UCR-AOI2 (FE0028992): Engineering Metal Oxide Nanomaterials for Fiber Optical Sensor Platform

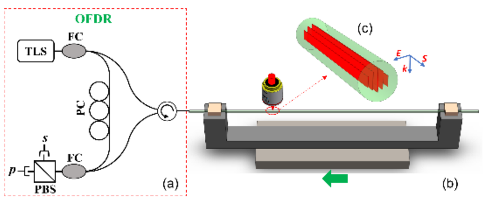
PI: Kevin Chen, Students: Aidong Yan, Sheng Huang, University of Pittsburgh
Department of Electrical and Computer Engineering, University of Pittsburgh, Pittsburgh, PA 15260
NETL Collaborators: Paul Ohodnicki, Michael Buric, Shiwoo Lee

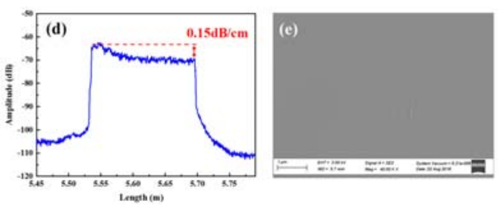
NATIONAL ENERGY TECHNOLOGY LABORATORY

Introduction

We report a technique to enhance the magnitude and high-temperature stability of Rayleigh back-scattering signals in silica fibers using femtosecond laser irradiation. Using optical fibers with enhanced Rayleigh backscattering as distributed temperature sensors, we demonstrated in-vivo monitoring of solid oxide fuel cell (SOFC) operations with 5-mm spatial resolution at 800ºC.

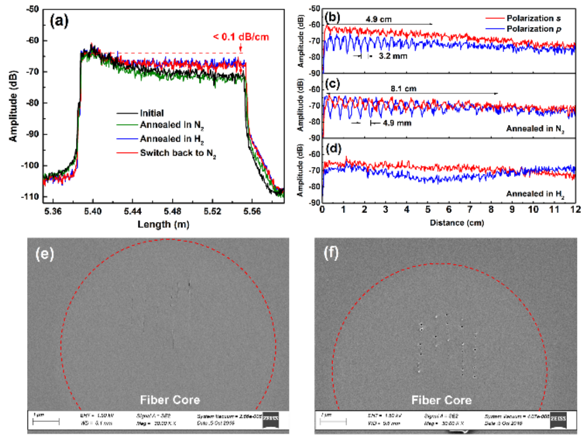
Method



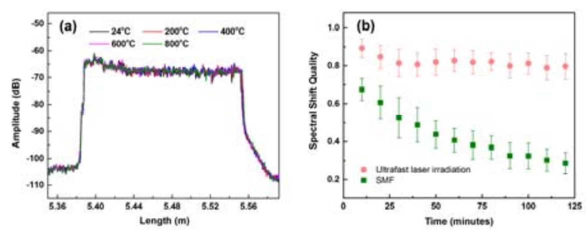


The ultrafast laser system consists of a Coherent MIRA-D Ti:sapphire seed oscillator and a RegA 9000 regenerative amplifier operated at 800 nm with a repetition rate of 250 kHz. The pulse width was adjusted to 300-fs. (a) OFDR system (LUNA OBR 4600). (b) Schematic sketch of fabrication setup and (c) nanograting. (d) Enhanced Rayleigh scattering profiles. (e) SEM images of the cross-sectional morphologies of nanogratings.

Laboratory Testing

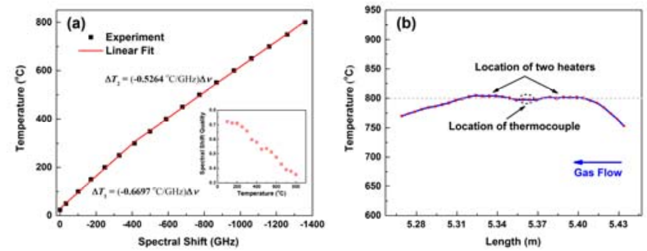


Anneal process at 800ºC in N_2 and 10% H_2. (a) Rayleigh scattering amplitude measured during annealing in N_2, and 10% H_2; (b)-(d) scattering signal amplitude of the s and p polarization states emitted by the irradiated fiber before and after annealing; (e)-(f) SEM images of nanogratings morphology changes occurring after annealing in N_2 and 10% H_2, respectively.

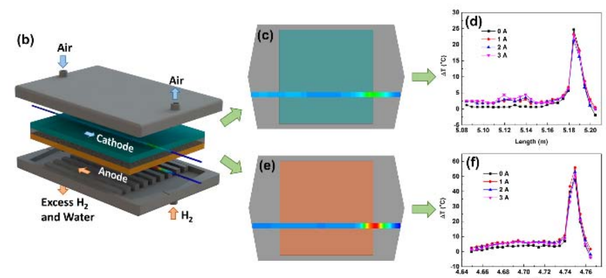


(a) Thermal stability of scattering features after an annealing process in 10% hydrogen at 800ºC for 10 minutes and (b) comparison of the spectral shift quality vs time at 800ºC for fiber irradiated by the ultrafast laser and un-irradiated standard fiber.

Results



Temperature measurement up to 800ºC in a tube furnace: (a) Rayleigh spectral shift measured by OFDR , (b) Temperature profile of the furnace.



Temperature variation change of the cathode and anode in the solid oxide fuel cell at different current load: 0 A, 1 A, 2 A, 3 A respectively with 100% hydrogen fuel.

Acknowledgement

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