the ENERGY lab

PROJECT FACTS

Fuel Cells

Liquid Tin Anode Direct Coal Fuel Cell—CellTech Power

Background

Direct carbon solid oxide fuel cells (SOFCs) offer a theoretical efficiency advantage over traditional SOFCs operating on gasified carbon (syngas). CellTech Power LLC (CellTech) has been developing a liquid tin anode (LTA) SOFC that can directly convert carbonaceous fuels including coal into electricity without gasification. One of the most significant impediments to direct conversion of coal into electricity is the trace species within coal and their interaction with LTA-SOFC components. In this project CellTech will develop the capability to test their LTA-SOFC technology at longer time scales (up to 1,000 hours) and will also quantify how trace species within coal affect LTA-SOFC performance and stability over shorter time scales (up to 100 hours).

This fuel cell project was competitively selected under the Small Business Innovative Research (SBIR) Program. It is managed by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL). With the Solid State Energy Conversion Alliance (SECA), NETL is leading the research, development, and demonstration of SOFCs for coal-fueled central generation power systems that will enable low cost, high efficiency, near-zero emissions and water usage, and capture carbon dioxide. This project supports the innovative concepts focus area of SECA research.

Project Description

Direct carbon conversion using an LTA-SOFC produces electrical power from coal or other common hydrocarbons without gasification. For utility-scale applications it is envisioned that the fuel oxidation step can be carried out in a separate tin-coal reactor (TCR) as shown in Figure 1. The liquid tin loops between the fuel cell (where it is oxidized to produce power) and the tin reactor (where it is reduced with coal) in a process called electro-chemical looping (ECL). The net effect is that power is produced directly and efficiently from coal (or biomass) without gasification, which requires partial burning of the carbonaceous fuel. In the first phase of this SBIR project, flow sheets for the concept were created and analyzed to estimate efficiency and cost of large central generation LTA-SOFC systems.

In the second phase of this project CellTech developed the ability to test LTA-SOFCs at longer time scales (up to 1,000 hours) on gas feed and also to test their LTA-SOFC directly on coal for shorter time scales (up to 100 hours). Before direct coal tests could begin it was necessary to quantify how much of the trace species within coal would transfer to tin. These tests established the spiking levels of trace species in tin to quantify how each trace species present in coal may affect the LTA-SOFC. Finally, the experimental results of solubility and cell performance and subsequent analysis of degradation mechanisms will be used to propose future mitigation strategies including selection and optimization of materials, components, and processes to ensure long-term, stable, direct coal conversion in liquid tin.

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PARTNERS

None

PROJECT DURATION

Start Date	End Date
08/14/2009	11/30/2011

COST

Total Project Value
$850,000

DOE/Non-DOE Share
$850,000/$0

AWARD NUMBER

ER00085006

Goals and Objectives

The goal of this program was to evaluate the technical merit and feasibility of a direct coal LTA-SOFC and qualify its durability in a coal environment.

Accomplishments

Accomplishments for the fiscal year 2011:

- Completed tin contaminant solubility testing with all metallic and non-metallic elements including the halogen species.
- Conducted study of coal trace species impact by spiking individual metallic and non-metallic elements into the tin anodes of laboratory-scale cells for 100-hour testing.
- Completed a 1,000-hour cell longevity test at two amps using hydrogen with tin showing a 1.1 percent per 1,000 hour voltage degradation.
- Analyzed experimental results to develop mitigation strategies to minimize the impact of harmful trace species.

