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TMS2025

154th Annual Meeting & Exhibition

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MGM Grand Las Vegas
Hotel & Casino
Las Vegas, Nevada, USA
#TMSAnnualMeeting

SUBMIT AN ABSTRACT FOR THE FOLLOWING TMS2025 SYMPOSIUM:

NUCLEAR MATERIALS

Solid-State Processing and Manufacturing for Extreme Environment Applications: Integrating Insights and Innovations

This symposium invites talks focusing on novel solid-state processing and manufacturing technologies aimed at fabricating and developing advanced alloys and components for harsh environments in nuclear reactors. Solid-state processing and manufacturing involve high shear stresses that create deformation and heat, plasticizing the material and resulting in significant grain refinement due to dynamic recrystallization. Thus, materials produced using this method are expected to have enhanced radiation tolerance due to the high density of grain boundaries, which can act as sinks for radiation-induced defects (RIDs). In the context of nuclear applications, it is critical to understand how these processes affect the microstructure and mechanical properties of materials post-irradiation.

Current manufacturing technologies such as forging and rolling for core structural materials (e.g., low alloy steels, stainless steels, Ni alloys) used in Light Water Reactors and Advanced Reactor Concepts are often expensive for significant components. They can be restrictive in geometrical designs for complex parts such as heat exchangers. “Enabling technologies” such as laser and electron beam-based fusion additive manufacturing (AM) and friction stir welding (FSW) have caught the attention as a modular manufacturing technology to enable a more rapid and streamlined on-site fabrication process for large meter-scale fully dense nuclear structural components. However, fusion-based AM techniques are limited in size, inherently due to the size of the machines, and have limitations in producing fully dense parts. Moreover, achieving the necessary density for safety compliance often requires an additional process, hot isostatic pressing (HIP), which adds to the cost of an already expensive manufacturing technique. Parallel work initiated in the last decade on advancing solid-state manufacturing technologies like Additive Friction Stir Deposition and friction-based extrusion have proved to be a highly efficient AM substitute for fusion-based AM techniques. These solid-state techniques offer a higher production rate, a completely dense final product, refined microstructures, and enhanced mechanical properties. They also serve as effective methods for part repair and allow large-scale fabrication of meter-sized components at higher production rates. These attributes, combined with their cost-effectiveness and energy efficiency make them highly relevant to nuclear applications.

Despite the increasing interest in solid-state processing and manufacturing for nuclear materials, relatively limited studies have reported on the irradiation performance of materials processed via solid-state additive manufacturing. This symposium seeks to exchange and explore novel materials and methods developed through solid-state routes for nuclear applications, aiming to broaden our understanding of the field.

This symposium will integrate invited and contributed talks in the following categories:

- Radiation tolerance of materials processed via solid-state route for harsh environments of nuclear reactors: a) Solid-state AM, (b) Solid-State Processing, (c) Solid-State Extrusion.
- For different harsh environments: a) Different irradiations – neutron, proton, ion, plasma, etc. as per the requirements of the nuclear component, b) Environment - corrosion resistance, stress corrosion cracking resistance, and high temperature oxidation resistance, c) Dosage and d) Temperature.
- Characterization: a) Mechanical behavior – hardness, tensile, creep, fatigue, and creep-fatigue behavior, and b) Micromechanical behavior) - heterogeneous damage, strain localization or deformation patterns in the micro-level, slip, and diffraction investigations, c) Microstructural characterization – radiation-induced defects like voids and void swelling, dislocation, and dislocation loops, radiation-induced precipitation, radiation-induced segregation, and H-embrittlement.
- Discovery, development, and fabrication of new alloys that are difficult to fabricate via conventional routes, along with traditional and ODS alloys currently used in nuclear applications for significant production rates in the form of rods, tubes, 3D components along with functionally graded materials, compositionally graded materials, coatings and multimaterials, metamaterials and architectured materials.
- High-throughput routes: testing, modeling, simulations, and machine learning for screening materials with a particular focus on solid-state processing for nuclear applications.

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