Ultra low cost LED based Gas Sensing

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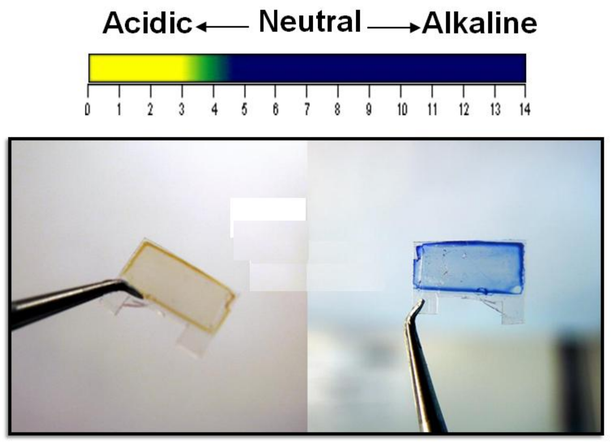
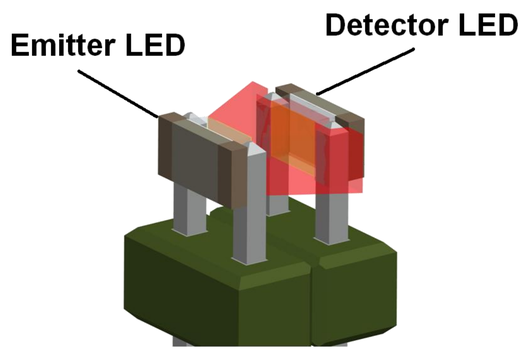
Rationale

Over the next ten years, it's predicted that gas sensors will start to become **smaller, lower power, lower cost and be of improved accuracy** [1]. With these criteria in mind a paired emitter diode setup has been optimised for gas phase sensing. Different species are detected by using different colorimetric film chemistries, and by choosing LED's of overlapping emission/absorbance spectra tuned to the specific dye wavelength.

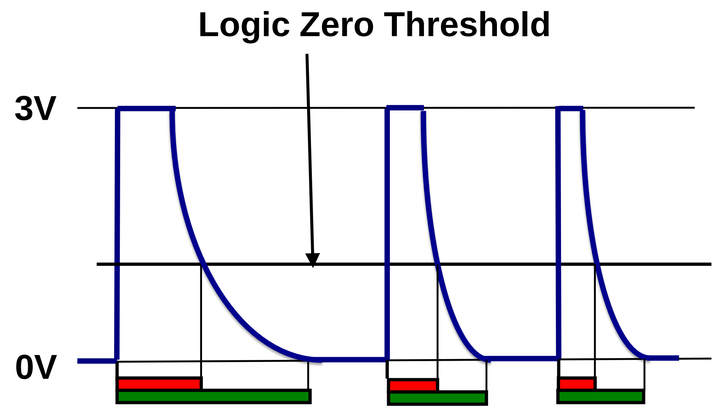
Method of Sensor Operation



Sensing initiates with a colour change. The chemistry will change from light to dark - with the introduction of the target species (or visa versa).



The colorimetric chemistry is immobilised on or between an emitter (forward bias), and detector LED (reversed bias), thus modulating the penetrating light.

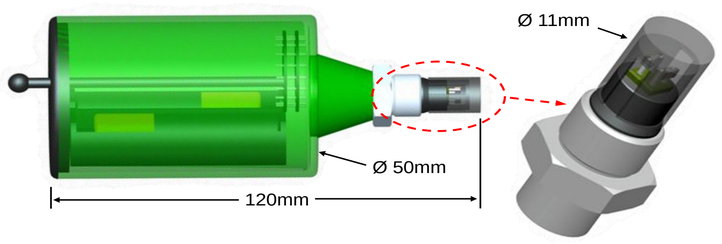


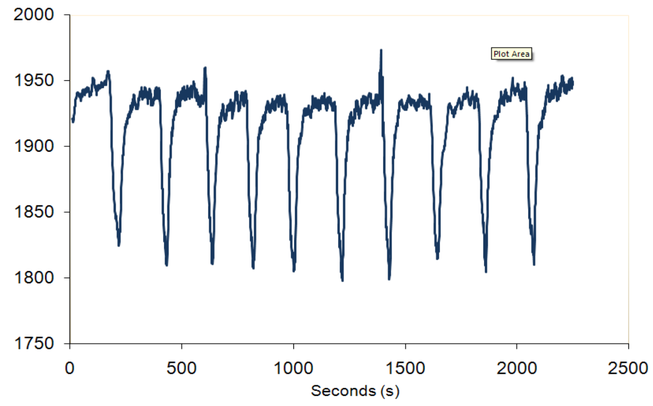
The microcontroller checks the amount of processor counts taken until the discharging capacitance from the reverse biased LED passes a logic threshold. This discharge is proportional to the light falling on it.

