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1 FERRITIC/MARTENSITIC STEEL DEVELOPMENT

1.1 STATUS AND IMPROVEMENT OF REDUCED ACTIVATION FERRITIC-MARTENSITIC STEELS FOR HIGH TEMPERATURE SERVICE — L. Tan and Y. Katoh (Oak Ridge National Laboratory), A.-A.F. Tavassoli and J. Henry (CEA), M. Rieth (KIT), H. Sakasegawa and H. Tanigawa (JAEA), Q. Huang (INEST) **1**

Summary of the content of two presentations at ICFRM 17 now in preparation for submission in two open literature publications.

1.2 FABRICATION OF LOW ACTIVATION FERRITIC-MARTENSITIC STEELS CONTAINING ^{54}FE ISOTOPE — Y. Yamamoto (Oak Ridge National Laboratory) **3**

Reduction of the mixed oxide steel powder consisting primarily of ^{54}Fe was successfully conducted via a combination of a hydrogen reduction process, vacuum-melting, and arc-melting with reactive elements. The arc-melted ingot of ^{54}Fe to date contains 78 wppm oxygen and 70 wppm nitrogen, together with ~1 wt.% of Cr and W, with the total weight of ~200 g. The detailed procedure of each reduction process is summarized in this report. The results were presented in a poster at ICFRM-17.

1.3 ADVANCED BAINITIC STEEL DEVELOPMENT FOR FUSION STRUCTURAL APPLICATIONS — Y. Yamamoto (Oak Ridge National Laboratory) **9**

Four heats of 3Cr-3WV base bainitic steels with or without minor alloying additions of Mn, Si, and N were prepared. Continuous cooling transformation (CCT) diagrams of the bainitic steels were produced by using a Quenching Dilatometer (Material Measuring Corp.). The results indicated successful control of the bainitic transformation kinetics with lower bainitic transformation temperatures in a wide range of continuous cooling rates, compared to those of the base steels. It promoted the formation of “carbide-free acicular bainite ferrite” which improved relatively short-term creep-rupture properties tested at 600°C. Improved oxidation resistance during creep testing was also observed in the modified steels with the Si addition. Weldability screening of the steels has been initiated by using bead-on-plate weld together with cross-sectional hardness measurements.

1.4 MICROSTRUCTURE EVOLUTION IN TEMPERED MARTENSITIC STEELS UNDER IN-SITU He INJECTION EXPERIMENT IN HFIR JP28/29 — Takuya Yamamoto, Yuan Wu, G. Robert Odette (University of California Santa Barbara), Dan Edwards, Rick Kurtz (Pacific Northwest National Laboratory) **15**

TEM studies have been carried out to observe the microstructure evolution in normalized and tempered 8-9Cr martensitic steels (TMS) Eurofer 97 and F82H under in situ helium injection (ISHI) fission reactor irradiation at nominally 500°C to ≈ 39 dpa and ≈ 2100 appm helium at 500°C. The irradiations were carried out as part of the JP-28&29 US DOE – JAEA collaboration. The cavity microstructure analyses showed cavities with an average size of ≈ 2.5 nm and number density of ≈ 2.4 x $10^{24}/m^3$, resulting in a total cavity volume fraction of ≈ 0.35%. The corresponding void volume fraction is ≈ 0.18%. The magnitude of void swelling is significantly smaller than what was previously observed at 21 dpa and 1230 appm He in JP-27 specimens. The reason for less swelling at higher dpa and He is that the intended 500°C irradiation temperature fell significantly below 500°C during the irradiation.

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1.5 TENSILE FRACTURE MECHANISM OF HFIR-HEAVILY-IRRADIATED F82Hs — H. Sakasegawa, H. Tanigawa, T. Hirose, M. Ando (Japan Atomic Energy Agency), Y. Katoh, C. O. Stevens, and M. R. McAlister (Oak Ridge National Laboratory) **22**

Irradiation embrittlement and hardening of tensile properties were observed in the heavily irradiated F82Hs at high temperatures, though it is still necessary to confirm the result of diametric analysis of silicon carbide passive temperature monitors. For F82Hs irradiated at 573 K, the three dimensional fractography revealed that the fracture mechanism was affected by irradiation. Dimples became smaller and shallower after irradiation, and grain boundary sliding was observed. These results contribute to development of a tensile fracture mechanism model explaining how the fracture is affected by irradiation.

