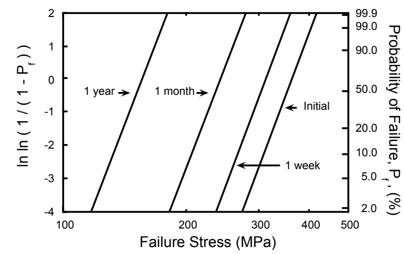
Prediction of High Temperature Gas Sensors

Metal Oxide Mechanical Properties as Life Limiters of Sensors

New and next-generation electrochemical sensors will be used in a variety of elevated temperature service environments to detect and measure CO, CO_2, H_2, H_2O, NH_3, NO_x, O_2, or SO_x gases or combinations thereof. The measurement of these species relies on high-temperature-activated ion-conduction in thin metal oxides (ceramics). A substantial amount of research is presently devoted to the identification and fabrication of those metal oxides to increase measurement sensitivity to those listed gases and to lessen measurement response times. Unfortunately, these same metal oxides typically have inherently poor mechanical properties (e.g., low strength, low toughness, low thermal shock resistance, etc.). Consequently, rationalization exists to identify, understand, and predict those mechanical limitations, so their effects may be minimized or averted (through engineering design) and the intended thermochemical operation and gas species measurement may be realized.

What Can Be Done?

Thermomechanical testing and characterization of metal oxides and probabilistic design (Weibull) of metal oxide - containing components may be combined to ultimately (1) identify combinations of sensor geometry - permissible operating service conditions that will not cause premature or unanticipated failure of the sensor, and (2) predict sensor lifetime for specific sensor geometry - service condition combinations.



Fatigue of Metal Oxides Can Limit Sensor Function and Capability

How is This Accomplished?

- Mechanical, thermal, and physical testing and characterization of candidate metal oxide ceramics are performed. Additional techniques (measurement of chemically-induced strains, environmental testing, in-situ testing, Hertzian indentation, IR-ultrasound) are utilized where needed.
- Microstructure, material state, and potential strength-limiting flaw populations are characterized and linked to fabrication technique and mechanical performance.
- Effects of corrosion on mechanical performance (*i.e.*, service life) are assessed.
- Generated metal oxide material design data is combined with FEA of service conditions and geometrical sensor designs to determine probability of survival of the sensor. Geometries are refined to minimize tensile stresses and maximize probability of survival.
- Proof testing is used to screen materials and sensor designs, and to ultimately be used as a tool to improve confidence of manufactured sensors. Mechanical testing proof testing (and statistics associated with it) is linked to electrical/gas-sensing operation.

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