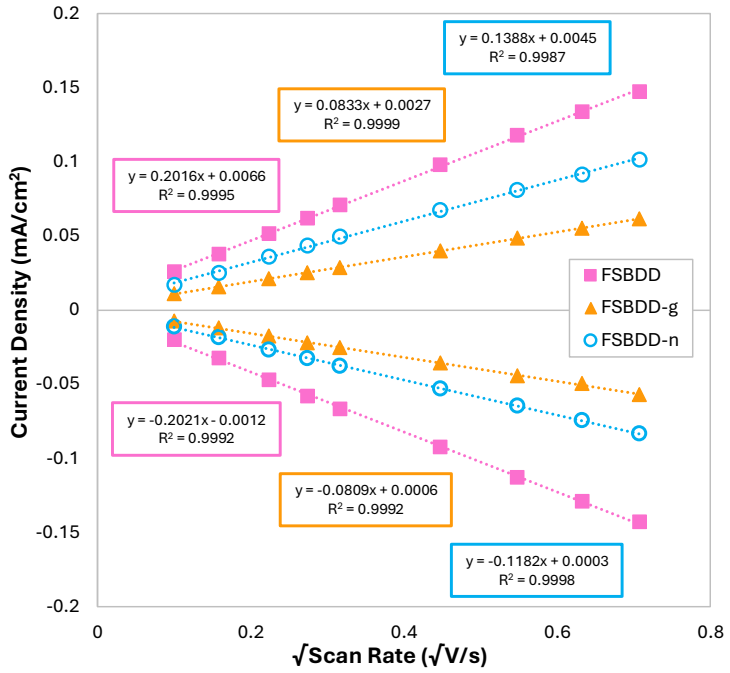


- **Can't** solve for *D* due to high concentration
  - Among other assumptions…
- **Can** confirm semi-infinite linear diffusion
  - Linearity of regressions
- **Can** compare magnitude of current responses
  - Indication of WE-dependence on response
- **Can** describe "apparent" (relative) kinetics based on peak separations and peak shapes





