BOILER: Behavior Of In-situ Lead Environments & Radiation

Irradiation-Corrosion of Alumina-Forming Austenitic Stainless Steels in Static Lead

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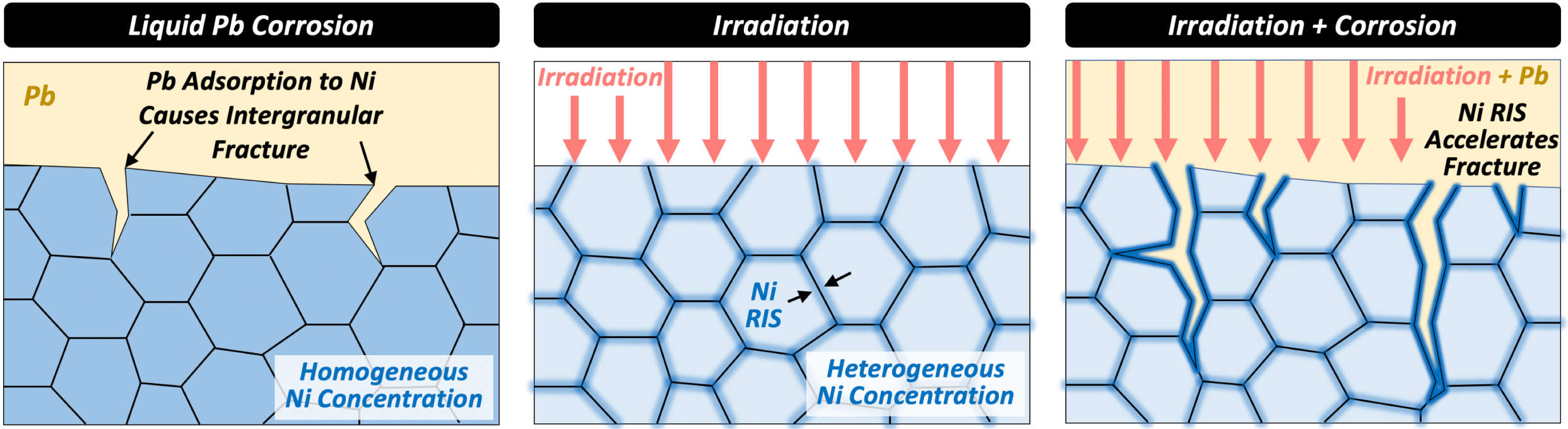
ILLINOIS

