Materials Facilities Initiative

<u>The ability of the facilities to contribute to world-leading science in the next decade (2014-2024)</u>
Grade (a) - absolutely central

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 materials that can tolerate this intense fusion neutron environment. To address this significant challenge and to open new frontiers in materials science requires the development of facilities that more accurately simulate fusion relevant conditions. Today, there are no facilities in the world that can reproduce, in a sustained way, the harsh environment created by a fusion reactor—in particular, the high-energy 14 mega-electron volt (MeV) neutrons produced from a deuterium-tritium (D-T) reaction, and the combined high heat and ion fluxes produced by the plasma. The most direct route to the study of materials under neutron bombardment is to utilize existing spallation sources, which have a similar energy spectrum as D-T neutrons, with a small test apparatus. The exposure of materials to spallation neutrons would provide first-of-a-kind irradiation damage data. Of equal importance is a facility dedicated to the study of the response of material to simultaneous exposure to the high heat and ion fluxes generated by the plasma. The interaction of the plasma and wall material is essentially a new state of materials science, since one affects the other, and thus both are needed for actual, relevant studies to be made.

<u>The readiness of the facilities for construction</u>
Grade (a) - ready to initiate construction

The two facilities discussed above—one dedicated to 14 MeV neutron material irradiation and the other dedicated to fusion-relevant plasma-material interaction testing—are ready for construction. Some research and development on the power source for the plasma-material interaction facility is required.

<u>Scientific community considerations</u>

The need for the addition of facilities that provide fusion-relevant conditions, with respect to neutron energy level 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.

The Fusion Energy Sciences Advisory Committee (FESAC) reports *Scientific Challenges, Opportunities, and Priorities for the US Fusion Energy Sciences Program* (April 2005) and *Priorities, Gaps, and Opportunities: Towards A Long-Range Strategic Plan for Magnetic Fusion Energy* (October 2007) discuss the need for materials research facilities. This need was further described in the report *Research Needs for Magnetic Fusion Energy* (2010), which resulted from a community exercise that culminated in a research needs workshop (June 2009). Two recent FESAC reports: *Opportunities for Fusion Materials Science and Technology Research Now and During the ITER Era* (February 2012) and *Fusion Nuclear Science Pathways Assessment* (February 2012) expand on this need.