Overview of the US Fusion Materials Sciences Program

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This presentation will provide an overview of recent experimental and modeling research highlights on advanced structural materials for fusion energy systems. A series of high-performance structural materials have been developed over the past ten years with significantly improved properties compared to earlier materials. Recent advances in the development of high-performance ferritic/martensitic and bainitic steels, nanocomposited oxide dispersion strengthened ferritic steels, high-strength V alloys, improved-ductility Mo alloys, and radiation-resistant SiC composites will be reviewed. Multiscale modeling activities are providing important insight into defect production and migration mechanisms, plastic deformation mechanisms, and fracture mechanics behavior. In-situ straining experiments performed in electron microscopes have provided new information on the deformation processes that occur in irradiated metals. Fundamental modeling and experimental studies are in progress to determine the migration and trapping behavior of helium in metals, in order to design materials with improved resistance to void swelling and high temperature helium embrittlement in fusion reactor irradiation environments. Recent chemical compatibility tests have identified several promising new candidates for magnetohydrodynamic (MHD) insulators in lithium-cooled systems, and have determined that SiC has good chemical compatibility with Pb-Li up to very high temperatures. Work on advanced joining techniques such as friction stir welding will also be described. Work performed by US materials science researchers in support of the ITER international team activities will be briefly described. Finally, research in progress as part of a US-Japan collaboration to investigate the effects of fusion-relevant helium generation rates on the mechanical properties and microstructures of neutron irradiated advanced ferritic/martensitic steels will be summarized.

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