U.S. DEPARTMENT OF ENERGY | Nuclear Energy

LWRS Advanced LWR Nuclear Fuels

George Griffith

Lightwater Reactor Sustainability Advanced LWR Nuclear Fuel Pathway Lead

Second Workshop on U.S. Nuclear Power Plant Life

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Technology Drivers

- **Advanced LWR nuclear fuel development**
  - Nuclear fuel technology helps define safety margin at LWRs
  - Increased safety margin can be used to compensate for aging that is related to loss of safety margin
  - Reduced operating and economic risks
- **Higher capability fuels allow for increased reactor economics**
  - Improved economic optimization – fuel cycle length, power uprates, less used fuel, and more reliable fuel
- **Improved understanding allows for shorter design and test cycles**
  - Faster response to reactor needs
  - Improved fuel design process and better margin maintenance
- **Technology demonstration can allow step improvement in fuel designs**
  - Step improvement allowed by higher risk/reward design work

SiC Ceramic Matrix Composite (CMC) Potential Benefits

SiC Clad – Application to Current LWRS Issue

- Flagship approach to LWRS advanced nuclear fuels development
- High-temperature strength and low chemical activity allows cladding to operate at very high temperatures
- Allows longer service life and exposure
- Thermal creep may not be an issue at operational temperatures
- SiC fiber-reinforced composite may exhibit better mechanical characteristics for PCI
- Use of SiC composite may mitigate flow-induced modes and subsequent fretting

LWR Cladding Outside Surface Nanometer-Scale Coating for Corrosion and Crud Control

Haiyan Wang Texas A&M University

- **Create zirconium cladding that is less susceptible to fretting failures and hydrogen reactions than conventional cladding**
- **Lower risk technology than fuel SiC cladding technology**

Zircaloy-4 tube for TiN coating
(a) Before polishing
(b) Cut and polished
(c) Mounted zircaloy-4 tube on heater of PLD chamber
(d) TiN-coated tube.

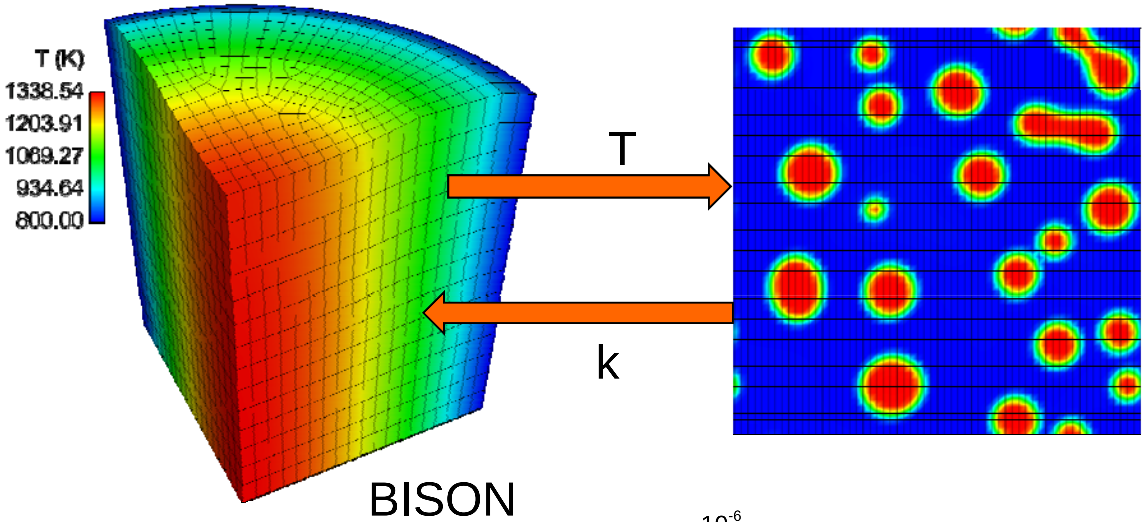
(a)

(b)

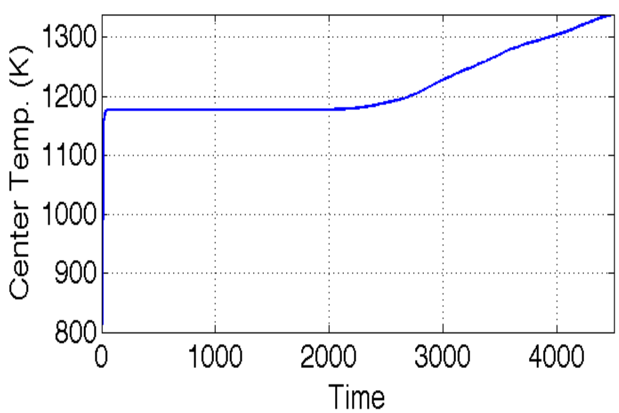
(c)

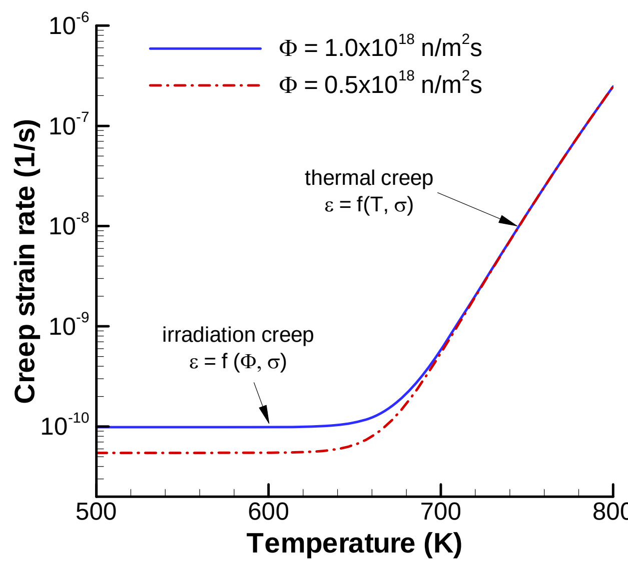
(d)

Supporting the nuclear renaissance



- **Simulation of heat conduction in a UO2 fuel pellet, coupled to a mesoscale simulation of void nucleation under irradiation**





Irradiation creep (Hoppe empirical model)
Secondary thermal creep (power law)
Plasticity with linear strain hardening
Thermal expansion

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Status

- *Commercial prototype SiC cladding is being irradiated at the Oak Ridge HFIR reactor*
- *Fabrication of advanced SiC/metallic hybrid cladding is ongoing completed.*
- *ATR irradiation plans are on schedule for FY 2011*
- *Transient, Loop and Failure irradiations are being planned.*
- *Thin ceramic films have been applied to zirconium samples*
- *Advanced modeling is providing design inputs*
- *Mechanical modeling has started*
- *A shared technology project on SiC reactor structures is being developed*