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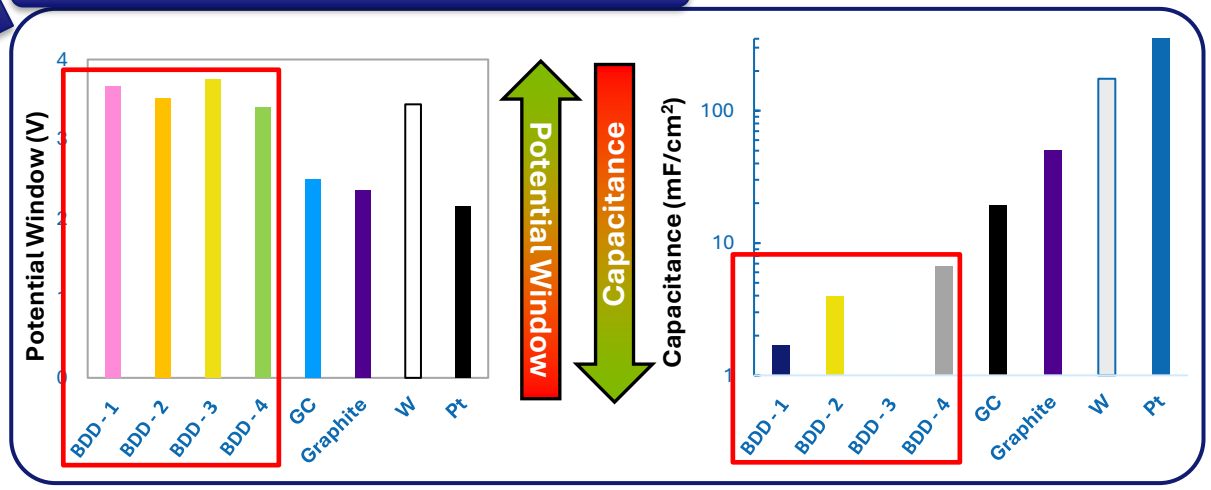
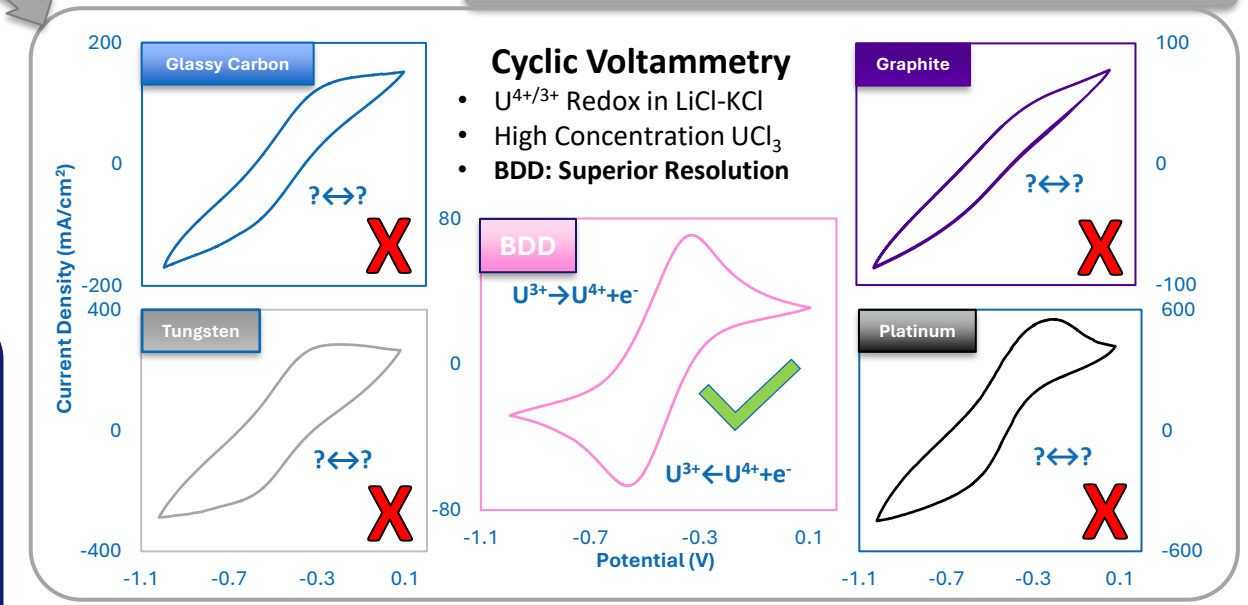
Summary of BDD Performance in Molten Salts

- ✓ Survived **exposure studies** in Cl and F molten salts
- ✓ Successful **redox measurements** in Cl and F molten salts
- ✓ **Out-performs** standard molten salt electrodes
  - Wider working windows
  - Lower background
  - Enabled novel investigations of 'fuel-like' chloride salts

Inherent Improvements to Sensitivity



Exceeds Capabilities of Standard Materials



Molten Salt BDD Electrochemical Sensor Development Stage:

TRL 2 (*fluorides*) & 3 (*chlorides*)

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Data Source: Patenaude et al., (*under review*).

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Conclusions

- **WE selection** measurably affects electrochemical response
- **Novel materials** (e.g., BDD) may offer significant advantages
- **Electrode fabrication** deserves greater attention in molten salt electrochemistry

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Conclusions

- **WE selection** measurably affects electrochemical response
- **Novel materials** (e.g., BDD) may offer significant advantages
- **Electrode fabrication** deserves greater attention in molten salt electrochemistry

Future Work

- Expansion to measurements of **fluorides**
  - (e.g., FLiNaK, FLiBe)
- Exploration of **Pu redox chemistry**
  - New materials may unlock new capabilities
- **Application:** Online monitoring
  - MSR applications for electroanalysis
  - Novel sensor development

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Lab Queen & Electrochemistry Genius

Molten Salt Reactor PROGRAM

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LDRD

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Diamonds are a ~~Girl's~~
Best Friend
^Reactor's

