J. Keith Jewell, Chief Scientist

NSUF Users Organization Meeting

March 7, 2024

NSUF Scientific Program

Nuclear Science User Facilities

The Nuclear Science User Facilities (NSUF)

Vision

- Continue U.S. leadership in nuclear energy research with cutting edge resources.

Mission

- Coordinate a consortium of institutions to provide no-cost access to unique and highly specialized nuclear research facilities and technical expertise.

Goal

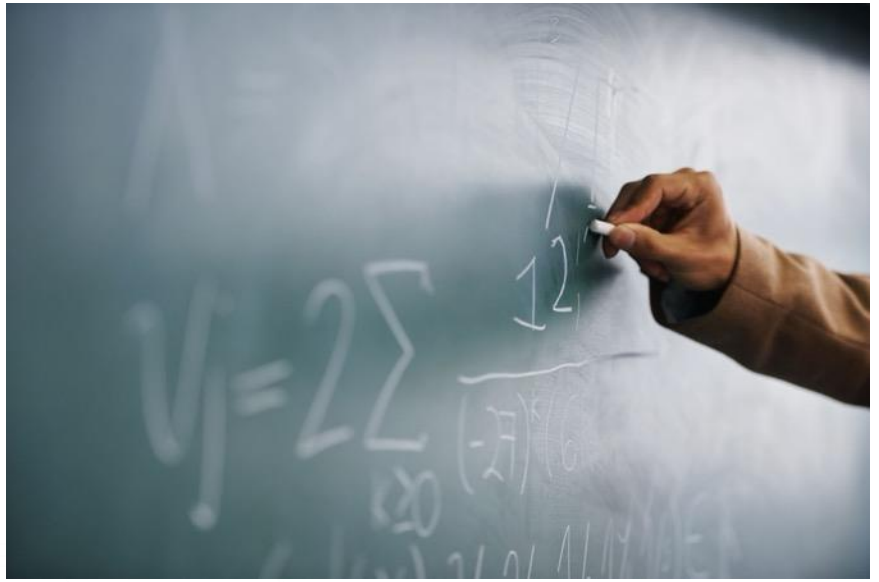
- Produce the highest quality research results that increase understanding of advanced nuclear energy technologies important to DOE-NE, industry and create new innovative concepts.

Strategy: Strategic R&D Support

- Provide mechanisms for research organizations to conduct irradiations and post irradiation analyses and utilize computing and experimental resources not normally accessible to these organizations.

Research Output

- In terms of scientific output, publications are one of the best tangible demonstrations of our impact in the field of nuclear science.
- Our team manually tracks NSUF publications monthly. Your NSUF-supported research is only accounted for when NSUF is accurately credited in the acknowledgments section of your publications. When publishing your work, please be sure to utilize the approved language. Going forward, please be sure to also identify what award you received, and the award number.
- The better we are able to demonstrate our impact, the better positioned we are to justify our presence in the nuclear science community – which ultimately benefits our ability to obtain funding and resources for NSUF, and inevitably, the funding and resources to support you, our users.



NSUF Projects (2007-2023)

- **Total NSUF Access Award Funding: $124M**
- **751 Total Awarded Projects**
  - Web of Science shows 743 publications
  - NSUF Website lists 738 publications
- **RTE Projects Executed 553, 71 Ongoing**
  - RTE Publications 538
- **CINR Projects Executed 77, 24 Ongoing**
  - CINR Publications 198

RTE Publications

- **Roughly 1 publication per project-very roughly**
- **Many examples of 5-6 articles coming from a single RTE award**
  - Dr. Xiaoyuan Lou, FY 2020 RTE 1st Call 20-2990, randomly selected
  - All have NSUF acknowledgement
- **One RTE project listing 16 associated publications, including a Nature citation**
  - None of them (so far) have an explicit NSUF acknowledgment
  - User (assumed) has made the association to the RTE project
  - Multiple funding sources and acknowledgements

