Low-Cost Manufacturing of High Temperature Electrolysis Stacks

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AMR Project ID: P200

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Project Goals

The project goal is to develop cell and stack manufacturing technologies to enable an HTE stack manufacturing cost of less than $100 per kW.

- Demonstrate cell design, electrode materials and manufacturing methods to reduce cell cost by 15 percent; improve performance to enable stack operation at 1.285 V/cell and 1.0 A/cm^2.
- Implement lower cost and higher performance cells in stacks, with the goals of achieving a stack cost of $150/kW and defining a path to a stack cost of $100/kW.
- Demonstrate target stack performance and achieve steady-state stack degradation rate of less than 10 µV/hour over 3000 hours.
- Validate cell and stack manufacturing cost reductions via third-party analyses; validate stack performance and durability enhancements via third-party stack testing.

Project Overview

Timeline and Budget

Project Start Date: 04/01/22

Project End Date: 03/31/22

Total Project Budget: $4,166,575

DOE Share: $3,333,260

Cost Share: $833,315

Project Partners

Project Lead: Nexceris

Subcontractor: Idaho National Laboratory (INL)

Subcontractor: Strategic Analysis Inc. (SAI)

Team Member Roles

Nexceris: Project management, cell and stack cost reduction, stack fabrication and testing.

INL: HTE stack validation testing.

SAI: Cell and stack manufacturing cost analysis.

Industry Collaborators

Xigent: Automation of stack component manufacturing.

Edison Welding Institute: Stack component manufacturing technology.

Relevance and Impact

Attribute	Current DOE Metric	Nexceris (demonstrated)	Nexceris (this project)
Cell Performance	< 1.4 V at 2.0 A/cm^2	1.4 V at 2.0 A/cm^2	1.4 V at 2.0 A/cm^2
Stack Performance	1.285 V at 1.0 A/cm^2	1.25 V at 0.6 A/cm^2	1.285 V at >1.0 A/cm^2
Stack Durability	11 µV/hr	< 10 µV/hr (700 hours)	< 10 µV/hr (>3000 hours)
Cell Active Area	n/a	228 cm^2	228 cm^2
Cell Production Yield	n/a	> 90 percent	> 98 percent
Stack Cost	$155-188/kW (*)	$426/kW (#)	< $100/kW
Stack Size	n/a	4 kW	29 kW (&)

(*) Based on analyses performed by Strategic Analysis and Idaho National Laboratory.
(#) Based on a production volume of 50,000 stacks per year (100 cells, 228 cm^2 active cell area).
(&) Based on 100-cell, 228-cm^2 active area stack at 1.285 V/cell and 1.0 A/cm^2 (enabled by project).

Successful execution of this project will enable high temperature electrolysis stacks to be manufactured at a cost of $100 per kW, which is required to achieve DOE's Earthshot goal of producing hydrogen at $1/kg.

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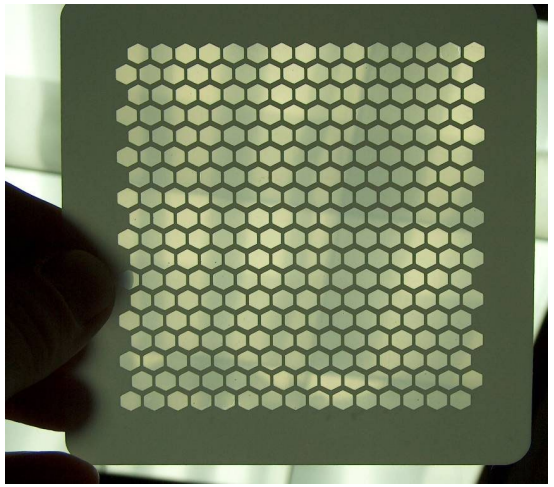
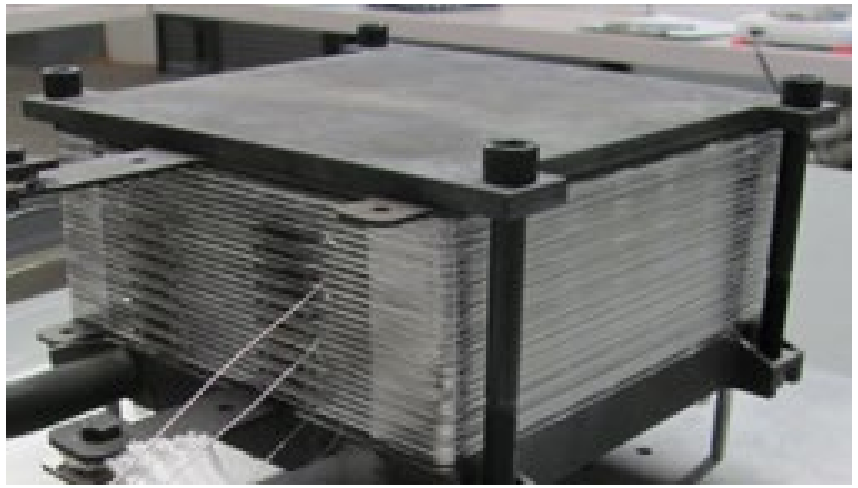
Nexceris Cell and Stack Designs





Nexceris' FlexCell

- Two-layer membrane mesh layer mechanically supporting a thin electrolyte membrane.
- Thin membrane for improved performance.
- Dense cell periphery facilitates sealing.
- Electrode material/process flexibility.

