



High Temperature Irradiation Resistant Thermocouples

Advanced Sensors and Instrumentation
Annual Webinar

October 30, 2019

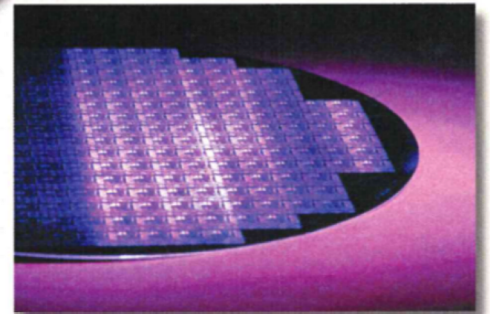
Richard Skifton, PhD
Idaho National Laboratory

Project Overview

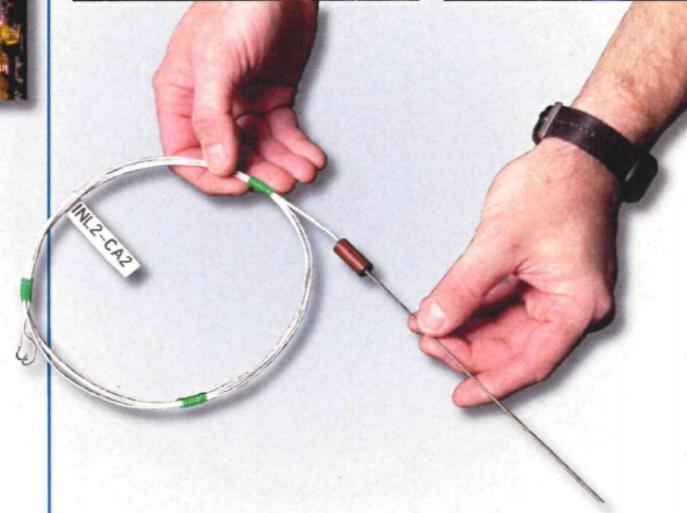
- Real-time temperature measurement is key to validation of irradiations. Specialized low-drift thermocouples for irradiation testing, High Temperature Irradiation Resistant Thermocouples (HTIR-TCs) are being developed and commercialized as a Baseline Instrumentation Capability.
- Participants:
 - Richard Skifton, INL
 - Brian Jaques, Scott Riley, BSU
 - Ember Sikorski, Lan Li, BSU
- Schedule
 - (8/21/2020) M3: Test high temperature irradiation resistant (HTIR) thermocouples in the INL flowing autoclave system (FAS)
 - (9/30/2020) M3: Characterize out of pile long term drift of high temperature irradiation resistant (HTIR) thermocouples and compare with modeling results

Technology Impact

- Fills technology gap of temperature measurements during irradiations between 1100°C and 1700°C
- Improvement in lifetime and uncertainty of temperature measurements for irradiations
- HTIRs are now successfully commercialized
 - Currently, can be ordered through Idaho Laboratories Corporation (www.idaholabs.com)
- HTIRs can be used in existing reactor fleet and advanced reactor pipeline and fuel cycles.



2019
R&D
100



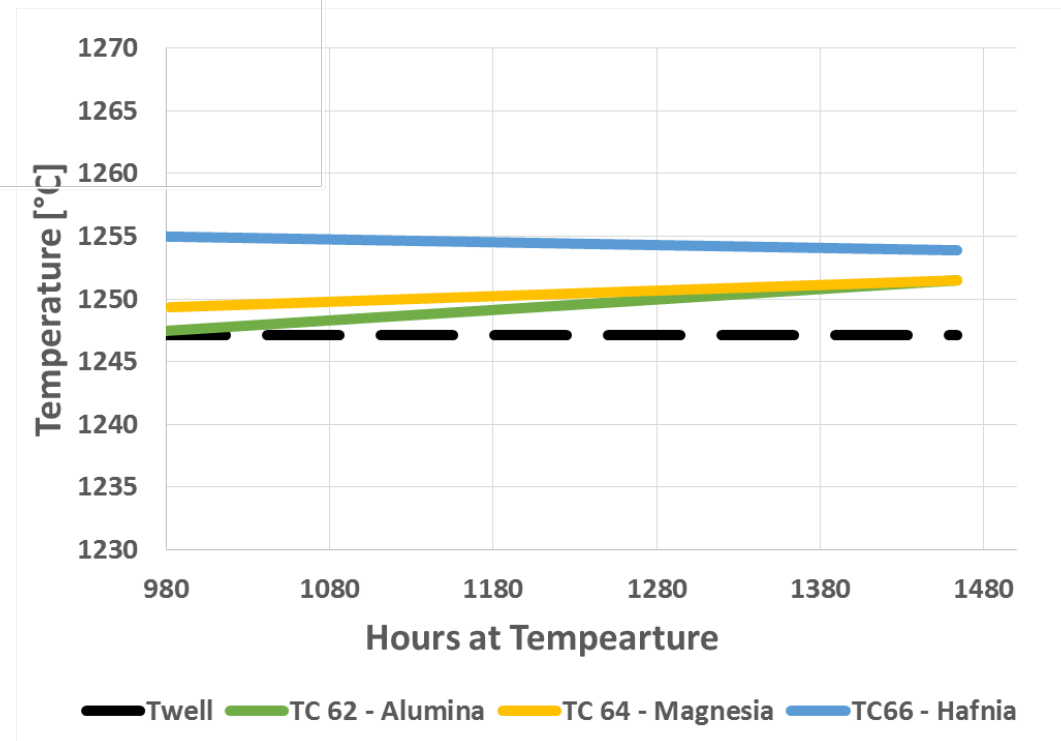
Measuring High Temperatures

High-Temperature Irradiation-Resistant Thermocouples (HTIR-TCs) are an innovative new sensor for a wide spectrum of industries.