NSUF CINR Awards FY 2022 – 2023: Projects

FY	PI	Title	Institution	NSUF Capabilities	Award Budget
2023	Janelle Wharry	Irradiation-Corrosion of Alumina-Forming Austenitic Stainless Steels in Static Lead	Purdue University	ORNL/HFIR irradiation, ORNL PIE, Purdue surface science lab	$2,288,974
	Elizabeth Sooby	UN multi-design irradiation campaign: a critical assessment of accelerated burnup and main correlations for mechanistic fuel performance modeling	University of Texas at San Antonio	ORNL/HFIR irradiation, ORNL PIE	$2,498,000
	Maxim Gussev	Investigation of intergranular cracking of highly irradiated austenitic stainless steels – materials of pressurized water reactors – in ambient conditions	Oak Ridge National Laboratory	ORNL PIE, Michigan PIE, WCLS PIE	$1,575,111
2022	Maria Okuniewski	Mechanical response and chemical effects at the fuel-cladding interface of HT-9 and metallic fuel	Purdue University	INL/MFC PIE	$651,854
	Junhua Jiang	Accelerated Irradiation and Evaluation of Ultrastrong and Elastic Glassy Carbon	Idaho National Laboratory	TAMU Ion Beam Lab, CAES	$256,423
	Gabriel Meric	Integrated Effects of Irradiation and Flibe Salt on Fuel Pebble and Structural Graphites for Molten Salt Reactors	Kairos Power	MITR irradiation, INL/MFC PIE	$833,191
	Andrew Whittaker	Gamma irradiation effects on the mechanical behavior of seismic protective devices	University at Buffalo	INL Gammacell, INL/MFC PIE	$451,337

CINR Publications

- **No publications yet from any FY19, FY20, FY21, FY22, FY23 CINR awards**

- **Most recent CINR Project to publish**
  - 2018 CINR Award 18-CINR-14749
  - Publication date June 2020
  - Very rapid turnaround from award to publication
    - More typical is 4-5 years

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Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms

Volume 472, 1 June 2020, Pages 46-52

In-situ measurement of irradiation behavior in $LiNbO_3$

Gaofeng Sha [a], Cole Harlow [a], Aleksandr Chernatynskiy [b], Joshua Daw [c], Marat Khafizov [a]

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https://doi.org/10.1016/j.nimb.2020.03.007

Abstract

In-situ measurement of $LiNbO_3$ based surface acoustic wave (SAW) crystal resonator device under irradiation was demonstrated and used to characterize the impact of radiation on physical properties of this material. The resonant frequency of the SAW device was monitored as the output power of the reactor was varied. Upon step increase of the reactor power, a gradual shift in the device's resonant frequency was observed. This frequency shift initially exhibits a linear growth and eventually reaches an equilibrium value proportional to the reactor power. The observed behavior can be attributed to two competing processes: increase of temperature due to gamma heating or accumulation of irradiation induced defects. In both cases, the response is attributed to changes in the physical properties of $LiNbO_3$, particularly the elastic constants. This demonstrated ability to measure materials properties under irradiation is attractive for development of sensors and performing materials science under irradiation.

CINR Publications

- **Most recent CINR publications**
  - **2015 CINR Award 15-CINR-8242**
    - February 2023 publication date
  - **2016 CINR Award 16-CINR-10537**
    - February 2023 publication date

ELSEVIER

Nuclear Engineering and Design

Volume 402, February 2023, 112114

Experiment design for the neutron irradiation of PM-HIP alloys for nuclear reactors

Donna Post Guillen [a], Janelle P. Wharry [b], Gregory K. Housley [a], Cody D. Hale [a], Jason V. Brookman [a], David W. Gandy [c]

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Acta Materialia 246 (2023) 118714

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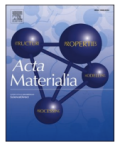

Novel effects of grain size and ion implantation on grain boundary segregation in ion irradiated austenitic steel

Andrew K. Hoffman [a,1], Yongfeng Zhang [b,1], Maalavan Arivu [c], Li He [b], Kumar Sridharan [b], Yaqiao Wu [e,f], Rinat K. Islamgaliev [d], Ruslan Z. Valiev [d], Haiming Wen [a,c,*]

[a] Department of Nuclear Engineering and Radiation Science, Missouri University of Science and Technology, Rolla, MO 65409, USA
[b] Department of Engineering Physics, University of Wisconsin, Madison, WI 53706, USA
[c] Department of Materials Science and Engineering, Missouri University of Science and Technology, Rolla, MO 65409, USA
[d] Institute of Physics of Advanced Materials, Ufa University of Science and Technology, Ufa 450076, Russia
[e] Micron School of Materials Science and Engineering, Boise State University, Boise, ID 83725, USA
[f] Center for Advanced Energy Studies, Idaho Falls, ID 83401, USA

CINR Publications Example

- **Characterization of the Microstructures and Mechanical Properties of Advanced Structural Alloys for Radiation Service: A Comprehensive Library of ATR Irradiated Alloys and Specimen**
  - 2008 Award 08-139 Pre CINR
  - T. Yamamoto, B. Odette UCSB project
  - 17 publications associated with this project
  - Numerous follow on RTE projects
    - These are not captured well and publications are associated with new projects.

