

A Novel Low-Cost Microsensor for Point-of-care Multi-Gas Monitoring

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○ Occupational workers encounter multiple hazardous gases

○ Firefighters during salvage

- ❑ Carbon Dioxide (CO_2)
- ❑ Phosgene (COCl_2)
- ❑ Carbon Monoxide (CO)
- ❑ Hydrogen Cyanide (HCN)
- ❑ Oxygen (O_2)

○ Mining

- ❑ Methane (CH_4)

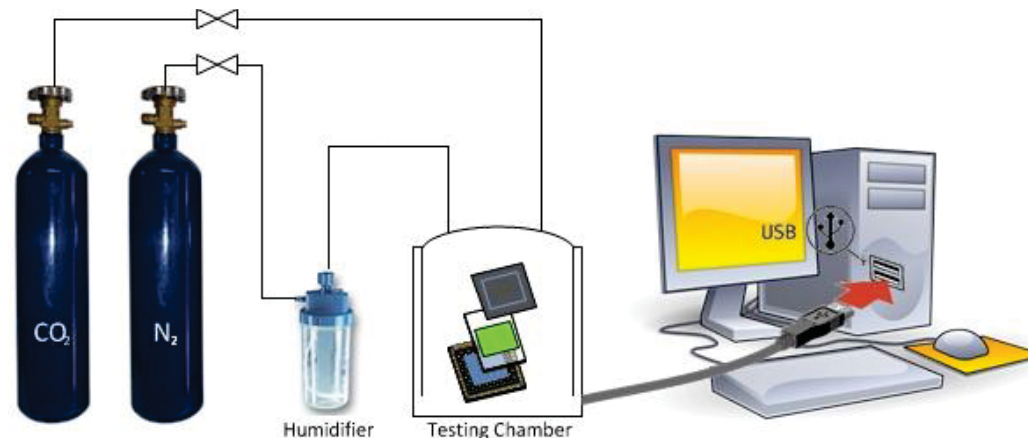


○ MultiRae Plus

- ❑ Can detect multiple gases
 - » Photoionization (VOC's)
 - » Electrochemical (O_2 , HCN, CO)
- ❑ Rugged
- ❑ Expensive
- ❑ Bulky
 - » Used by HAZMAT team



- **Demonstrate a portable O₂ sensor**
 - Further develop our optical O₂ sensor
- **Demonstrate a portable, optical CO₂ sensor**
 - Develop an optical CO₂ sensor based on the photoluminescent quenching of Hydroxypyrenetrisulfonicacid (HPTS)
- **Demonstrate simultaneous detection of CO₂ and O₂ gases**
 - Integrate both sensors into a single device

