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Sandia National Laboratories

Hot Plate Based Technology and BTU Monitors

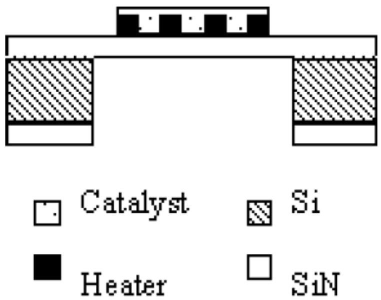

Figure 1. Schematic cross section.

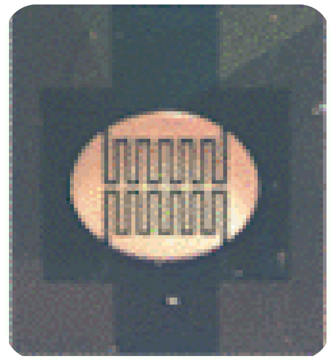

Figure 2. Microhotplate.

Overview

The microhotplate, used as a basis for the microcombustor, is fabricated by through-wafer silicon etching. It consists of a silicon nitride membrane suspended form a frame of Si.

Either Bosch etching or KOH etching can be used to release the membrane, with no discernable operational differences between the completed devices made by either method. Due to their thermal sensitivity, typically better than 0.4 mW/°C, microhotplates have been used in a number of other applications including flow sensing, gas thermal conductivity detection, infrared bolometry, and conductometric gas sensing; typically using tin oxide as a gas sensitive layer for the latter.

The microcombustor, consisting of a catalytic film deposited on the surface of a microhotplate, allows for sustained combustion on the microscale. This micromachined design has low heat capacity and thermal conductivity, making it ideal for heating catalysts placed on its surface. The catalytic materials provide a natural surface-based method for flame ignition and stabilization and are deposited using a micropen system, which allows precise and repeatable placement of the materials.

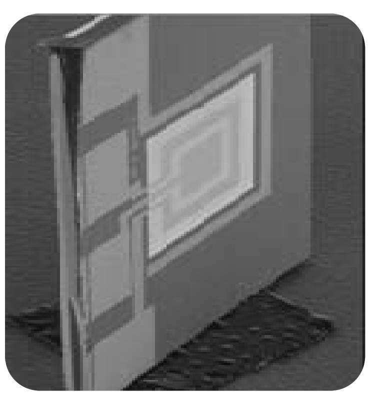

Figure 3. SEM of microhotplate front side.

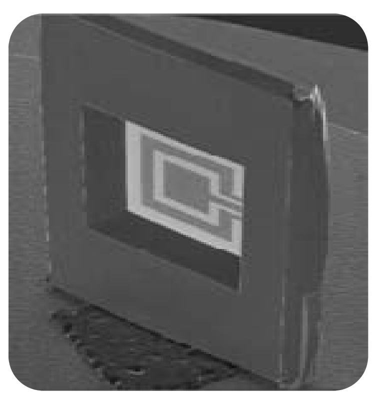

Figure 4. SEM of microhotplate etch side.

Current Status of the Technology

Sandia National Laboratories has been working on two gas sensors based on a microcombustor platform. While both sensors are in their early stages of testing and development, they exhibit good detection limits and signal quality. In addition to testing the sensors themselves, headway has also been made in understanding the combustion characteristics of hydrocarbons when exposed to a variety of catalysts. The two sensor technologies are a micro flame ionization detector (microFID) and a calorimetric gas sensor. Both are utilized in the determination of fuel mixture, though the microFID has a demonstrated analyte set that expands beyond hydrocarbon detection.

1. The calorimetric sensor was created with one primary sensing goal in mind: the determination of a hydrocarbon mixture's heating value by combusting a given sample of fuel and measuring the heat released. In this way the sensor is capable of a direct, as opposed to inferred in the case of a traditional GC, measurement of fuel heating value.
2. The micro flame ionization detector (microFID) design measures a current generated from hydrocarbon ionization to measure analytes carbon content. Sandia has accomplished a demonstration of a microFID utilizing lean premixed fuel and a catalytically-stabilized flame. Importantly, the catalyst not only aids in combustion, but also apparently aids in reduced-temperature (relative to conventional flames) formation of hydrogen radicals, which are necessary for cracking of analytes into single carbon fragments.

Figure 5. Micropenned Pt/alumina.

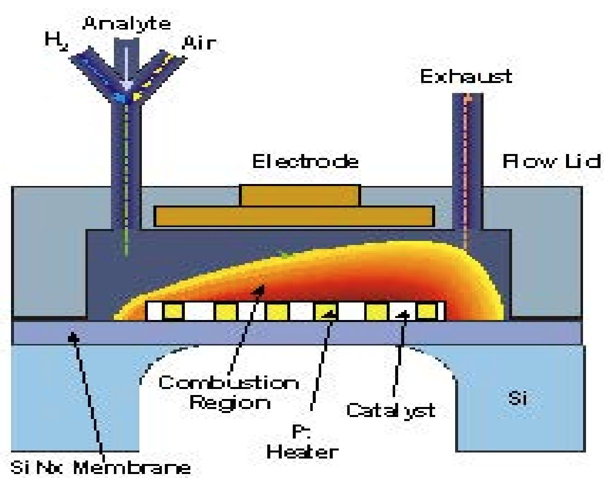

Figure 6. Cross-sectional schematic of MicroFID.

For additional information or questions, please email us at MGA@sandia.gov.

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