CINR Publications-Improvements and Observations

- **Design and Process Articles**
  - Partner or performing facility involvement
  - Unique designs
  - Standard designs
  - Not necessarily high impact articles

- **Citations and capture**
  - Capture and tracking is not straightforward

ELSEVIER

Nuclear Engineering and Design

Volume 414, 1 December 2023, 112630

A standard capsule design for structural material testing in the Advanced Test Reactor

K.S. Anderson, D.D. Hale, J.L. Schulthess, M.M. Arrowood

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https://doi.org/10.1016/j.nucengdes.2023.112630

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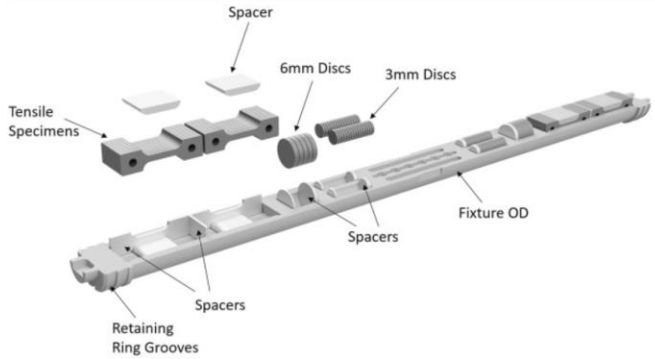

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Fig. 6. Schematic of the standard capsule fixture with specimens and spacers.

NSUF Publication Tracking

- **Publications are tracked monthly**
  - Publications can be added to NSUF website with or without an associated NSUF project
    - Obvious bias to associate publication with an NSUF project
- **Surprising degree of match between Web of Science and NSUF site**
  - Many WoS entries and NSUF acknowledgements that are difficult to link to a specific project

Search our internal database of NSUF publications and presentations.

View Presentations | + Add Publication | Export | view Non-NSUF

10 | Search...

Proposals	Projects	Category	Year	Publication Title	Authors	Publication	File
	Q20-2990		2024	Dislocation channel broadening–A new mechanism to improve irradiation-assisted stress corrosion cracking resistance of additively manufactured 316 L stainless steel	Xiaoyuan Lou	*Acta Materialia*, 266, 119650.	
Q24-4977	Q20-4118		2023	Experimental Measurement and Multiphysics Simulation of Tritium Transport in Neutron Irradiated Flibe Salt	Kieran Dolan, Guiqiu Zheng, Michael Ames, David Carpenter, Lin-wen Hu	*Nuclear Technology*, 209 (4), 515-531.	
	Q20-2990		2023	Void swelling in additively manufactured 316L stainless steel with Hafnium composition gradient under self-ion irradiation	Xiaoyuan Lou	*Journal of Nuclear Materials*, 578, 154351.	
	Q20-2990		2023	Intragranular irradiation-assisted stress corrosion cracking (IASCC) of 316L stainless steel made by laser direct energy deposition additive manufacturing: Delta ferrite-dislocation channel interaction	Xiaoyuan Lou	*Journal of Nuclear Materials*, 577, 154305.	
	Q19-1723		2023	The role of Cr, P, and N solutes on the irradiated microstructure of bcc Fe	Janelle Wharry, Patrick Warren, Caleb Clement, Amrita Sen, Chao Yang, Wei-Ying Chen, Yaqiao Wu, Ling Wang	*Journal of Nuclear Materials*, 583, 154531.	

NSUF Citations

- When submitting publications based on NSUF projects, make sure to include the following citation:

"This work was supported by the U.S. Department of Energy, Office of Nuclear Energy under DOE Idaho Operations Office Contract DE-AC07- 051D14517 as part of Nuclear Science User Facilities award #_____."

