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Title: Fundamental Materials Science Challenges for Next-Generation Nuclear Energy Systems

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Development and deployment of a diverse mixture of economic and environmentally sustainable energy sources is important for international energy security. Nuclear power currently provides 20% of the US electricity, and a variety of fission and fusion energy concepts are under consideration for meeting future energy needs. After a brief review of current and proposed fission and fusion energy systems, some of the key materials challenges for fission and fusion energy will be summarized. The fuel system and structural materials in fission reactors must function in a hostile operating environment, with intense neutron and gamma radiation fluxes, high temperatures, corrosive coolants, and high mechanical stresses. Recent advances in plasma physics are bringing the prospect of fusion energy close to achievement of steady state operation at fusion reactor-relevant conditions. The anticipated temperatures, heat fluxes and radiation damage levels for plasma-facing and structural materials represent an extraordinary jump compared to the conditions experienced by fuel cladding and core internal structures in existing fission power plants. A science-based approach will be crucial for the successful resolution of these extreme materials challenges. This talk will summarize on the challenges associated with neutron radiation damage, high heat flux and high operating temperatures on materials for fission and fusion reactors. Selected examples will be given for coupled experimental and modeling studies that are exploring fundamental radiation effects phenomena and for the development of new high-performance radiation-resistant materials.