Olfactory Receptor Cell-Based Odorant Detection

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Introduction
We are developing a standalone system for odorant detection and identification utilizing cell based biological sensing. A hybrid system has been designed consisting of olfactory sensory neurons integrated with proprietary CMOS IC technology for amplification and processing of extracellular potentials in response to olfactory stimul.

Applications include:
- Explosives detection
- Interdiction of illegal drugs
- Medical diagnosis
- Food spoilage

Passive Arrays
- Electrodes are Au/Ti, long traces are passivated
- Array is packaged in pin grid array ceramic package
- Au/Ti electrodes have high impedance
- Pt-black electroplated on Pt for robust electrode surface

Active Arrays
Bioamplifiers in Standard CMOS
- Amplifies weak extracellular potentials originating from electrically active cells
- Bioamplifier 2.0: designed and fabricated in commercially available 0.5um CMOS process. 6x4 array, Power Supply = ±1.5 V, Gain = 100, Bandwidth = 3 kHz, Input Referred Noise = 25µV
- Bioamplifier 3.0: designed and fabricated in 130 nm, 6-metal, 1-poly, CMOS process. 5x3 array. Power supply =±1.25V, Gain = 40 dB, Bandwidth = 3 kHz, Input referred noise ~ 50 µV

Experimental Setup
- Test board placed inside a Faraday cage for noise immunity and protection of electronic components from incubator humidity
- Cells loaded on top of the chip using standard aseptic techniques
- Test fixture maintained inside the incubator at 37 °C, 5% CO₂

Electrode surface close-up

Pt and Pt-black electroplating

Array with vial in PGA package

Electrolytically Active Cell Response to KCl Stimulation
- KCl used to stimulate bovine smooth muscle cells
- Recordings show electrical signals vs. time for cells in media, without and with KCl

Electrical Hardware
- Custom PCB for extracellular potential recording
- 52 channel recording capability
- Single ended and differential amplification modes
- Low noise, high performance amplifiers
- Integration with popular commercial software platforms

Intellectual Merit
New paradigm for odorant sensing.

Broader Impact
Benefits to society: health, safety, medicine, commerce. Interdisciplinary education.

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Long Term Monitoring

Packaging
CMOS IC embedded in epoxy substrate. Two dimensional metal traces allow for a flat surface to facilitate microfluidics integration. Traces are encapsulated with SU-8 for biocompatibility. Traditional bondwires were determined to be too delicate and incompatible with fluid environment.