

# ImmunoSensor

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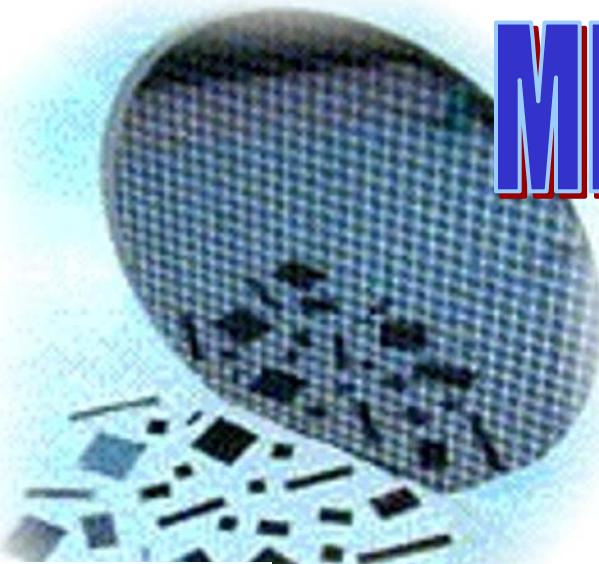
Berkeley Sensor & Actuator Center  
Dept. of Electrical Engineering and Computer Sciences  
University of California, Berkeley



# Biology



# MEMS



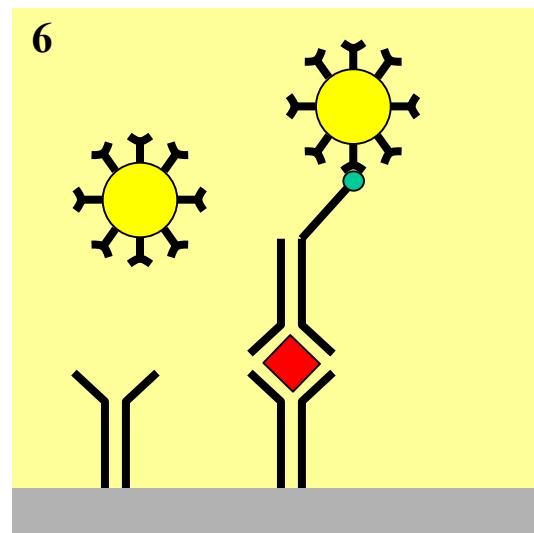
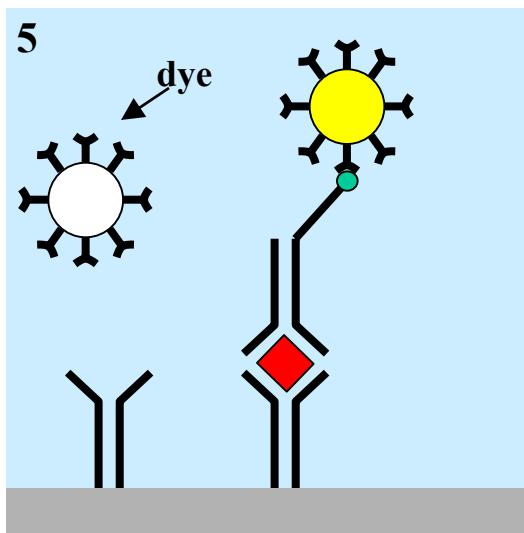
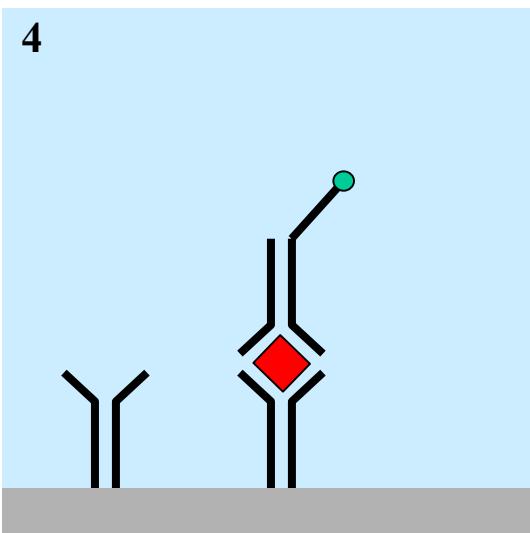
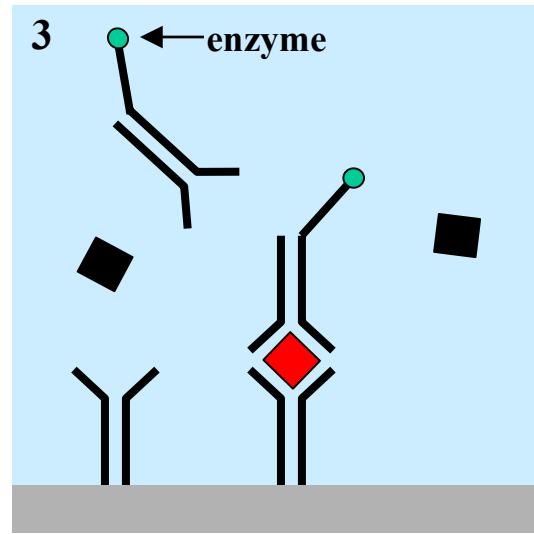
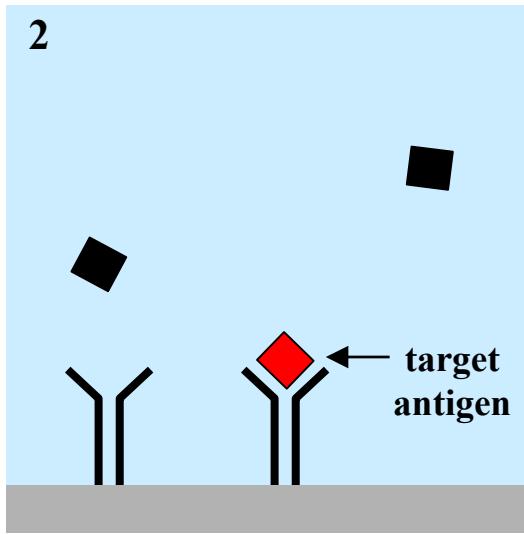
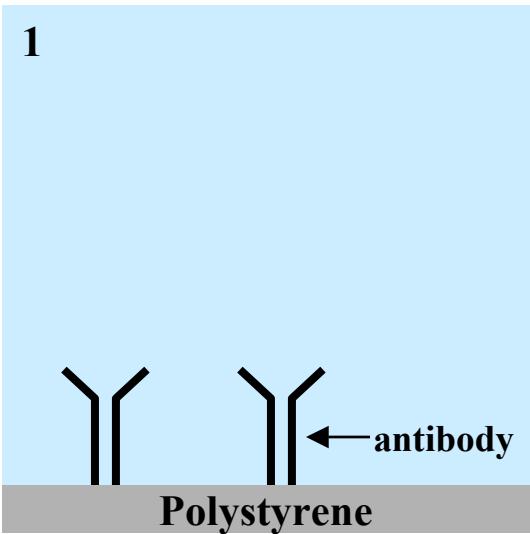
# Health

