Mapping of Temperature Profiles of the Entire Solid Oxide Fuel Cells with 8-mm Spatial Resolution During 800^{o}C Operations

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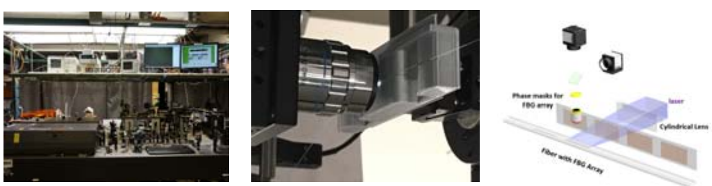
Abstract: Objectives of this project is to develop distributed fiber sensor technology to perform real-time, high spatial resolution physical and chemical measurements during operations of solid oxide fuel cells (SOFCs) to understand physical and chemical processes that underpin operational efficiency and longevity of SOFCs systems. Through integrated research and development efforts include ultrafast laser fabrication of high-temperature resistant fiber sensors, 3D printing of sensor-fused fuel cell interconnect, integrated testing of SOFCs, and data analytics, this research work aims to develop sensor technology that enables direct measurements of temperature, strain, and chemical profiles inside a single fuel cell, fuel cell assembly, and fuel cell systems with better than 1-cm spatial resolution. Data harnessed by fiber sensors will provide new insights to understand operational of fuel cell systems as functional of structures, materials, and times. It will improve numerical fuel cell models, fuel cell designs, and catalyst material optimization that lead to improve SOFC efficiency and operational longevity.

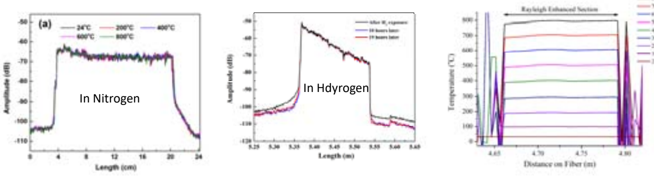
Distributed fiber Temperature sensors that are hydrogen resistant:

- Ultrafast laser fabrications
- Phase mask for FBG fabrication (2nd and 3rd grating)
- Point-by-point fabrication for distributed fiber sensors using roll-to-roll process

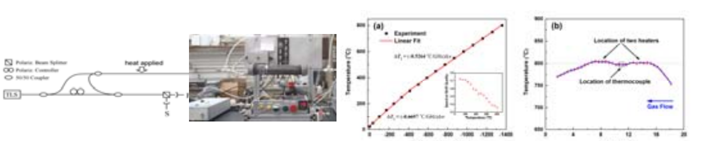
Ultrafast Lasers fabrication and high-T stable FBG



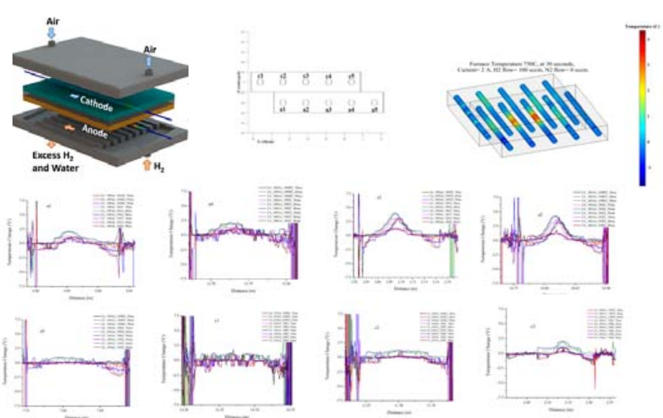
Distributed Fiber Sensors via Point-by-Point writing



Measurement Repeatability better than 4C from the RT to 800C with 4-mm Spatial Resolution



Temperature Profiles of SOFC at 800C

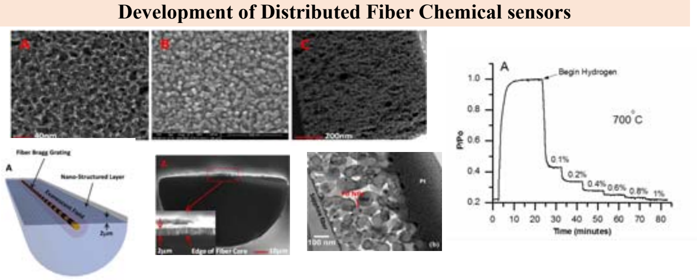


Summary: This poster presents experimental results of temperature-stable FBG sensors and distributed fiber physical/chemical sensors fabricated by femtosecond lasers. The results show that when appropriate fibers are chosen and suitable laser fabrication techniques are implemented, sensors can survive extreme environments of SOFC at high temperatures. Through sensor fused additive manufacturing, fiber sensors have been successfully integrated into fuel cell metal interconnects to perform dynamic and distributed temperature and chemical measurements in anodes and cathodes of fuel cells with 8-mm spatial resolutions. Data harnessed by fiber sensors will provide new insights to understand operational of fuel cell systems as functional of structures, materials, and times. It will improve numerical fuel cell models, fuel cell designs, and catalyst material optimization that lead to improve SOFC efficiency and operational longevity.

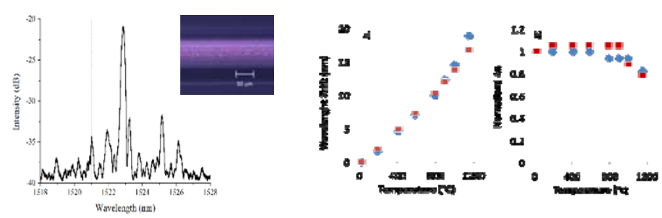
Development of distributed fiber chemical sensors:

- Metal oxide nano-materials sensitive for hydrogen
- Integration on specialty fibers for distributed H_2 measurement with 4-mm resolution
- Perform H_2 measurement at up to 750C

Development of Distributed Fiber Chemical sensors

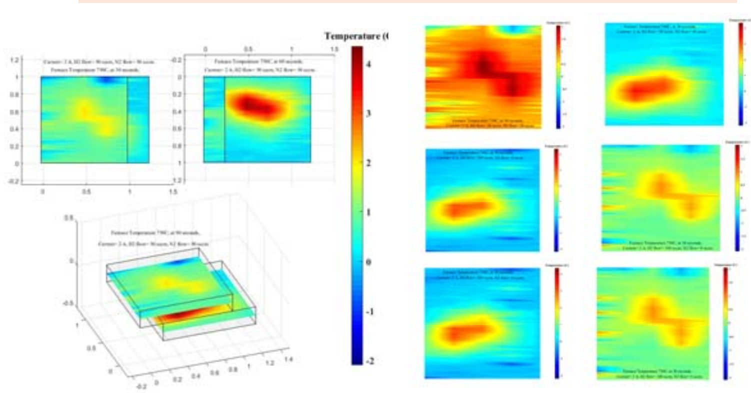


Fiber Bragg Grating via Phase Masks



3D printed Fuel Cell Interconnect for Sensor Insertions

Temperature Profile Mapping of SOFC at 750C



Acknowledgments

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