Nano-Derived, Micro-Chemical Sensors for SO_2 and H_2S Sensing at High-Temperature

Engin Ciftyurek[a], Katarzyna Sabolsky[a] and Edward M. Sabolsky[a]

[a]Department of Mechanical & Aerospace Engineering, West Virginia University
Morgantown, WV 26506, USA

Abstract:

The objective of our work is to develop micro-scale, chemical sensors and sensor arrays composed of nano-derived, metal-oxide semiconducting (MOS) materials to detect gases such as H_2, SO_x, and H_2S within high-temperature environments (>500°C). The impact of this work will enable the inexpensive implementation of sensor arrays within broad sensor nets. These sensor nets will allow for *in situ* gas testing for three-dimensional fuel and emission maps within various industrial energy applications, such as current coal-fired power plants, and future Integrated Combined Cycle Gasification (IGCC) systems and direct-coal fuel cell generator systems.

The sensors investigated in this work are based upon a chemi-resistive sensor platform. The functionality of these micro-sensors is dependent upon the incorporation of refractory MOS nanomaterials within thin-film electrode patterns. The selective nanomaterials used for this work were synthesized by hydrothermal process. A range of baseline binary (WO_3 and MoO_3) and complex ternary tungstate and molybdates compositions, due to their well-known properties as reversible absorbents in harsh environments, were successfully synthesized by co-precipitation and/or hydrothermal methods. The powders characterized by x-ray diffraction showed no secondary phases with various anisometric morphologies and sizes, depending upon the initial composition, solution saturation, reaction time and reaction conditions.

The sensing materials were deposited on macro-sensor platform, and the chemi-resistive response of the sensing materials were investigated for SO_2 and H_2S exposure at levels of 100 to 2400 ppm and 50 to 300 ppm, respectively. The electrode used was an interdigitized electrode (IDE) pattern. Both CO and H_2 cross-sensitivity tests were also included.

The sensing nanomaterials were also deposited over high-temperature stabile Pt IDEs, which were developed at WVU (see Fig.1) with dimensions in the millimeter to micron size range set upon a polished alumina substrate. The resistance change as a function of exposure time, temperature, and gas composition was monitored (see Fig. 2). The measurements were conducted at temperatures from 400 to 1000 °C. Post-mortem microstructural and compositional analysis including XRD, XPS, SEM and EDS was completed to better understand both the sensing and degradation mechanisms.

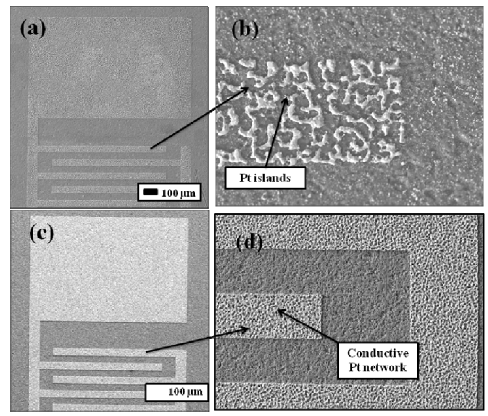

Figure 1: High temperature compatible micro electrodes

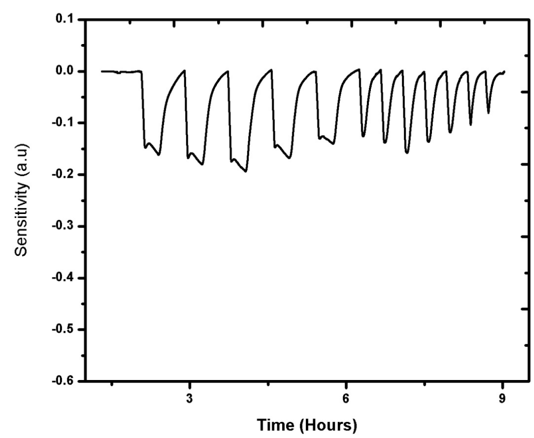

Figure 2: Molybdates at 1000°C for SO_2 detection under 1%O_2 partial pressure.

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