# Biology → MEMS ?

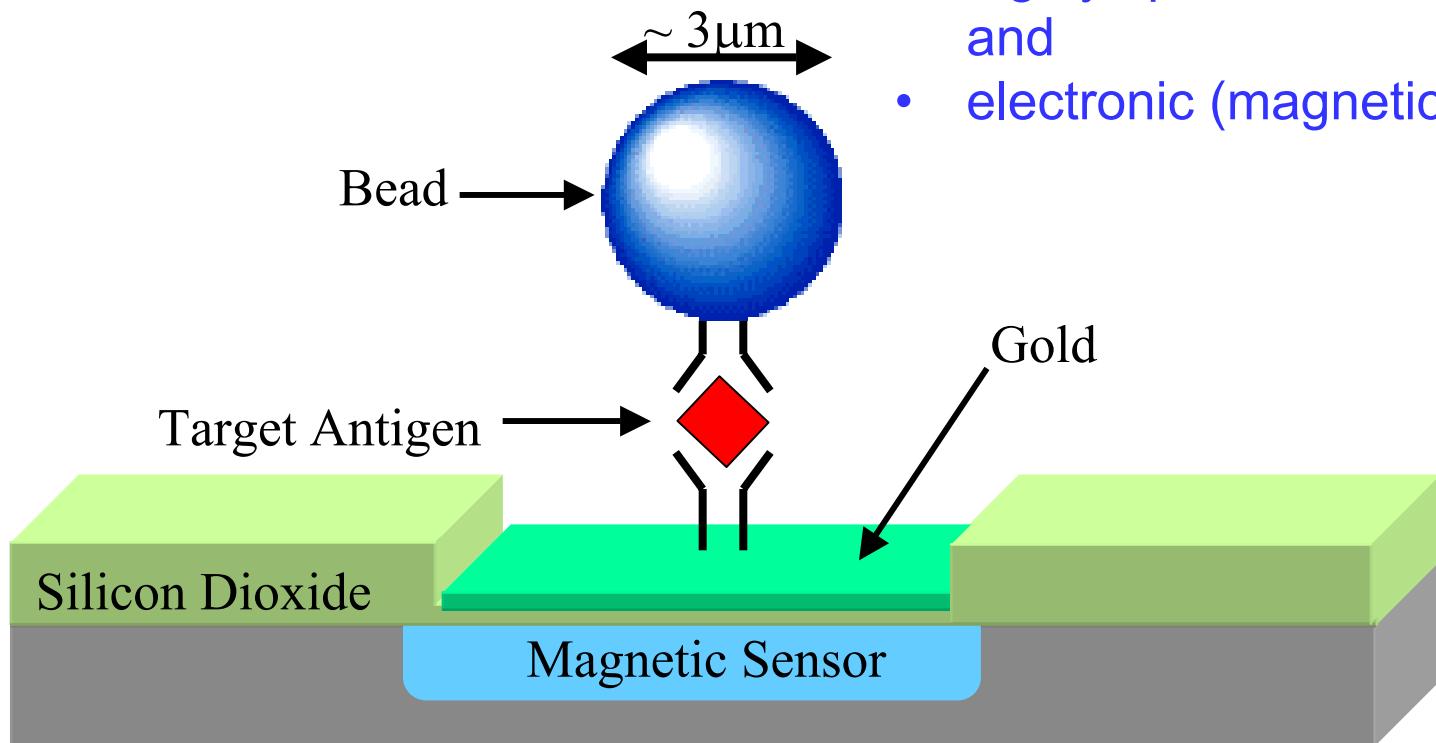


- **Objective:** Diagnose infectious disease
- **Approach:** Detect antigen in blood
- **Challenges:**
  - How?
  - With MEMS?