Accomplishments

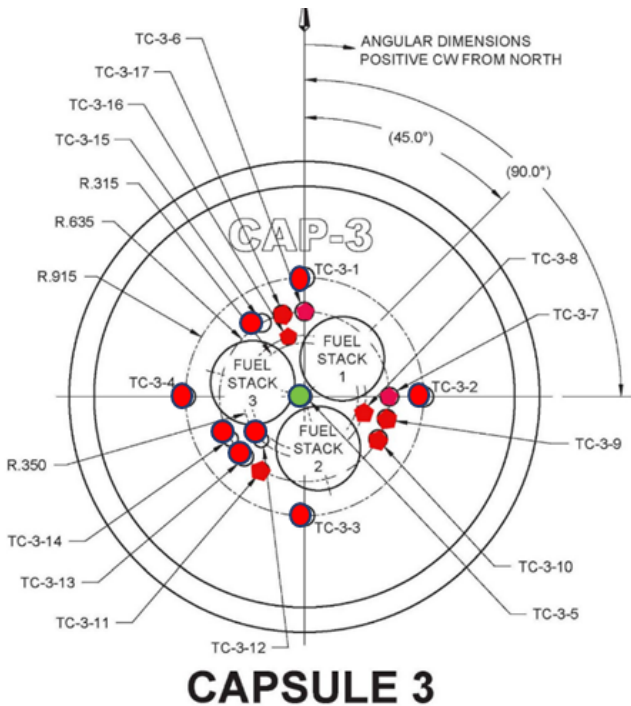
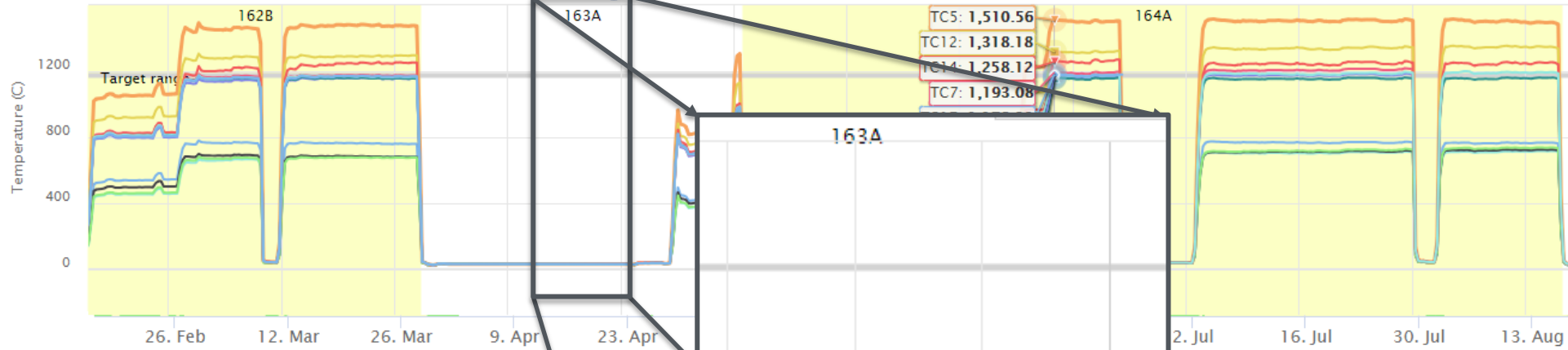
Thermocouple	Type K	Type B	Type N	HTIR-TC
Materials	Chromel vs Alumel	PtRh30% vs PtRh6%	Nicrosil vs. Nisil	Molybdenum vs. Niobium
Temperature Range	-270°C to 1260°C	0°C to 1700°C	-270°C to 1260°C	0°C to 1700°C
Cost	~\$30/ft	~\$250/ft	~\$50/ft	~\$250/ft
Radiation Tolerance as compared to HTIR-TC	1/10 th	~1/100 th	1/4 th	

HTIR-TC ‘marries’ the high temperature of the Type B thermocouple with the radiation tolerance of Type N & K



