Biosensor Systems in Standard CMOS: Fact or Function?

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Why Biosensors? Why Genomics?

Small details in the DNA can make a huge difference!

Albert Einstein (1879-1955)
Greatest Achievement: Theory of Relativity

Bobo the Chimp (1995-Now)
Greatest Achievement: Shown Above

1.5% DNA Difference
CMOS-Integrated Biosensors

- Fluidic Package
- Sensor Array
- Pixel
CMOS-Integrated Biosensors

CMOS-Compatible Transducer

CMOS Integrated Sensor
CMOS Biosensing Capabilities

> 95% of molecular detection systems rely on visible-range optical or LF electrical transducers

Crystallography  Absorption Spectroscopy  Bioluminescence and Fluorescence  Absorption Spectroscopy  NMR and ESR Spectroscopy  Electro-Analytical

<table>
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<th>X-RAY</th>
<th>ULTRAVIOLET</th>
<th>Visible</th>
<th>INFRARED</th>
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<td>400 nm</td>
<td>800 nm</td>
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CMOS-Compatible

A. Hassibi
CMOS Biochip Examples

Optical

Fluorescence

Impedance

Bioluminescence

Electro-Analytical

pH

ISSCC 2009

ISSCC 2010

VLSI 2011

Nature 2011
Example: Sequencing CMOS Biochip

(to appear) VLSI Symp. 2012
Example: Sequencing CMOS Biochip

- DNA sequence: CGGCAGCA
- Magnetic Bead
- Streptavidin
- Biotin
- Self-Primed DNA

Graphs showing the current changes over time for different nucleotides (dATP, dCTP, dGTP, dTTP) during the polymerization process.
Fabrication/Assembly (1)

Additional Steps are required to create a disposable biochip

1. CMOS Chip
2. Electrical Packaging
3. I/O Isolation
4. Bio-functionalization
5. Sample Interfacing

Additional Steps are required to create a disposable biochip.
Chip Fabrication/Assembly (2)

Example: Affinity-based biosensors

CMOS Chip

Electrical Packaging

I/O Isolation

Bio-functionalization

Sample Interfacing

Capturing Molecules

Linker
Chip Fabrication/Assembly (3)

Example: Random bead arrays

1. CMOS Chip
2. Electrical Packaging
3. I/O Isolation
4. Bio-functionalization
5. Sample Loading
### Huge Application Space

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<td>Active Electrode</td>
<td>Electrode</td>
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