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

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In addition to the engineering challenges associated with building and operating any complex facility, a range of critical materials issues must be addressed in order to make fusion power commercially viable. These 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 such as electrical insulators, optical fibers, and tritium breeding materials. The US fusion reactor materials program (FRM) has a well-developed focus on radiation effects in candidate structural materials and tungsten as a plasma-facing material. This includes both computational materials science and an extensive irradiation program utilizing the High Flux Isotope Reactor at ORNL. Recent results from the US FRM program will be discussed with an emphasis on advanced ferritic-martensitic steels, including the oxide-dispersion-strengthened and castable nanostructured alloy variants; SiC composites; and tungsten. The computational and experimental research is addressing the effects of helium produced by nuclear transmutation. In both the structural materials and tungsten, helium may increase tritium retention which has implications for operational safety in the event of an accident and for the successful recovery of tritium for use as fuel. In addition, it has been shown that low energy helium ions from the plasma may degrade the surface of tungsten components with the potential for increasing the amount of radioactive dust and plasma contamination.

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