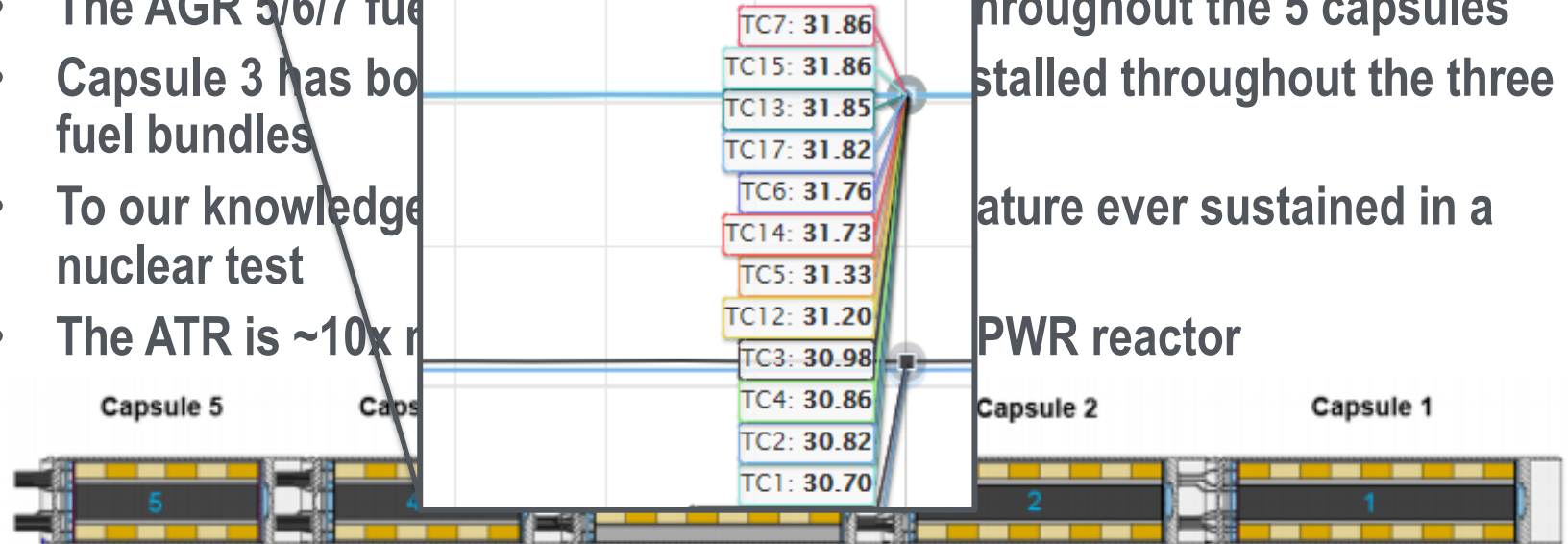
Accomplishments

Current Performance @ Advanced Test Reactor



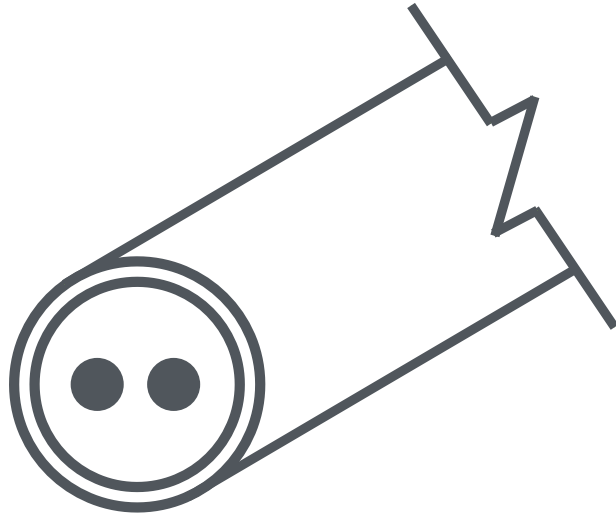
- The AGR 5/6/7 fuel bundles
- Capsule 3 has both fuel bundles
- To our knowledge nuclear test
- The ATR is ~10x more

throughout the 5 capsules stalled throughout the three (3) temperature ever sustained in a PWR reactor