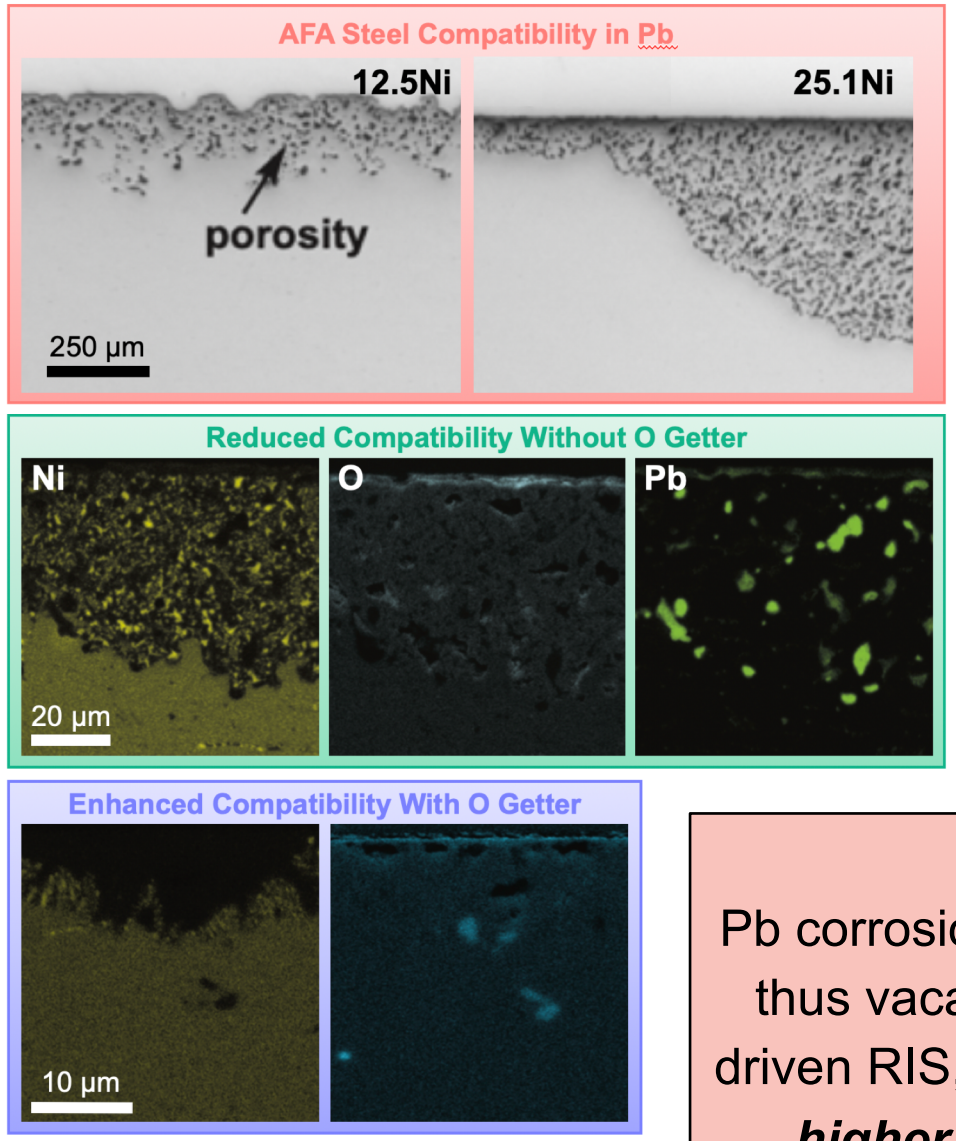
Objective

Evaluate the susceptibility of alumina-forming austenitic (AFA) stainless steels to liquid metal embrittlement (LME) under coupled extremes of irradiation and corrosion.

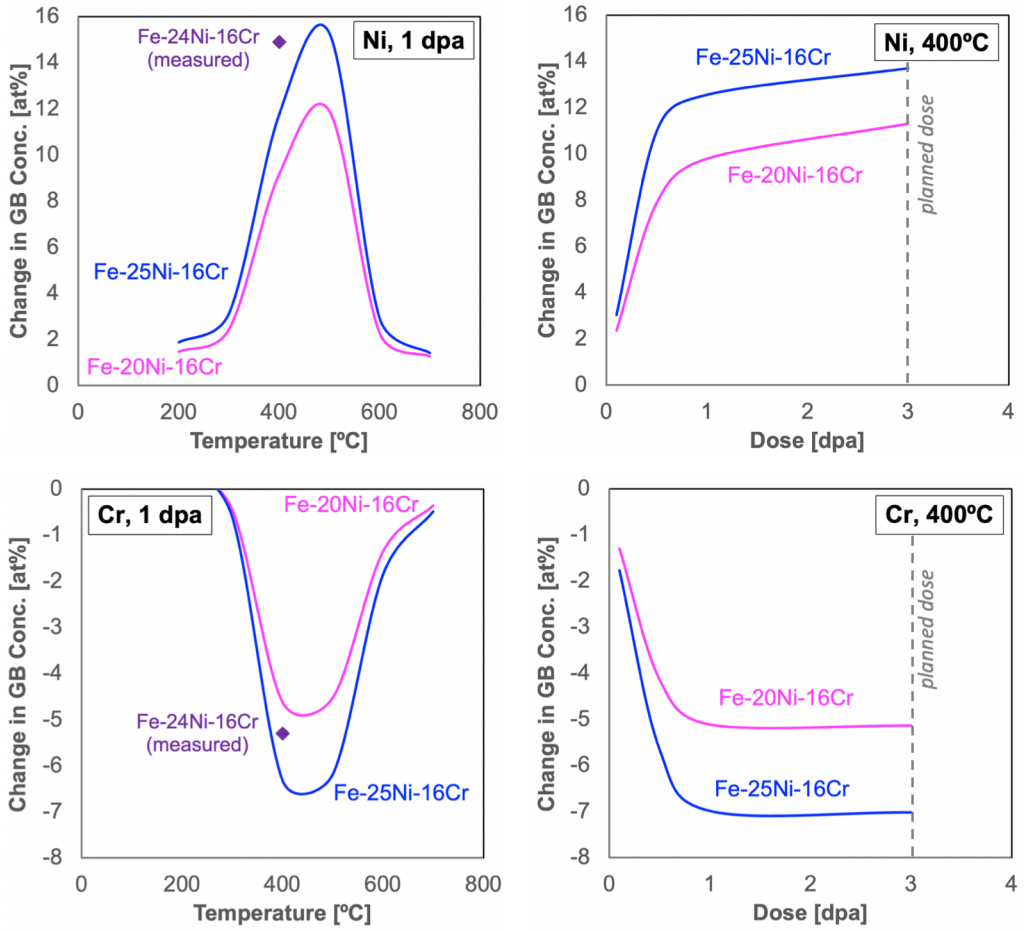
AFA steels have been studied in liquid Pb alone and under irradiation alone, but never together