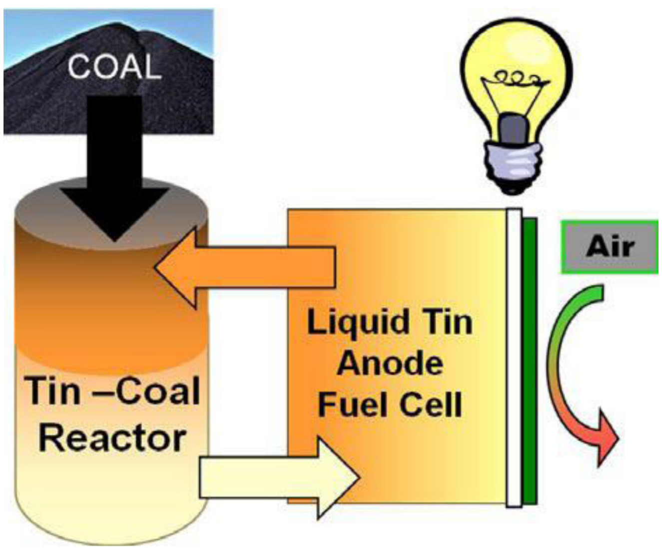

Figure 1. The two major elements of the ECL flowsheet are the tin-coal reactor that reduces tin oxide via coal and the LTA-SOFC, which produces electrical power through the electrochemical reaction of tin.

Benefits

This SBIR project assists the SECA program in meeting its cost and performance targets by advancing a direct coal LTA-SOFC. This atmospheric pressure SOFC system is capable of exceeding 60 percent efficiency (HHV coal basis). SECA will ultimately enable fuel cell-based near-zero emission coal plants with greatly reduced water requirements and the capability of capturing 99 percent of carbon at costs not exceeding the typical cost of electricity available today. Achieving this goal will significantly impact the nation given the size of the market, expected growth in energy demand, and the age of the existing power plant fleet. Federal funding support of this research is appropriate given the game changing nature of the technology accompanied by risks higher than the private sector initially can accept.

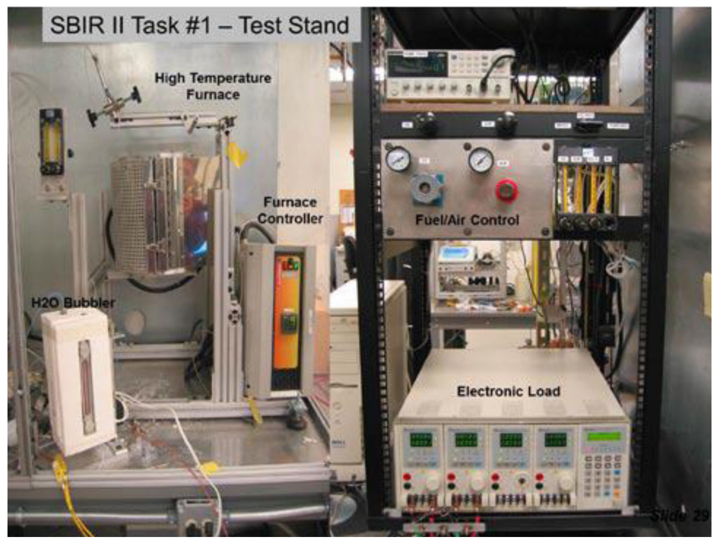

Figure 2. CellTech test stand.

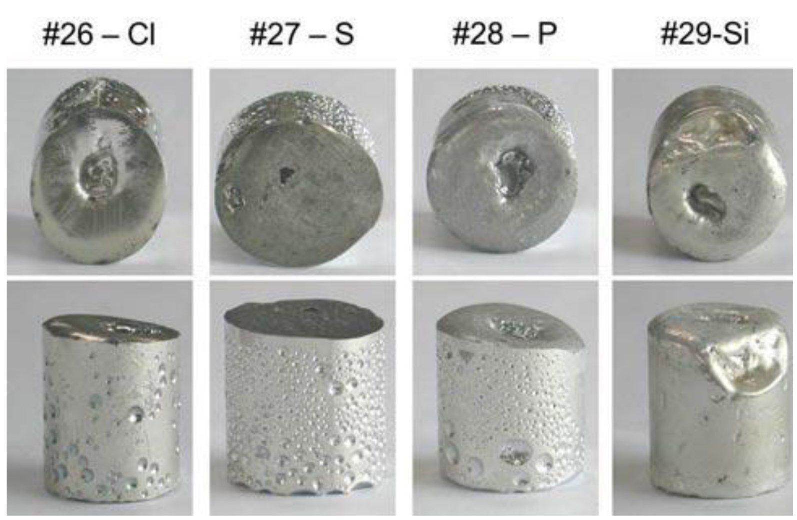

Figure 3. Coal trace species solubility in tin samples showing tin morphology for different trace species spiking.