Westinghouse Accident Tolerant Fuel Program

Peng Xu
Westinghouse Electric Company LLC
Columbia, SC

August 21, 2013

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Overall Timeline

- 2012 to 2014
  - Planning overall Research &Development (R&D), licensing and business approach
  - Identification and evaluation of technical issues involved with achieving overall objectives
  - Describe test program to answer technical issues
  - Manufacture test specimens for experimental evaluations
- 2014 to 2016
  - Testing in Advanced Test Reactor (ATR), High Isotope Flux Reactor (HIFR) and Massachusetts Institute of Technology Reactor (MITR) to evaluate various technical approaches and pick optimum cladding and pellet designs
- 2016 to 2022
  - Interface with Nuclear Regulatory Commission (NRC) and technical groups to determine procedures, standards, etc. required for licensing
  - Long term test reactor testing of integrated cladding/pellet concept(s) to generate data for Lead Test Rod (LTR)/Lead Test Assembly (LTA) in 2022
  - Develop manufacturing technology for making economic manufacture of accident tolerant fuel designs

Technical Approach

- Cladding
  - Mid term - Zr Alloy Coatings (Ti_2AlC and NanoSteel® SHS 9172) to provide major corrosion resistance increase (alleviating oxidation and hydriding degradation), moderate temperature (~200°C) resistance increase
  - Long term - SiC composites to provide major increases in maximum tolerable cladding temperature (up to 2000°C) and corrosion resistance
- Fuel
  - Mid term – U_3Si_2 for 17% U235 increase and 5x increase in thermal conductivity
  - Long term – waterproofed $U^{15}N$ for up to 35% U235 increase (estimate) and 10x increase in thermal conductivity

Coating Work Update

- University of Wisconsin made cold spray Zr samples coated with Ti_2AlC and NanoSteel ™
- Edison Welding Institute (EWI) made hot sprayed samples of Ti_2AlC and NanoSteel ™
- Hot sprayed samples did not survive the 800°F steam autoclave test (3 day and 28 day). Cold spray samples survived
- Cold sprayed samples were tested at MIT in 1200°C steam for various times. No significant difference between uncoated or coated Zr alloy samples
- Conclusion is that the edges were not completely sprayed and that the coatings in general did not provide a significant barrier to O ion and/or steam diffusion
- Densification and pre-oxidation studies are being conducted to determine if diffusion can be significantly lowered

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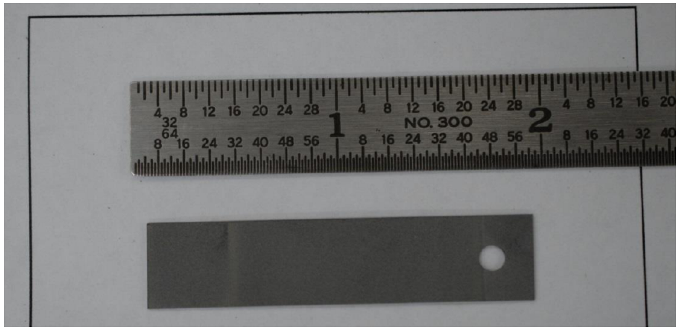
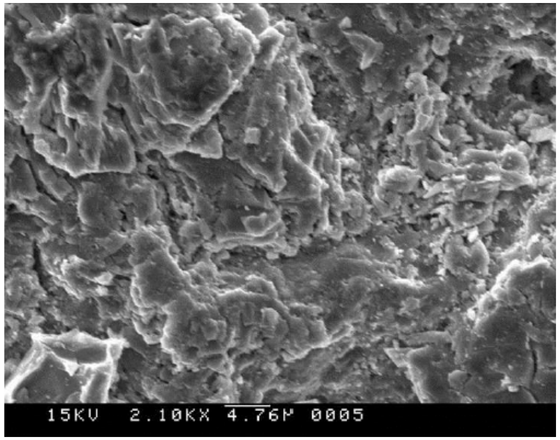
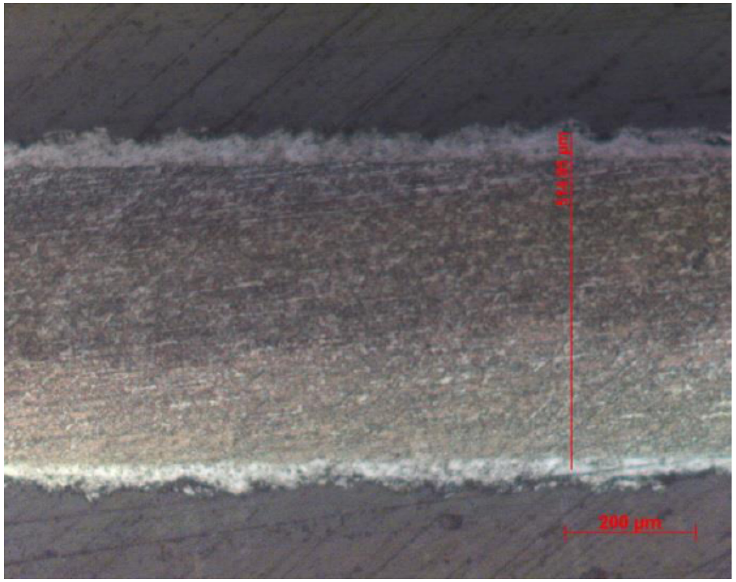
Ti_2AlC