Pb corrosion from GAIN program



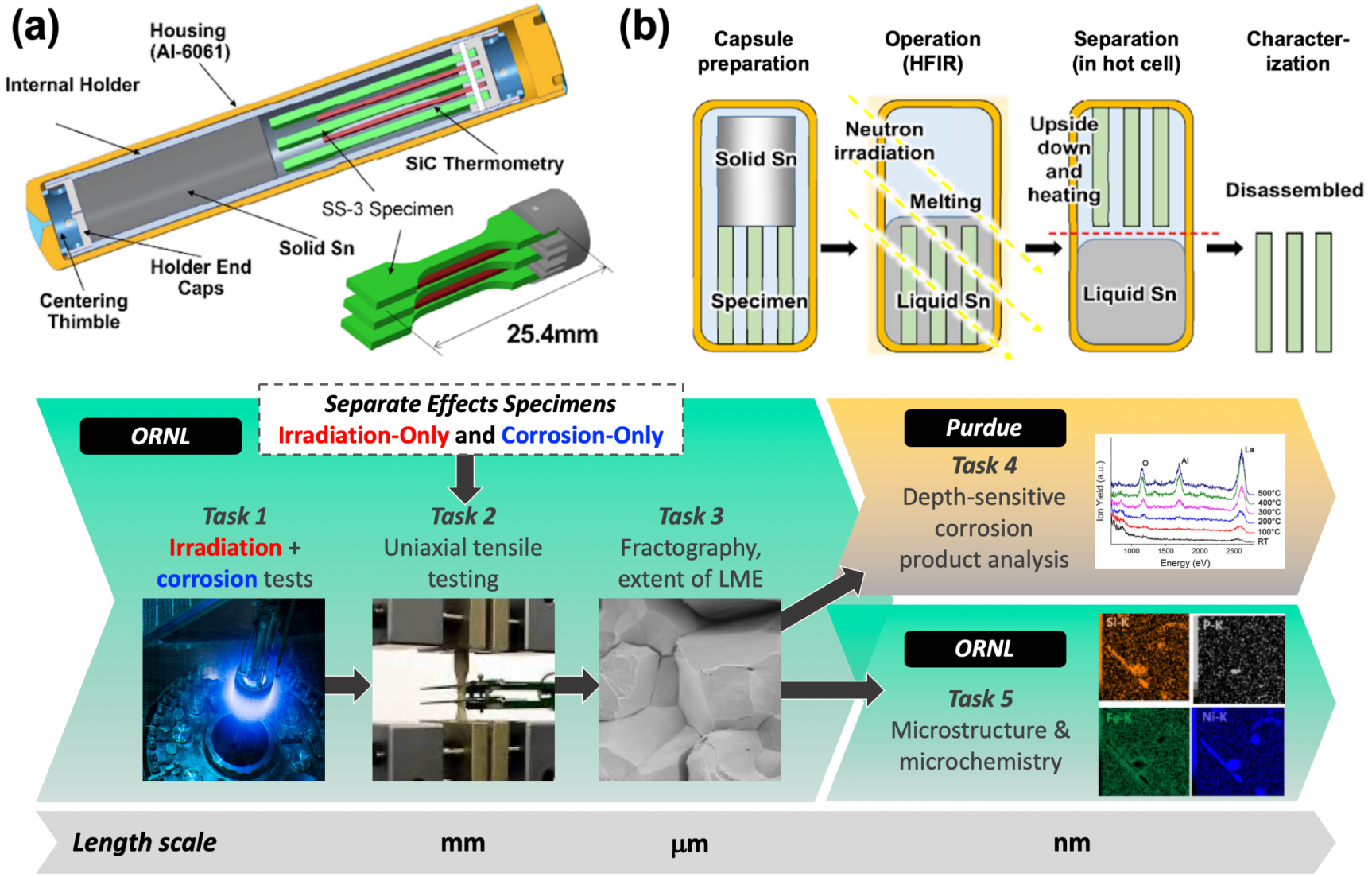
Modified inverse Kirkendall RIS model



HYPOTHESIS

Pb corrosion of AFA steels is ascribed to adsorption or wetting of Pb to Ni; thus vacancies are not introduced to the AFA steel substrate. Vacancy-driven RIS, leading to Ni enrichment, will not be disrupted. ***Consequently, higher Ni concentrations at surfaces and grain boundaries will accelerate Pb wetting, exacerbating liquid metal embrittlement.***

