

Novel and Diverse Applications of Silicon Nanosensors and Imagers

Blake Jacquot, Ph.D.

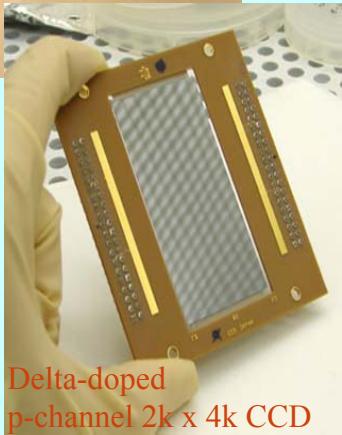
Member of Technical Staff
Jet Propulsion Laboratories

April 28, 2009

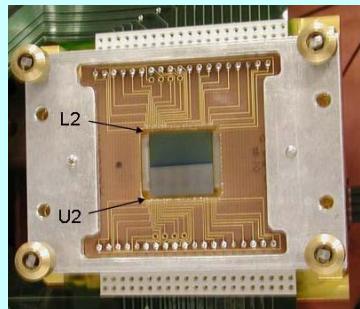
National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Advanced Detector Arrays and Nanoscience Group

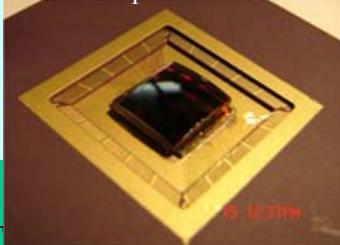
Cylindrically curved CCD



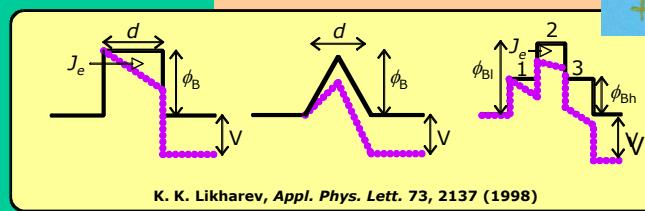
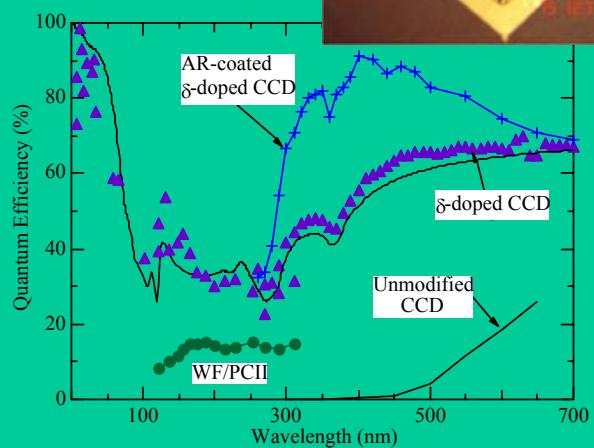
Back illuminated Si UV/Vis/NIR Imagers



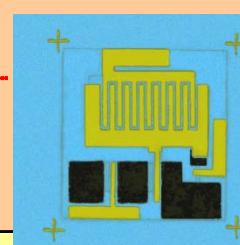
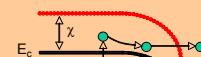
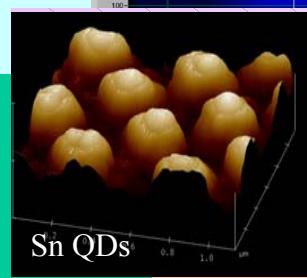
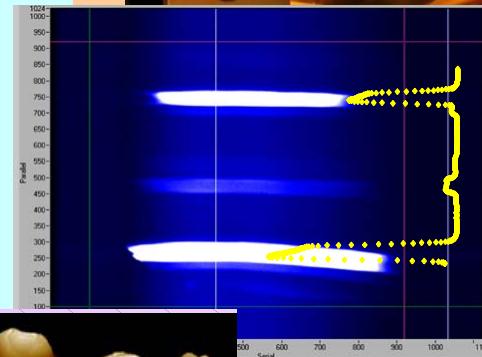
Delta-doped n-channel CCD



