Optical fiber-based real-time chemical sensor development for SOFC applications

Youngseok Jee*a,b, Shiwoo Lee a,b, Michael P. Burić, Harry W. Abernathy a,b, Thomas L. Kalapoa,b, Gregory A. Hacketta*

Abstract

Optical fiber sensors exhibit inherent advantages such as the electrical wiring-free configuration, compatibility with broadband wa
ten and distributed interrogation, and the elimination of electrical sparks in flammable atmospheres. For these reasons, the SOFC an
c sensors groups at the National Energy Technology Laboratory have collaborated to develop sensors that will allow for in situ distributed
measurements of temperature and/or gas composition with centimeter-scale resolution. An overview of the gas sensing program will be
presented focusing on recent results on developing functional coating materials for the optical fibers that allow (1) distributed oxygen mon
itoring across the cathode or (2) monitoring of H2/H2O/CO/CO2 across the anode. The impact of the coating composition, thickness, an
d deposition will be discussed.

Optical fiber sensing platform for the SOFC application

1) Small diameter → compatible with anode and cathode flow field integration
2) No electrical wiring → enhanced stability & compatibility with electrified systems
3) Robust in harsh environment / high temperature conditions
4) Distributed sensing → able to monitor parameters spatially internal to SOFC

Optical fiber sensor preparation procedure

Sensitivity test procedure for the perovskite decorated optical fiber sensors
1) Plastic jacket (stripping) and cladding (HF etching) removal exposing the core of multi-mode fiber. (Thorlabs FGA100-SCA)
2) Sputter deposition (LSC, LSCF) with 3-inch targets of (La0.8Sr0.2)0.95Co0.2Fe0.8O3-δ (LSM), (La0.8Sr0.2)0.95Co0.2Fe0.8O3 (LSC), and (La0.8Sr0.2)0.95Co0.2Fe0.8O3-δ (LSCF) at 50(W) [in Ar:O2(4:1)] environment using a custom-made rotational fixture.
3) Placement of the prepared fiber in a gas feeding tubular furnace and connection to the light source (DH-2000-RAL, Arcapico) and both visible (VIS) and near infrared (NIR) range detectors. (J. Zier, Optics, inc.: FTNIR U-09-026, Arcapico)
4) Ramping the temperature in N2 up to 800°C and pre-treatment in several O2 concentration cycles.
5) Sensitivity test exposing the fiber to the operational gas conditions. (1-19% O2 balanced with N2)

Optical fiber-based sensors exhibit inherent advantages such as the electrical wiring-free configuration, compatibility with broadband wa
ten and distributed interrogation, and the elimination of electrical sparks in flammable atmospheres. For these reasons, the SOFC an
c sensors groups at the National Energy Technology Laboratory have collaborated to develop sensors that will allow for in situ distributed
measurements of temperature and/or gas composition with centimeter-scale resolution. An overview of the gas sensing program will be
presented focusing on recent results on developing functional coating materials for the optical fibers that allow (1) distributed oxygen mon
itoring across the cathode or (2) monitoring of H2/H2O/CO/CO2 across the anode. The impact of the coating composition, thickness, an
d deposition will be discussed.

Optical fiber sensing platform for the SOFC application

1) Small diameter → compatible with anode and cathode flow field integration
2) No electrical wiring → enhanced stability & compatibility with electrified systems
3) Robust in harsh environment / high temperature conditions
4) Distributed sensing → able to monitor parameters spatially internal to SOFC

Optical fiber sensor preparation procedure

Sensitivity test procedure for the perovskite decorated optical fiber sensors
1) Plastic jacket (stripping) and cladding (HF etching) removal exposing the core of multi-mode fiber. (Thorlabs FGA100-SCA)
2) Sputter deposition (LSC, LSCF) with 3-inch targets of (La0.8Sr0.2)0.95Co0.2Fe0.8O3-δ (LSM), (La0.8Sr0.2)0.95Co0.2Fe0.8O3 (LSC), and (La0.8Sr0.2)0.95Co0.2Fe0.8O3-δ (LSCF) at 50(W) [in Ar:O2(4:1)] environment using a custom-made rotational fixture.
3) Placement of the prepared fiber in a gas feeding tubular furnace and connection to the light source (DH-2000-RAL, Arcapico) and both visible (VIS) and near infrared (NIR) range detectors. (J. Zier, Optics, inc.: FTNIR U-09-026, Arcapico)
4) Ramping the temperature in N2 up to 800°C and pre-treatment in several O2 concentration cycles.
5) Sensitivity test exposing the fiber to the operational gas conditions. (1-19% O2 balanced with N2)