the ENERGY lab

PROJECT FACTS

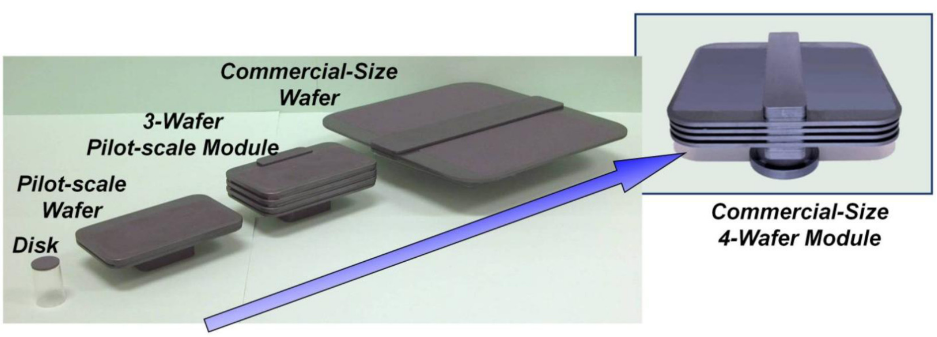
Gasification Technologies

Reaction-Driven Ion Transport Membrane

Description

Integrated Gasification Combined Cycle (IGCC) technology offers a means to utilize coal – the most abundant natural resource in the United States – to produce clean synthesis gas (a mixture of hydrogen and carbon monoxide) that can be utilized in a turbine or used to produce a host of products, ranging from electricity to value-added chemicals like transportation fuels and hydrogen fuel, in an efficient, environmentally friendly manner. The overall cost (capital, operating, and maintenance) of IGCC technology remains higher than that of pulverized-coal and natural gas power plants, which has impeded the commercialization of the technology. A number of factors contribute to the overall cost; for example, IGCC plants require a high-purity oxygen (O_2) supply and although a cryogenic air separation unit (ASU) can be used, this commercially available technology is both capital- and energy-intensive. To reduce the capital costs and parasitic load of air separation systems, the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) is funding the development of novel gas separation technologies, including ceramic based membranes that selectively separate oxygen (as oxygen ions) from high temperature gas streams to produce high-purity oxygen for the gasifier and an oxygen depleted stream which can be used downstream in the turbine cycle to recover additional power.

Air Products and Chemicals, Inc. is currently developing reaction-driven ion transport membranes (ITMs). These membranes create a strong driving force for the separation of oxygen from air by reacting the permeated oxygen with a fuel, resulting in a very low oxygen partial pressure on the permeate side of the membrane. This concept allows operation of the membrane without the need to compress the air, thereby



Progression of Reaction Driven ITM Wafer Development – Through material and wafer development, ion transport membranes offer the potential to improve gas separation and reactions for low cost operation. Wafers shown were developed under a separate DOE Cooperative Agreement and enhanced under this project.

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PERIOD OF PERFORMANCE

10/01/2008 - 09/30/2011

COST

Total Project Value
$3,213,644

DOE/Non-DOE Share
$2,570,915 / $642,729

AWARD NUMBER

DE-FC26-98FT40343-CDP

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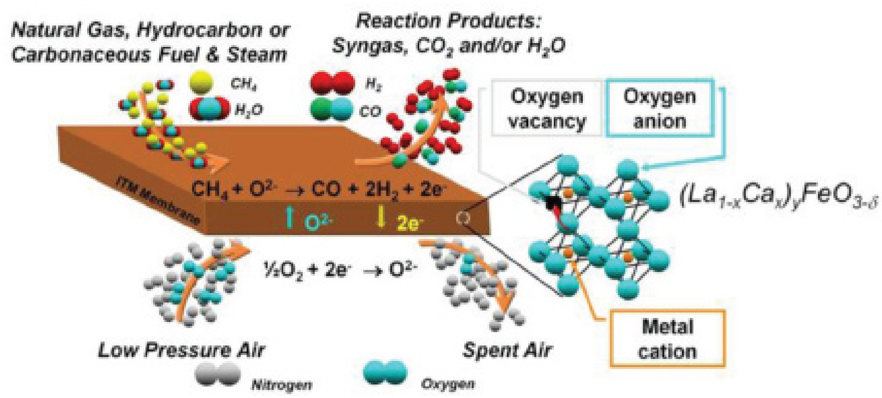
potentially conserving the power needed for compression. Prior work, under a separate DOE Cooperative Agreement, DE-FC26-97FT96052, developed and evaluated Reaction-driven ITMs, using natural gas. The results of this current research effort will provide an initial basis for evaluating the potential for reaction-driven ITM membranes to be integrated with gasification and pyrolysis systems.

Primary Project Goals

The primary goal of this project is to develop reaction-driven ITM technology for advanced power generation systems including gasification applications for fuel production (hydrogen and synthesis gas), in order to reduce the capital cost, operating cost, and carbon dioxide footprint of advanced power system as well as boost efficiency of select systems. This includes both direct application of reaction-driven ITM technology into gasifier systems and integrated application with pressure-driven ITMs to improve overall gasification system performance.



Reaction-Driven ITM Process

Accomplishments

Materials Development

- The operating performance, material stability, mechanical properties, and reliability of the existing Reaction Driven ITMs developed under the ITM Syngas DOE project, when operating at the aggressive conditions required by these applications, were determined. A correlation for tensile stress creep rate to predict creep-to-failure time was developed and verified.
- ITM materials were tested at 900°C and 1000°C, the expected temperatures under reaction conditions.
- Tests in a reducing atmosphere at 750°C verified that the atmosphere has no significant effect on baseline ITM material strength, slow crack growth, or aging.
- Sixteen alternative and four composite ITM materials with expected improved thermal and chemical stability were identified and are under evaluation to determine physical properties under aggressive operating conditions. One prime composite candidate has a measured improvement by a factor of six in creep rate, with twice the strength of the baseline material.

Equipment Development

- Evaluation of heat exchange equipment for preheating feed gases such as steam, air, and process feeds to the reactor at proposed operating conditions was completed. The introduction of compact heat exchangers for high efficiency, low cost heat transfer has the potential to reduce the capital cost of an overall reaction driven ITM process by approximately 10 percent. Compact heat exchangers are currently available for use at temperatures up to ~650°C, and development programs are in place for equipment capable at the required higher operating temperatures.

Process Cycles Development

- Alternative schemes to employ reaction-driven ITM technology for the production of nitrogen purge-and-transport gas were evaluated. A process design using re-compression of the oxygen depleted non-permeate stream exiting the ITM combustor has a 40 percent advantage over a cryogenic ASU for both capital and operating costs with no impact on the base ITM process.

Benefits

Using reaction-driven ITM technology to integrate oxygen generation within advanced power systems such as gasification can significantly reduce the capital and operating cost of systems utilizing heavier hydrocarbon feedstocks for both syngas and power generation. Success with new higher temperature ceramic materials will also have a very positive impact on the economics for broader feedstock applications—for example, pyrolysis—using renewable feed-stocks. Materials and processes that have improved resistance to low level impurities in treated syngas would provide a tremendous opportunity to lower gas processing costs.