2 ODS AND NANOCOMPOSITED ALLOY DEVELOPMENT

2.1 CHARACTERIZATION OF PROCESSING INDUCED IMPURITY PHASE PRECIPITATES IN THE AS-PROCESSED FCRD-NFA-1 — S. Pal, M. E. Alam and G. R. Odette (UCSB), S. Maloy (LANL), D. Hoelzer (ORNL) **26**

The NFA-1 contains detrimental impurity phases along with the desirable nano-oxides (NOs). The impurity phase precipitate particles appear as black, nearly round features in SEM micrographs, with a size distribution between 10 and 260 nm. The impurity particles are arranged as stringers in the direction of primary deformations during hot extrusion, and cross-rolling. Chemical analysis using electron probe micro-analyzer demonstrates that these particles are either rich in Ti or Y. TEM shows these features are primarily formed on grain boundaries and triple junction. The EDS shows that the particles are primarily Ti-O and fewer Y-O phases. Heat treatment at 1300°C/5 hr shows the complete dissolution of these particles, suggesting they are a metastable phase. The precipitates act as nucleation sites for ductile fracture at high temperature, reducing tensile ductility and fracture toughness.

2.2 MICROSTRUCTURAL AND MECHANICAL BEHAVIOR OF AS-FABRICATED AND ANNEALED 14YWT NFA-1 ALLOY — M.E. Alam, S. Pal, D. Gragg, G. R. Odette (UCSB), D. T. Hoelzer (ORNL) and S. A. Maloy (LANL) **35**

FCRD NFA-1 is a new 14YWT nanostructured ferritic alloy (NFA) processed to form a 12.5 mm thick plate. Ultrafine, nearly equiaxed grains dominate the plate's face (LT), while the front (LS) and side (TS) views contain pancake-shaped, trimodal grains with very large aspect ratios, along with a population of embedded microcracks that are readily visible in profile. Low temperatures tensile tests on the longitudinal (L) direction show a delamination driven ductile fracture, even at liquid nitrogen temperature, with strengths up to 1563 MPa. In contrast, the room temperature tensile specimen loaded in the short thickness (S) direction fails prematurely in its elastic regime, with a flat, faceted fracture surface. Annealing at 1300°C for 1 and 5 hrs helps to alter the grains towards equiaxed in all plane views and heals the microcracks, which results in much improved room temperature tensile ductility. However, microhardness, tensile strength and fracture toughness have been compromised, and the fracture mechanism has also been changed from delamination driven to microvoid coalescence dimple fracture.

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2.3 **THE CRYSTAL STRUCTURE, ORIENTATION RELATIONSHIPS AND INTERFACES OF THE NANOSCALE OXIDES IN NANOSTRUCTURED FERRITIC ALLOYS —** Y. Wu , S. Kraemer, G. R. Odette (University of California Santa Barbara), J. Ciston (Lawrence Bekeley National Laboratory), N. Bailey, P. Hosemann (University of California Berkeley) **47**

Fast Fourier Transform analysis of focal series images revealed the nano-oxide (NO) crystal structure, including the smallest at < 2 nm in diameter, to be $Y_2Ti_2O_7$ pyrochlore in all cases, consistent with both exit wave analysis and scanning transmission Z-contrast imaging of the atomic columns in larger features. The faceted NOs exhibit a quasi-epitaxial orientation relationship to the ferrite matrix: $[110]_{YTO}||[100]_{Fe}$ and $[001]_{YTO}||[010]_{Fe}$, forming a 5x7 near coincidence site interface, and exhibit size-dependent strains in both the oxide and matrix ferrite phases.

