CHARACTERIZATION AND THERMAL FAILURE ANALYSIS OF A MICRO HOT PLATE CHEMICAL SENSOR

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Micromachined chemical sensor substrates offer many advantages over more traditional sensor substrates. Some of these include batch fabrication, ready fabrication of sensor arrays and ease of integration with electronic circuitry. In addition, microfabrication offers unique thermal advantages for sensors that require high-temperature operation. Conductivity measurements at high temperature (> 150 °C) of thin film materials such as tin oxide and phthalocyanine are a common approach in the development of chemical sensors. Traditional manufacturing of these sensor substrates results in devices that require large amounts of power for operation and limits their use in applications that require battery operation such as field deployment.

For these reasons, we have investigated micromachined micro hot plate substrates for chemical sensor applications. Interesting materials for this application are phthalocyanine molecular films that are intensely colored, organic semiconductors. Their conductivity is very sensitive to gas exposure and is dependent on the metal atom in the center of the molecule. Therefore the gas sensitivity can be easily modified. Previously we have developed chemical microsensors, such as an HCl sensor using magnesium phthalocyanine and macro hot plate sensor substrates.

The thermal characterization and failure analysis of a micro hot plate (μHP) sensor is described. The substrate was fabricated using the MUMPs foundry and in-house post processing. An IR microscope was used for thermal imaging of the micro hot plates and shows that the devices are very efficient (11.5 ˚C/mW). The performance is very good compared to similar micromachined devices and much better than macro hot plate devices. Here thermal characterization of the sensor substrates is described to obtain information about the primary heat loss mechanism and the thermal failure mode of the substrate. From efficiency measurements of devices with different size diaphragms as well as measurements in air and in vacuum, the dominant heat loss mechanisms are determined to be convection in air as well as conduction. SEM and EDX analysis shows that the thermal failure mode of the devices is eutectic formation between gold and polysilicon at ~ 350 ˚C which determines the high temperature limit for these MUMPs devices. However, this temperature limit is sufficient for most chemical sensor applications.

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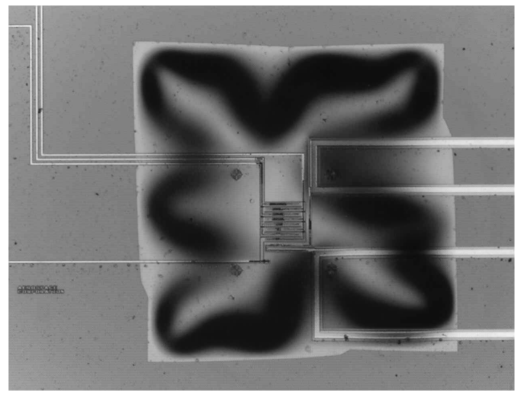

Figure 1. Photograph of the Micro Hot Plate

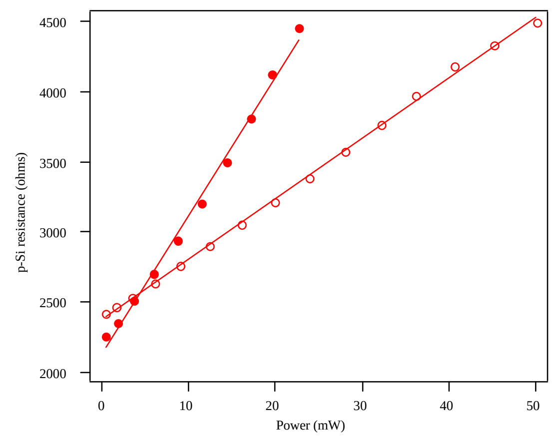

Figure 2. Thermal Response of the Micro Hot Plate in Air and in Vacuum.

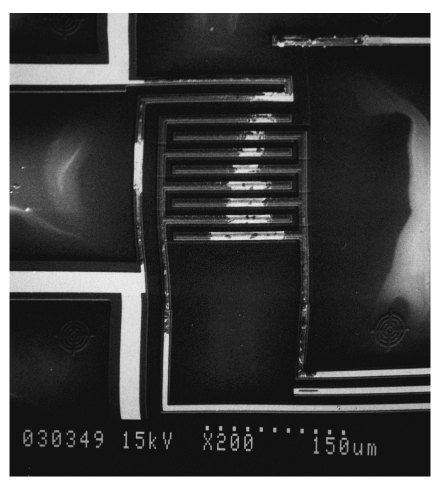

Figure 3. SEM of the Micro Hot Plate After High Temperature Operation