# Present Solution: ELISA



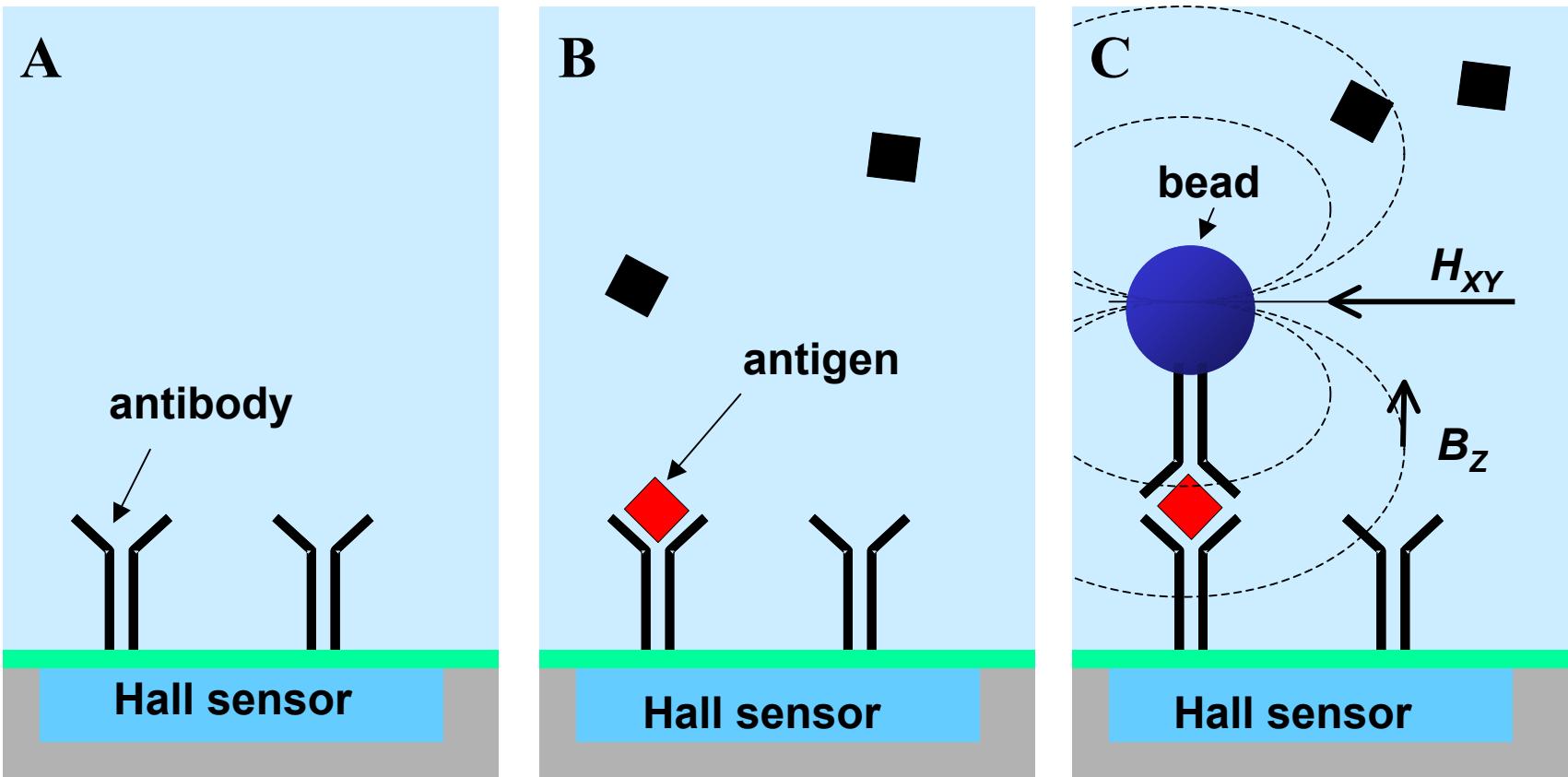
# Magnetic Beads



*Link between*

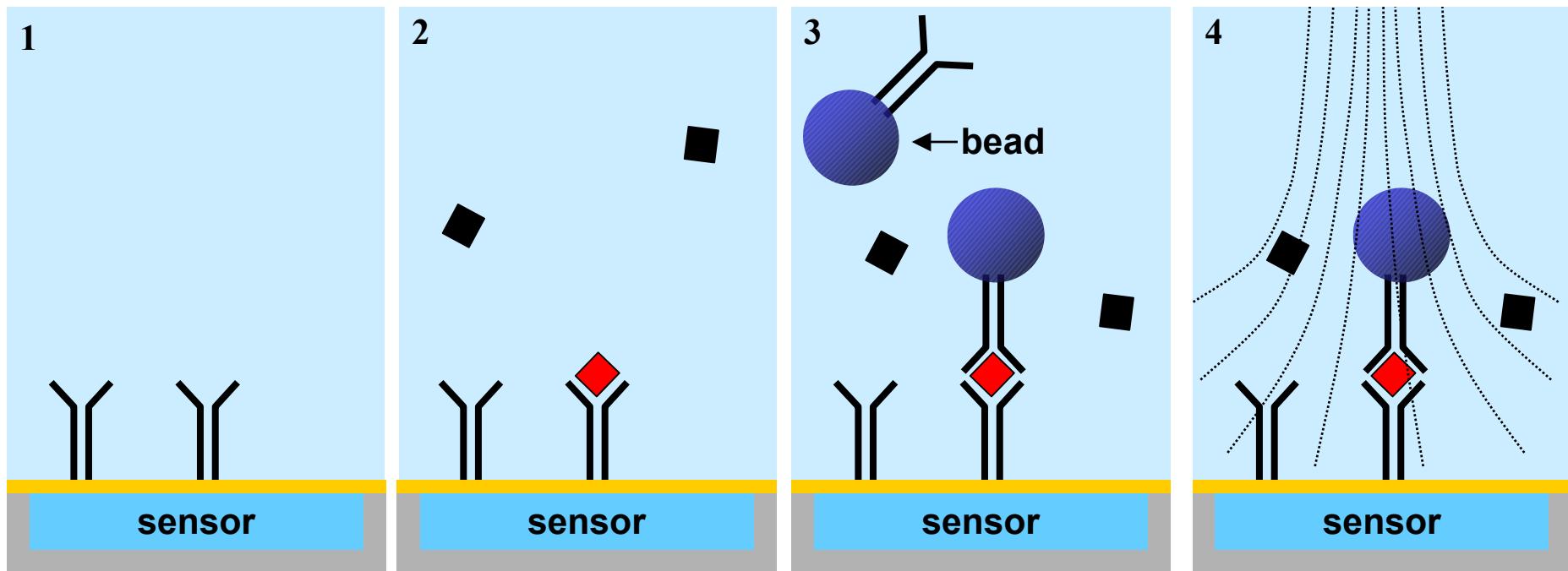
- highly specific molecular binding and
- electronic (magnetic) detection.