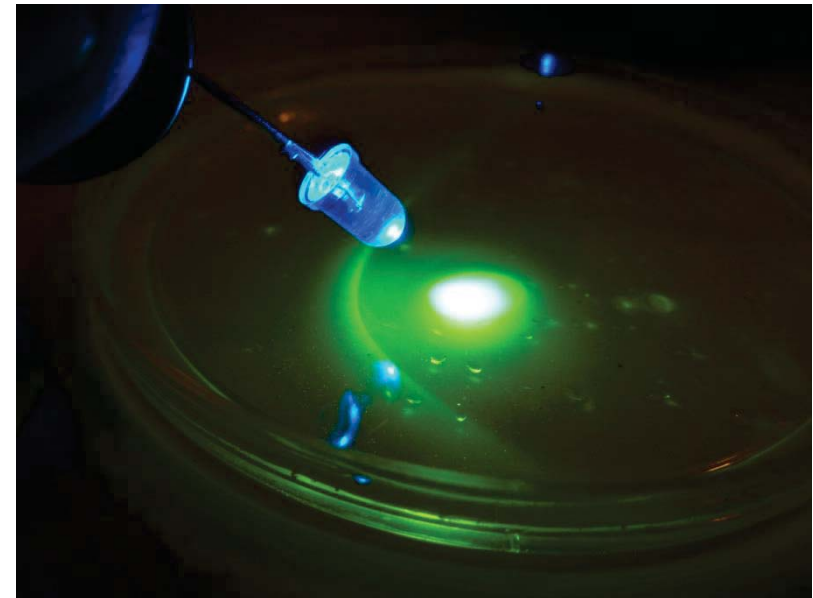


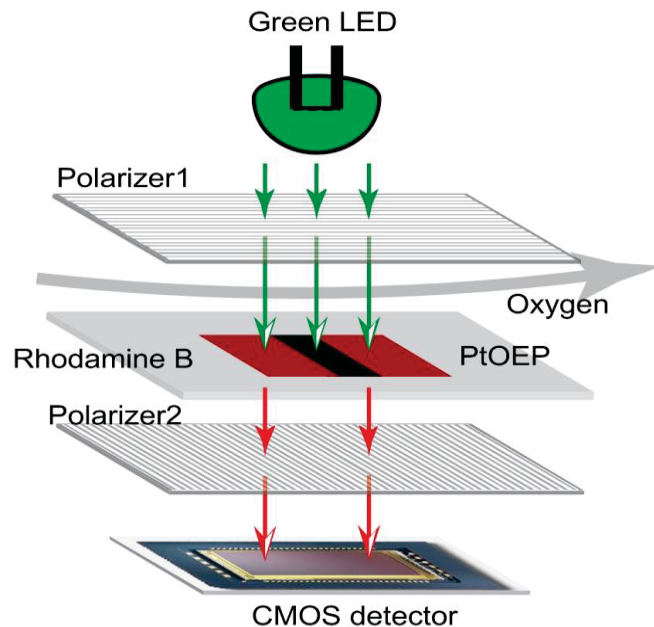
○ Photoluminescence

- ❑ emission of light
 - » surface and impurity levels
 - » quality of the material
- ❑ Non-invasive measurements
- ❑ Time response
- ❑ Cross-polarization

○ Fluorescein

- ❑ $C_{20}H_{12}O_5$
- ❑ Excitation: ~495 nm (Blue)
- ❑ Emission: ~520 nm (Green)





○ CMOS array detector

- ❑ Bayer filters offer color discrimination
- ❑ High resolution (9M pixels!)
- ❑ Low cost (OmniVision)