Concept leverages melting to immerse specimens in static Pb during irradiation

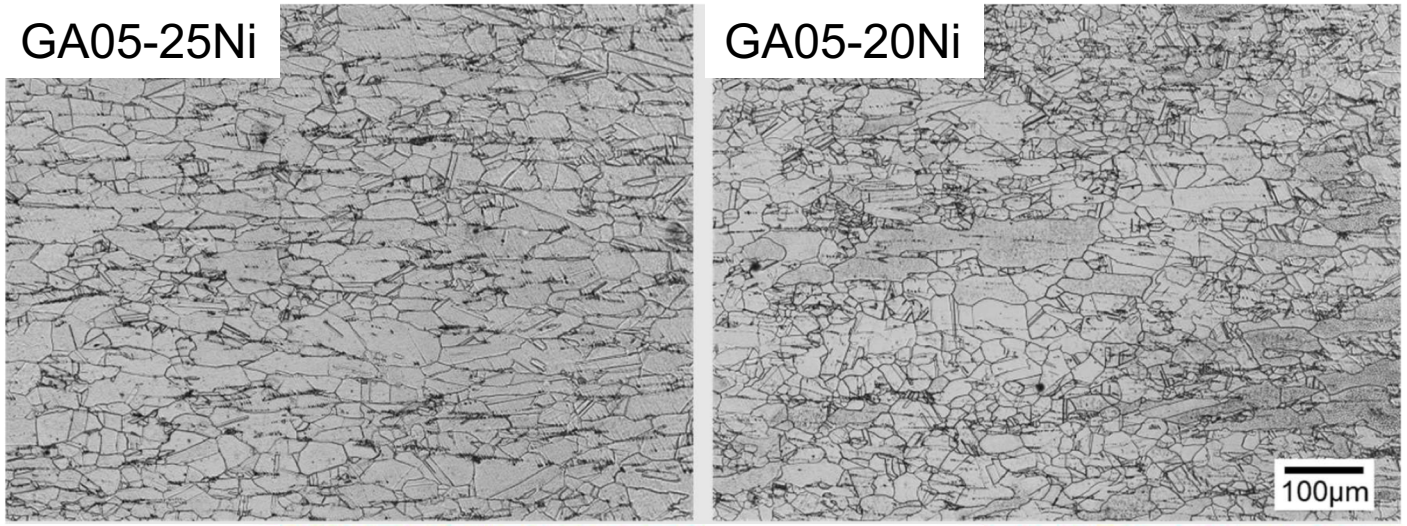


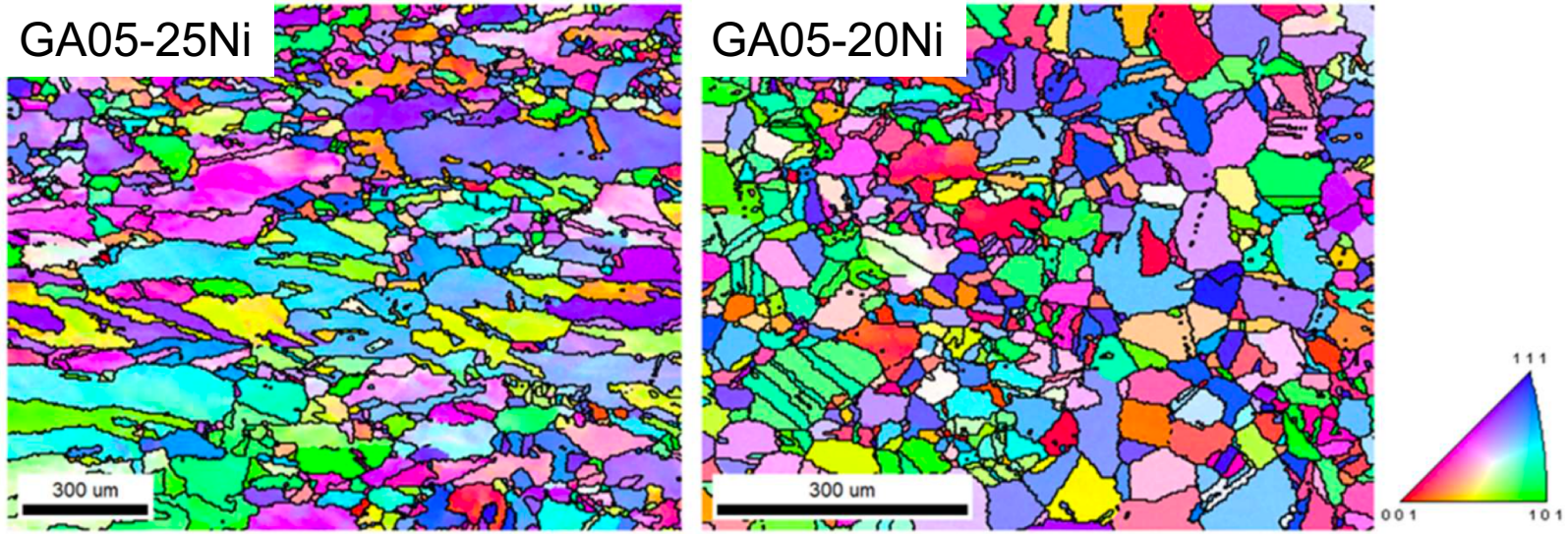
Two Ni compositions are planned, and we also leverage GAIN and NIFT-E