Upcoming Webinars

Date	Title	Presenter
10 September 2026	Thermal properties of molten salts: crucial data for the development of MSRs	Prof. Juliano Schorne-Pinto, University of South Carolina, USA
15 October 2026	Temperature-based approach to estimate decay heat in sodium-cooled fast reactors and validate associated computational tools	Dr. Dorian Da Cunha, CEA, France
12 November 2026	MELCOR: The evolution of nuclear safety analysis technology to enable nuclear innovation	Dr. Matthew Christian and Dr. David Luxat, Sandia National Laboratories, USA

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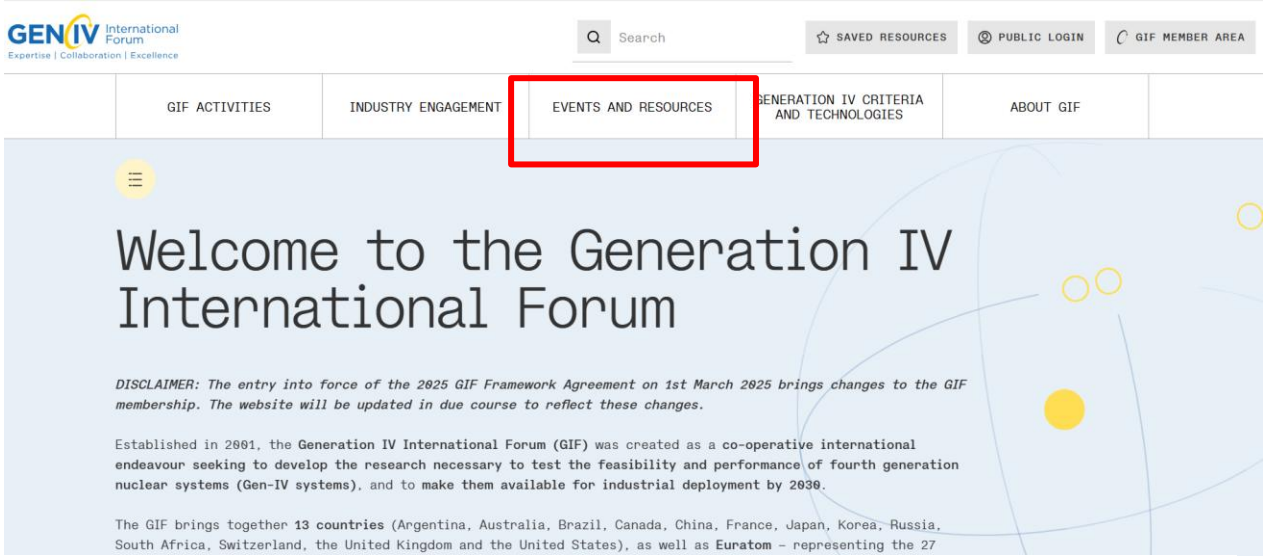