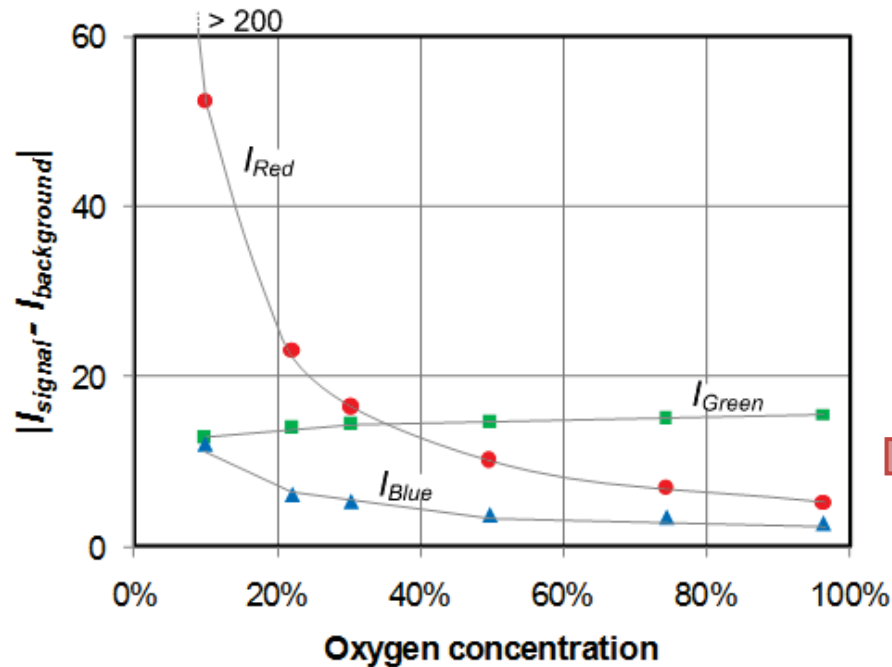
○ Cross polarization

- ❑ Filters out excitation light

○ Gas sensitive photoluminescent film

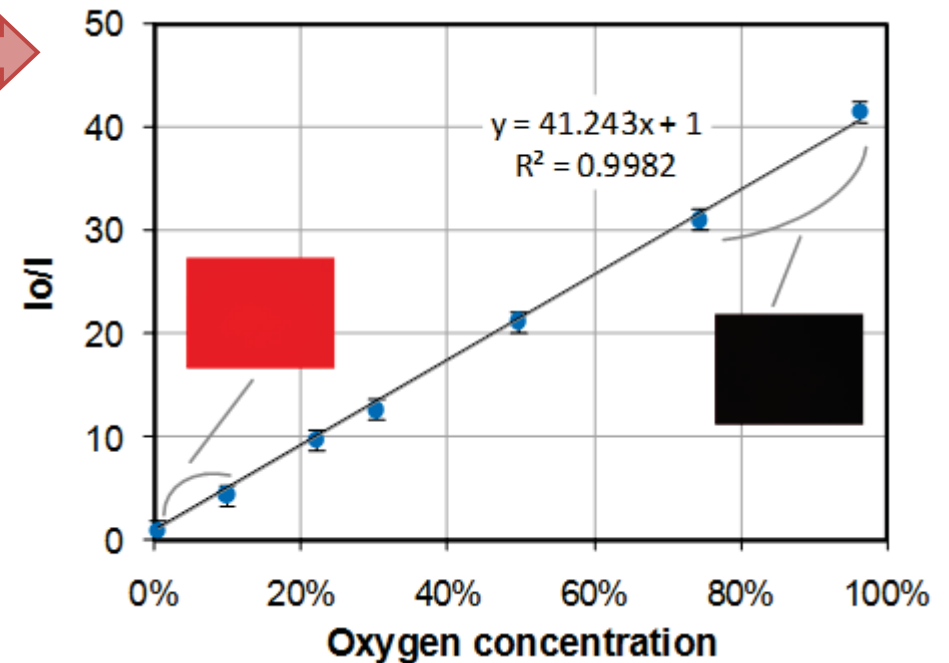
- ❑ Quenches emission as gas concentration rises





Stern-Volmer equation:

$$\frac{I_0}{I} = K_{SV}[\text{O}_2] + 1$$

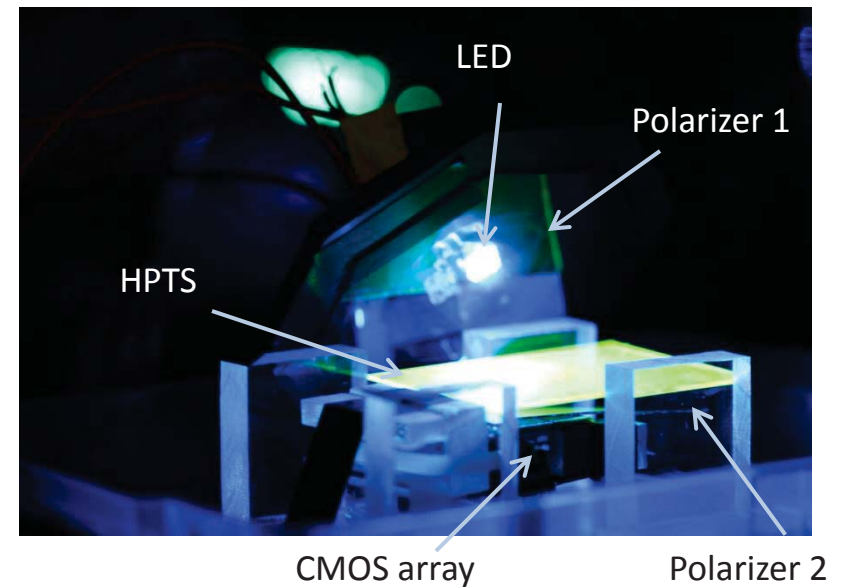
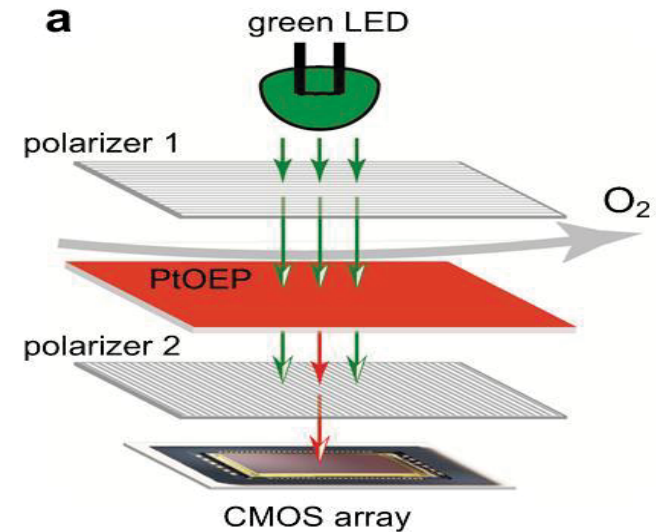


