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Application of Materials Science Advances to Fusion Energy

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The development of practical fusion energy as a commercial energy source is widely acknowledged as one of the greatest scientific and technical challenges for the 21st century. Due to the extreme operating conditions in the first wall and blanket regimes, utilization of very high performance materials is vital for achieving a viable cost-competitive fusion reactor design. The materials to be utilized in ITER are based on relatively conservative engineering designs and 1990s-era (or earlier) materials. Many of the current reference materials for the structure and functional applications of proposed DEMO fusion reactors are similarly based on 1990s-era knowledge. Significant advances in materials science and engineering have occurred over the past 20 years, including the emergence of computational thermodynamics as an accurate tool for rapidly assessing phase stability in structural alloys that can enable the design of improved high performance materials. Similarly, improvements in advanced manufacturing such as additive manufacturing for fabrication of geometrically complex and/or multiple-material components and friction stir welding for joining melt-sensitive alloys can enable innovative new component designs that would have been impossible 20 years ago. Several examples will be reviewed to illustrate the potential for achieving ultra-high performance and radiation resistance in new generations of structural materials for high heat flux and blanket structural applications, including new creep-resistant copper alloys and reduced activation ferritic/martensitic steels. Opportunities for utilizing advanced manufacturing in DEMO reactor components will also be summarized.

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Eligible for student paper award?

No

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