# Magnetic Detection

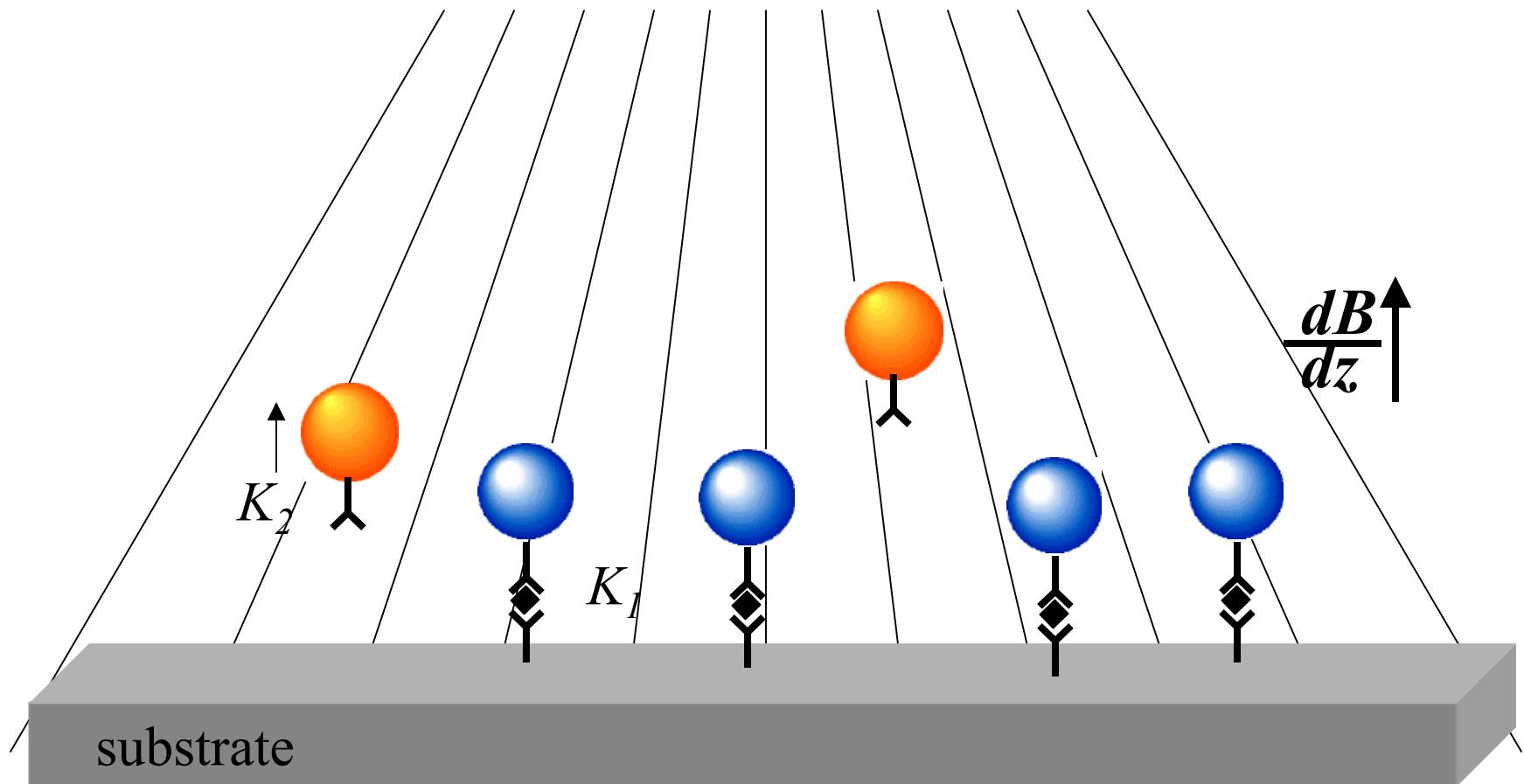


- The magnetic bead acts as highly specific bio/electro interface
- Hall sensor detects only immobilized beads
- The other beads are collected by the magnet

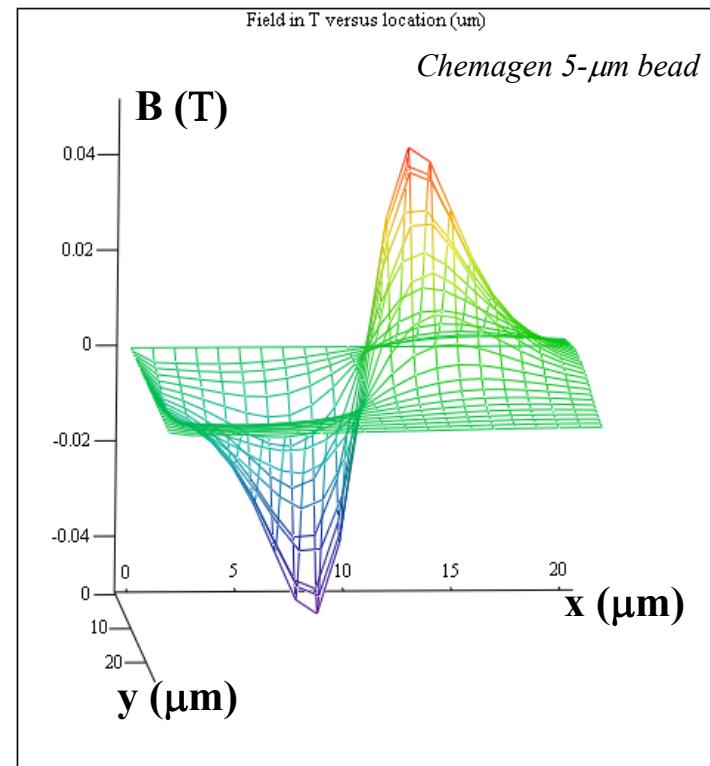
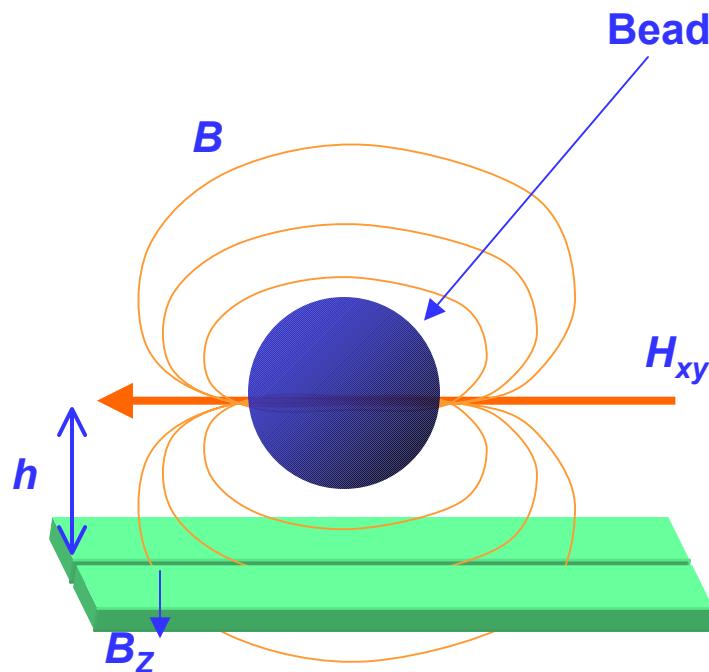
# Magnetic Immunoassay