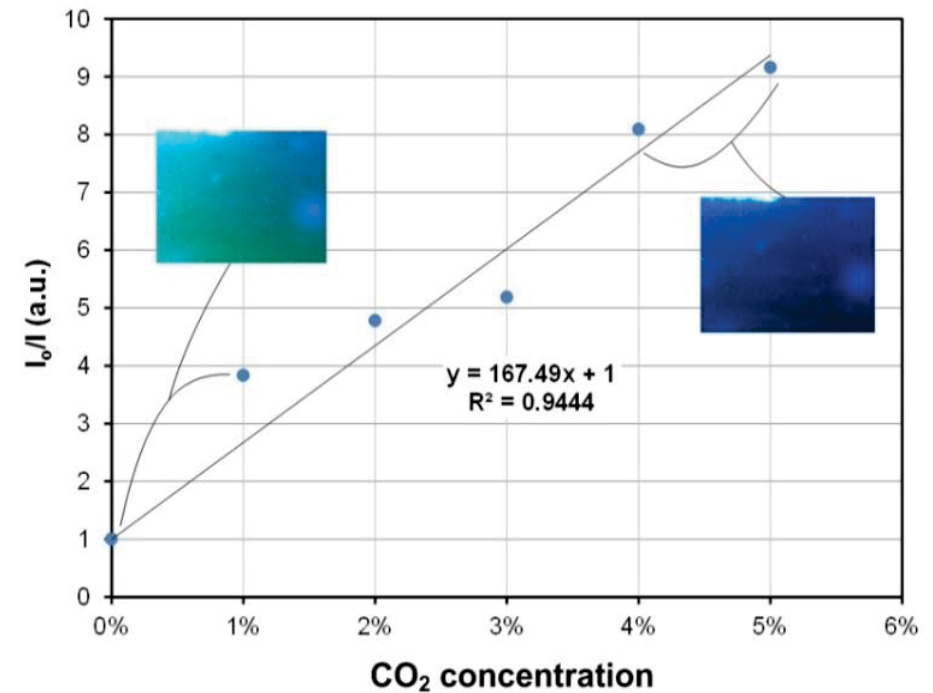
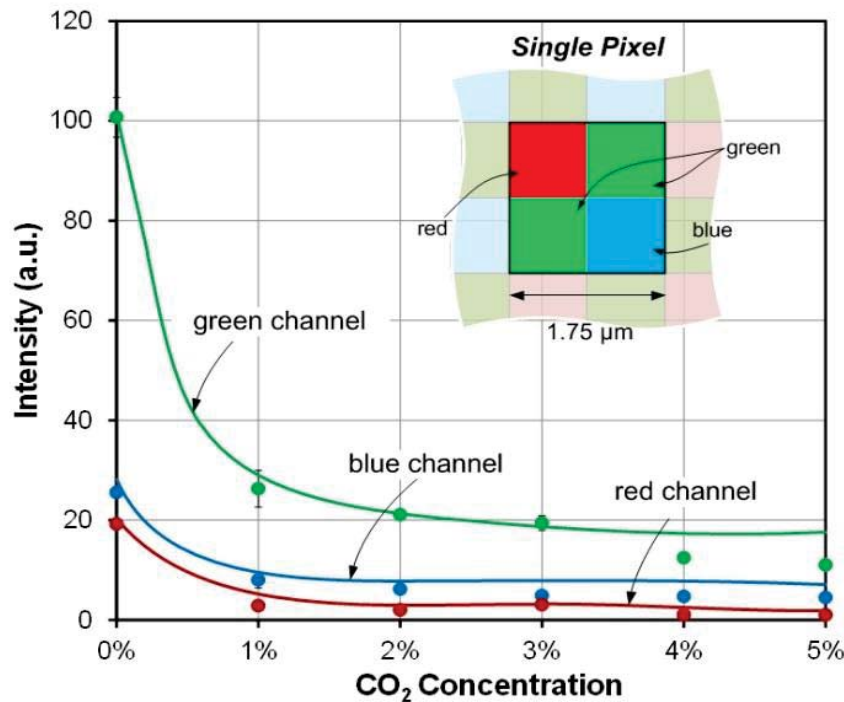
○ PtOEP emission