2.4 **NANOSCALE 3D CORRELATIVE ATOM PROBE-ELECTRON TOMOGRAPHY: CHARACTERIZATION OF MICROSTRUCTURES IN DUAL ION IRRADIATED NFA MA957 —** P. B. Wells, S. Krämer, Y. Wu, S. Pal, G. R. Odette and T. Yamamoto (University of California, Santa Barbara) **57**

Transmission Electron Microscopy (TEM) can resolve very small helium bubbles (HB), down to approximately 1 nm, but is not optimal for observing populations of very small nano-oxides (NO) in nanostructured ferritic alloys (NFA). In contrast, atom probe tomography (APT) excels in measuring the location, size and composition of NO, but cannot resolve small bubbles. Because a typical APT tip has dimensions similar to those needed for TEM (on the order of 50-100 nm thickness), it is possible to characterize HB by 3D TEM tomography, hereafter called ET, prior to destructive 3D characterization of the NO by APT. Here, for the first time, APT and ET are used to assess the association between HB and NO in full 3D reconstructions, which also reveal strong NO-HB associations with a grain boundary.

2.5 **He IMPLANTATION OF Fe–{110}YTO BILAYERS** — T. Stan, Y. Wu, T. Brown, C. Palmstrom, and G.R. Odette (University of California Santa Barbara), and F. Allen, P. Hosemann (University of California Berkeley) **64**

The Fe-Cr matrix nanostructured ferritic alloys (NFAs) are dispersion strengthened by < 5 nm Y-Ti-O nano-oxide (NO) phases. The characteristics of the interfaces between the NOs, such as $Y_2Ti_2O_7$ (YTO), and the surrounding ferrite matrix are critical to trapping He in fine scale bubbles. As a compliment to current characterization efforts of the NOs themselves, a surrogate bulk Fe-YTO interface was fabricated by molecular beam epitaxy (MBE) and electron beam Fe deposition on {110}YTO. Areas of the sample were then implanted with 25 keV He. The He bubble sizes, number densities, and volume fractions are reported. Bubbles at the Fe-YTO interface were on average larger than in the matrix. No bubbles were seen in, but this does not indicate that He is not present in the YTO.

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2.6 SEQUESTRATION OF CAVITIES AT NANOPARTICLE-MATRIX INTERFACES IN HELIUM PLUS HEAVY ION IRRADIATED NANOSTRUCTURED FERRITIC ALLOYS — C. M. Parish[1*], K. A. Unocic[1], L. Tan[1], S. J. Zinkle[1,2], S. Kondo[3], L. L. Snead[4], D. T. Hoelzer[1], and Y. Katoh[1] - [1] Oak Ridge National Laboratory, [2] University of Tennessee, Knoxville, [3]Institute of Advanced Energy, Kyoto University, [4] Massachusetts Institute of Technology **71**

Abstract of a manuscript being submitted to Journal of Nuclear Materials.

3 CERAMIC COMPOSITE STRUCTURAL MATERIAL DEVELOPMENT

3.1 LOW ACTIVATION JOINING OF SiC/SiC COMPOSITES FOR FUSION APPLICATIONS: MODELING DUAL-PHASE MICROSTRUCTURES AND DISSIMILAR MATERIAL JOINTS — C. H. Henager, Jr., B. N. Nguyen, and R. J. Kurtz; (Pacific Northwest National Laboratory, Richland, WA, USA); M. Ferraris, (Politecnico di Torino, Torino, Italy); Y. Katoh, (Oak Ridge National Laboratory, Oak Ridge, TN, USA) **72**

The international fusion materials community designed miniature torsion specimens for joint testing and irradiation in test reactors with limited irradiation volumes since SiC and SiC-composites used in fission or fusion environments require joining methods for assembling systems. HFIR irradiation results indicated two broad types of joint damage due to irradiation at either 500˚C or 800˚C to 3 dpa or 5 dpa. One type of damage can be categorized as microcracking within multi-phase joints at the micron length scale. The other type of damage can be categorized as cracking within the miniature torsion sample and within the joint where the cracks are now on the scale of the joint thickness and are not considered to be microcracks. This report discusses methods to model both types of cracking due to differential properties within the joint due to multiple phases or due to the fact that the joint itself is dissimilar from the joined CVD-SiC material. This analysis requires two different models to account for these effects.