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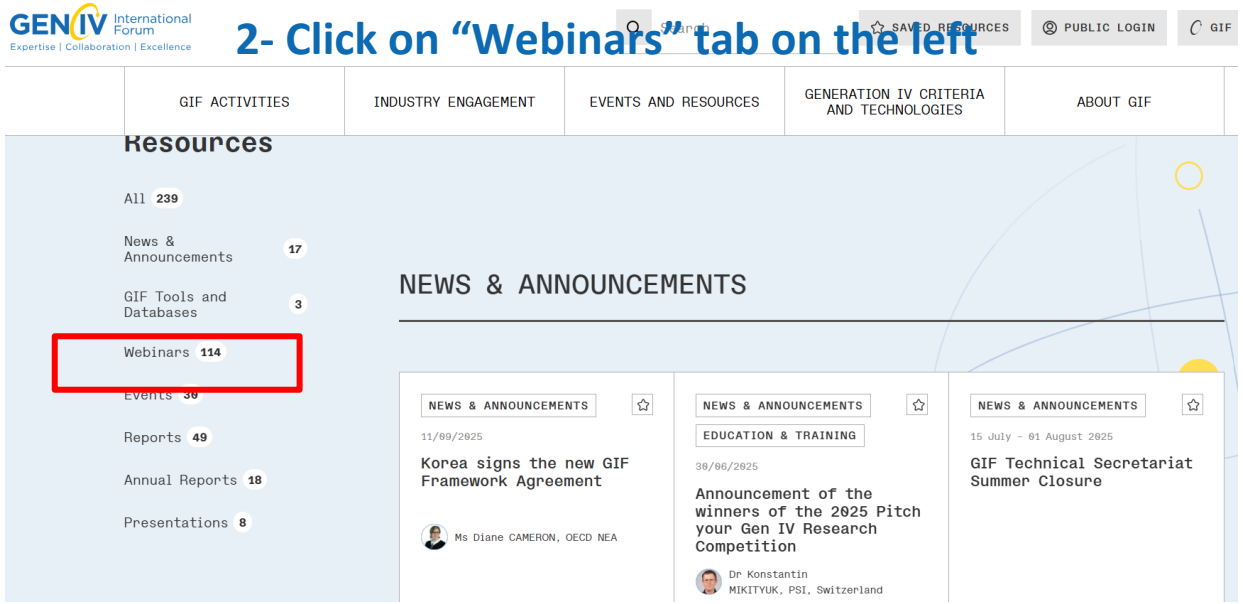

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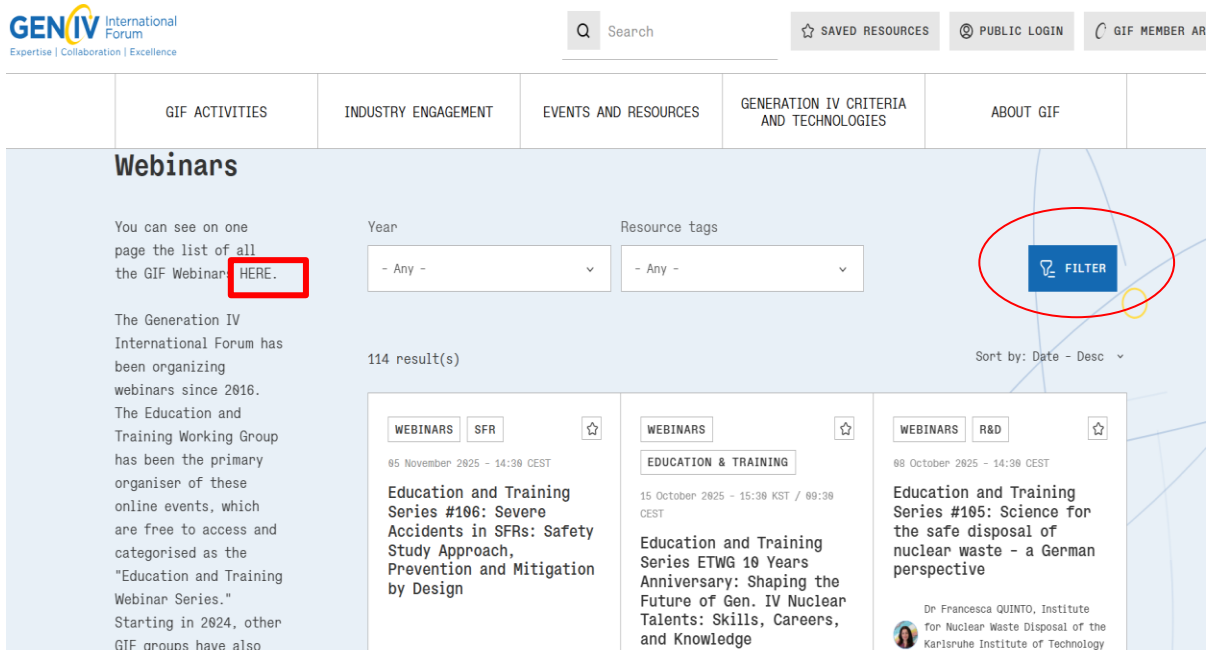

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Thank you
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