- R channel varies with oxygen
- G & B remain constant

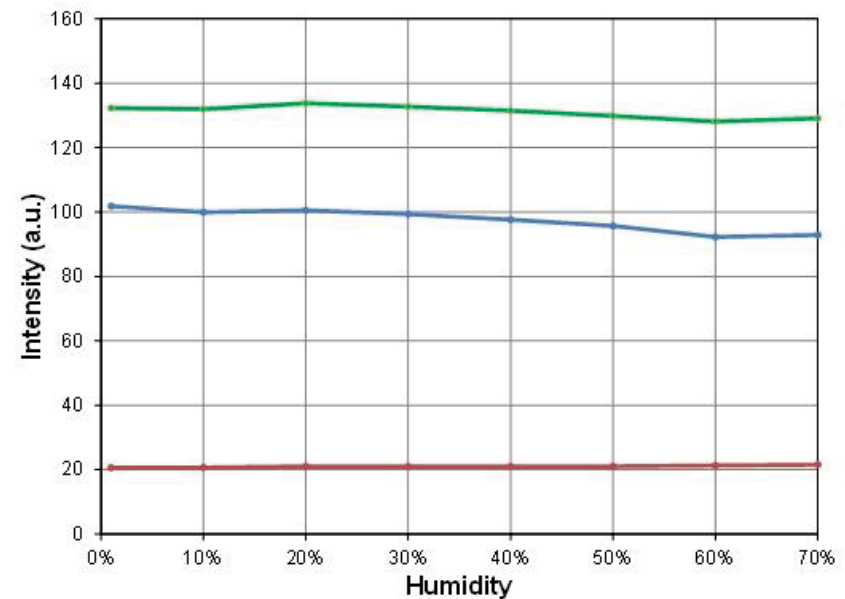
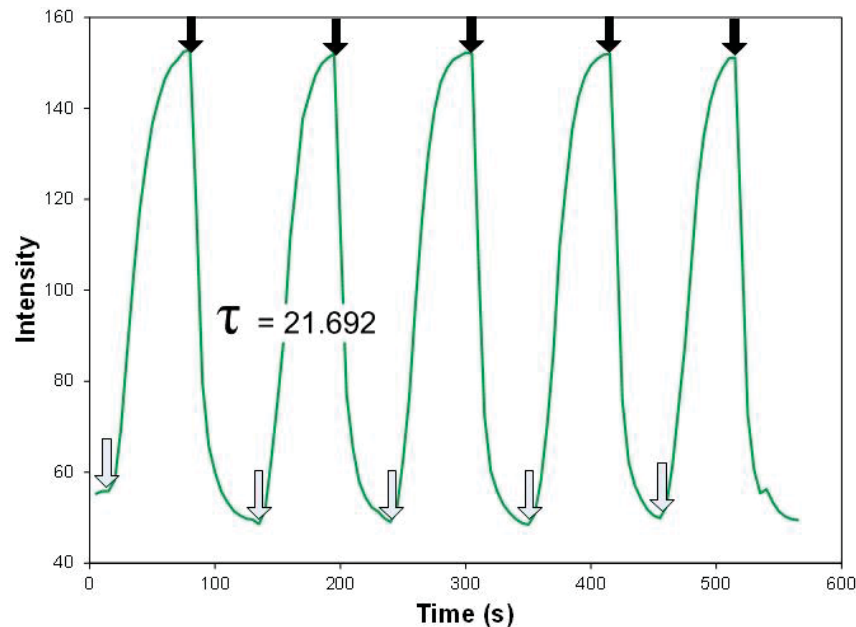
○ Sensor setup

