

hydrogen separations are membrane processes. The only non-membrane process is the hydrate process, which must operate at low temperatures. This solicitation seeks completely novel CO₂ and/or H₂ separation technologies, with particular interest in technologies that maintain CO₂ pressure and do not require a significant drop in temperature.

Partitioning and Mechanism Studies for Mercury and Associated Trace Metals Within Coal-Fired Processes

Understanding mercury chemistry and process-related speciation mechanisms and transformations in laboratory experiments provide necessary steps to first understanding partitioning and subsequently developing mercury removal processes for advanced power systems, *i.e.*, industrial and coal-fired applications for PC-boilers, cyclone boilers, tangentially-fired boilers, fluidized-bed boilers and gasification processes. Past research has shown a reasonable link between mercury speciation and several parameters including the various constituents of fly ash (*i.e.*, unburned carbon/ LOI); fly ash properties (such as fly ash alkalinity); and process specific information (coal rank, boiler type, flue-gas temperature, Cl concentration, NO_x concentration, sulfur compounds, and CO/CO₂ concentrations). Grant applications are sought to further understand partitioning and chemistry of mercury and other trace metal and organic substances in coal-fired (bituminous, subbituminous, and lignite) systems. Specifically, modeling or experiments using statistical analysis of these identified parameters on chemical intermediaries and mechanisms is sought.

Solid Oxide Fuel Cells (SOFC) Sealing Systems

A secure future for our Nation depends on the continued availability of reliable, affordable, and environmentally-safe technologies for production of energy from advanced power systems, such as fuel cells. Solid oxide fuel cells are capable of operating on a variety of fossil fuels, including coal derived synthesis gas. Currently, numerous SOFC design concepts are under development by industry. These industrial developers have identified sealing as a top-priority technical barrier in their efforts to commercialize advanced power generation systems based on solid oxide fuel cell technology and operating on coal and other fossil fuels. These seals have a demanding set of imposed performance criteria due to the extreme SOFC

operation environment. The seals must prevent the mixing of fuel and oxidant streams as well as prevent reactant escape to the surrounding environment. The seal material must have a low electrical conductivity and be mechanically and chemically stable under reducing/oxidizing/wet conditions, as well as with oxidizing and reducing environments separated by the seal. Of particular importance is the ability to seal, with adequate bond strength, materials (*e.g.* Fe-Cr alloys, Ni-YSZ cermet and LSM) with differing coefficients of thermal expansion (CTE), and do so while exposed to temperature transients over a range from room temperature up to SOFC operating temperature (~850 °C). In addition, the seals must accommodate the thermal expansion of the fuel cell caused by temperature gradients in the direction of fuel flow, the result of the electrochemical reaction, without imposing excessive stresses within the cell. In the case of auxiliary power unit (APU) and mobile applications, the seals must be resistant to thermal shock in order to permit a rapid (~10 minutes) transition from ambient to operating temperature, and in the latter case, vibration. The seal material must be capable of a service life of more than 40,000 hours and hundreds of thermal cycles for stationary systems, or at least 5,000 hours and 3,000 thermal cycles for transportation systems.

Current state-of-the-art sealing concepts utilizing glass or glass-ceramic materials have been largely successful in meeting performance requirements in the *short-term*. The viscous, wetting behavior of glass facilitates hermetic sealing, and glass-ceramics avoid viscous flow and uncontrolled, progressive crystallization during operation. The properties of these materials (CTE, T_g for glasses) can be affected via composition/structure modifications. Furthermore, glasses are relatively inexpensive and easily fabricated.

However, *long-term* performance under thermal cycling has been unsatisfactory. Glasses and glass-ceramics are brittle; consequently, thermal stress-induced bulk microcracking of the seal, resulting from as few as one start-up/shut-down/start-up cycle, may cause unacceptable reactant leakage. Furthermore, these stresses are affected by a host of factors, including the cell/interconnect/seal geometry and the unique component material properties of the particular SOFC stack design. The potential for seal fracture is exacerbated by the potential chemical reaction of glass with metal interconnects, resulting in the

formation of interfacial compounds and/or extensive porosity in the glass near the glass/metal interface.

Glass, glass-ceramic, ceramic-filled glass composite, metal-filled glass composite and/or ceramic-filled metal composite based seal materials and systems are sought with significantly improved long-term durability under SOFC operating conditions, with particular emphasis placed upon the ability of the seal or seal system accommodate dimensional changes of cell components resulting from thermal transients (shock) and thermal gradients. Material composition and/or structure modifications may potentially possess the capability to accommodate larger displacements, local dimensional variations and material movement. In addition, these materials must be chemically and physically stable in a high temperature reactive environment. The seal material must be compatible with the cell and interconnect materials of the particular SOFC system design. The ultimate objective is the development of an economically-practical seal material/system that can provide hermetic sealing under all operating conditions for the life of planar SOFC stacks.

Financial assistance applications are sought to research and develop glass, glass-ceramic, ceramic-filled glass composite, metal-filled glass composite and/or ceramic-filled metal composite based seal materials and systems to address planar SOFC sealing needs. Of particular interest are novel seal concepts focusing on seal material composition and structure with an emphasis on attaining long-term durability under typical SOFC operating conditions. Emphasis in this solicitation is on investigating and developing viable sealing materials for us with synthesis coal gas compositions feed to SOFC. Current Solid-State Energy Conversion Alliance (SECA) program goals require a seal service life of more than 40,000 hours and hundreds of thermal cycles for stationary systems, or at least 5,000 hours and 3,000 thermal cycles for transportation systems. Effective sealing concepts must perform under high temperature, chemically reactive conditions and need to accommodate thermal transient/gradient-induced movement of cell and stack components and enclosures while minimizing transmission of structural loads to delicate cell components. Proposed approaches should combine analysis and experimentation to establish theoretical limits, and to evaluate the practical limit of the sealing concept. Manufacturability and