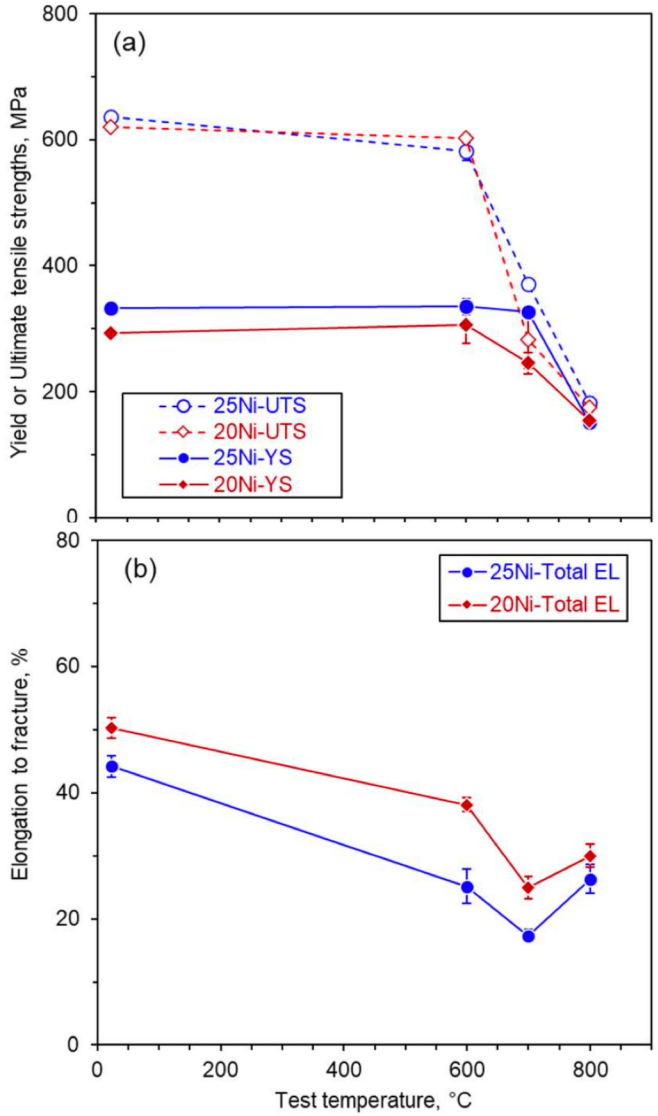
Alloy	Environment	Irrad/Corr Temp [ºC]	Dose [dpa]	Specimens per Capsule	# of Capsules	Tensile Test Temp [ºC]	Specimen Source
20Ni	Irradiation + Liquid Pb	400, 650	3	3	4	RT, 350, 600	This project
	Irradiation Only	400, 650	3	–	–	RT, 350, 600	NSUF/NNUF Pilot
	Liquid Pb Only	400, 650	–	–	–	RT, 350, 600	GAIN 18-16167
25Ni	Irradiation + Liquid Pb	400, 650	3	3	4	RT, 350, 600	This project
	Irradiation Only	400, 650	3	–	–	RT, 350, 600	NSUF/NNUF Pilot
	Liquid Pb Only	400, 650	–	–	–	RT, 350, 600	GAIN 18-16167

Name	wt.%	Fe	Al	C	B	Cr	CU	Mn	Ni	Nb	Si	Ti	V	N	Remarks
GA05-25Ni	**Analyzed**	**Bal.**	**4.0**	**0.22**	**0.011**	**16.0**	**2.8**	**1.9**	**24.9**	**0.6**	**0.2**	**<0.01**	**<0.01**	**<0.01**	Heat #: 23086504-1
	Target	**48.99**	**4**	**0.2**	**0.01**	**16**	**3**	**2**	**25**	**0.6**	**0.2**	**0**	**0**	**0**	
	Max	Balance	4.2	0.22	0.015	16.5	3.5	2.5	25.5	0.8	0.5	0.05	0.05	0.02	
	Min	Balance	3.9	0.15	0.005	15.5	2.5	1.5	24.5	0.5	0.15				
GA05-20Ni	**Analyzed**	**Bal.**	**4.0**	**0.21**	**0.011**	**16.0**	**2.8**	**2.0**	**20.0**	**0.6**	**0.2**	**<0.01**	**<0.01**	**<0.01**	Heat #: 23086504-2
	Target	**53.99**	**4**	**0.2**	**0.01**	**16**	**3**	**2**	**20**	**0.6**	**0.2**	**0**	**0**	**0**	
	Max	Balance	4.2	0.22	0.015	16.5	3.5	2.5	20.5	0.8	0.5	0.05	0.05	0.02	
	Min	Balance	3.9	0.15	0.005	15.5	2.5	1.5	19.5	0.5	0.15				

