DOE-NE Microreactor Program Winter Review

(Project 23-29784) Deciphering Irradiation Effects of YHx Through In-situ Evaluation and Micromechanics for Microreactor Applications

Eric Lang – UNM

NUCLEAR ENGINEERING

Goals, Objectives, and Team

- **Goal:** Evaluate the high temperature irradiation effects on YH_x to decipher phase stability, H retention, and corresponding impact on mechanical properties through ion irradiation and micro-mechanical testing to help determine the efficacy of YH_x as a microreactor moderator material.
- **Team:**
  - **PI:** Eric Lang, University of New Mexico
  - **Co-PI:** Khalid Hattar, University of Tennessee-Knoxville
  - **Co-PI:** Adi Shivprasad, Los Alamos National Laboratory
  - **Co-PI:** Caitlin Kohnert, Los Alamos National Laboratory
  - **Two** UNM graduate students
  - **One** UTK graduate student

Goals, Objectives, and Team

The overall objectives of this project are to:

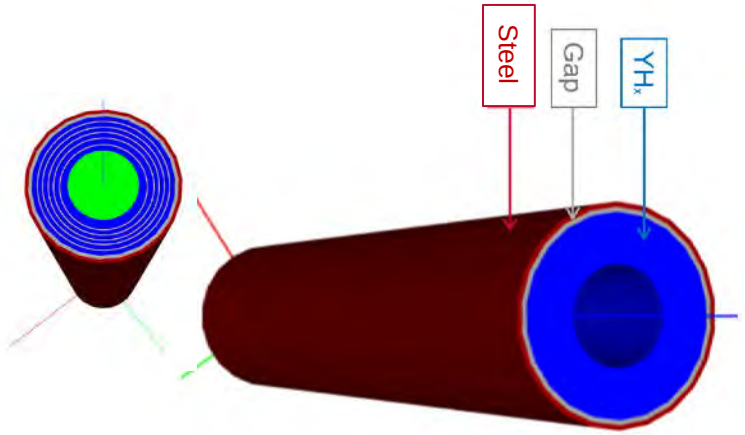
- Identify the effects of ion irradiation on the YH microstructure and phase stability at elevated temperature
  - i.e. H decoration surrounding voids
- Understand how radiation-induced defects, such as voids and dislocation loops, affect mechanical properties
  - i.e.e mechanisms of
- Establish a facility for further ion irradiation studies of YH and nuclear materials under gas exposure
  - i.e. limit loss of H under vacuum ion irradiation

Path and progress

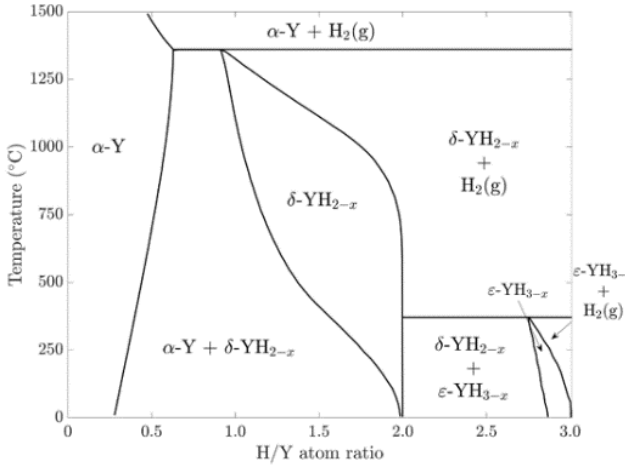
- Thrust 1: Establish a baseline understanding of YH fabricated properties vs. H content (Primary work: Q1-Q5)
- Thrust 2: Probe radiation damage effects with reactor-relevant doses of irradiation (Primary work: Q2-Q8)
- Thrust 3: Structure-property relationships of ion irradiated YH materials (Primary work: Q4-Q12)
- Thrust 4: Decipher real-time YH dynamics and interplays with structural materials (Primary work: Q8-12)

Thrust 1 progress

- Thrust 1: Establish a baseline understanding of YH fabricated properties vs. H content
  - 24 specimens in various geometries at Y:H ratios of 1.5, 1.7, and 1.9 (all delta-phase) in geometries of discs, annular cylinders, and cubes hydride at LANL
  - In-situ SEM picoindenter to arrive at UNM in late March
  - Creation of small vacuum chamber to test thermal gradient effects on H transport designed at UNM