- ❑ CMOS image sensor used as a detector
 - » Alignment
 - » Multiple analytes
- ❑ Cross polarization used to isolate signal
- ❑ Hydroxypyrenetrisulfonic acid (HPTS) film emission is quenched at high CO₂ concentration



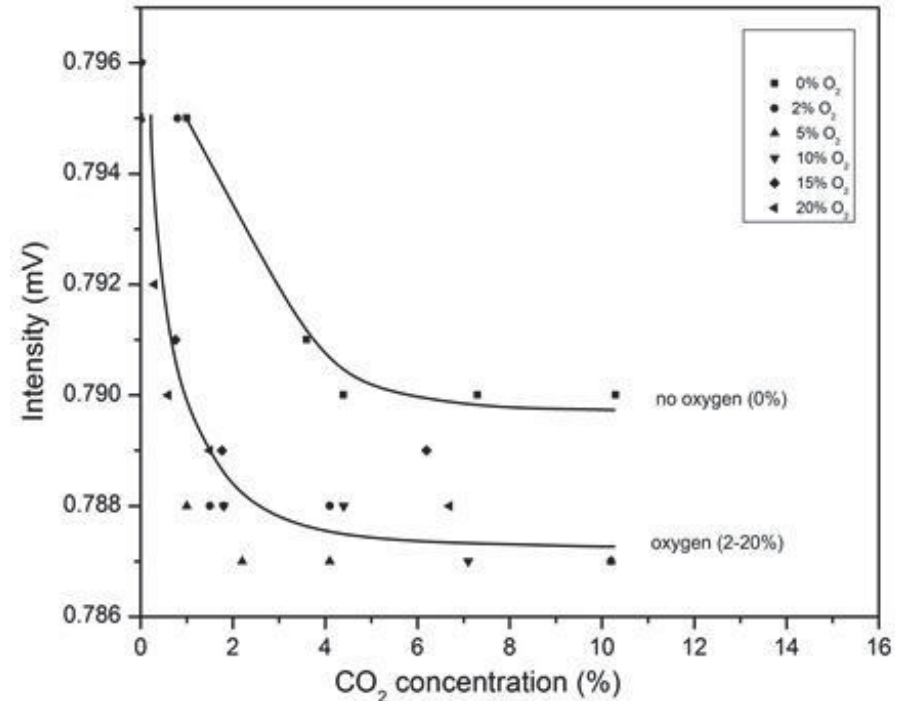


- Images taken of film
- RGB channels monitored
- Background subtracted from signal



- Sensor shows good repeatability and increased time response
- Shows stability in environments of varying humidity

- O₂ film and CO₂ film were physically placed together
- Different LED's for excitation
 - $\lambda_{\text{ex}} = 460$ (Blue)
 - $\lambda_{\text{ex}} = 520$ (Green)
- Multi gas detection is possible!