- Include the citation to NSUF
- Helpful to include Award ID #
- Add it to the Project page on nsuf.inl.gov
- Send us an email

Acknowledgements

This research was primarily supported (atomistic simulations by D.A.) by the National Science Foundation Materials Research Science and Engineering Center program through the UC Irvine Center for Complex and Active Materials (DMR-2011967). Work by T.J.R. was supported by the US Department of Energy, Office of Science, Basic Energy Sciences, under Award No. DE-SC0021224 (theory and analysis of grain boundary complexions). Work by J.P.W. was supported by the US Department of Energy, Office of Science, Basic Energy Sciences, under Award No. DE-SC0020150 (irradiation tailoring of phase transformations). Experimental results from ion irradiated Cu-Ta were obtained at the Intermediate Voltage Electron Microscope (IVEM)-Tandem Facility at Argonne National Laboratory through the US Department of Energy, Office of Nuclear Energy, Nuclear Science User Facilities, under Award No. 19-1757. J.R.T. acknowledges support from the US Department of Energy, Office of Science, Basic Energy Sciences, under Award No. DE-SC0021060. P.C. was supported by the US Department of Energy, Basic Energy Sciences, under Award No. DE-SC0022295.

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Page 146
Research Article
https://doi.org/10.1007/s12613-023-2711-9

Spark plasma sintering of tungsten-based WTaVCr refractory high entropy alloys for nuclear fusion applications

Yongchul Yoo[1)], *Xiang Zhang*[1)], *Fei Wang*[1)], *Xin Chen*[1)], *Xing-Zhong Li*[2)], *Michael Nastasi*[3)], *and Bai Cui*[1,2)]✉

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(Received: 11 March 2023; revised: 3 July 2023; accepted: 13 July 2023)

Abstract: W-based WTaVCr refractory high entropy alloys (RHEA) may be novel and promising candidate materials for plasma facing components in the first wall and diverter in fusion reactors. This alloy has been developed by a powder metallurgy process combining mechanical alloying and spark plasma sintering (SPS). The SPSed samples contained two phases, in which the matrix is RHEA with a body-centered cubic structure, while the oxide phase was most likely Ta_2VO_6 through a combined analysis of X-ray diffraction (XRD), energy-dispersive spectroscopy (EDS), and selected area electron diffraction (SAED). The higher oxygen affinity of Ta and V may explain the preferential formation of their oxide phases based on thermodynamic calculations. Electron backscatter diffraction (EBSD) revealed an average grain size of 6.2 μm. WTaVCr RHEA showed a peak compressive strength of 2997 MPa at room temperature and much higher micro- and nano-hardness than W and other W-based RHEAs in the literature. Their high Rockwell hardness can be retained to at least 1000°C.

Keywords: refractory high entropy alloy; plasma-facing material; fusion reactor; spark plasma sintering

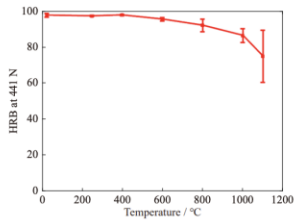

Fig. 9. Temperature dependence of Rockwell HRB for the SPSed WTaVCr RHEA.

3.8) is still compared to many stainless steels and nickel alloys at room temperature, indicating the outstanding hardness of this RHEA at high temperatures.

The compression test performed at room temperature suggested that the peak compressive strength of the SPSed WTaVCr RHEA was 2997 MPa, which is comparable to that of the SPSed WNbMoTaV RHEA (3472 MPa) [35] but much higher than that of arc-melted WNbMoTaV RHEA (1270 MPa) [33]. To further improve the performance of WTaVCr RHEA in PFCs of fusion reactors, the next step of research will focus on minimizing the particle size of the oxide phase to tens of nanometers. This oxide dispersion strengthening (ODS) strategy may improve its microstructural stability at high temperatures [40,59], enhance its mech-

Acknowledgements

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Conflict of Interest

Bai Cui is an editorial board member for this journal and was not involved in the editorial review or the decision to publish this article. The authors declare no potential conflict of interest.

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[1] R.G. Abernethy, Predicting the performance of tungsten in a fusion environment: A literature review, *Mater. Sci. Technol.*, 33(2017), No. 4, p. 388.
[2] K. Huang, L.M. Luo, X. Zan, *et al.*, Microstructure and damage behavior of W–Cr alloy under He irradiation, *J. Nucl. Mater.*, 501(2018), p. 181.

NSUF Nuclear Science User Facilities

Summary

- **Publications remain the most effective measure of scientific impact**
- **Large variance in publication numbers per project**
  - True for both CINR and RTE-maybe author specific
- **Typical 4-5 year lag in CINR award to publication**
  - Smaller, PIE only awards are quicker
- **CINR projects enable new RTE and follow on awards**
  - NSUF is not capturing this well
- **Partner Facilities can produce Design and Process publications**
- **NSUF Publication tracking can be improved**
- **Your help is needed.**

NSUF

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