3.2 APT AND TEM CHARACTERIZATION OF PRECIPITATES IN Mg^+ ION IMPLANTED CUBIC SILICON CARBIDE — W. Jiang, J. Liu, D. K. Schreiber, D. J. Edwards, C. H. Henager, Jr., R. J. Kurtz (Pacific Northwest National Laboratory), and Y. Wang (Los Alamos National Laboratory) **79**

This research update reports on the results from our preliminary atom probe tomography (APT) data reconstruction and analysis as well as from our recent transmission electron microscopy (TEM) examinations on Mg^+ ion implanted cubic silicon carbide (3C-SiC). APT studies have been performed for 3C-SiC implanted with $^{25}Mg^+$ ions to 9.6×10^{16} ions/cm^2 at 673 K and subsequently annealed at 1073 and 1573 K for 2, 6, and 12 h. TEM examinations have been focused on a lower-dose (5.0×10^{15} ions/cm^2) 3C-SiC implanted with $^{24}Mg^+$ ions, followed by annealing at 1573 K for 12 h. The TEM study suggests that some of the nanometer-scale Mg precipitates are associated with Frank loops in the implanted and annealed 3C-SiC, while the APT results show that most of Mg-bearing particles contain both Si and C. Further efforts on APT reconstruction and TEM examination are still in progress.

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3.3 ADVANCED CHARACTERIZATION OF IRRADIATION DEFECTS IN SILICON CARBIDE: POSITRON ANNIHILATION SPECTROSCOPY — X. Hu, T. Koyanagi, Y. Katoh (Oak Ridge National Laboratory) **85**

Positron annihilation spectroscopy (PAS), i.e., positron annihilation lifetime spectroscopy and coincidence Doppler broadening, was used to characterize the small vacancy clusters in 3C-SiC subject to various neutron irradiation conditions by capturing the dependence of irradiation temperature (380~800°C) and dose (0.01~30dpa). The vacancy cluster distribution obtained from PAS investigation is critically important to complement the current understanding of the microstructural evolution in SiC under the abovementioned neutron irradiation conditions, due to the cluster invisibility in TEM characterization. Subsequently, the vacancy clusters are then linked to the measured swelling behavior to provide insight into the correlation between microstructure and physical properties of SiC.

4 HIGH HEAT FLUX MATERIALS AND COMPONENT TESTING

4.1 PRELIMINARY PROGRESS IN THE DEVELOPMENT OF DUCTILE-PHASE TOUGHENED TUNGSTEN FOR PLASMA-FACING MATERIALS: DUAL-PHASE FINITE ELEMENT DAMAGE MODELS — C. H. Henager, Jr., B. N Nguyen, R. J. Kurtz (Pacific Northwest National Laboratory) **91**

A promising approach to increasing fracture toughness and decreasing the DBTT of a W-alloy is by ductile-phase toughening (DPT) [1-3]. In this method, a ductile phase is included in a brittle matrix to prevent fracture propagation by crack bridging or crack deflection. Liquid-phase sintered W-Ni-Fe alloys and hot-pressed and sintered W-Cu composites are two examples of such materials that PNNL and UCSB are investigating. However, there is a need for improved mechanical property models of such composite systems in order to begin to optimize these structural materials with regard to strength and fracture toughness. This report describes such a model that is currently under development at PNNL.

4.2 FABRICATION OF FUNCTIONALLY GRADED TUNGSTEN STEEL LAMINATES — L. M. Garrison (Oak Ridge National Laboratory) **97**

Analysis is underway of the tungsten-steel laminate composites. The composite was fabricated from tungsten foils in thicknesses 250, 100, and 25 µm and grade 92 steel foils in nominal thicknesses 250, 100, and 76 µm. The fabrication was by forging and hot rolling at 1000°C. Shear punch tests were completed on the tungsten foils. Tensile and shear punch samples are being machined from the composite.

4.3 NEUTRON ENERGY SPECTRUM INFLUENCE ON IRRADIATION HARDENING AND MICROSTRUCTURAL DEVELOPMENT OF TUNGSTEN — Makoto Fukuda[1], N.A.P. Kiran Kumar[2], Takaaki Koyanagi[2], Lauren M. Garrison[2], Lance L. Snead[3], Yutai Katoh[2], Akira Hasegawa[1], 1- Tohoku University, 2- Oak Ridge National Laboratory, 3- Massachusetts Institute of Technology **100**

This is the abstract of a paper submitted to The Journal of Nuclear Materials.