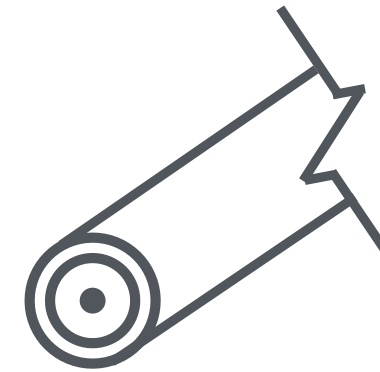
Accomplishments

Traditional



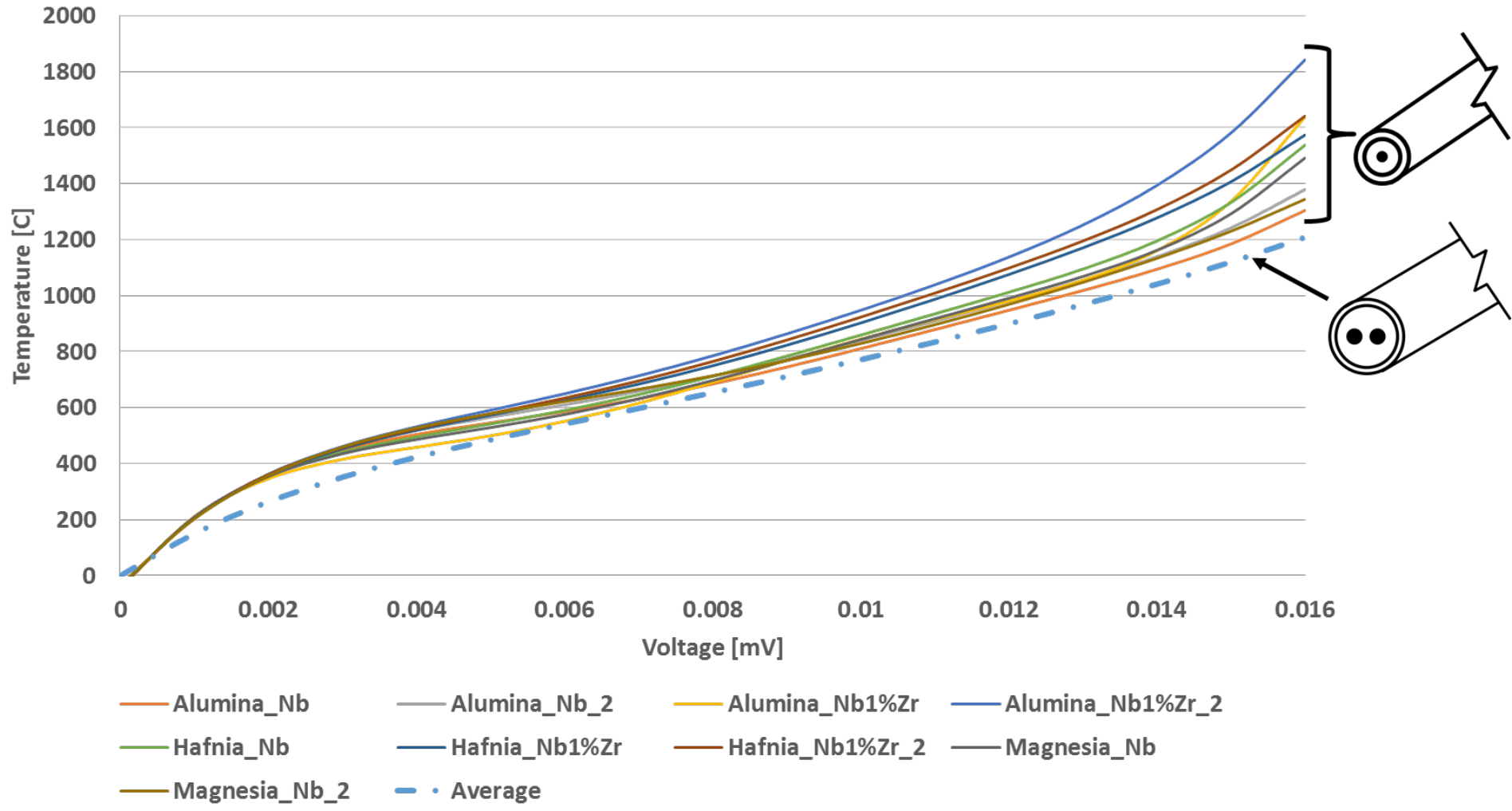
- One-off design
- Ungrounded
- Min. OD: 0.0625 inch
- Max Length: ~20 ft

Coaxial



- Manufactured off a spool of cabling!
- Grounded
- Fast Response
- Min. OD: < 0.020 inch
- Max Length: Any length!
- Surface mountable

