U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Clean. Reliable. Nuclear.

DOE Microreactor Program

Current Yttrium Hydride Research and Future Plans

Technology Maturation Panel

GAIN-NEI-EPRI Microreactor Program Workshop

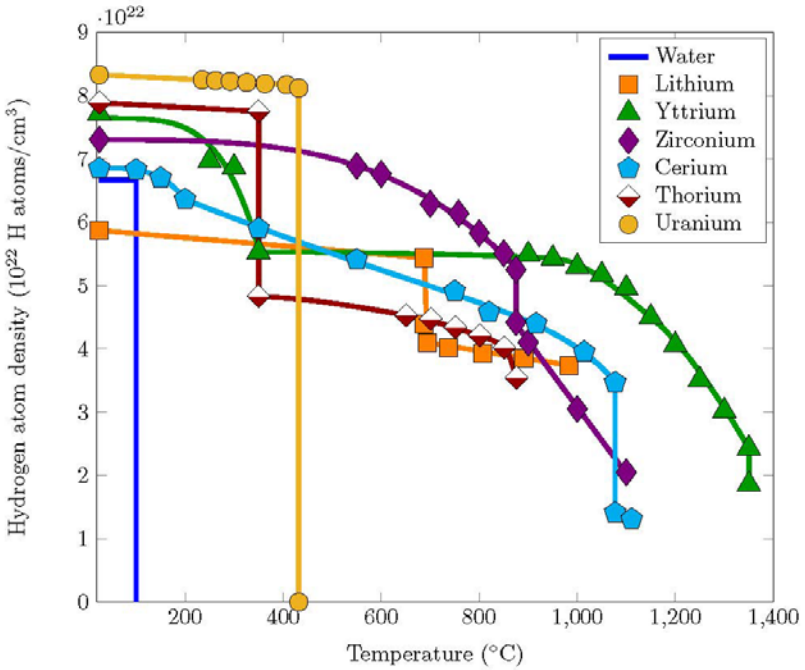
June 2-3, 2020

Erik Luther

Moderator Work Package Manager

High Temperature Moderator Overview

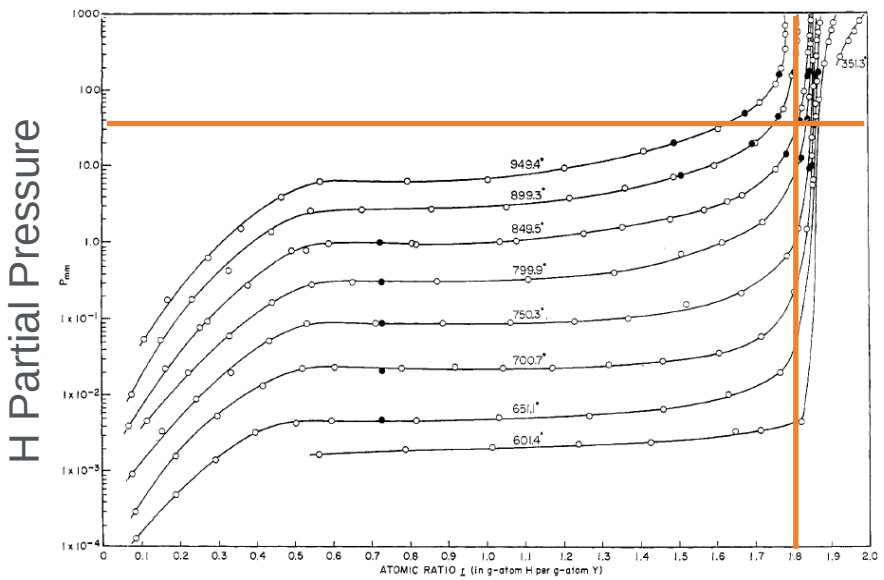
- Moderating material reduces fuel mass requirements in microreactors
- Yttrium hydride retains H at high temperatures for more efficient energy production
- The focus is to perform activities to qualify $YH_{1.X}$ for use as a moderator
  - Efforts follow the needs identified in the moderator development plan.
  - Research will advance knowledge and satisfy needs for developers with moderated cores.



