Hydrogen, Fuel Cells & Infrastructure

Intra-Fuel Cell Diagnostics Map Dynamics of Fuel Cell Operations

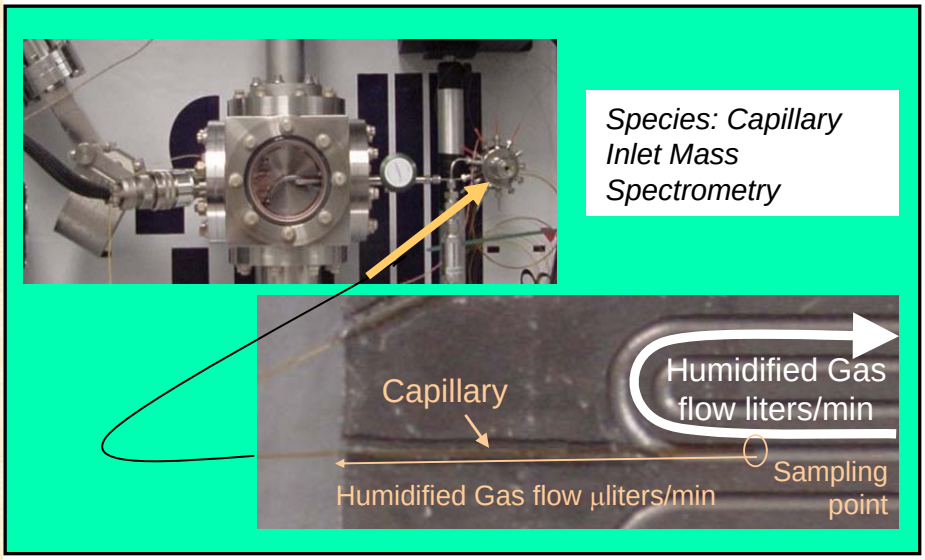
Mass Spectrometry Measures Species in Operating Fuel Cells

Background

Improved fuel cell efficiencies can be realized through detailed understanding of the chemical and physical processes taking place in operating fuel cells. Intra-fuel cell measurements that resolve transient species concentration distributions across, and within, cells are required to understand operating details, validate reactor models and optimize system design and efficiency. Models that rely only on data for fuel cell inputs and outputs are insufficient for understanding the processes that occur within the cell. Intra-reactor measurements allow higher order optimization that considers factors such as the distribution and transport of reactants and products, localized and possibly dynamic active-site blocking, and membrane degradation. In turn, such species measurements can be used to better understand and optimize specific component processes.

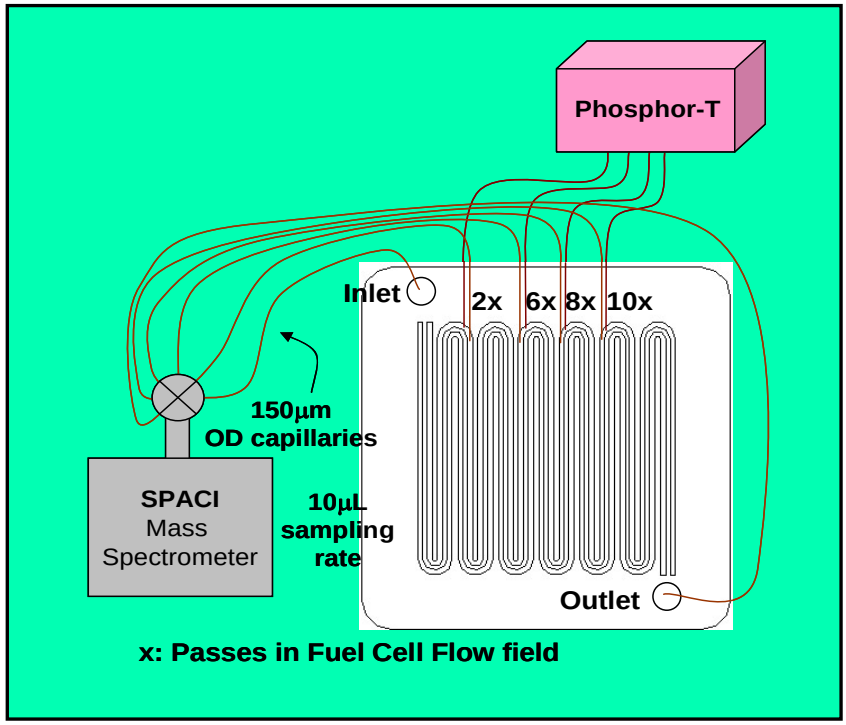
Technology

Spatially resolved capillary-inlet mass spectrometry (SpaciMS) is a candidate species diagnostic for making minimally invasive intra- and inter-stack measurements within fuel cells. The instrument is based on direct capillary sampling to a residual gas analyzer. Capillaries are directly mounted in the bipolar-plate channels, blocking less than 3% of the flow path, and sampling at approximately 10 μL min-1. This sampling methodology is minimally invasive, and enables species measurements in both single- and multi-cell configurations. Moreover, the SpaciMS measurement methodology is relatively easy to configure and implement, and thus is accessible to the entire fuel-cell community. The ORNL Fuels, Engines and Emissions Research Center has previously applied the SpaciMS successfully to other operating reactors including diesel catalyst, air-exhaust mixing systems and non-thermal plasma reactors.



Accomplishments

SpaciMS measurements of species including O_2, N_2 and water at several positions across the flow path were made at realistic humidity levels in proton exchange membrane (PEM) fuel cells. These measurements demonstrated the relationship between fuel cell output power and oxygen consumption along the cathode serpentine flow path. Moreover, the intra-PEMFC measurements identified intra-cell concentration gradients and non-uniformities, as well as anomalous operation.



Benefits

- SpaciMS has minimally invasive probe size and sample collection rate
- Sensors are stack capable
- Allows mapping of temperature, humidity and species distribution, including contaminants
- Data allows improvements over a broad range of process components including flow-path design, reactant stream concentrations and materials formulations
- Yields understanding of degradation processes such as start-stop and thermal cycling, effects of impurities, localized drying and membrane or bipolar plate degradation

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