Accomplishments

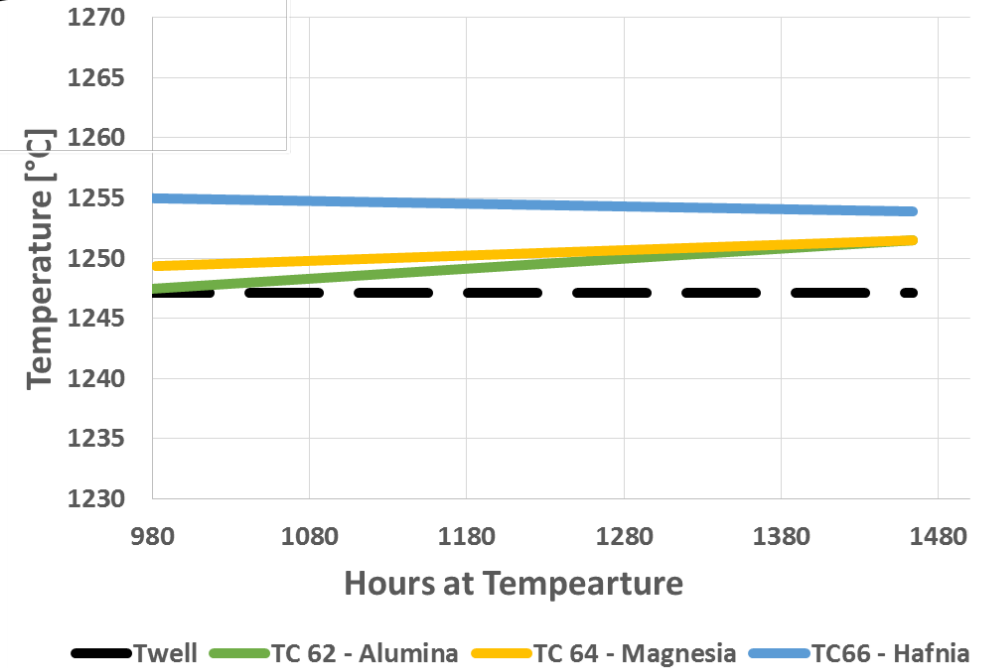


Accomplishments

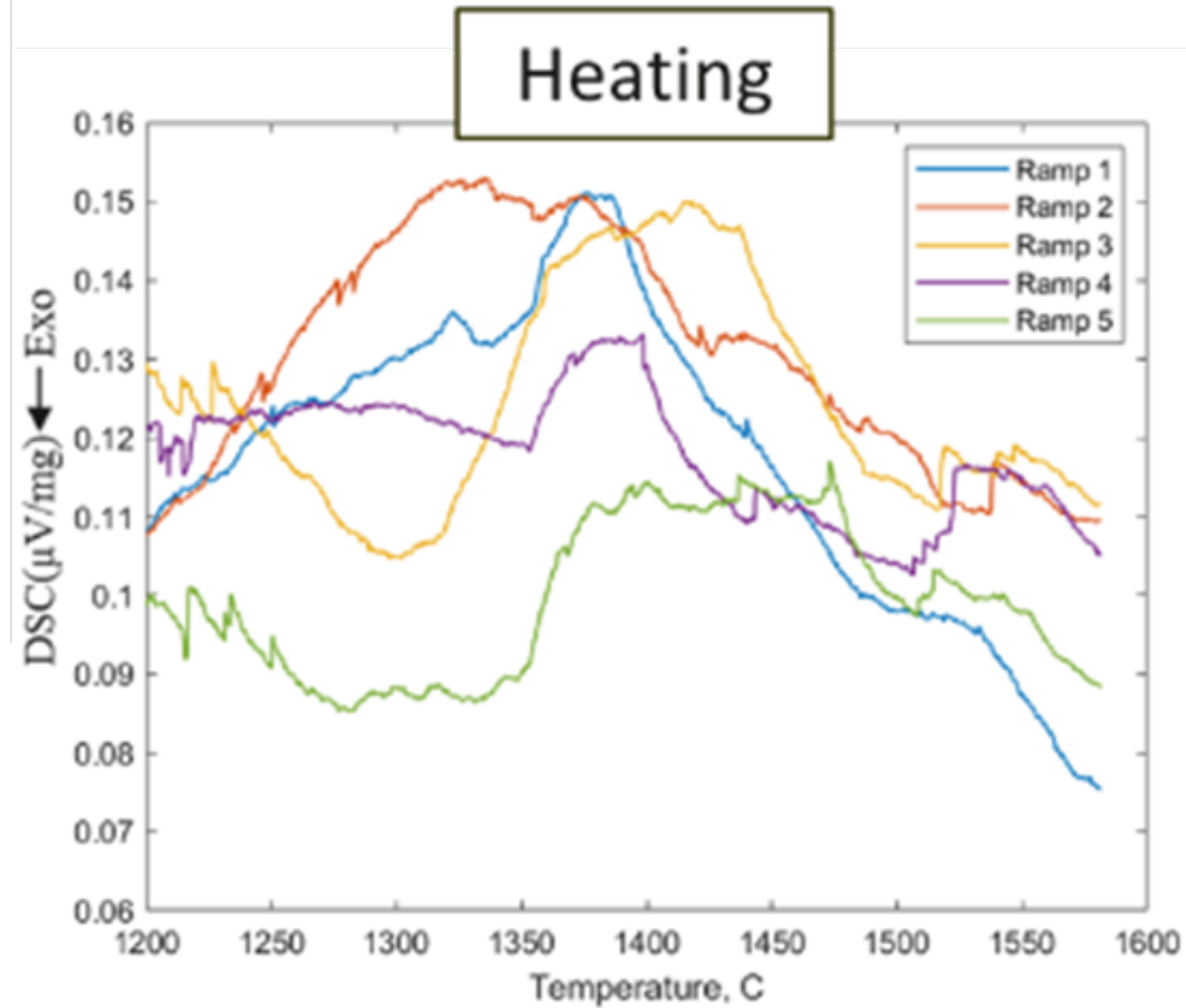
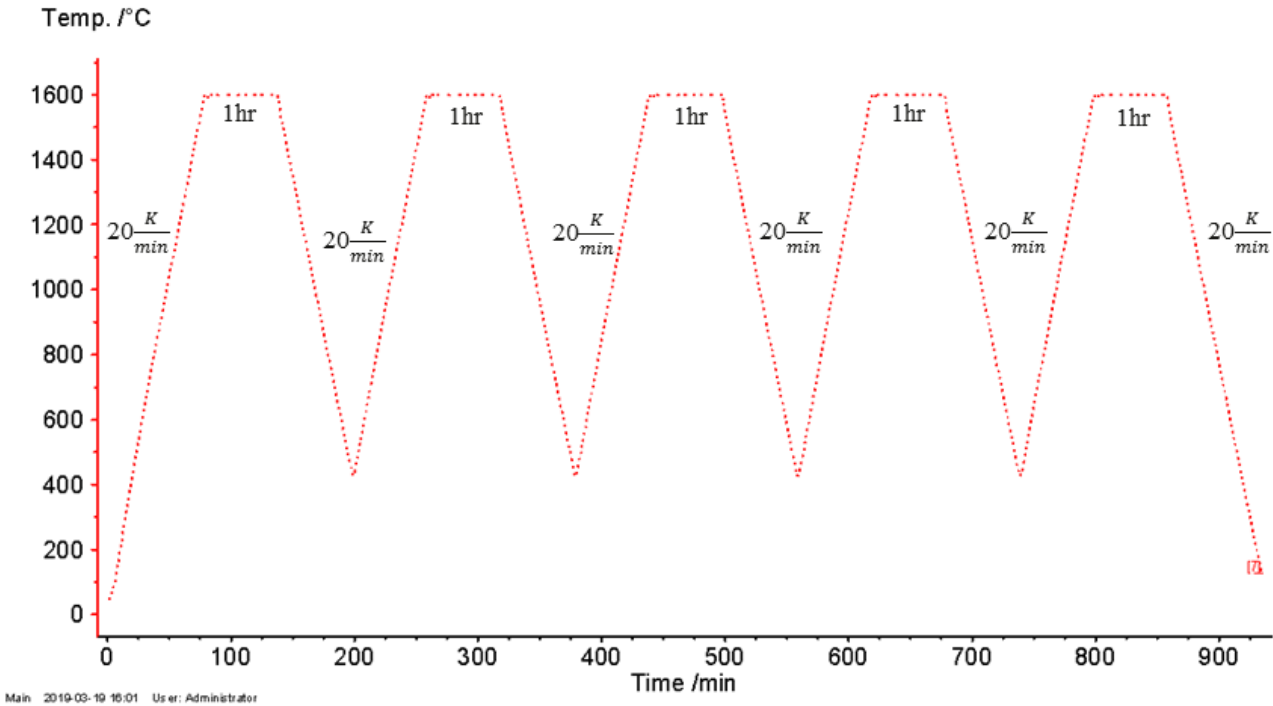
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\$100/ft

