Recent Advances in Radiation Materials Science from the US Fusion Reactor Materials Program

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26th IAEA Fusion Energy Conference

Kyoto, Japan

17–22 October 2016

Research supported by the U.S. Department of Energy, Office of Fusion Energy Sciences

Summary: Recent Advances in Radiation Materials Science from the US Fusion Reactor Materials Program

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- Primary materials challenges for successful fusion energy include: (1) developing structural materials with suitably long lifetimes, (2) obtaining a plasma-facing material with sufficient ductility and low tritium retention, and (3) verifying the performance of functional materials
- US fusion reactor materials program focused on radiation effects in candidate materials with emphasis on advanced ferritic-martensitic (FM) steels, including oxide-dispersion-strengthened (ODS) and castable nanostructured alloy (CNA) variants, SiC composites, and tungsten, with extensive use of both computational materials science and extensive irradiation programs
- Key computational results include development of: (1) a new He-Fe interatomic potential for atomistic simulations of helium effects in irradiated steels, (2) a detailed kinetic model describing the behavior of helium and its use to predict swelling and embrittlement in FM steels and their ODS variants, (3) an integrated computational approach for investigating near-surface mechanisms responsible for “fuzz” formation on W surfaces, (4) an atomistically informed for crystal plasticity of W, and (5) integrated multiscale models for design of fusion reactor components
- Key experimental results and insights include: (1) use of dual ion irradiation and neutron irradiation with *in situ* implantation of He demonstrate a strong correlation between swelling and He/dpa ratio, swelling is reduced in ODS relative to conventional FM steels; (2) CNA variants exhibit high strength and longer creep lifetimes than conventional FM steels; (3) high-dose neutron irradiation of advanced nuclear grade SiC demonstrate limited effects on high-temperature strength with only modest swelling and reduction in thermal conductivity; (4) impact of He on SiC microstructure observed, impact on mechanical properties is being assessed; (5) good progress in development of radiation-resistant joints for SiC composites

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