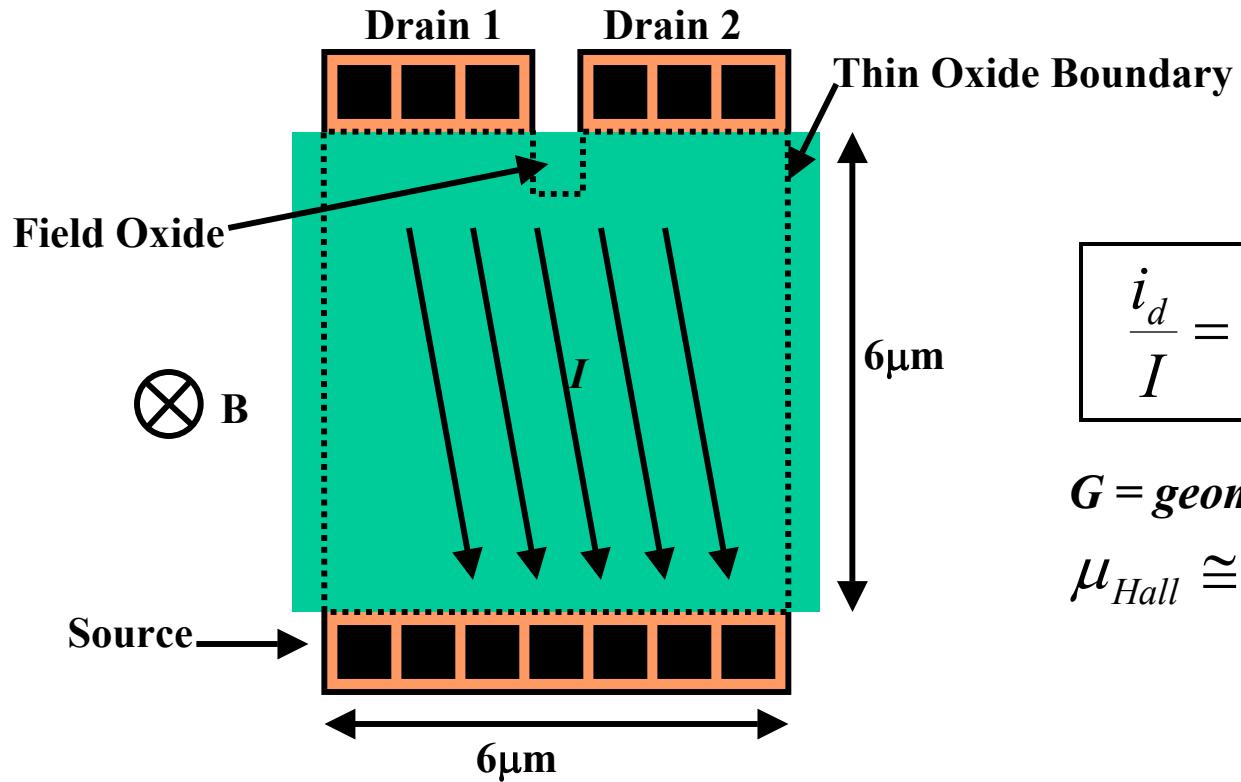
# Magnetic Washing



# Magnetic Detection



# Dual-Drain MOS Hall Sensor



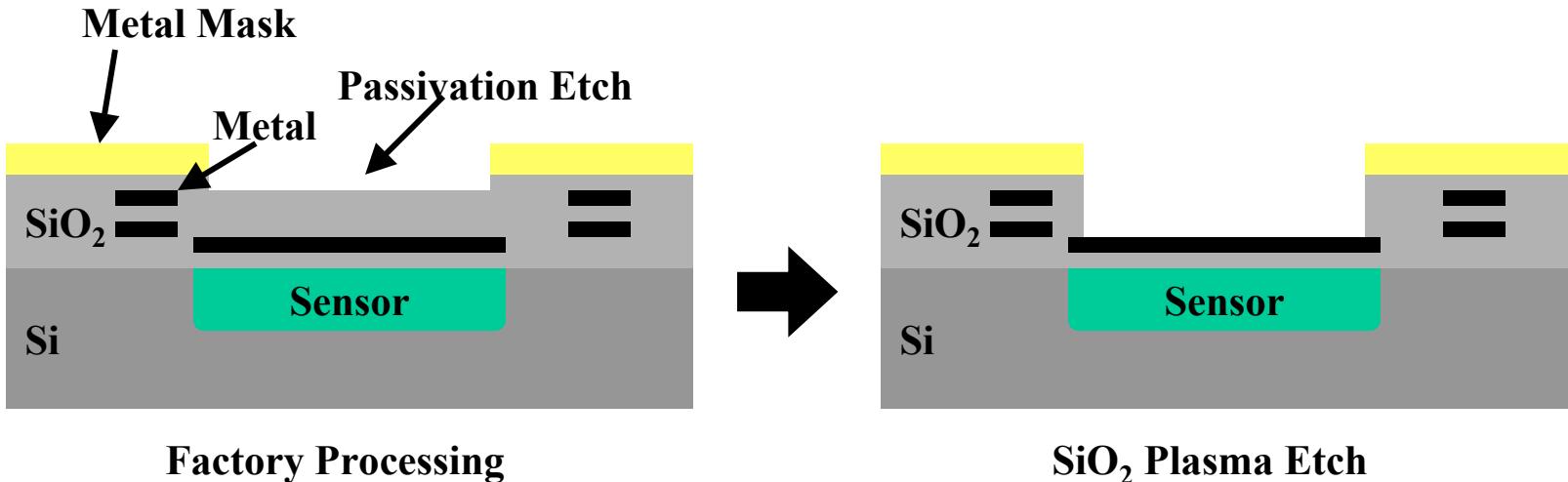
$$\frac{i_d}{I} = \mu_{Hall} B_{\perp} G$$