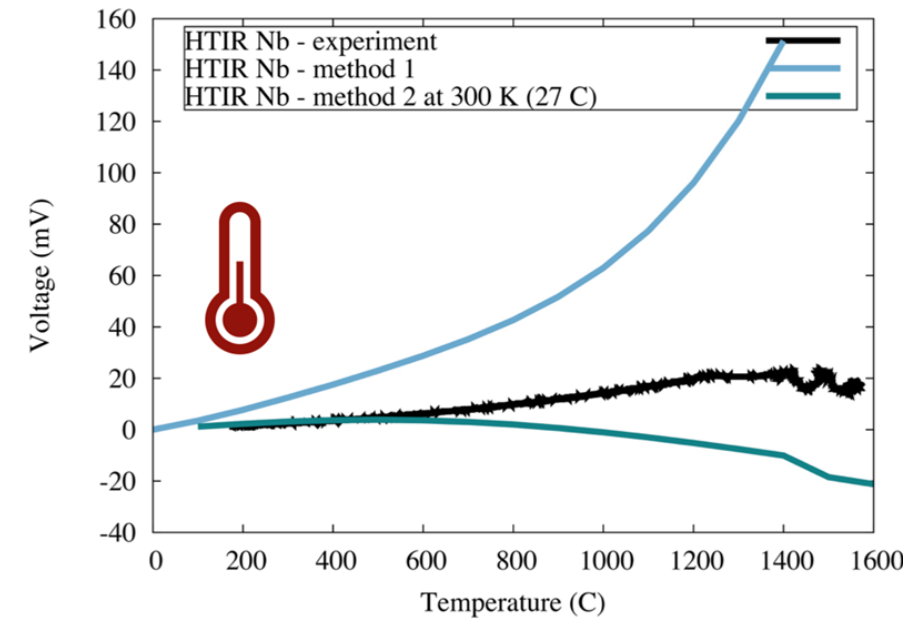
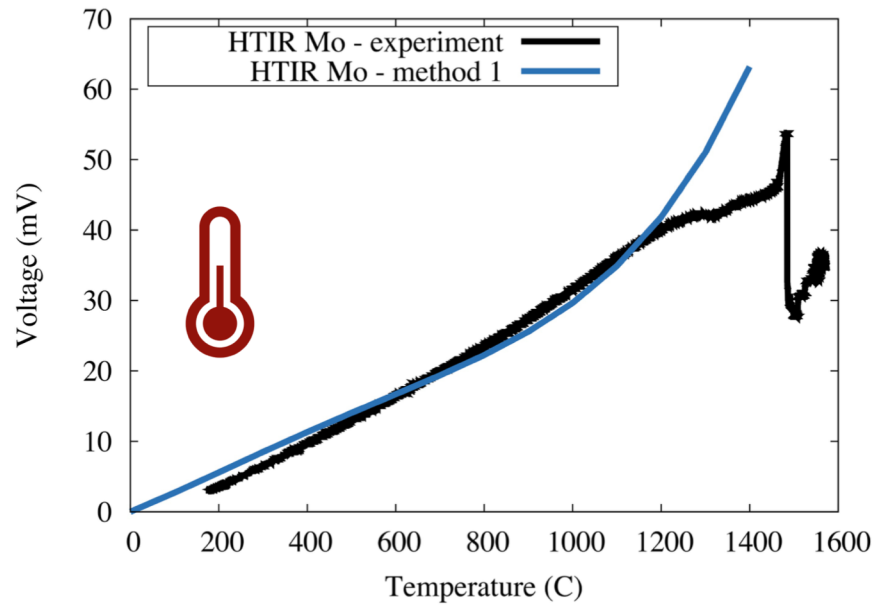
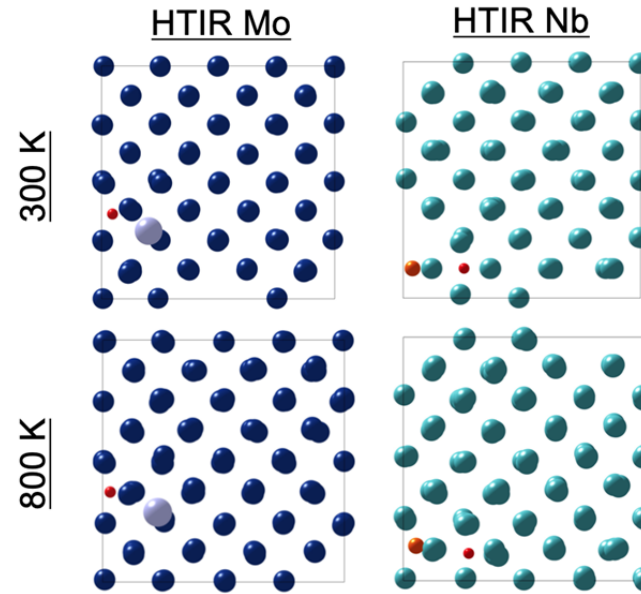


