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Design and Integration of Infrared Absorber Structures into Polymer Membranes based Thermal Detectors

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Abstract

Different types of gas detection systems utilize of thermal detectors such as thermopile detectors. These detectors have a significant advantage over photon detectors when operated at ambient temperature; the cooling requirement of photon detectors makes them bulky and expensive. The non-dispersive infrared sensor techniques/systems utilize thermal detectors, such as thermopile detectors, for the detection of different gases, i.e. carbon dioxide (CO2) and methane (CH4) gases. The most important part for the performance of a thermopile detector is the radiation absorber. Graphite black paint can be used as radiation absorber, as it has high absorption values (80—93%) for a wide spectral range of wavelength (2.5μm — 20μm). The deposition of black paint can be done either by spraying it onto the detector surface or by using a small brush. The thermal capacitance of the detector will rapidly increase due to uneven distribution and unknown thickness of the absorber, though, the response of the thermopile detector will be maximum due to high absorption, however the response time (τth) for the detector will be longer.

In order to improve the performance of the thermal detectors, SU-8 epoxy membrane based thermal detectors have previously been fabricated. In this thesis work, infrared absorbers have been designed by utilizing the membranes (SU-8 epoxy) of the detector as an active part of the infrared absorber used as a dielectric medium. This utilization of SU-8 epoxy will result in a maximum detector sensitivity and a minimum increase in both thermal capacitance and thermal conductance of the thermopile detector. Absorber structures (one with a specific wavelength known to be a $\lambda/4$ absorber structure and a second with a wider absorption band, 3-6 μm, namely a multilayered absorber) based on SU-8 epoxy were designed, simulated, fabricated, and their integration into the membranes of thermopile detectors have been presented. The absorber structures were characterized for infrared absorption by Fourier transform infrared spectroscopy. The fabricated thermopile detectors were characterized for voltage response with infrared sources. The time constant (τth) of a single thermocouple with a multilayered absorber structure and with a black paint absorber has been estimated to 75ms and 168ms from COMSOL, respectively. The fabricated thermopile detectors have been optimized for detection of gases such as CO2 and CH4 —as both gases have strong absorption peaks in the mid-infrared region. The surface treatment of SU-8 epoxy was performed in order to improve adhesion of metal over SU-8 epoxy, the results were evaluated and characterized using different techniques.

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