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4.4 **ANALYSIS OF NEUTRON IRRADIATED TUNGSTEN MICROSTRUCTURES** — N.A.P. Kiran Kumar, L. M. Garrison, Y. Katoh (Oak Ridge National Laboratory) **101**

There are two components to neutron irradiation response that change the structure of tungsten: neutron created lattice displacement defects such as interstitials and vacancies, and transmutation products, especially rhenium and osmium. This study is examining the effects of both of these on the tungsten microstructure. Tungsten irradiated to four different doses from 0.7 to 4.5 dpa was examined by transmission electron microscopy, scanning transmission electron microscope, and electron dispersive spectrometry. The tungsten types included single crystal tungsten and as-rolled tungsten foils. The Re and Os transmutation products form needle-shaped precipitates preferentially along the <110> direction. The average precipitate and void sizes increased with increasing dose.

4.5 **IRRADIATION EFFECTS IN TUNGSTEN-COPPER LAMINATE COMPOSITES** — L.M. Garrison[a*], Y. Katoh[a], L.L. Snead[a, b], T.S. Byun[a, c], J. Reiser[d], M. Rieth[d], [a]Oak Ridge National Laboratory, [b]Present affiliation-Massachusetts Institute of Technology, [c]Present affiliation-Pacific Northwest National Laboratory, [d]Karlsruhe Institute of Technology **106**

Extended abstract of a paper ready for journal submission

5 **MAGNETIC AND DIAGNOSTIC SYSTEM MATERIALS**
No contributions this reporting period.

6 **FUSION CORROSION AND COMPATIBILITY SCIENCE**

6.1 **COMPATIBILITY OF AN FeCrAl ALLOY WITH FLOWING Pb-Li IN A THERMAL CONVECTION LOOP** — S. J. Pawel and K. A. Unocic (Oak Ridge National Laboratory) **108**

This is the abstract of a manuscript that has been submitted to the Journal of Nuclear Materials.

7 **MECHANISMS AND ANALYSIS**

7.1 **EFFECT OF STRAIN FIELD ON THRESHOLD DISPLACEMENT ENERGY OF TUNGSTEN STUDIED BY MOLECULAR DYNAMICS SIMULATION —** D. Wang, N. Gao, (Institute of Modern Physics, Chinese Academy of Sciences) W. Setyawan, R. J. Kurtz (Pacific Northwest National Laboratory), X. Gao, W. H. He (Institute of Modern Physics, Chinese Academy of Sciences) **109**

The influence of hydrostatic strain on point defect formation energy and threshold displacement energy (E_d) in body-centered cubic (BCC) tungsten was studied with molecular dynamics simulations. Two different tungsten potentials (Fikar and Juslin) were used. The minimum E_d direction calculated with the Fikar-potential was <100>, but with the Juslin-potential it was <111>. The most stable self-interstitial (SIA) configuration was a <111>-crowdion for both potentials. The stable SIA configuration did not change with applied strain. Varying the strain from compression to tension increased the vacancy formation energy but decreased the SIA formation energy. The SIA formation energy changed more significantly than for a vacancy such that E_d decreased with applied strain from compression to tension.

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7.2 DAMAGE MECHANISM INTERACTIONS AT THE PLASMA-MATERIALS INTERFACE (*An Early Career Award Project*) — C. M. Parish (Oak Ridge National Laboratory) **114**

This first reporting period of the five-year project has emphasized experimental technique developments as the necessary foundation for all later work, and has begun several valuable collaborations with other institutions. Specifically, tungsten high-purity sheet stock has been obtained and characterized to act as a constant and known baseline for further experiments. Focused ion beam (FIB) methods to prepare samples for transmission electron microscopy (TEM) of plasma-exposed tungsten have been refined. This includes tall (>1000 nm) "nanofuzz" tendrils, which is a significant experimental challenge. A non-FIB technique for nanotendrils has also been developed. Collaborations thus far include UCSD PISCES laboratory, and Dr. D. Donovan, UT-Knoxville.

