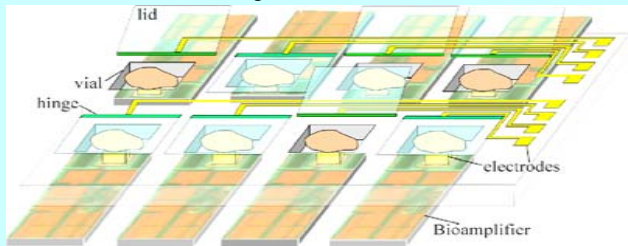


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## Project Overview



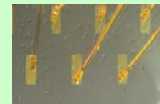
- Bio-labs-on-a-chip for capture and in-situ investigation of cells.
- Micro-electro-mechanical structures form cell-sized cavities (vial) and lids that can be opened and closed. The base of the vial has gold electrodes for recording extracellular electrical signals.
- Devices fabricated on silicon and complementary metal oxide semiconductor (CMOS) substrates. The integrated circuits are fabricated through standard commercial foundries.
- Potential applications in physiology, whole cell studies, collecting cell secretions, medicine, environmental monitoring, and remote biosensing.



## Three Stages of "Evolution" for the Electrical Interface

### Previous: passive test fixture

- Signals travel long distances prior to amplification
- Susceptible to environmental noise



### Currently: active test fixture

- Signals amplified very close to site of activity
- Expect reduced baseline noise
- Overlapping potentials from many cells
- Successfully tested on bench and with cells



### Near future: instrumented cell clinics

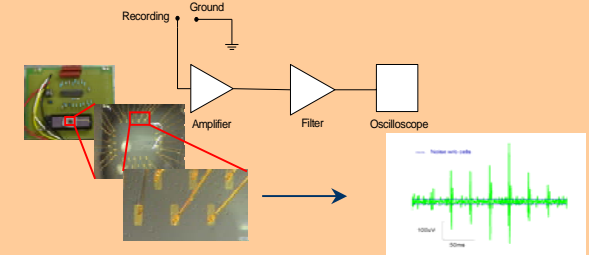
- Integrated Circuits isolated by cell-sized micro vials with lids
- Anticipate reduced environmental noise
- Isolated potentials from single or few cells
- First samples fabricated, but not yet tested with cells



## Recordings of Electrical Activity

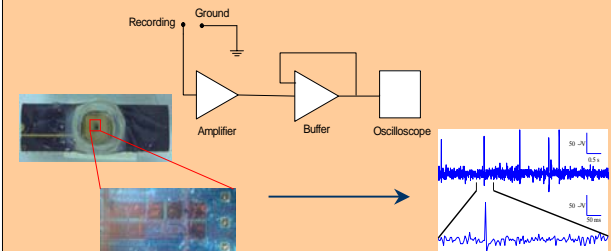
### Passive Test Fixture

- Passive test fixture comprises discrete amplifier and band pass filter (8th order; pass band 500-5000 Hz, total gain of 100)
- Silicon die patterned with gold/chromium electrodes and wire bonded into a chip fixture
- Cells are plated onto Cr/Au electrodes on Si substrate.



### Active Test Fixture

- Active test fixture comprises of an array of bioamps on a custom VLSI chip in 40 pin DIP chip package with bond wires encapsulated by epoxy and with well to hold culture medium
- Electrodes defined using Al layers in the CMOS process are electrolessly plated with Au
- Silicone RTV used to encapsulate bond wires, to isolate cells from toxic packaging and to form a well to contain the cell medium
- Cells are plated onto Au electrodes on VLSI substrate.



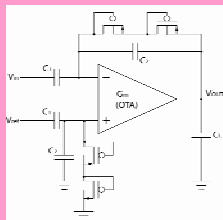
## Custom Amplifier Design

### Extracellular electrical signals from electrically active cells:

- Small in amplitude (10-500mV),
- Large unknown DC offset (1-2V possible),
- Frequency content 100Hz - 8kHz

### Bioamplifier Design

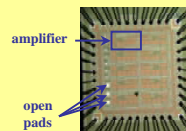
- The interface must amplify weak extracellular signals and isolate the noise in the cell medium from the signals originating from the cells.
- A low voltage, low noise CMOS differential transconductance amplifier designed for a +/-1.5 V supply.
- Has a cut off frequency of 3kHz with low pass characteristics.



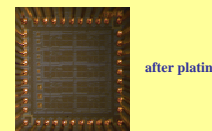
- Fabricated in a commercially available 0.5μm CMOS technology
- Gains of 20, 40, 100, 1000 designed, fabricated, and tested successfully

## Custom Amplifier Packaging

- Al electrodes of the bioamplifier are electrolessly plated with gold
- Creates a rough layer with a higher surface area.
- Electroless plating is preferred since electroplating requires an electrical connection to the plated surface that will reduce sensitivity and increase noise during measurement.



before plating



after plating



A Silicone Room Temperature Vulcanate isolates cells from toxic packaging and insulates exposed bond wires from cell medium.



A well is formed on the 40 pin DIP chip to contain the cell medium



Fixture developed for testing with cells

## Future Work

Integrating sensors such as contact imagers and capacitive sensors, to enhance the utility of the Bio-Lab System on a Chip.

### Acknowledgements

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