Smart Nano-Structured Titania based MEMS Multi Gas Sensor for High Temperature and Harsh Fossil Environment Application

Novelty

(1) Multi Sensors: 64 vs. 1 single sensor in ONE platform
(2) MEMS Sensor: Leverage unique Ti based MEMS Technology:

Nano Structured-Titania Sensing Platform
Increased the absorption surface by x 2500/mm²

(3) Sensitivity: Extremely sensitive with a shorter response time compared to any existing sensor technologies
(4) Gas Selectivity: Capable to detect accurately a specific target gas in a mixed gases environment
(5) New Material: Oxidation resistance alloy that withstands 1200 °C operating temperature and 1000 psi pressure.

(6) Leverage Data Fusion: to post-process the collected data resulting a reliable output signals
(7) Extremely Robust

Future Work (Phase II)

(1) Develop the Sensor Selectivity: Will incorporate into the sensing layer metallic (Al, Cr, Nb) or metal-oxide (Al₂O₃, Y₂O₃) dopants, or deposit a thin layer of noble metal (Pt, Pd)
(2) Develop the Data Fusion Algorithm: Will develop multivariate Principal Component Analysis (PCA) and Partial Least Squares Algorithms to post-processing 320 collected signals from each 64 individual sensor (5 sensors in one platform)
(3) Design, Fabricate and Test the Prototype Sensor: Will implement PiMEMS’s patented fabrication processes to design and fabricated the Ti-based MEMS Gas Sensor and will test the fabricated prototype at NETL/PiMEMS facilities.

Phase I Achievements

(1) Developed a New Material Successfully integrated Nano-structured Titania (NST) thin film as the sensing platform to oxidation-resistant TiAlCrY and FeCrAlY coatings

(2) Successfully developed an etching process to fabricate the micro pillars sensing platform on the developed alloy: 46-5Ti-37Al-17Cr-0.1Y

The developed process is scalable and enables to control the shape of the etched pillars

Micrographs of the pillars. 50nm in diameter, 5 nm in height formed by etching at the surface of a TiAl alloy coupon, a) well distributed arrays of pillars, b) back scattered SEM image showing the bcc phase structure of the TiAl alloy and well defined pillars.

MEMS Sensor Concept

Gas composition data

@ T > 800 °C

Subcontractor: Sebastien Dryepondt, PhD
Oak Ridge National Laboratory

MEMS Sensor Concept

O₂
H₂
CO₂
Noₓ

SEM surface micrographs showing an NST layer deposited on a pre-oxidized Ti/SiO₂ coupon, annealed at 800°C, a) for 10h, b) for 15h

SEM surface micrographs showing an NST layer deposited on a TiO₂-coated Ti coupon pre-oxidized at 800°C for 16h, a) fabricated NST layer, b) annealed at 800°C for 16h, c) annealed at 800°C for 13h

1µm

Substrate gas # 1.
Substrate gas # 2.
Substrate gas # 3.
Substrate gas # n.

Data Fusion Module

Signals Readout Module 1
Signals Readout Module 2
Signals Readout Module 3
Signals Readout Module n

The sensors platform

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