KWJ ENGINEERING INC
INNOVATIVE SOLUTIONS FOR GAS DETECTION

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An Ultra-Low Power Fast-Response Nano-TCD CH4 Sensor for UAV Airborne Measurements | NASA Phase I: NNX14CC84P

Need: NASA Airborne Science Program provides data to benefit the earth science community and support NASA spaceborne missions (Figure 1). However, there remains a significant technology gap in the development of high performance trace gas sensors that meet the stringent requirements for UAV deployments, such as low-power, low-weight, fast response and reliability. This SBIR Phase I program addresses development of a new, miniature, lightweight, ultra-low power (micro watts), ultra-fast, nano thermal conductivity (TCD) sensor technique to enable high resolution, fast analysis of methane (CH4) in atmosphere.

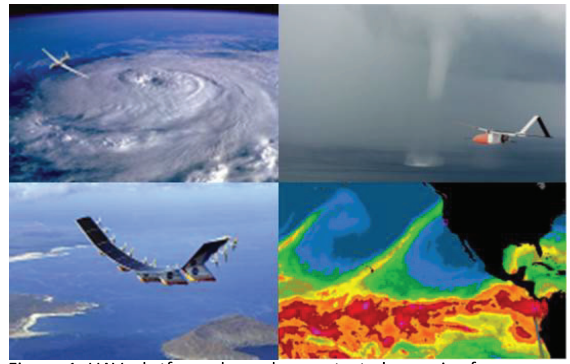

Figure 1. UAV platforms have demonstrated promise for atmospheric chemistry field studies.

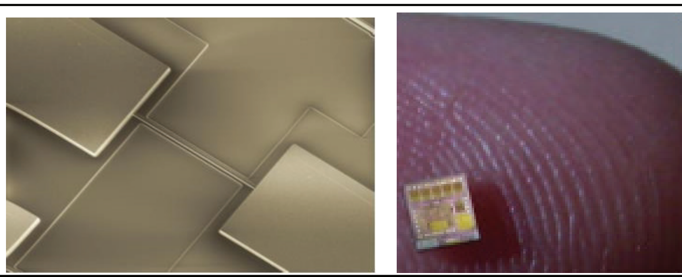

Figure 2. Left: The single thermal element of 1 x 50 µm. Right: A TCD die with multiple devices on board

Approach/Results: The operating principle of TCD relies on the differences in thermal conductivity between different gases. KWJ has developed a process for fabricating sub-µm dimension TCDs, whose low thermal mass allows sub-millisecond measurement times, average power requirements of a few µW, and temperatures low enough to allow billions of measurements without drift (Figure 2). KWJ has demonstrated quantitative measurement of a range of gases, including CH4, as well as H2, He, N2, O2 and CO2, using the nano-TCD sensors. The novel nano-TCD sensor proposed here is sensitive, lightweight, low power (nano-watt power consumption), low maintenance, >5 year stability/calibration-lifetime, and can provide high speed measurement (> 1000Hz). Figure 3 shows the response of nano-TCD sensor to 100-500 ppm CH4 with 1 standard deviation error bars. The results have demonstrated detection of CH4 at 100 ppm with the KWJ MEMS sensor.

In Phase I, KWJ will develop nano-TCD based CH4 sensors, and improve its sensitivity such that 5ppm accuracy will be obtained, and sensor will be characterized to demonstrate CH4 detection with all target specifications. Multiple strategies will be investigated to improve the sensitivity, such as reducing the TCD structure and size, coating the TCD element with sensing materials, and operating the sensor at transient mode.

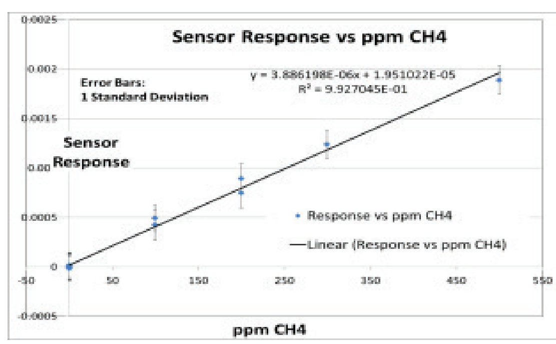

Figure 3. Response of KWJ TCD sensor vs. CH_4.

Benefits/Innovation: This novel MEMS CH4 sensor will support NASA's airborne science missions. Utilizing unmanned aircrafts, the sensor can accurately map the spatial and temporal distribution of CH4 in atmosphere. This ultra-low power, ultra-fast miniature nano-TCD sensor can be expanded to other gas detection for NASA's earth and space applications. Meanwhile, the low power CH4 sensor has large market of low cost long lifetime gas detection, including home CH4 alarms, pipeline monitors and fenceline monitors as well as leak detectors in the rapidly growing oil and gas "fracking" industry.