7.3 A CODE FOR AUTOMATED DERIVATION OF POST NECKING TRUE STRESS-TRUE STRAIN CONSTITUTIVE LAWS FROM STANDARD TENSILE TEST ENGINEERING STRESS STRAIN CURVES — Shuangyu Li, Takuya Yamamoto, G. Robert Odette (UCSB) **118**

We previously developed a self-consistent approach to derive true stress-stain constitutive [$\sigma(\varepsilon)$] laws from measured tensile test engineering stress-strain $s(e)_m$ data based on finite element method (FEM) simulations. The simulated $s(e)_s$ were based on trial input $\sigma(\varepsilon)_n$ that were adjusted in an iterative fashion until convergence at $s(e)_s \approx s(e)_m$. The adjustments between $\sigma(\varepsilon)_n$ and $\sigma(\varepsilon)_{n+1}$ were based on experience and judgment but in some cases convergence required many time consuming iterations. Here we report an automated iterative process that is much more efficient and less time consuming for the researcher.

8 MODELING PROCESSES IN FUSION SYSTEM MATERIALS

8.1 OBJECT KINETIC MONTE CARLO SIMULATIONS OF RADIATION DAMAGE IN TUNGSTEN SUBJECTED TO NEUTRON FLUX WITH PKA SPECTRUM CORRESPONDING TO HFIR — G. Nandipati, W. Setyawan, H. L. Heinisch, K. J. Roche, R. J. Kurtz (Pacific Northwest National Laboratory) and B. D. Wirth (University of Tennessee) **126**

We used our recently developed lattice based object kinetic Monte Carlo (OKMC) code, *KSOME* [1], to carry out simulations of radiation damage in bulk W. In this report, we present preliminary results of our study of, the effect of the maximum size of self-interstitial atom (SIA) clusters allowed to rotate on the defect accumulation in bulk tungsten with 1µm grain size when subjected to neutron flux having PKA spectrum corresponding to HFIR at 1025 K for the dose rates in the range 0.17×10^{-4} to 0.17×10^{-8} dpa/s.

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8.2 **STABILITY OF SMALL SELF-INTERSTITIAL CLUSTERS IN TUNGSTEN —** W. Setyawan, G. Nandipati, and R. J. Kurtz (Pacific Northwest National Laboratory) **130**

Density functional theory was employed to explore the stability of interstitial clusters in W up to size seven. For each cluster size, the most stable configuration consists of parallel dumbbells. For clusters larger than size three, parallel dumbbells prefer to form in a multilayer fashion, instead of a planar structure. For size-7 clusters, the most stable configuration is a complete octahedron. The binding energy of a [111] dumbbell to the most stable cluster increases with cluster size, namely 2.49, 3.68, 4.76, 4.82, 5.47, and 6.85 eV for clusters of size 1, 2, 3, 4, 5, and 6, respectively. For a size-2 cluster, collinear dumbbells are still repulsive at the maximum allowable distance of 13.8 Å (the fifth neighbor along [111]). On the other hand, parallel dumbbells are strongly bound together. Two parallel dumbbells in which the axis-to-axis distance is within a cylindrical radius of 5.2 Å still exhibit a considerable binding of 0.28 eV. The most stable cluster in each size will be used to explore interactions with transmutation products.

8.3 **A GENERALIZED ISING MODEL FOR STUDYING ALLOY EVOLUTION UNDER IRRADIATION AND ITS USE IN KINETIC MONTE CARLO SIMULATIONS —** Chen-Hsi Huang and Jaime Marian (University of California Los Angeles) **137**

We provide an Ising Hamiltonian for kinetic simulations involving interstitial and vacancy defects in binary alloys. Our model, which we term `ABVI', integrates solute transport by both interstitial defects and vacancies, and thus represents a generalization to the widely- used ABV model for alloy evolution simulations. The Hamiltonian captures the three possible interstitial configurations in a binary alloy: A-A, A-B, and B-B, which makes it useful for irradiation damage simulations. We implement the ABVI Hamiltonian in kinetic Monte Carlo simulations and perform a verification exercise by comparing our results to published irradiation damage simulations in simple binary systems with Frenkel pair defect production and several microstructural scenarios, with matching agreement found.

