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FOREWORD

This is the thirty-eighth in a series of semiannual technical progress reports on fusion materials science activities supported by the Fusion Energy Sciences Program of the U.S. Department of Energy. This report focuses on research addressing the effects on materials properties and performance from exposure to the neutronic, thermal, and chemical environments anticipated in the chambers of fusion experiments and energy systems. This research is a major element of the national effort to establish the materials knowledge base of an economically and environmentally attractive fusion energy source. Research activities on issues related to the interaction of materials with plasmas are reported separately.

The results reported are the product of a national effort involving a number of national laboratories and universities. A large fraction of this work, particularly in relation to fission reactor irradiations, is carried out collaboratively with partners in Japan, Russia, and the European Union. The purpose of this series of reports is to provide a working technical record for the use of program participants, and to provide a means of communicating the efforts of fusion materials scientists to the broader fusion community, both nationally and worldwide.

This report has been compiled and edited under the guidance of R. L. Klueh and Teresa Roe, Oak Ridge National Laboratory. Their efforts, and the efforts of the many persons who made technical contributions, are gratefully acknowledged.

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The objective of this task is to assess the long-term, high-temperature compatibility of high electrical resistance, multi-layer coatings with lithium at high temperatures. Electrically insulating coatings on the first wall of magnetic confinement reactors are essential to reduce the magnetohydrodynamic (MHD) force that would otherwise inhibit the flow of the lithium coolant. An assessment of the crack tolerance for these coatings determined that a multi-layer coating with metal and ceramic layers was needed to prevent Li from wetting cracks or defects in a single-layer ceramic coating. Experimental compatibility tests are being conducted on bulk materials and single and multi-layer coatings.

The objective of this task is to assess the long-term, high-temperature compatibility of various materials with Pb-Li. One proposed fusion reactor concept uses SiC/SiC composites with a self-cooled Pb-17Liblanket. Another concept uses a SiC/SiC flow channel insert with a dual coolant of He and Pb-Li at~800°C. This concept also requires tubing material to carry the Pb-Li between the first wall and the heat exchanger. As a first step in the evaluation process, monolithic SiC and potential tubing and coating materials are being exposed to Pb-17Li in capsule tests at 700°-1200°C.

This research is aimed at designing and implementing a novel method for in-situ He implantation in mixed spectrum reactor irradiations at controlled and fusion relevant He/dpa ratios and dpa rates. The implantation of He from $^{6}Li(n,\alpha)$ reactions into and through vanadium alloy substrate insulator coatings in fusion neutron spectra is also examined.

The temperature dependence of the initiation and crack arrest fracture toughness of cleavage oriented Fe single crystals have been measured. The primary objective is to assess the hypothesis that a universal master toughness temperature curve shape, $K_{Jc}(T - T_o)$, observed in structural steels, where T_o is reference temperature, derives from an underlying universal temperature dependence of the intrinsic ferrite lattice micro-arrest toughness, $K_{\mu}(T)$. These results also represent the first database on the fundamental toughness properties of Fe and will provide critical insight on the atomic processes governing the brittle-to-ductile transition (BDT).

This research has two main objectives.

- On one side is the development of computational tools to evaluate alloy properties, using the information contained in thermodynamic functions to improve the ability of classic