Accomplishments



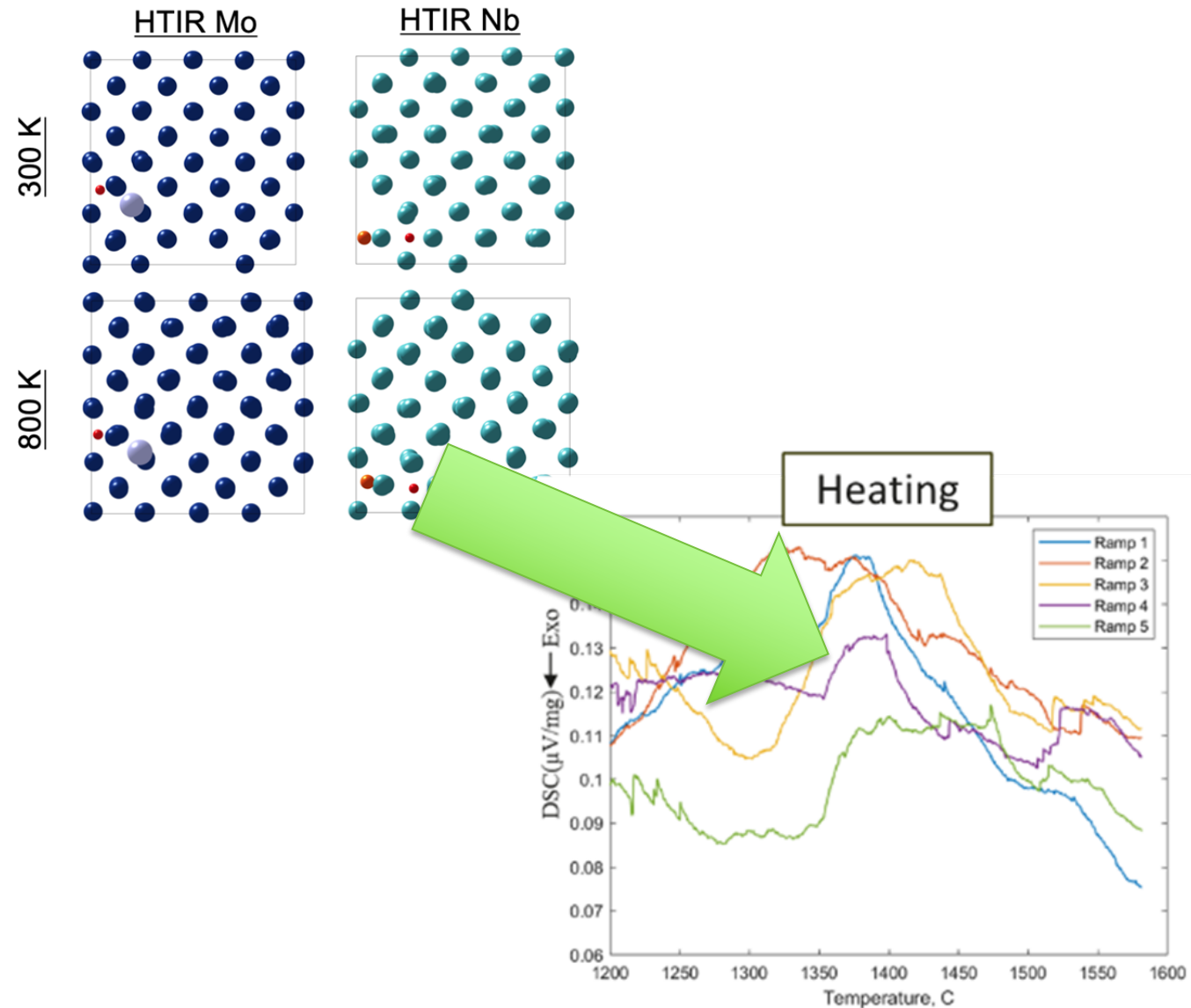
Accomplishments

The effects of temperature on the atomic structure.