$G$  = geometric factor (0.65)

$\mu_{Hall} \approx \mu_{eff}$

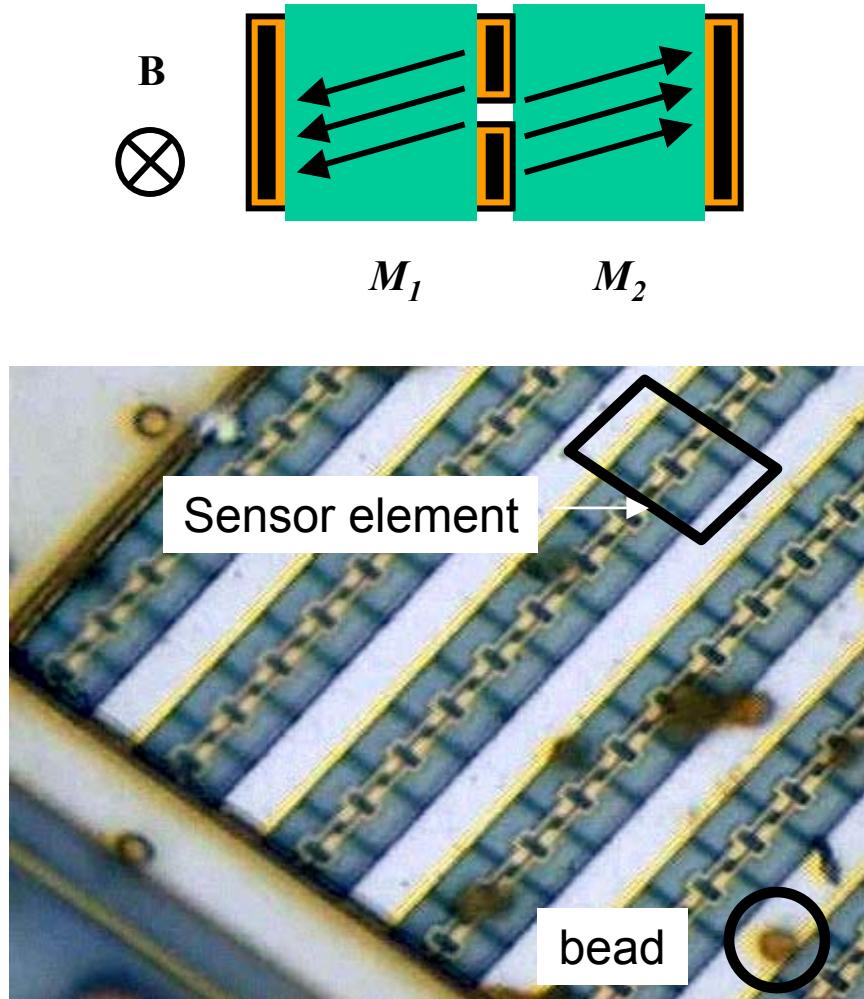
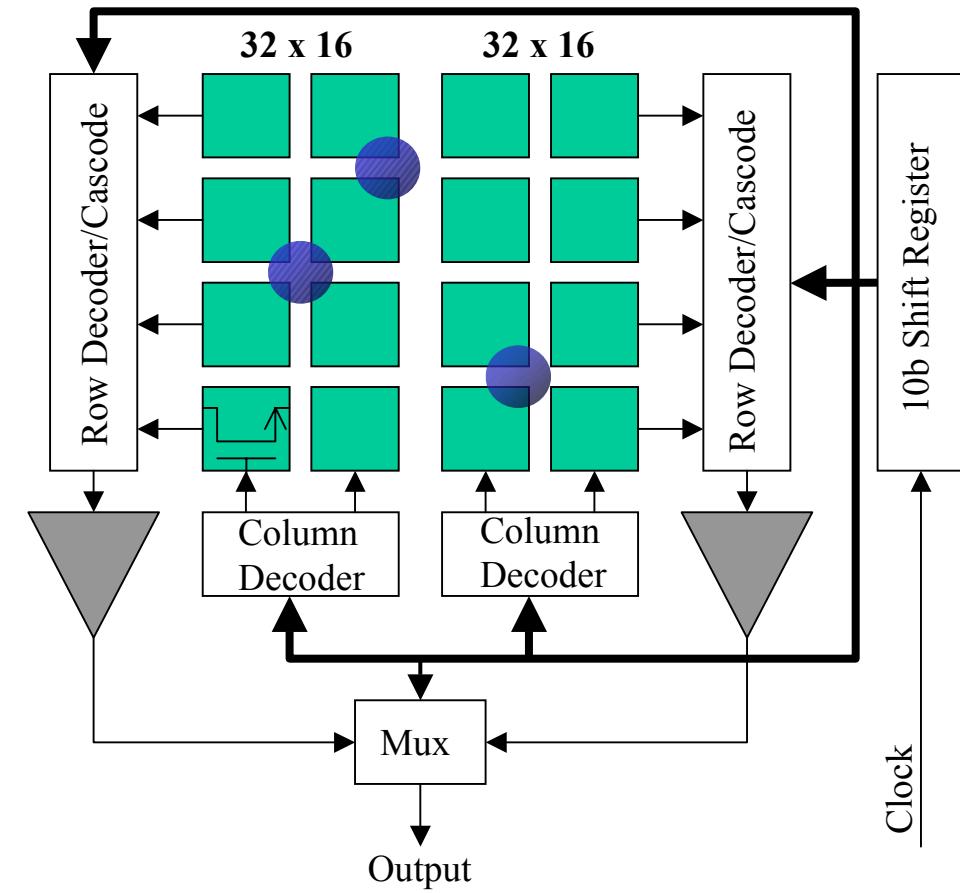
- Device dimensions selected to match magnetic field perturbation from a single 5 μm diameter bead

# Sensor Fabrication



- Based on standard 0.25 $\mu$ m CMOS with custom post-processing
- SiO<sub>2</sub> thinned to improve signal (cubic dependency)
- Top metal is factory defined and serves as etch mask for thinning SiO<sub>2</sub>
- Bottom metal provides precise etch stop and limits surface roughness resulting from post processing

