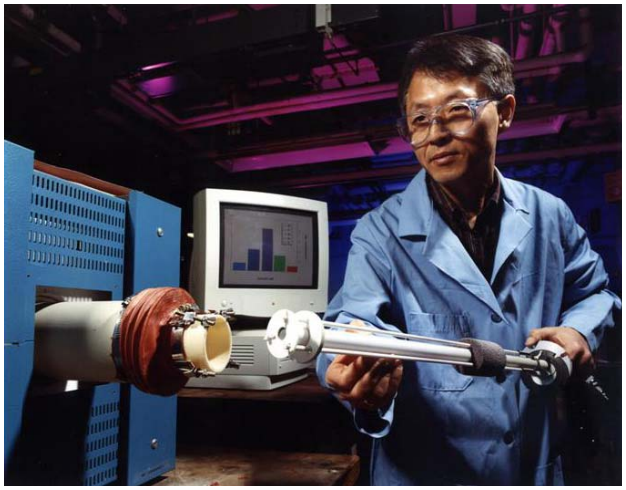
Mixed-conducting Dense Phase Ceramic Membranes for Hydrogen Separation

Description



The development of cost-effective membrane-based reactor and separation technologies is of considerable interest for advanced coal-based power and fuel production technology applications. Specifically, the development of dense ceramic membranes is critical to transitioning to hydrogen-based energy. In the long term, hydrogen is anticipated to be the fuel of choice for both power and transportation industries. For a hydrogen-based energy structure, fossil fuel based technologies will be required to generate hydrogen for various uses including energy production and value-added chemicals. A cost effective hydrogen separation technology is integral to successful fossil-based hydrogen production technologies. Thin, dense ceramic membranes fabricated from mixed protonic and electronic conductors and ceramic-metal (cermet) composites may provide a simple, efficient means for separating hydrogen from fossil-based gas streams.

In this project, dense ceramic membranes are developed to separate hydrogen in a non-galvanic mode from hydrogen-containing gaseous mixtures such as products from coal gasification, natural gas partial oxidation, and water gas shift reaction. These membranes consist of either dual-phase ceramic/metal composites or monolithic mixed protonic and electronic conductors. The work involves identifying and evaluating materials with suitable hydrogen permeability and the development of methods for fabricating thin, dense membranes. Chemical, mechanical, and thermal stabilities of these materials are studied.

Accomplishments

- Developed dense mixed-conducting and cermet membranes that non-galvanically separate hydrogen from mixed-gas streams.
- Highest hydrogen flux ; ≈66 SCFH/ft^2 at 900°C and ≈42 SCFH/ft^2 at 500°C was measured using feed gas of 100% H_2 at ambient pressure. Flux greater than 400 SCFH/ft^2 can be achieved with feed pressures at ≈350 psig. Measurements made at

high pressures at both Argonne and National Energy Technology Laboratory support this conclusion.

- Dense membranes are stable in the range 500-800°C in a simulated syngas mixture containing ≈21% steam.
- Hydrogen flux is stable for ≈1200 h in gas streams with ≈400 ppm H_2S at 900°C.
- A hydrogen-selective membrane developed as part of this project was selected by an independent judging panel and the editors of R&D Magazine as one of the 100 most technologically significant products introduced into the marketplace in 2004.

Benefits

Cost-effective ceramic membrane technology will benefit hydrogen-based power production and transportation where pure hydrogen is needed to power solid oxide fuel cells. The use of a ceramic membrane to separate hydrogen from a shifted syngas stream will also produce a higher concentrated CO_2 steam at higher pressures which is beneficial for sequestration.