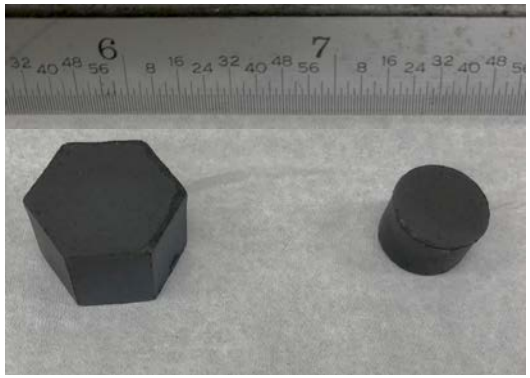
- ATR irradiation for post irradiation properties
- NCERC integral test for reactivity
- Initial version of Advanced Moderator Handbook

Fabrication of Yttrium Dihydride

- Direct (massive) hydriding
  - Yttrium hydride prepared by direct reaction of yttrium metal with hydrogen gas at 820ºC +/-5˚C in a Sievert's apparatus
    - 4.5 v% expansion from hydriding
    - Large yttrium castings may have defects
    - Expansion depends on microstructure
      - Post hydride machining
- Powder metallurgy
  - $YH_{1.x}$ powder crushed, milled and sieved
  - Green pellets pressed
  - Pellet sintered (patented method)
    - Oxidation
    - Complexity of process
- Scale up of fabrication capability
  - Sizes to 12"
  - Kilograms of material