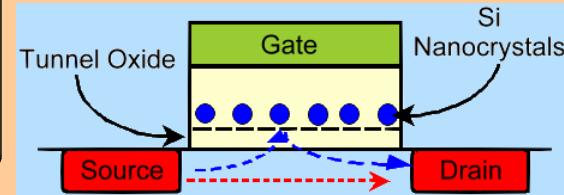
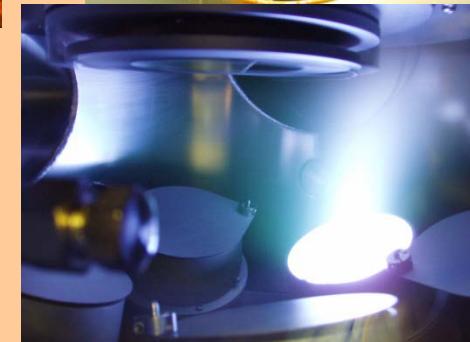
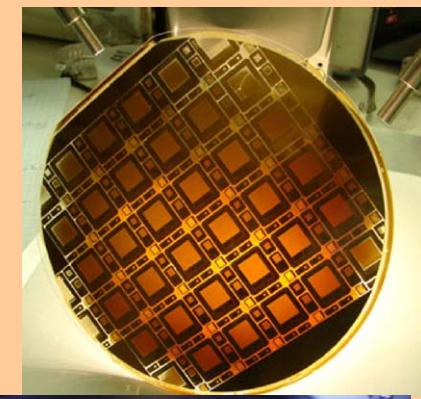
Delta-doped p-channel 2k x 4k CCD



