Development of Optical Fiber Sensor Technology for Fuel Cell Diagnostics
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The objective of this program is the development of optical sensors to monitor critical parameters in fuel cells. Initial focus will be on measurement of hydrogen concentration and relative humidity using compact optical-fiber sensor elements but applying different detection mechanisms. For hydrogen, a surface plasmon resonance in a metal film on the fiber tip will provide information on absorbed hydrogen concentration. For relative humidity, the sensing element is a dielectric resonant waveguide grating on the fiber tip. For both mechanisms, the incident optical signal is guided in the fiber and reflected in a narrow spectral band. Slight changes in the parameters of the resonance element, such as refractive index or thickness of an attached transduction layer, result in a spectral shift of the reflected peak and the corresponding transmitted notch. Owing to the relatively narrow spectral linewidth associated with these resonance effects, the sensors are predicted to possess high sensitivity, high accuracy, extensive dynamic range, as well as excellent spatial resolution. For the waveguide resonance sensor, preliminary experimental results strengthen the feasibility of the project. Development of prototype sensor systems is proposed. This includes the design and fabrication of the sensing elements on fiber tips in single-fiber and multi-fiber bundle versions. Testing under white-light and laser light illumination will be conducted. If good results are obtained in this preliminary work, this resonant-fiber-probe scheme will be extended to quantify other fuel cell parameters. The proposed sensors are superior to comparable existing devices in sensitivity, resolution, and dynamic range. Thus, the proposed research provides foundation for development of new sensor systems with high economic and technological potential.