Pre Oxidation



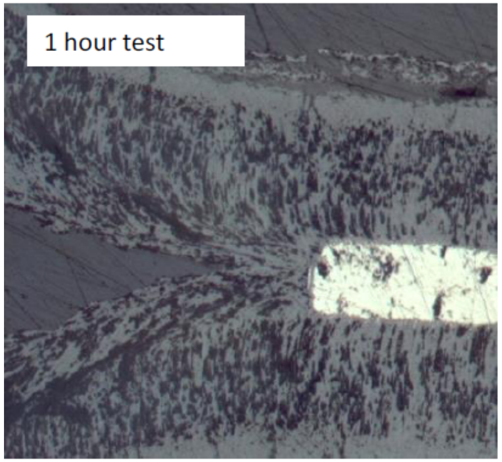
SEM micrograph on the surface

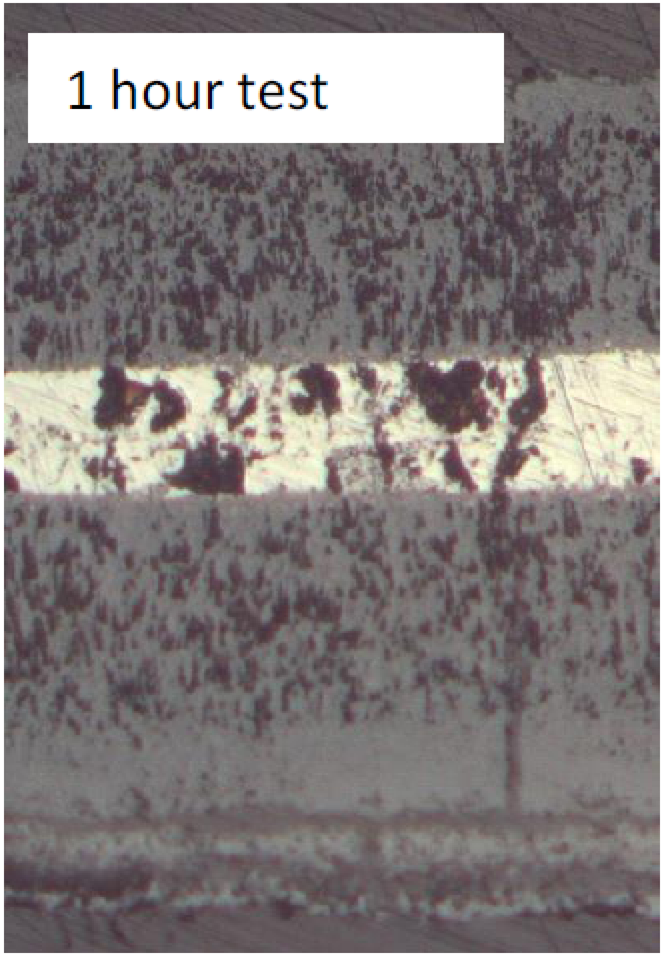


Cross section

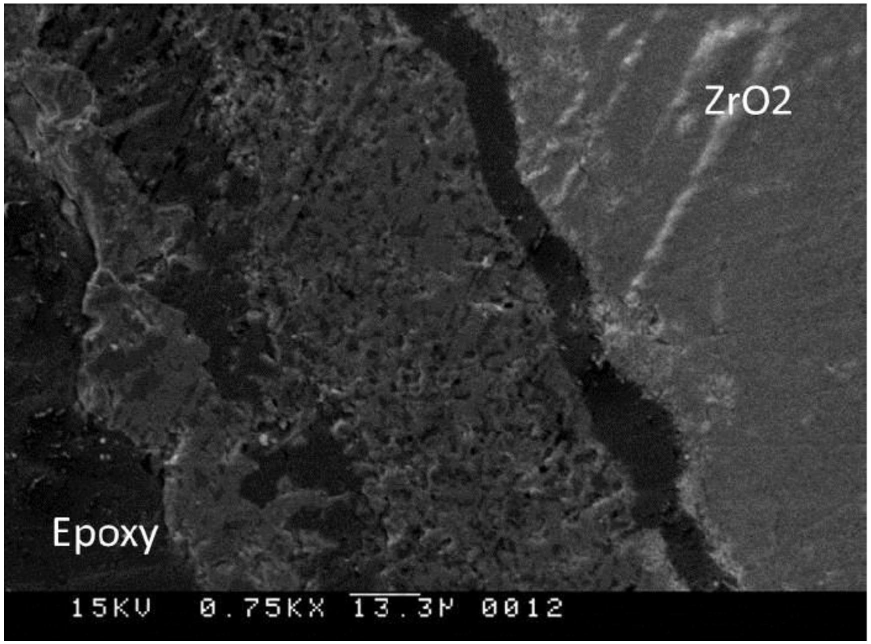
Ti_2AlC After Exposure

