Materials and Engineering

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SNS-HFIR User Group (SHUG) virtual Town Hall on
Community Feedback on the STS Grand Challenges

November 26, 2024

“Grand Challenges” workshop (Aug. 24-25, 2024, DC)

- Materials and Engineering subgroup breakout cochairs:
  Steve Zinkle (UTK), Janelle Wharry (Univ. Illinois)
- Key participants included Adrian Brügger (Columbia), Don Brown (LANL), Kevin Field (Univ. Michigan), Zhenzhen Yu (Colorado School of Mines), Srikanth Pilla (Univ. Delaware), Les Butler (Iowa State), Matt Steiner (Univ. Cincinnati), George Nelson (Univ. Alabama-Huntsville)
- Converged on 3 Grand Challenges and 3 “topical sidebars”

Grand Challenge 1: Accelerated Discovery and Deployment of Advanced Materials

- Neutron characterization can accelerate science-based certification of materials and manufacturing
  - Simultaneous in-situ multimodal characterization; enable creation of accurate digital twins
  - Component-scale characterization requires high neutron fluxes at 3-15Å wavelengths (only available at SNS-STS)

Understanding multiscale phenomena is important for deployment of structural materials for various extreme environments (schematic example for a fusion reactor)

Grand Challenge 2: Autonomous construction

- Transformative manufacturing is identified by DOE as a critical development area
  - Sustainability, additive manufacturing, high-performance systems
  - Replacement of traditional Portland cement; locally sourced construction materials

- 3D SANS characterization of concrete
- Dynamic imaging of concrete aging under load

Bioinspired functionally graded porosity materials for simultaneous structural and environmental (weather) performance

Extrusion deposition printing of complex structures

Shotcrete spray deposition of reinforced steel column

Artist rendering of robotically built Mars habitats

Grand Challenge 3: Circular economy materials

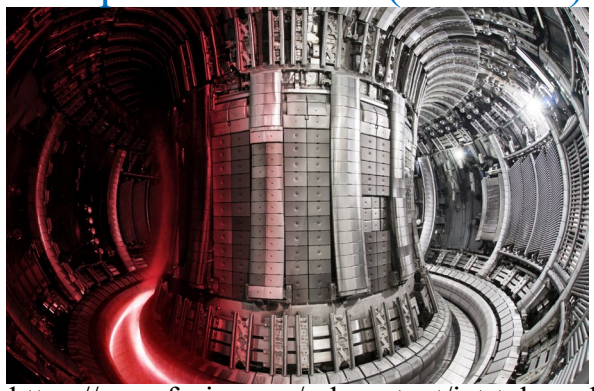
- Composition (impurity) effects on performance, reliability and reuse of materials
  - Understand material behavior across multiple scales for original use, recycling, regeneration, repurposing, and reuse
- Characterization of hierarchical structures (need expanded range of wavelengths)
  - Batteries, solar cells, green steels, green composites, etc.

Neutron wavelengths need for battery characterization

Sidebars: Materials under Extreme environments

- Fusion materials
  - Design and develop high performance materials to withstand intense heat and particle fluxes, neutron bombardment, and thermomechanical stresses
  - Characterization of multi-material components
    - High field magnet characterization
- H_2 transport through structures
  - Fuel cells, gas pipelines, etc.
  - Spatial mapping of H velocity fields in complex structures
- Additive manufacturing
  - Multiscale characterization of build defects

JET plasma device (UKAEA)

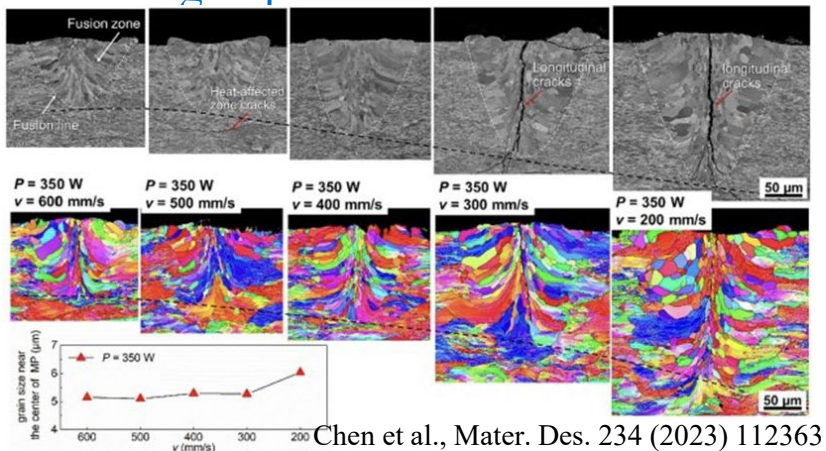


https://euro-fusion.org/ml-content/jet-tokamak/

H embrittlement cracks in steel

https://www.imetllc.com/hydrogen-embrittlement-steel/

Cracking in powder bed laser fusion W



Chen et al., Mater. Des. 234 (2023) 112363