Particle Detectors

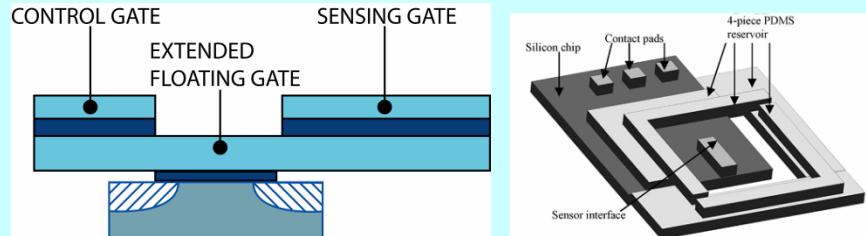


End-to-end Processing

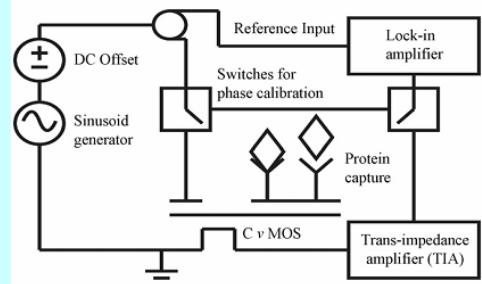


CvMOS: Charge-based sensors

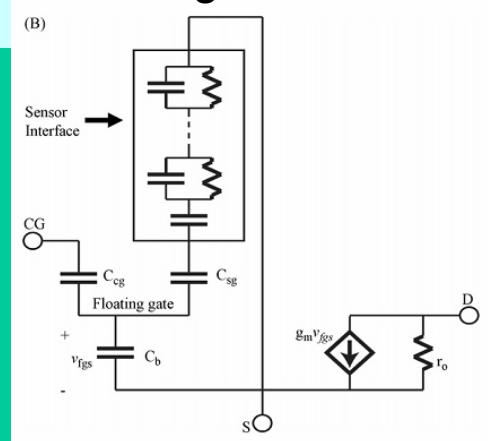
CMOS-Based Biosensors



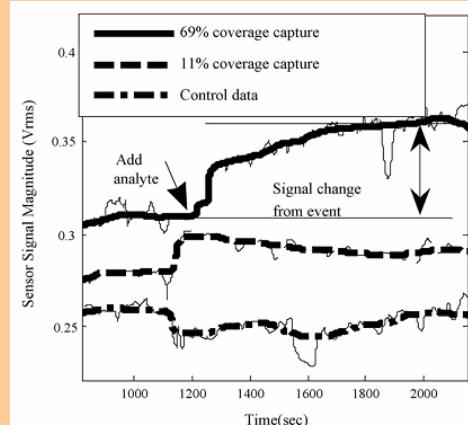
Measurement of Protein Binding



Small-Signal Model



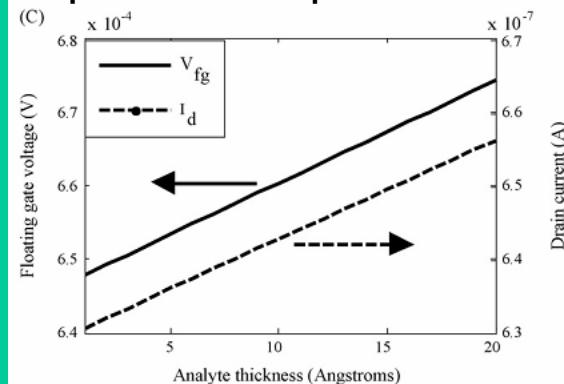
Real-Time Detection



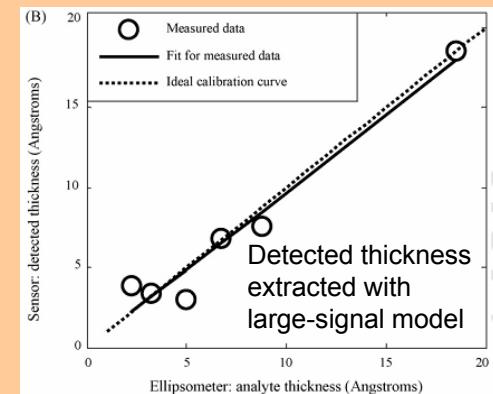
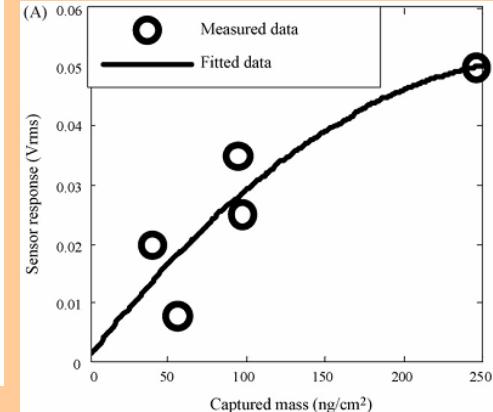
Impedance Model

- (A) Bulk Potential
- C_{diff} : Electrolyte Diffusive Layer ($\sim 25\text{\AA}$): second component of Gouy-Chapman-Stern model. Assume $\epsilon_r > 78$
 - C_{EDL} : Electrolyte Double Layer ($\sim 5\text{\AA}$): first component of Gouy-Chapman-Stern model. Assume $\epsilon_r > 78$
 - C_{strept} : Streptavidin ($\sim 19\text{\AA}$): analyte protein for capture. Thickness increases as binding occurs. Assume $\epsilon_r \approx 10$
 - C_{BSA} : Biotinylated BSA ($\sim 11\text{\AA}$): BSA protein covalently bonds to 3-GPS. Biotin captures streptavidin. Assume $\epsilon_r \approx 10$
 - $C_{\text{3-GPS}}$: 3-GPS ($\sim 14\text{\AA}$): Molecule attaching protein to sensor. Assume $\epsilon_r \approx 11.8$
 - C_{oxide} : Native Oxide ($\sim 26\text{\AA}$): $\epsilon_r \approx 4.0$

Expected Response



Calibration Curves



- Detection limit: 25 ng/cm^2 or 2\AA
- $1.5\mu\text{m}$ technology scaled down
- Different materials to block mobile ions



Cornell University