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Materials Challenges for Nuclear Energy: Accident Tolerant Fuels and Beyond

Electricity generated from nuclear power presently constitutes over ten percent of total worldwide capacity and is critical for remote power generation to support terrestrial needs as well as space exploration. Realization of novel reactor designs and improvements to reliability, safety, and economics of existing plants is contingent upon continued development and optimization of materials. The service environments of nuclear fuels and structural materials will vary depending upon the specific reactor type but are among the most demanding known. Extended exposure to extreme temperatures, irradiation damage, chemical and structural evolutions, and other factors challenge scientists and engineers to develop novel solutions and characterization tools. Service conditions relevant to a range of reactor systems will be compared to those of advanced designs with an emphasis placed on recent interest in 'accident tolerant fuels' for light water reactors. The failure mechanisms for the reference zirconium-uranium dioxide fuel system currently used in commercial nuclear power plants will be discussed along with a summary of contemporary efforts at overcoming these vulnerabilities

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