Thermal gradient effects

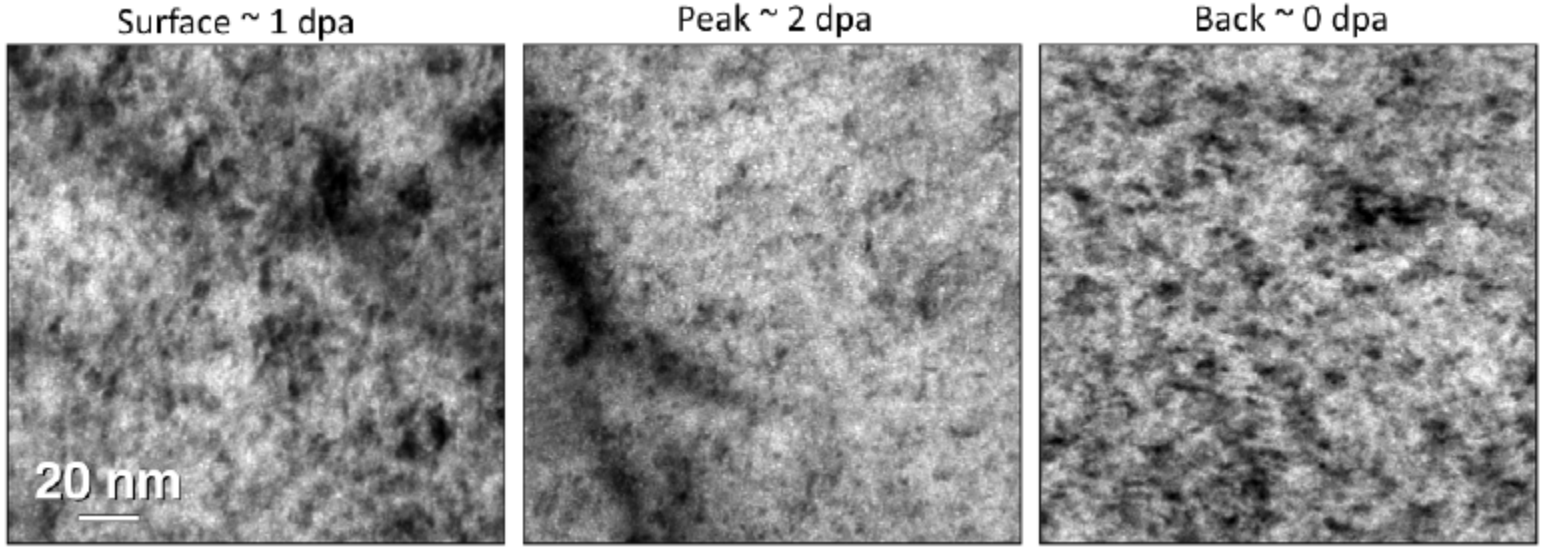


Specimens fabricated in the delta phase

Thrust 1 progress

- Thrust 1: Establish a baseline understanding of YH fabricated properties vs. H content
  - Old ion irradiated specimens shipped from LANL to UNM for further characterization (APT specimen fabrication and micro/nano-cantilever fabrication)

Previously irradiated YH specimens with 9 MeV Au at 700 C.



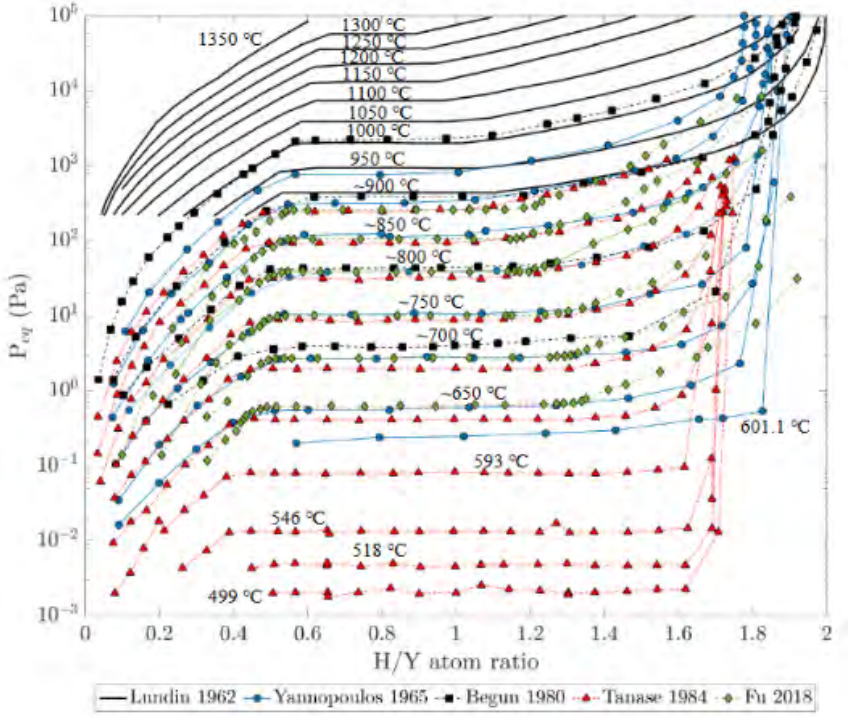
Thrust 2 progress

- Thrust 2: Probe radiation damage effects with reactor-relevant doses of irradiation
  - UTK Tennessee Ion Beam Materials Lab successfully ran a 2MeV Y beam
  - Successful runs of Au and H beams demonstrated many times previously
  - New high temperature stage operational to 1000 °C with various sample mounting mechanisms

Yttria powder cathode and new high temperature stage commissioned at UTK

Thrust 4 progress

- Thrust 4: Decipher real-time YH dynamics and interplays with structural materials
  - Residual gas analyzer (RGA) attached to UTK beamline to decipher real-time desorption monitoring of H during irradiation
  - SiN windows purchased to maintaining H environment in beamline
  - Co-PIs have previous experience with these SiN windows up to atmospheric pressure in a high vacuum environment



In-situ gas environment cell at UTK will need to be ~1 Torr

Future goals and near-term outcomes

- Thrust 1:
  - Pre-characterization of as-hydrided specimens in Q2 of CY 2024
- Thrust 2:
  - Ion irradiations at elevated temperatures with H, Au, Y beams in Q3 of CY 2024
- Thrust 3:
  - Pre-irradiation characterization of mechanical properties in Q2 of CY 2024
- Thrust 4:
  - Y films to be deposited at LANL on SiN windows for H gas experiments at UTK