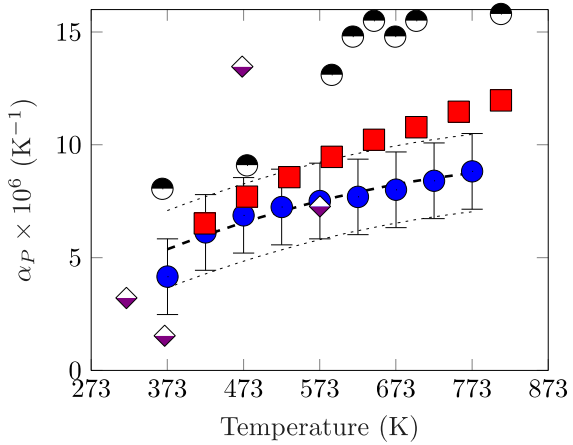


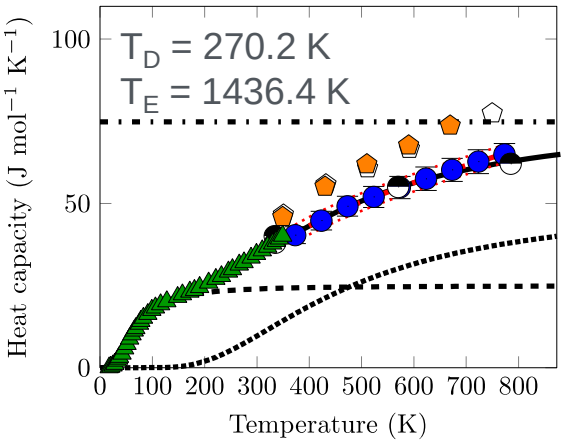
Direct hydrided

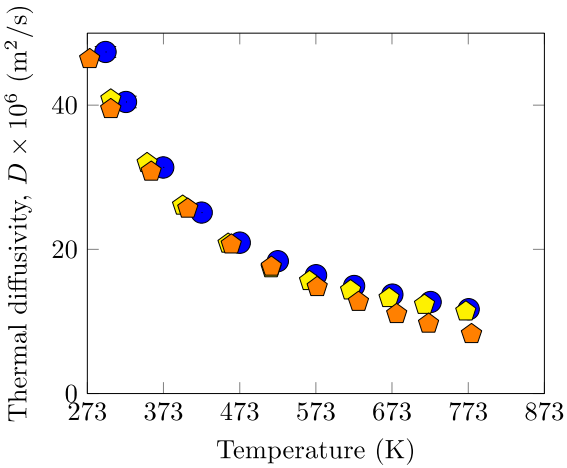


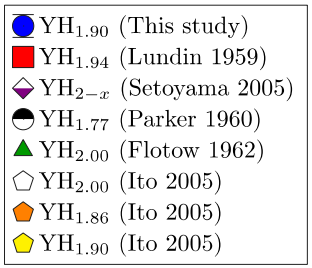
Powder Metallurgy

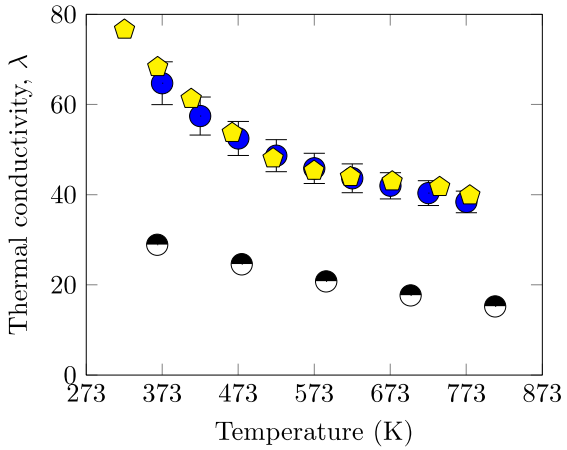
Thermophysical Properties Consistent with Literature