Nexceris' FlexStack

- Stack components designed for low-cost manufacture.
- External air manifolding scheme simplifies egress of oxygen effluent into ambient.
- Large active cell area enables appropriate stack module size for megawatt-scale HTE systems.

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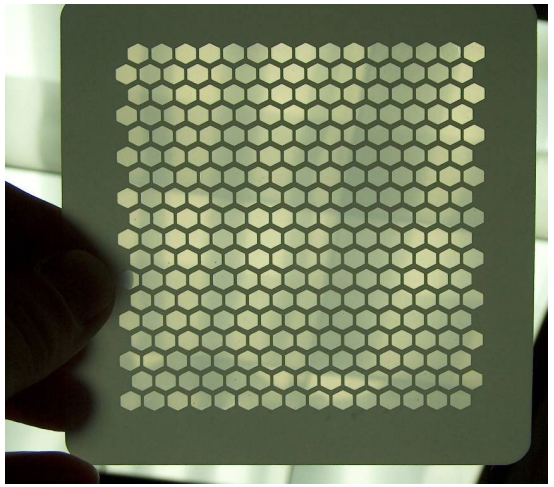
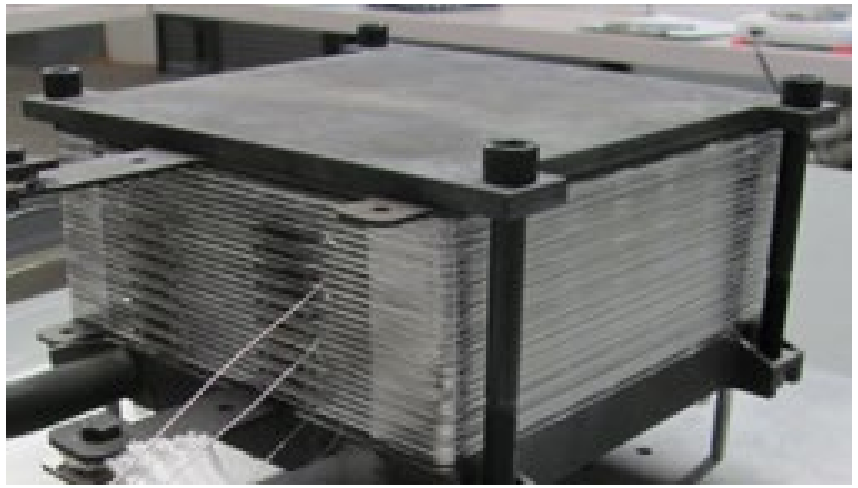
Cell and Stack Cost Reduction Approaches





Cell Cost Reduction

- Scale-up production of advanced barrier layer and oxygen electrode materials.
- Reduce thicknesses of FlexCell support and membrane layers
- Increase active cell area.

Stack Cost Reduction

- Validate low-cost interconnect alloy material.
- Long term stack durability testing.
- Reduce number of components in stack repeat unit.
- Automation of stack component manufacturing.

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Tasks and Milestones (Budget Period 1)

Task 1. Manufacturing Cost Analyses

Milestone 1.1: Current-state cell manufacturing cost model (M3).

Milestone 1.2: Current-state stack manufacturing cost model (M6).

Task 2. Cell Cost Reduction

Milestone 2.1.1: Define baseline performance and conditions (M3).

Milestone 2.1.2: Scale-up of oxygen electrode materials production (M6).

Milestone 2.1.3: Performance replicated with scaled-up electrodes (M9).

Task 3. Stack Cost Reduction

Milestone 3.2.1: Validate low-cost interconnect alloy material (M9).

Task 4. Stack Demonstration Testing

Milestone 4.1: Baseline and cost-reduced stacks tested at INL (M12).

Go/No-Go Decision Point (M12)

Demonstrate a 5-cell stack using advanced oxygen electrodes and low-cost coated interconnect alloy operating at ≤1.4 V/cell at ≥0.8 A/cm^2 with ≥75 mol% steam content and ≥50% steam utilization for ≥1000 hours.

Accomplishments and Progress

This project started on April 1, 2022.

Responses to 2021 AMR Review Comments

This project was not reviewed in 2021.

About Nexceris

Nexceris, LLC

- Founded in 1994, privately held, located in Lewis Center, Ohio.
- About 70 team members (increased by more than 80 percent in last four years).
- 25+ years of experience in the solid oxide fuel cell and electrolysis space.
- Vertically integrated manufacturer of solid oxide materials, cells, coatings and stacks.

Proven solid oxide technology provider and stack manufacturer with state-of-the-art high temperature electrolysis technology.

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