1 hour in 1,200°C Steam

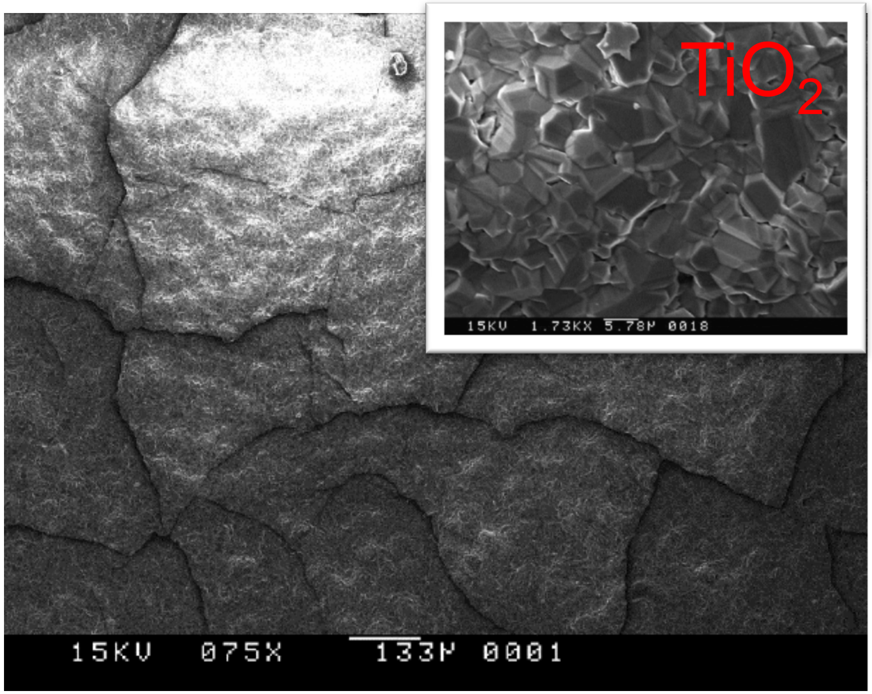




Characterization



Cross section



Surface

Courtesy of MIT

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NanoSteel ™ (0.28 hour in 1,200°C Steam)