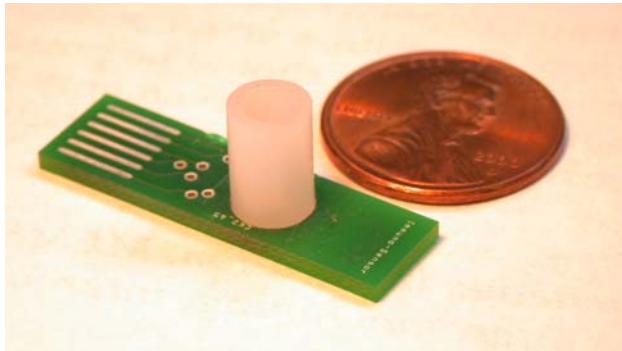
# Chip Architecture



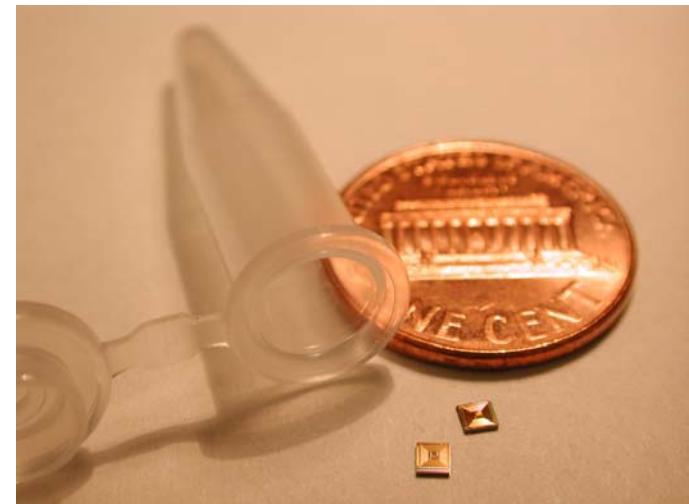
# Packaging Evolution



1) wires

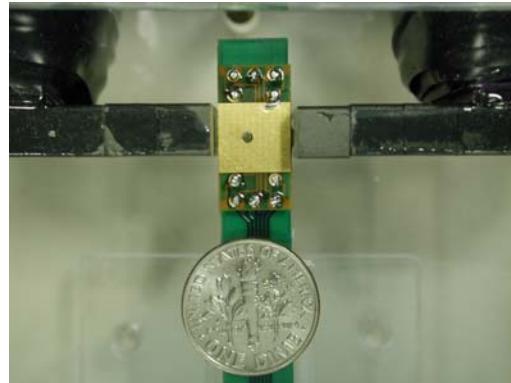
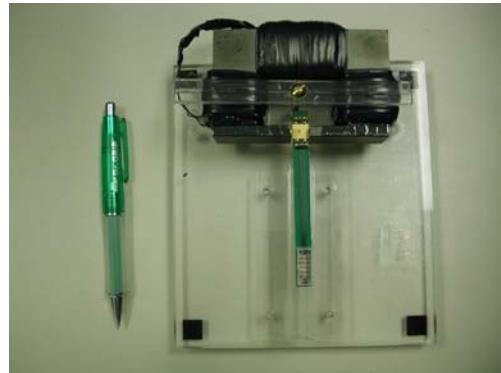
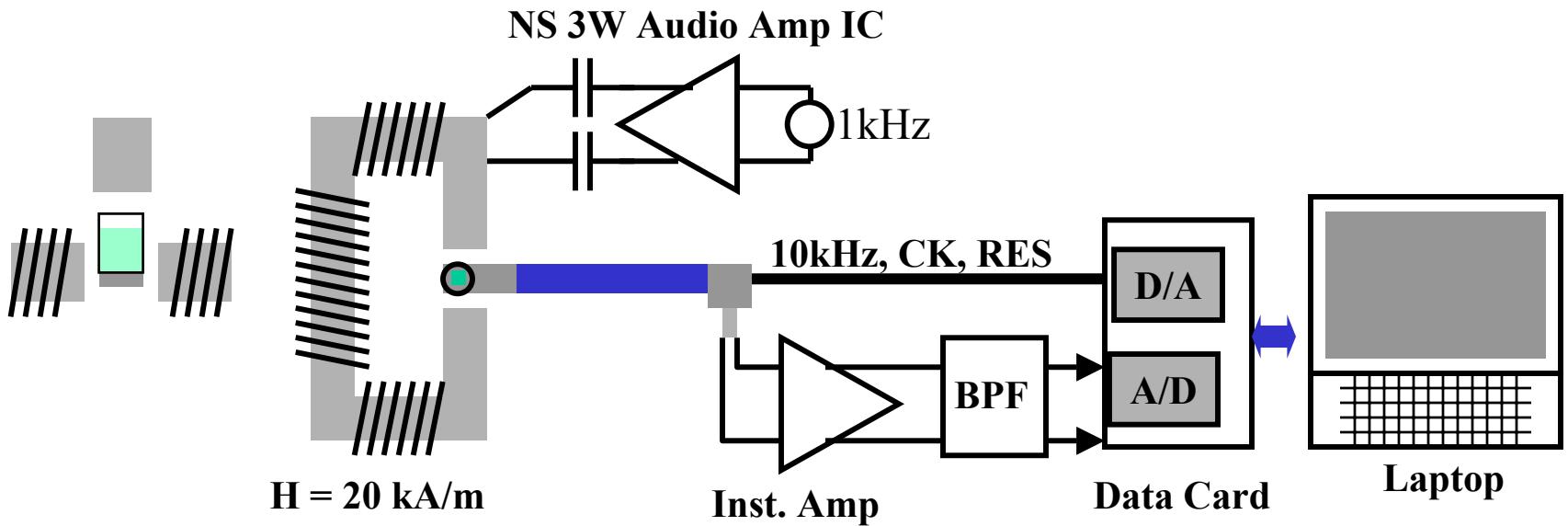


