Preface to the special issue on advanced materials for nuclear energy applications

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Nuclear energy is playing an essential role in modern human society. Because of renewed public concern with regard to energy generation and climate change, worldwide interest in nuclear energy and technology is increasing. According to Director General Rafael Mariano Grossi from International Atomic Energy Agency (IAEA), nuclear energy contributes to ~10% global energy. The development of advanced nuclear energy systems, including both fusion and fission, is significantly accelerated. The largest fusion device under construction, ITER, is now preparing to install the first coil pair. The Joint European Torus (JET) has recently started fusion experiments using tritium, a radioactive isotope of hydrogen which is very rare and expensive. In China, Hua-long One, the Chinese Generation III+ pressurized water nuclear reactor, enters commercial service at the beginning of 2021. As the power capability keeps increasing in these advanced nuclear energy systems, the materials in these nuclear systems are exposed to aggressive environmental conditions and damage from high-temperature radiation, which results in mechanical degradation and life reduction. As a highly active field, both challenges and opportunities are present, and thus, we encourage the youth and talents to join the field, contributing to the development of advanced nuclear materials.

This special topic issue is about advanced materials for nuclear energy applications, especially considering the neutron radiation effect. It includes contributions from researchers from various countries including China, Canada, Germany, Japan and United States, consisting of

three review papers and five research articles. Three contributions are about the development of advanced tungsten-based materials including nanostructured tungsten, self-passivating smart tungsten alloys and selective laser melting ZrC-reinforced tungsten. Prof. Xiang-Heng Xiao reviews the development status of nanostructured tungsten and the performance enhancement mechanism of diverse nanostructure. Prof. Andrey Litnovsky, a senior scientist from Forschungszentrum Jülich reports the progress in joining and upscale of self-passivating smart tungsten alloys for DEMO first wall mockups. Dr. Yan Zhou from China University of Geosciences presents the selective laser melting high-performance ZrC-reinforced tungsten composites, which suppresses the cracking susceptibility of elective laser melting in pure tungsten. The neutron radiation effect is discussed in both experimental and computational efforts. Prof. Toshimasa Yoshiie from Kyoto University reviews the experimental results on void swelling in austenitic stainless steels and highlights the role of alloying elements. Prof. Zhong-Wen Yao from Queen's University discovered the delayed irradiation-induced phase instability in a NiCr-FeTiNbAl alloy due to helium by means of in situ transmission electron microscopy (TEM). Dr. Xing-Zhong Cao from Institute of High Energy Physics, Chinese Academy of Sciences, presents thermal evolution of defects in tungsten and tungsten–rhenium alloy using the positron annihilation spectroscopy technic. Dr. Yuri N. Osetsky, a senior scientist from Oak Ridge National Laboratory, reports the results of an extensive atomic-scale modeling study of the interactions between moving edge dislocations and voids in tungsten, and Dr. Peng-Bo Zhang from Dalian Maritime University reviews the first-principles modeling of solute–point defect interactions in vanadium and its alloy.

We hope this issue could provide a clear insight about the development of advanced tungsten-based materials and recent research progress regarding neutron radiation effects and triggers potential interest for future research. At last, we want to thank all the authors, reviewers, editors, and

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