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Editorial: Some New Advances for Investigations on Nuclear Materials

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Editorial on the Research Topic

Some New Advances for Investigations on Nuclear Materials

As clean energy resource alternative to fossil fuels, nuclear energy is well known to play an increasingly important role in the industry development of the modern age. After the Fukushima disaster, the Accident Tolerant Fuels (ATF) is considered as a potential solution towards the improvement of the inherent safety during accidents. One of the major problems that ATF aims to solve is the development of the reliable materials used in the nuclear system such as fuels and claddings that can maintain their performance and functions for a considerably longer duration compared with the standard UO2-Zircaly system during accident scenarios. The goal of this Research Topic was to collect reports on new materials development for ATF from both theory and experiments to provide new insight into the design and evaluation of promising candidate materials for high performance in reactors and thus to drive more advances and interest in this area. In this collection, the articles cover the nuclear materials from nuclear fuels to alloys and composites and the diverse methods including numerical modelling as well as fabrication and characterization in the laboratory which have been adopted in order to find the connection between the phenomena and mechanisms. The reports here include experimental and theoretical investigations at different scales on the performance characterization of nuclear materials under both operation and accident conditions. Wang et al. prepared Fe–xCr–6Al alloy ($11 \le x \le 15$) by hot rolling and found that the mechanical properties and thermal conductivity of the Fe–xCr–6Al alloy are raised when Cr replacement of Fe atoms in Fe–xCr–6Al alloy rises from 11 to 15wt%. In addition, Cr content has less effect on Fe–xCr–6Al oxidation resistance compared with Al content. Feng et al. established a generalized multiscale (micro-macro) finite element (FE) model for SiC-fiber reinforced SiC-matrix ceramic (SiC_f/SiC) nuclear fuel claddings, and the mechanical behavior of the braided SiC_f/SiC nuclear fuel claddings are studied through this multiscale model. A new phase field tool PHAFIS to automatically incorporate the thermodynamic data for both of WBM and KKS phase field simulations which are widely used in the simulation of microstructure evolution of nuclear materials was developed by Guo et al. The integrity of this software tool will facilitate the coupling of phase field methods with thermodynamic data for other materials, paving a fundamental step for coupling more factors required in microstructure simulation. Zhong et al. systematically studied the influence of preparation parameters such as sintering atmosphere, mixing process, powder pretreatment and grain growth additives on the grain size of UO_2. Zhang et al. developed a multi-scale finite element method to simulate the irradiation process and postirradiation uniaxial tensile tests for metal-matrix composite fuels with representative volume elements (RVEs), and the effects of particle fission density, temperature, and initial particle volume fraction are investigated and analyzed. The structural stability and the elasticity of the ternary single-phase body-centered cubic (BCC) Ta-Ti-V alloys through a special quasi-random structure (SQS) model and first-principles calculations were studied by Hu et al. This work has provided further theoretical mechanism for

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the Ta-Ti-V medium-entropy alloys (MEAs) preparation and development. Hu and Beeler developed a phase-field model of gas bubble evolution in polycrystalline UMo under elastic-plastic deformation to study the dynamic interaction between evolving gas bubble/voids and deformation. With the developed model, they simulated the effect of gas bubble structures (different volume fractions and internal gas pressures) on stress-strain curves and the effect of local stresses on gas bubble evolution and the simulated results can serve as a guide to improve material property models for macroscale fuel performance modeling.

Although the present articles are far from covering all the important topics in materials promising in nuclear engineering, they provide clues how materials should be designed, and improved for utility under nuclear radiation environments from fundamental principles of materials sciences. From this topic, views out of different perspectives have together offered an outlook how the materials as the key factor control the performance of nuclear reactors. Research works worldwide are still ongoing to improve the current nuclear reactor systems. Therefore, we believe the purpose of this research topic to stimulate more research interest on the investigation on nuclear materials has been achieved.

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