Materials Facilities Initiative

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Fusion reactor materials will be required to function in an extraordinarily demanding environment that includes various combinations of high temperatures, chemical interactions, time-dependent thermal and mechanical loads, and intense neutron fluxes. This environment produces atomic displacement damage ultimately equivalent to displacing every atom in the material up to 150 times during its expected service life, as well as changes in chemical composition by transmutation reactions, including the introduction of damaging concentrations of reactive and insoluble gases. A long-standing feasibility issue as well as a critical factor in realizing the environmental and safety potential of fusion is the development of plasma-facing materials and components that exhibit unprecedented erosion resistance and self-healing capability during prolonged exposure to high particle/heat fluxes and intense D-T fusion neutrons.

This initiative introduces two midscale devices to address the critical fusion nuclear science on the road to a viable reactor and to open new frontiers in materials science, the Material-Plasma Exposure eXperiment (MPEX) and the Fusion Materials Irradiation Test Station (FMITS), which will extend the parameter range accessible in present world-wide capabilities, using a cost-effective, linear configuration conducive to thorough diagnosis (MPEX) and rapid testing and a low-cost modification to the target station of the Spallation Neutron Source (FMITS). Both facilities will leverage not only on ORNL's large-scale material irradiation facilities SNS and HFIR but they will also leverage on the infrastructure to handle and diagnose neutron irradiated material samples. Both facilities are technologically ready for construction.

1. The Material Plasma Exposure eXperiment (MPEX)

MPEX is a steady-state linear plasma device designed to contribute to the mission needs to of the *Long Pulse Burning Plasma Science*. However it will also contribute to the *Foundations of the Burning Plasma Science*. It will be able to expose material samples and "mock-up" sized plasma facing components to fusion reactor relevant plasmas. It will be designed to test a large variety of candidate PFC materials (solid, liquid, carbon-based, metallic, neutron irradiated) under different experimental conditions (temperature, wall loading, etc.). It will be the only device worldwide capable of accelerated lifetime testing of W divertor segments. With an installed heating power of 800 kW it will be the most powerful steady-state linear plasma device world-wide. MPEX will help to advance plasma-facing components from concept exploration studies (technical readiness level TRL3) to proof of principle solutions (TRL4 up to TRL6 for some end of lifetime studies).

2. The Fusion Materials Irradiation Test Station (FMITS)

The proposed FMITS at the SNS would provide world-leading capability to explore fusion-relevant helium-radiation defect synergistic evolution in a range of materials. A key feature of the proposed FMITS is the possibility to explore near fusion-prototypic irradiation with state-of-the-art temperature control at a per-experiment cost comparable with current fission neutron irradiation experiments. FMITS will provide the opportunity for the US program to solidify our scientific leadership in this critical area of fusion materials development leveraging our current strength in modeling, irradiation materials science, and fusion materials development.

The need for additional facilities that provide fusion-relevant conditions, with respect to neutron spectrum and combined effects of heat and particle flux, is well recognized in the fusion community. Numerous reports point to the addition of such facilities as a necessity to advance the scientific understanding of materials. The addition of these facilities would provide the U.S. with a world-leading capability and enable breakthrough understanding of materials in the near future at moderate cost. With both facilities together for the first time synergistic effects of fusion prototypic neutron irradiation and fusion prototypic plasma material interaction can be studied. In conjunction with large scale testing in toroidal devices and an aggressive materials development program this initiative will pave the way for a next step Fusion Nuclear Science Facility.