

REFLEX

Real-time Embedded Feedback and Layered EXcitation

Electrochemical energy systems such as solid oxide fuel cells (SOFCs) and solid oxide electrolysis cells (SOECs) are emerging as critical technologies for resilient power generation, long-duration energy storage, hydrogen production, synthetic fuels, and chemical feedstocks essential to a sustainable energy economy. However, these systems operate under complex thermal, chemical, electrochemical, and mechanical conditions that evolve dynamically during operation and directly affect efficiency, degradation, lifetime, and safety.

Despite major advances in SOFC and SOEC technologies, most high-temperature electrochemical stacks remain fundamentally “blind.” Current systems generally lack embedded internal sensors and active control architectures capable of directly monitoring or regulating internal thermal gradients, localized hot spots, and degradation processes. Critical components such as interconnect plates, current collectors, and structural substrates remain passive, forcing operators to rely on sparse external measurements, external heaters, and simplified models.

This creates several major limitations: internal temperature distributions cannot be directly observed; localized hot spots accelerate degradation and reduce stack lifetime; long startup procedures limit grid-responsive operation; and the absence of embedded sensing and actuation prevents digital twins and advanced closed-loop control.

REFLEX™ is the world's first intelligent interconnect platform for high-temperature electrochemical energy systems. The technology transforms conventional passive interconnect plates into multifunctional components capable of real-time sensing, active thermal management, and digital-twin operation.

REFLEX addresses a fundamental challenge facing solid oxide fuel cells (SOFCs) and solid oxide electrolysis cells (SOECs): these systems operate under complex thermal, electrochemical, and mechanical conditions but remain largely “blind” to their internal states. Existing systems rely on sparse external measurements and cannot directly monitor internal temperature gradients, hot spots, or degradation processes, resulting in reduced efficiency, accelerated degradation, and long startup times. By embedding distributed sensing and active control directly into the interconnect plate, REFLEX provides:

- Real-time distributed temperature and strain monitoring inside operating stacks.
- Rapid startup and localized thermal balancing through embedded heating elements.
- Closed-loop control and digital-twin capabilities for intelligent operation.
- Enhanced reliability, reduced degradation, and improved operational efficiency.

REFLEX brings Tesla-like Battery Management System (BMS) capabilities to high-temperature electrochemical energy systems. The platform enables a new generation of intelligent, grid-responsive SOFC and SOEC technologies for hydrogen production, synthetic fuel generation, long-duration energy storage, microgrids, and resilient power generation.