Nanostructured ferritic alloys (NFAs) have been considered as prominent materials for future fission and fusion reactor core components because of their excellent resistance to creep deformation and to radiation-induced property degradation. Such high-strength materials, however, often reveal drawbacks such as low fracture toughness and poor ductility, which would cause significant difficulties in fabrication processing as well as in maintaining structural integrity. The low fracture resistance of NFAs observed at reactor operating temperatures $\geq 300$ °C, in particular, is a major concern for these alloys. Such low fracture resistance was found to originate from the unique fracture mechanism of NFAs, in which microcracks propagate along grain or aggregate boundaries by a low energy decohesion process. Over the past several years significant efforts have been devoted to processing development to improve the fracture toughness of both 9Cr and 14Cr NFAs. This presentation aims to summarize the new processing routes and practices to improve the fracture toughness of NFAs. First, the research with phase-transformable 9Cr NFA (9YWTV) confirmed that a significant improvement of fracture toughness was achievable by carefully designed thermomechanical treatments (TMTs). This research also showed that choosing best processing practices, such as the selection of proper powder size, were needed to yield desirable mechanical properties. Second, it was also demonstrated that high fracture toughness can be achieved from the non-transformable 14Cr NFA (14YWT) by integrating best processing practices, such as cleaner mechanical milling, low-temperature consolidation, and optimum post-consolidation TMTs. Third, cryogenic mechanical alloying has been explored to pursue property improvement through further microstructure refinement. A significant improvement in fracture toughness was achieved for the 14YWT alloy by mechanical milling at a low temperature of -75°C. As the key processing technologies have advanced enough to produce high toughness NFAs, research activities have begun for nuclear applications, e.g., fabrication of cladding, and for demonstration of irradiation performance.
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Biosketch

Dr. T.S. Byun is currently a chief scientist at Pacific Northwest National Laboratory (PNNL). Prior to moving to PNNL in October, 2014, he had worked at Oak Ridge National Laboratory as a research scientist for 15.7 years since he came to the United States in January, 1999. After he earned his PhD from the Korea Advanced Institute of Science & Technology in 1992, he had 7 years of experience at Korea Atomic Energy Research Institute as a fuel performance code developer and a nuclear materials scientist. Throughout his career his researches have been focused on radiation effects and mechanical behavior in nuclear structural and fuel materials. He has developed expertise in the theoretical modeling of dislocation glide and mechanical behaviors in irradiated materials, testing and evaluation techniques for irradiated and miniature specimens, and design and implementation of irradiation experiments. He has also developed new grades of steels such as dual-phase and tri-phase steels for high toughness plates and pressure vessels and lately nanostructured ferritic alloys for high temperature reactor applications. For the nuclear materials society, he has served as a symposium organizer in TMS and MRS meetings and as a managing guest editor of the Journal of Nuclear Materials (JNM) since 2011. He is currently a member of advisory editorial board for the JNM. He is also serving as a part-time co-manager for the Mechanical Behavior and Radiation Effects program under the US DOE-Office of Basic Energy Sciences (BES).