Device Packaging & Results

Configuration 1: Standalone Wireless Sensor

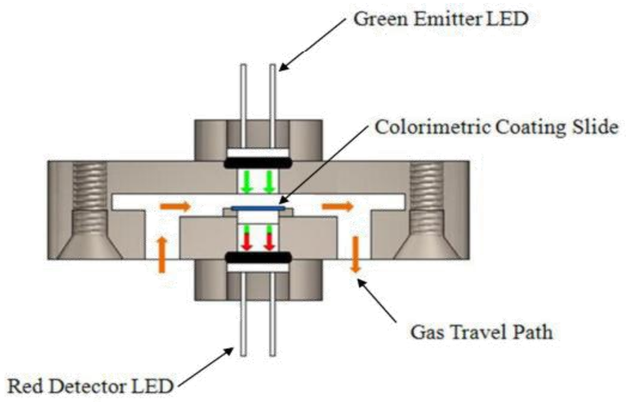
- Surface Mount Diodes utilised
- Colorimetric coating painted directly onto LED surface
- Graph generated from repeated 10µl acetic acid injection purged with ambient air

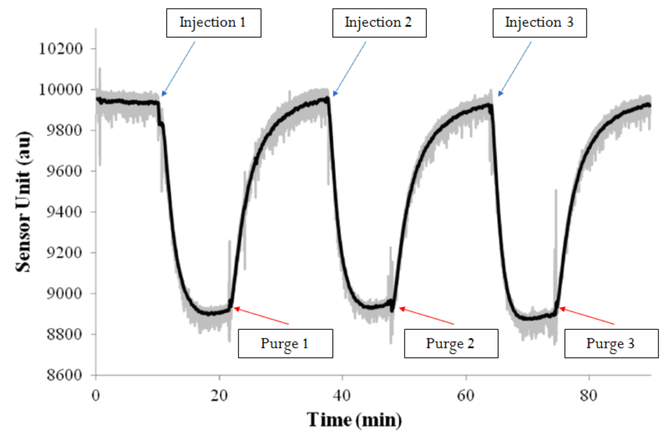




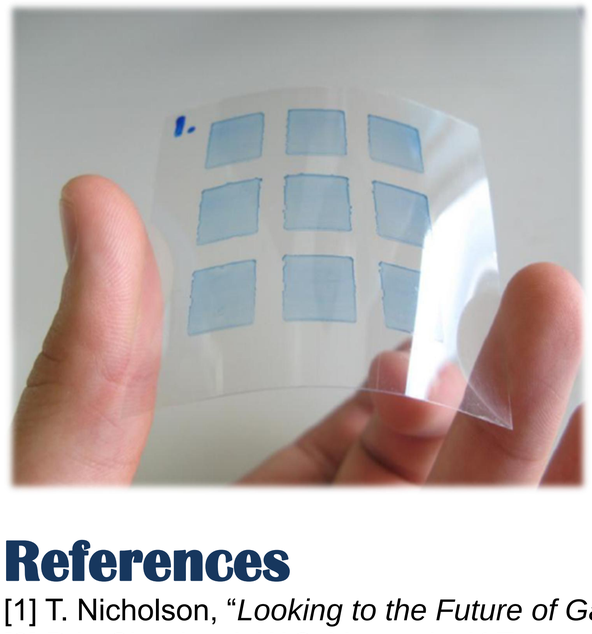
Configuration 2: Flowcell Sensor

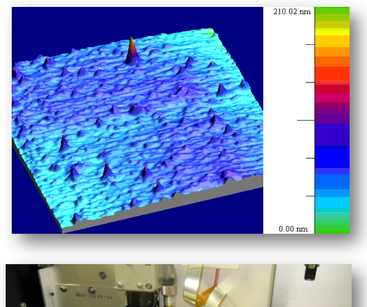
- Potential for coupling with pump to deliver fresh gas samples
- 5mm Bulb LED's (potential to discharge larger capacitance)
- Colorimetric coating inkjet printed (on clear PET)
- Extra grounding and shielding improves signal recognition
- Graph generated from repeated 7µl acetic acid injections purged with ambient air

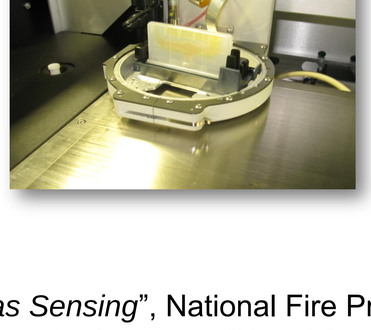




Summary & Future Work







This sensor configuration was first published in 2004 [2], where the aim was "to provide analytical performance at a significantly lower cost". More recently Beirne *et al*., proved with their study that these sensors were sufficiently accurate, of low cost, and of low power to act as sensing nodes as part of a wireless sensor network [3].

O' Toole *et al.,* and Orpen *et al.,* both aimed to improve sensor reproducibility and performance through use of inkjet printing, with positive results [4,5]. The work of both these studies resulted in the publishing of improved device specs [4,5]. Namely, a limit of detection of 12 ppb, repeatability of 99%, and a sensitivity of 44 units/mgL^{-1}. The speed of response and L.O.D. of the sensor can be tuned from film thickness, and a thin film will provide rapid sensor response (<30 secs). Future work will include the development of a PEDD sensor to detect biofilm growth in a pharmaceutical manufacturing pipe work assembly. Within such a structure, the sensor will be shielded from both environmental light and electrical interference, suggesting the application will suit the sensor type.

References

[1] T. Nicholson, "*Looking to the Future of Gas Sensing*", National Fire Protection Association Conference and Expo, Las Vegas, Nevada, America. June 5-7, (2010).
[2] R.L. Shepherd, W.S. Yeazunis, K.T. Lau and D. Diamond, "*Novel Surface Mount LED Ammonia Sensors*", IEEE Sensors, pp. 951–954, (2004).
[3] S. Beirne, ***et al.,*** "*Chemical Event Tracking Using a Low-Cost Wireless Chemical Sensing Network*", IEEE Sensors, pp. 1615–1618, (2008).
[4] D. Orpen ***et al., "****The Optimisation of a Paired Emitter-Detector Diode Optical pH Sensing Device",* Sensors and Actuators B: Chemical, Vol 153 (1), pp. 182-187, (2011).
[5] M. O'Toole and D. Diamond, "*Absorbance Based Light Emitting Diode Optical Sensors and Sensing Devices*", Sensors (8), pp. 2453–2479, (2008).

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