Courtesy of MIT

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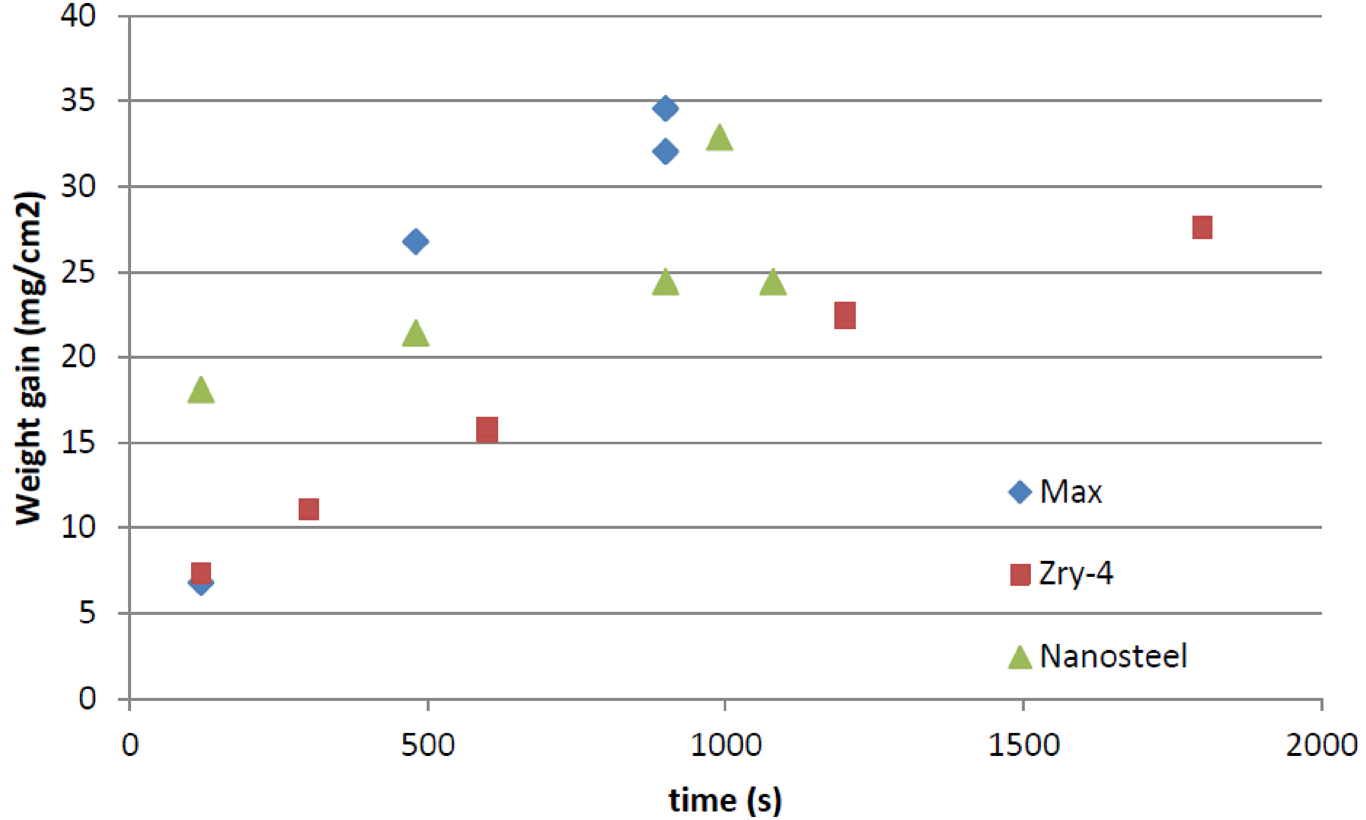
1200C Steam Test Results Summary



Courtesy of MIT

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Task 2 R&D Needs (2014 to 2020) Study Completed

- Initial materials identification Phase 1 (2012 to 2016)
- Long term test reactor Phase 2 (2016 to 2022)
- LTR (2022) not included
- Total cost is ~$48 million

	Dates	Estimated Costs
Phase 1 Deveolpment + Phase 2 Testing	to 2016	$ 31.6
Phase 3 Test Reactor	2016 to 2020	$ 6.0
Phase 3 PIEs	2018 to 2022	$ 6.0
N15 Development Costs	2018 to 2022	$ 4.6
Total		$ 48.2

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U_3Si_2 Powder Synthesis and Pellet Manufacture

- U_3Si_2 powder >98.5% pure phase has been made using arc-melting technique
  - No secondary uranium silicide phases (such as U_3Si or USi) visible using the SEM
  - No significant amounts of phases such as U, Si, UO_2, SiO_2 or other phases not related to arc melting or milling impurities were found.
- Pellets >94% Theoretical density have been made (objective is ~95.5%) using the conventional sintering technique and sintering for 1 hour at 1450°C

U_3Si_2 Pellets


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Outreach

- Will share results of coating work with C^3 program at University of Tennessee
- Paper will be presented at TopFuel 2013 (Preliminary Assessment Of The Performance Of SiC Based Accident Tolerant Fuel In Commercial LWR Systems, S. Ray, S. C. Johnson and E.J. Lahoda)
- Paper was presented at European Materials Research Society (EMRS) 2013 (Development of Nitride Fuel for LWR Applications, Peng Xu, Ed Lahoda, Lars Hallstadius, Andy Nelson, Ken McClellan, Sean McDeavitt)

Upcoming Tasks (9/30/2013)

- Task 3 - Document and propose a clear path and plan for regulatory approval of the ATF concept
- Task 4 - Develop a preliminary business plan that describes the investment and infrastructure needed to produce ATF on a commercial scale
- Interim Report

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