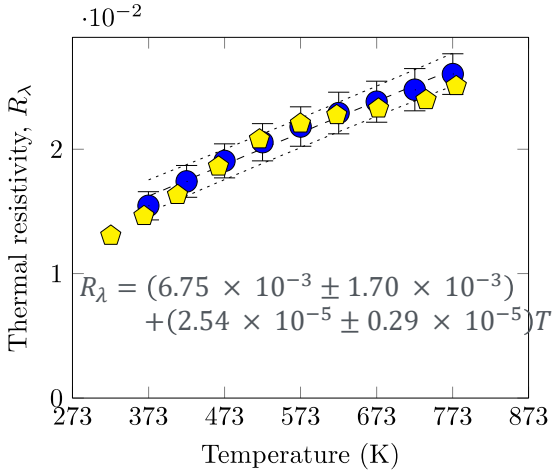








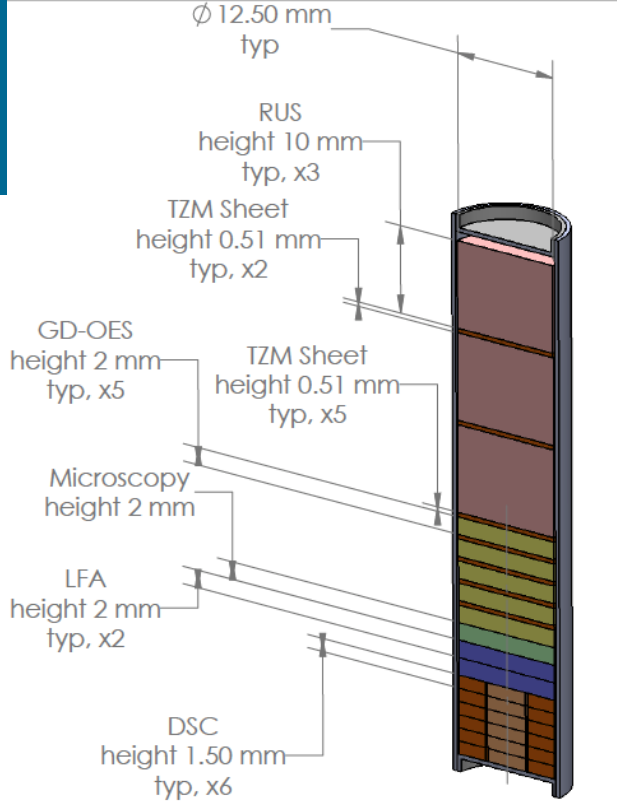




Shivprasad, et al. 2019

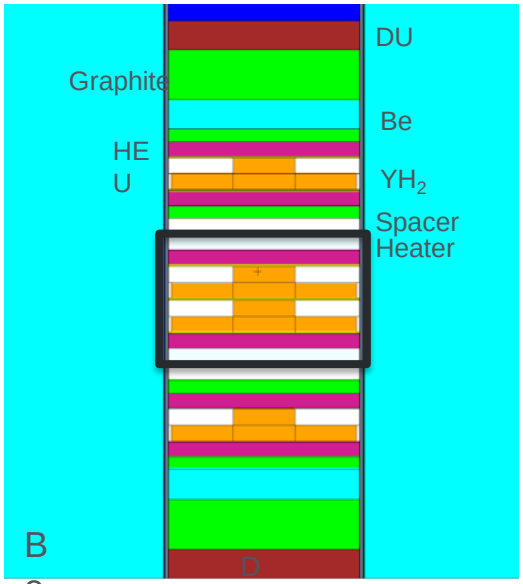
Measurements planned for YH

- Material Irradiation at Advanced Test Reactor (INL)
  - Focus on post irradiation thermophysical properties
  - Direct hydriding and powder metallurgy
    - 600˚C, 700˚C, 800˚C
- Integral Critical Experiment at National Criticality Experiments Research Center (LANL)
  - Measure reactivity with central region heated
    - Various temperatures from 20˚C to 330˚C
    - Repeat with and without YH_2 in central region
    - Compare the change in reactivity



Components for ATR Irradiation

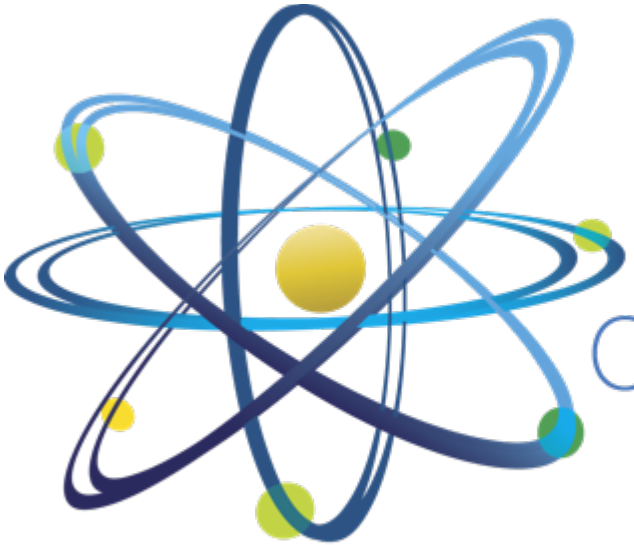
NCERC 6” Mo plate with YH_2



Current and Future R&D Activities

ATR Irradiation	Sample cans 8/2020	Insertion 2/2021	PIE 7/2021
NCERC Integral Critical Experiment	Sample cans 9/2020	Insertion 12/2020	
Establish Large-scale Fabrication Capability	Equipment 3/2020	Facilitization 9/2020	Installation 11/2020
Prepare Initial Version of Advanced Material Moderator Handbook	Draft 8/2020	Comments 9/2020	Issued 9/30/2020

- Investigate hydrogen redistribution under thermal gradients and irradiation
- Effects of irradiation vs stoichiometry of $YH_{1.x}$
- Effects of impurities and additives on hydrogen adsorption and desorption rates
- Effects of air exposure
- Cladding for maximum hydrogen retention and minimal cross contamination



Clean. **Reliable. Nuclear.**