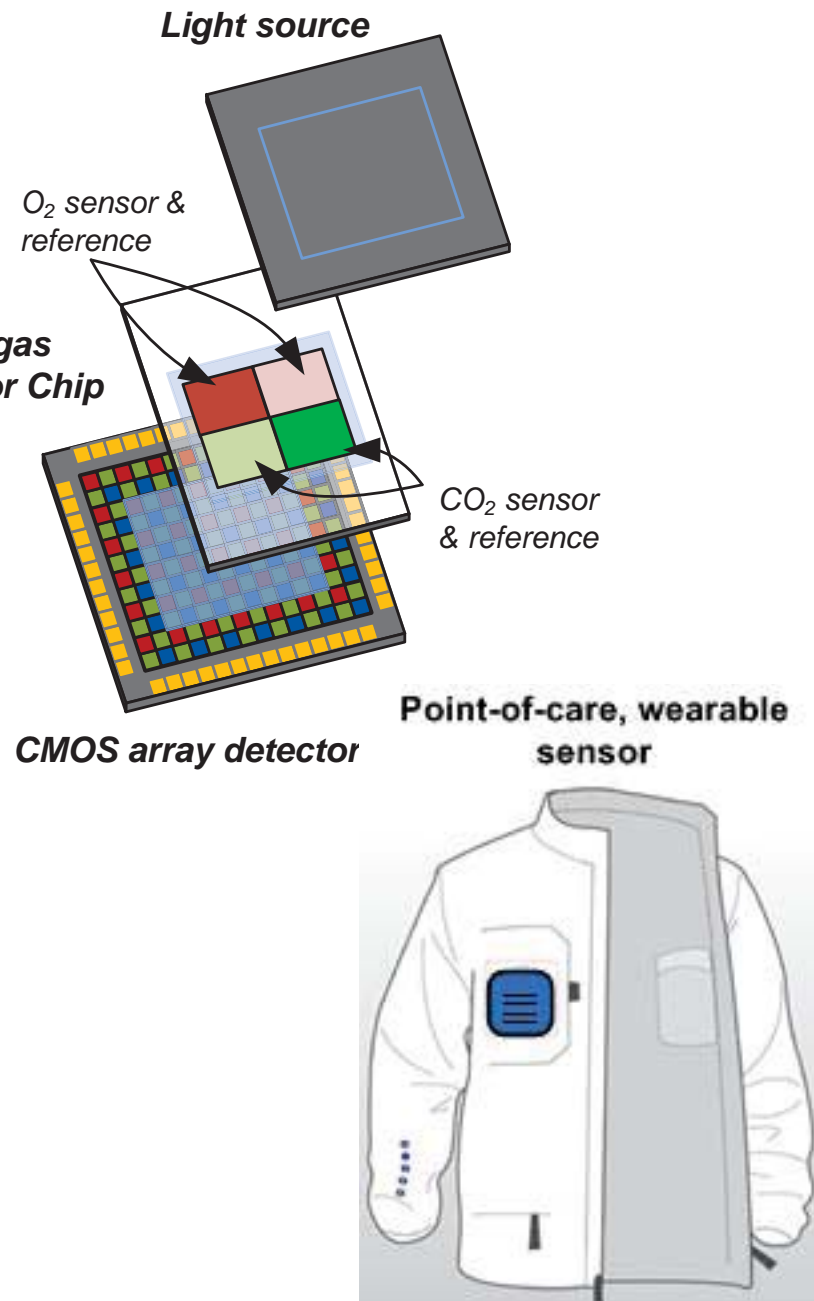


○ Field test

- ❑ We will be testing prototype in actual fire environment

○ Multi-gas microsensor

- ❑ Reduce size of current detectors
 - » Stacked method and patterning
 - » **Wearable!**
- ❑ Lower cost
 - » Parts used are inexpensive and readily available
- ❑ Increased detection response
 - » Typically <1 second for CO₂
- ❑ Detection film selection
 - » Films not yet discovered for some gases
- ❑ Wireless



- *NIH/NIOSH Pilot Research Project Program at the University of Cincinnati (T42OH008432).*