2) flip-chip

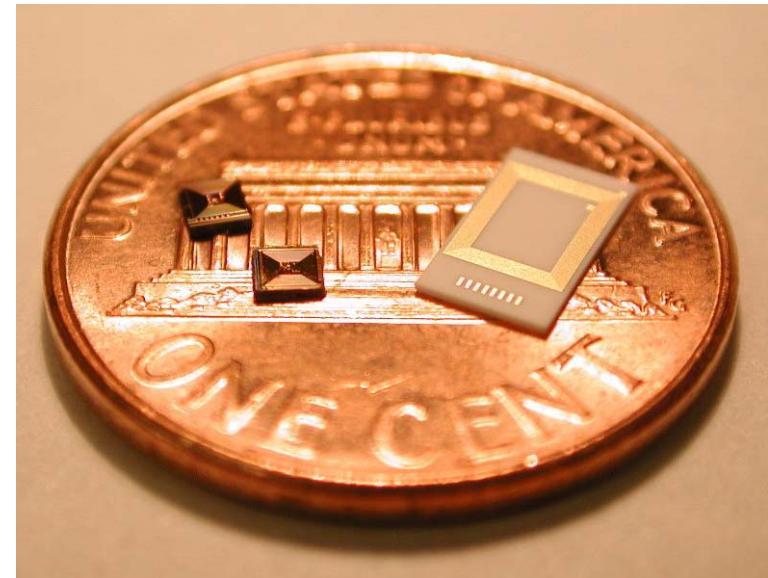
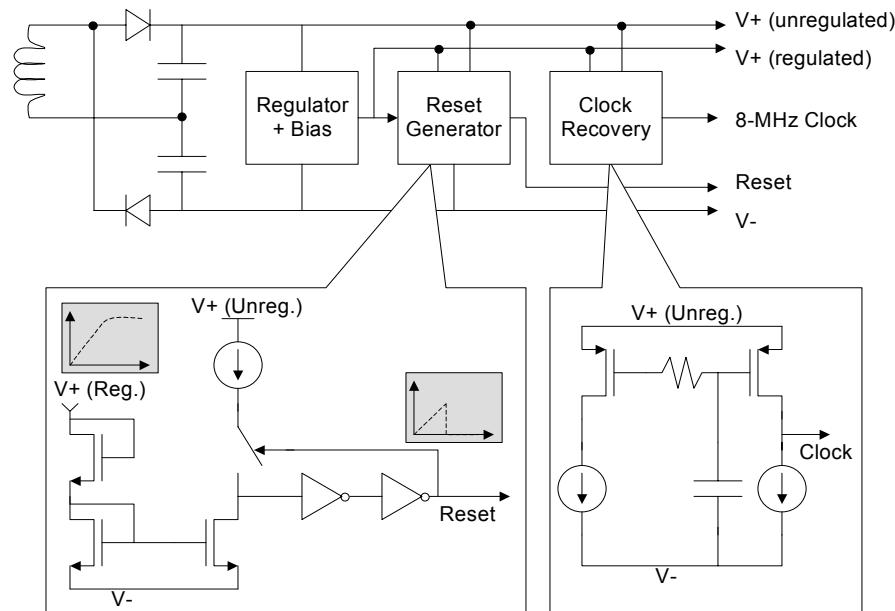


3) wireless

# Experimental Setup

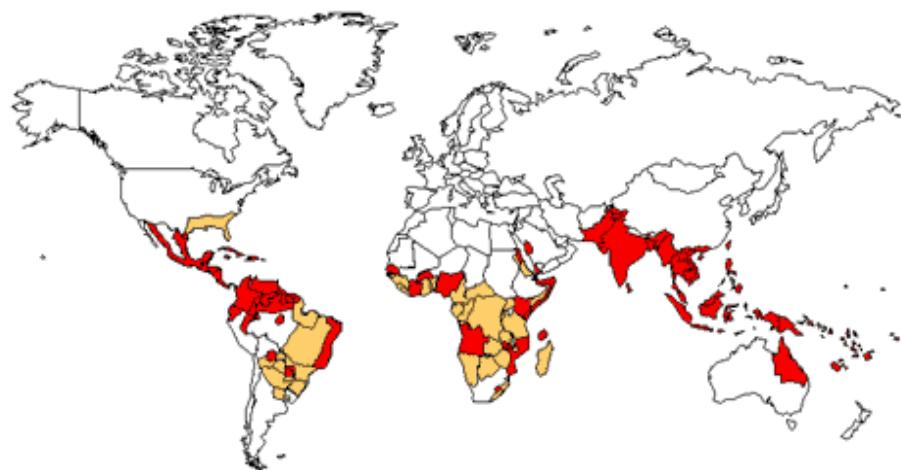


# Wireless Sensing



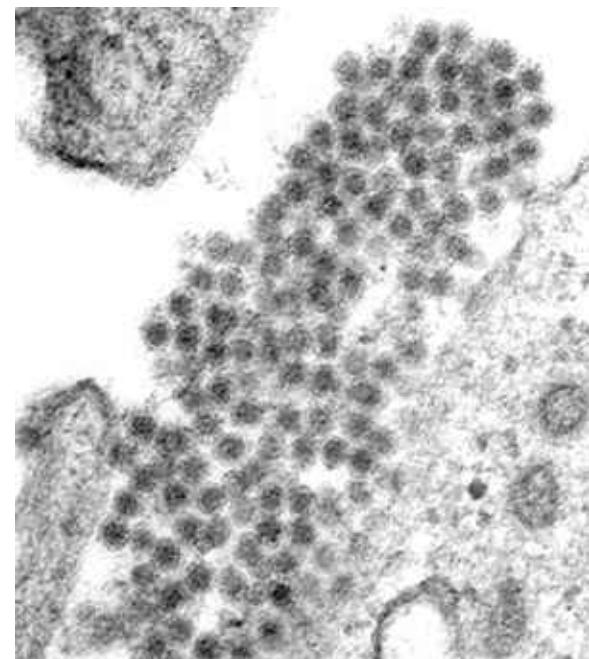
# Dengue Fever

World Distribution of Dengue - 2000



- Areas infested with *Aedes aegypti*
- Areas with *Aedes aegypti* and dengue epidemic activity

CDC



Tissue infected with dengue-2, ~120,000x

# Acknowledgements

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