Solid oxide cells for electricity and hydrogen generation

Subhash C. Singhal[1,*] and Xiao-Dong Zhou[2]

[1]*Battelle Fellow Emeritus, Pacific Northwest National Laboratory, Richland, WA 99352, USA*
[2]*Center for Clean Energy Engineering, University of Connecticut, Storrs, CT 06269, USA*
**singhalfuelcell@gmail.com*

Solid oxide cell (SOC) technologies encompassing solid oxide fuel cells (SOFCs)[1] and solid oxide electrolysis cells (SOECs)[2] offer unparalleled efficiency in electrochemically converting chemical energy to electricity and vice versa, leveraging high operating temperatures to achieve significant fuel flexibility and energy conversion efficiency. Recent advances have focused on enhancing the performance, durability, and economic feasibility of SOCs through innovative materials science, nanotechnology, and system integration strategies.

SOFCs, characterized by their ability to efficiently convert a wide range of fuels into electrical power, have seen significant improvements in electrode materials and designs, leading to lower operating temperatures and increased durability. Concurrently, SOECs have emerged as a promising technology for storing excess renewable energy in the form of hydrogen or syngas, addressing the intermittency of renewable sources like solar and wind. The dual functionality of SOCs not only facilitates the efficient use of renewable energy but also plays a critical role in decarbonizing industrial processes and transportation. Despite these advancements, challenges such as thermal cycling stability, long-term durability under operational conditions, and high system costs remain. Addressing these challenges requires a multidisciplinary approach, combining electrochemistry, materials science, and system engineering to develop cost-effective, reliable, and scalable SOC technologies.

This talk aims to provide a comprehensive overview of the current research landscape and the future directions necessary for SOC technologies to fulfill their potential in driving the clean energy transition to a sustainable, carbon-neutral future. We will discuss the latest materials and technologies that are shaping the future of SOCs. This includes the development of electrolyte and electrode materials that lower the operating temperature of SOFCs, enhancing their efficiency and durability. Furthermore, the use of nanotechnology in creating more robust electrode structures that can withstand thermal cycling and reduce performance degradation will be highlighted. The application of these materials in SOECs for efficient energy storage and conversion will also be discussed. Our recent research[3] on potential use of lightweight, high performance, metal-supported SOFCs for sustainable commercial aviation propulsion will be summarized.

References

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