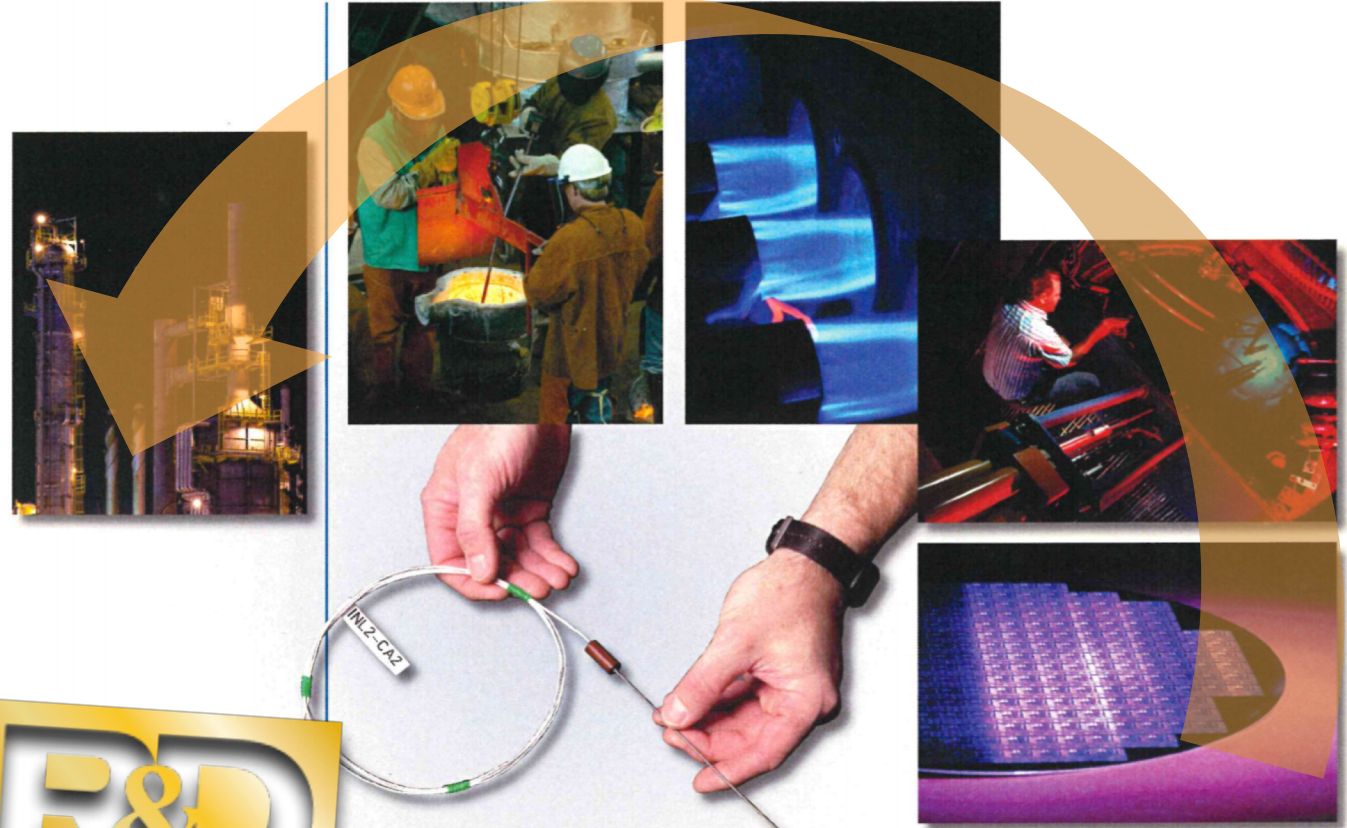
Conclusion

- Modeling lends understanding:
 - how structural changes affect performance
 - predict performance changes due to:
 - heat treatments
 - doped thermoelements
 - oxygen and hydrogen uptake
 - fission products
- We can then select materials and heat treatments for optimal in-pile thermocouple performance.



Conclusion

- HTIR-TCs:
 - are now successfully commercialized
 - Currently, can be ordered through Idaho Laboratories Corporation
www.idaholabs.com
208.522.0055
 - Can be used in existing reactor fleet and advanced reactor pipeline and fuel cycles.
 - Brings together the high temperature of the Type B thermocouple with the radiation tolerance of Type N & K



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Clean. **Reliable. Nuclear.**