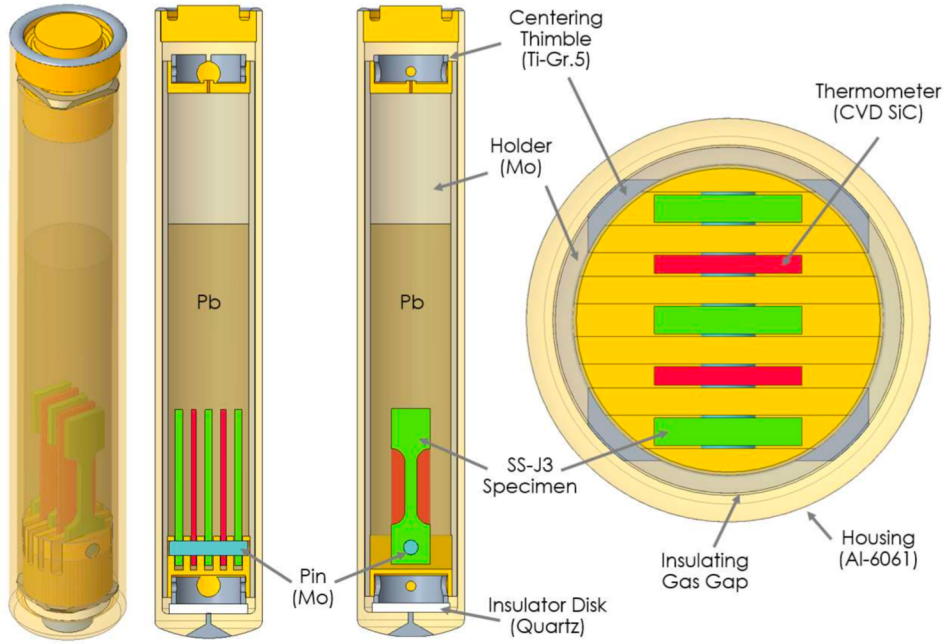
Alloys have equiaxed grain μ-structures and comparable mechanical properties

