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An Extreme-Temperature Load Frame for Reduced Length Scale Experimentation to Support Nuclear Materials Research and Education

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Collaborators: N/A

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ABSTRACT:

The objective of this project is to acquire a turn-key Psylotech µTS testing system and furnace chambers to enable elevated temperature testing (up to 1600°C) of reduced length scale specimens (dimensions from 10 µm to 10mm).

As reactor licenses are renewed, new reactor designs are conceptualized, and the desire to expand the library of materials certified in the ASME BPVC.III continues, it is increasingly important that a database of high-quality experimental data of material performance under in-service conditions be developed and expanded. The proposed equipment will provide the ability to characterize material behavior over a wide temperature range (ambient to 1600°C) under tension, compression, bending, creep, fatigue, and creep-fatigue loading conditions. The testing temperature range represented by the proposed system captures the operating temperatures of light water reactors (LWR), high-temperature gas-cooled reactors, and molten salt reactors (MSR). The proposed equipment will be supported by a suite of complementary tools that make the UofU fully equipped to support DOE-NE's current and future materials research needs.

The primary research objective of the proposed system acquisition is to enhance research capabilities at the UofU that support DOE-NE's needs, enhance collaborations between mountain-west universities with active nuclear materials research thrusts and with nuclear energy focused national laboratories. Expanding capabilities to enable reduced length scale investigations of nuclear materials directly supports DOE-NE's mission and current research needs by providing a cost-effective experimental apparatus for:

1) Assessing property degradation of ion-irradiated materials whose thicknesses are comparable to the limited penetration depth achievable via ion bombardment (≤10µm)
2) Characterizing the mechanical performance of activated materials that require small specimen volumes due to radioactivity safety considerations as well as candidate materials that are difficult to produce in bulk
3) Conducting high-temperature molten salt exposure experiments on candidate alloys (e.g., SS-316, Haynes 230, Hastelloy C-276) under creep conditions
4) Developing high-temperature full-field techniques for quantifying thermo-physical properties, fuel swelling, intragranular deformation heterogeneities, and failure processes
5) Identifying process-structure-property relationships of SiC-SiC composites
6) Capturing full-field plastic strain maps for validating mesoscale crystal plasticity models
7) Investigating damage and fracture processes of refractory alloys under elevated-temperature conditions with the objective of improving fracture toughness in extreme environments
8) Performing creep-fatigue experiments on legacy, current, and next-generation nuclear materials to assess mechanism interactions and their evolution up to failure

Additionally, the proposed equipment will improve the educational experiences of 180 graduate and undergraduate students annually. This will enable the UofU to continue to provide a pipeline of qualified individuals that are prepared to tackle current and future challenges in nuclear materials.