9 **FUSION SYSTEM DESIGN**
No contributions this reporting period.

10 **IRRADIATION METHODS, EXPERIMENTS AND SCHEDULES**

10.1 **FUSION MATERIALS IRRADIATION TEST STATION (FMITS) AT SNS —** Mark Wendel, Phil Ferguson (Oak Ridge National Laboratory) **161**

The FMITS is a design concept for installation at the SNS Facility. The project received funding from OFES during FY15 for (1) performing a mockup test on an FMITS-type target seal, (2) augmenting the safety assessment based on the 2014 technical review, (3) analyzing thermal-hydraulic off-normal transients with a full 3D model to assess the performance of the FMITS sensor array, and (4) remote-handling electrical connector operational mock-up, which was successfully completed in FY15. The work was continued in FY16 using residual funding. The main goals of the effort are to remove the project technical risks and prepare for a potential future project.

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10.2 **A HIGH ENERGY SELF-ION IRRADIATION STUDY OF METALLIC REACTOR MATERIALS AT THE LLNL CENTER FOR ACCELERATOR MASS SPECTROMETRY (CAMS) —** N. Almirall, T. Yamamoto, D. Gragg, K. Fields, N. Cunningham, P. Wells, G. R. Odette (University of California, Santa Barbara), S. Tumey, T. Brown (Lawrence Livermore National Laboratory) **164**

The LLNL CAMS accelerator experiment was designed to irradiate a range of reactor materials (~80 samples per condition) with 70 MeV Fe^{+9} ions to a dose of 3 dpa at two dpa rates that differ by a factor of 10. The experiment also explores ion versus neutron irradiation effects by cross-comparing the CAMS results with previous neutron and charged particle irradiation (CPI) data for the same alloy. Following a prototype test on 10/8/15, the actual CAMS irradiation was successfully conducted beginning on 12/3/2015. Extensive PIE is planned for the FeCr alloys, NFA, TMS and other fusion reactor relevant alloys, including W. One objective is to explore the concept of using precipitation as a damage meter to evaluate the relative effects of neutron irradiations versus CPI; and to isolate the effects of dpa rate from that of the irradiating particle. Here some preliminary ion versus neutron results are reported.

10.3 **METHOD FOR ANALYZING PASSIVE SILICON CARBIDE THERMOMETRY WITH A CONTINUOUS DILATOMETER TO DETERMINE IRRADIATION TEMPERATURE —** Anne A. Campbell (ORNL), Wallace D. Porter (ORNL), Yutai Katoh (ORNL), Lance L. Snead (MIT) **168**

This is the abstract of a paper published in Nuclear Instruments and Methods in Physics Research B, 370, (2016) 49-58.

10.4 **IRRADIATION STUDY OF ADVANCED CERAMICS: STATUS OF IRRADIATION EXPERIMENTS —** T. Koyanagi, C.M. Petrie, N.O. Cetiner, Y. Katoh (Oak Ridge National Laboratory) **169**

HFIR Rabbit capsules were designed for irradiation of various advanced ceramics. The materials include isotopically-controlled ultra-high temperature ceramics such as TiB_2 and ZrB_2, MAX phases such as Ti_2AlC, Ti_3AlC_2, and Ti_3SiC_2, SiC with various qualities, AlN, TiC, YAG, glassy carbon, and Si. The first phase of the irradiation has been completed.

10.5 **HFIR IRRADIATION EXPERIMENTS –** J.P. Robertson, Y. Katoh and J. McDuffee (Oak Ridge National Laboratory) **173**

HFIR completed 3.2 cycles during the second half of 2015. Cycle 460C (July 6 – July 11, 2015) added 406 MWdays to complete this cycle. Cycle 460 started on June 9, 2015, but there was a manual shutdown on June 13, 2015, in response to a reactor setback. The cycle was restarted on June 15, but the reactor was again forced to shut down due to abnormal fluctuations in the primary temperature. Cycles 461 (July 21 – August 15), 462 (October 6 – October 31), and 463 (November 17 – December 11) were completed without incident.