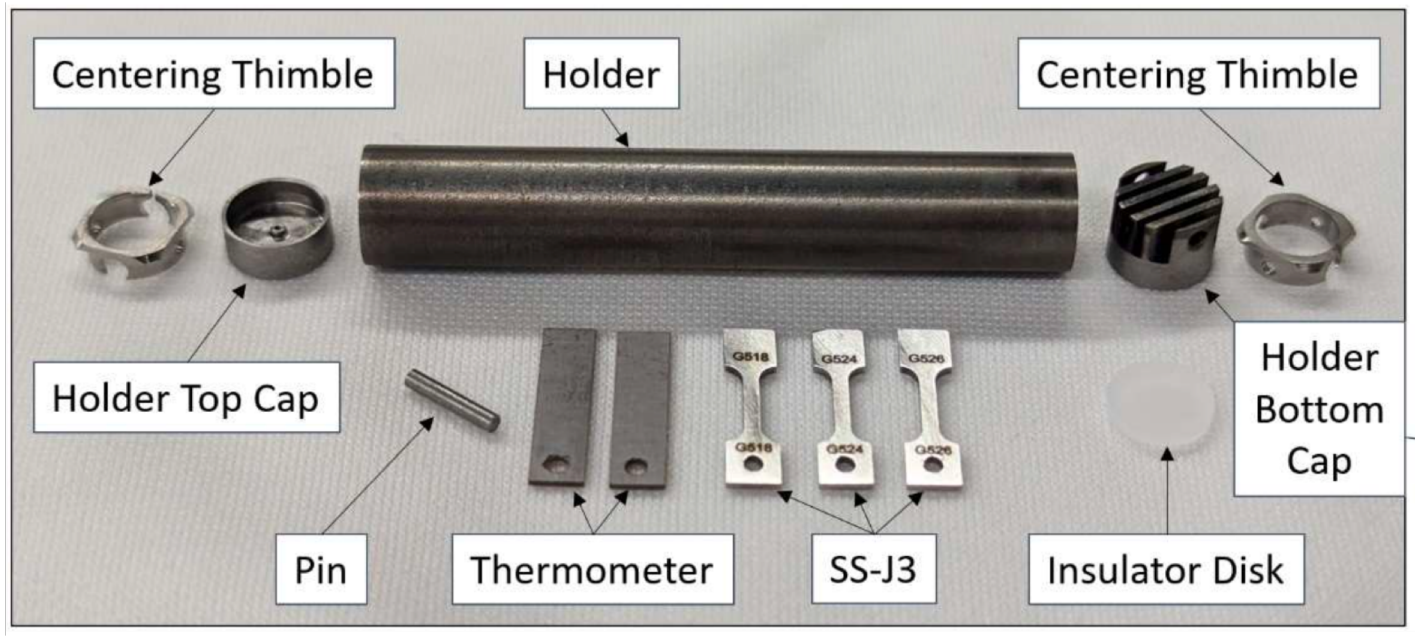


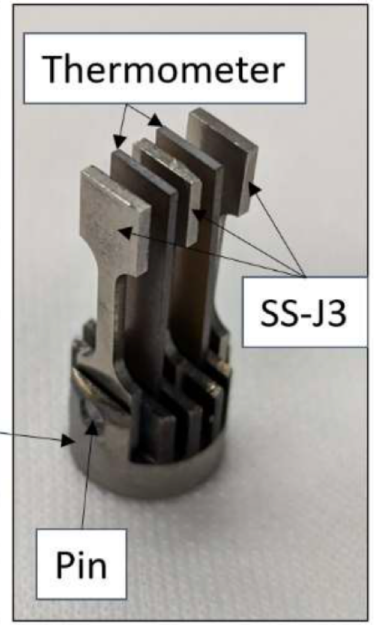




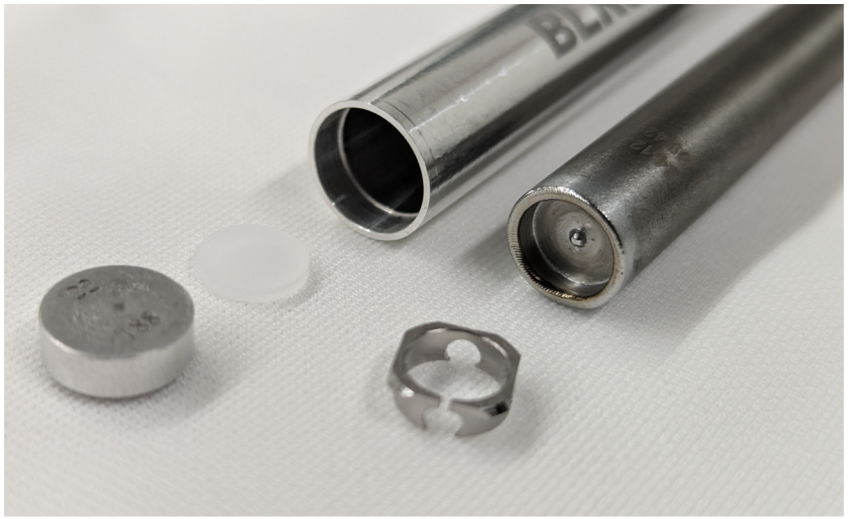
Assembly of 30 SS-J3 miniature tensile specimens prepared from each alloy into capsules

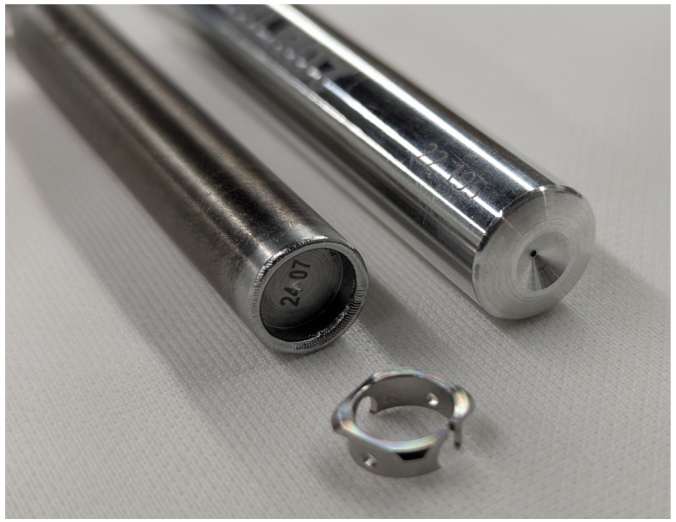






Final assembled capsules in Mo holders

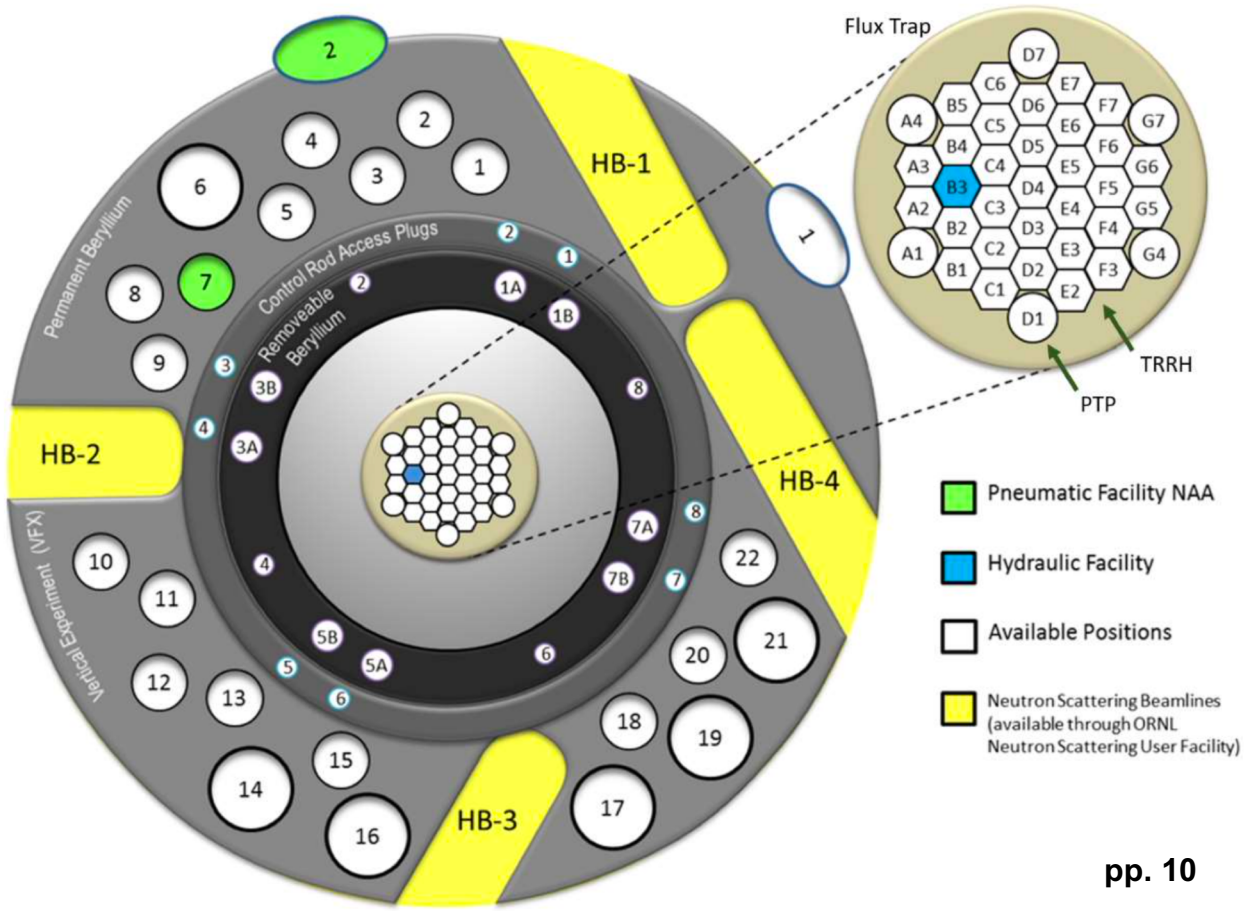




HFIR irradiations are ongoing

- **Cycle 511** – Six of eight capsules completed first of two cycles; will be removed after cycle 512
- After cycle 511 – heat exchanger issue, delayed restart of cycle 512 to ~June 2025
- **Cycle 512** – Last two capsules approved for insertion, will be removed after cycle 513
- If HFIR restarts in June, capsule removal would occur ~July and ~September, respectively

Capsule ID	Irradiation Temperature (°C)	Alloy	Dose (dpa)	# of Cycles
BLR01	400	GA05-20Ni	3	2
BLR02				
BLR03	650			
BLR04				
BLR05	400	GA05-25Ni		
BLR06				
BLR07	650			
BLR08				



We may have some PIE results for you at next year's meeting!

- Hope to begin early PIE during FY2026 Q1-Q2
- Individuals who have contributed significantly:
  Ronit Roy, Arya Chatterjee, Michael Ickes, Bruce Pint

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Thank you!

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