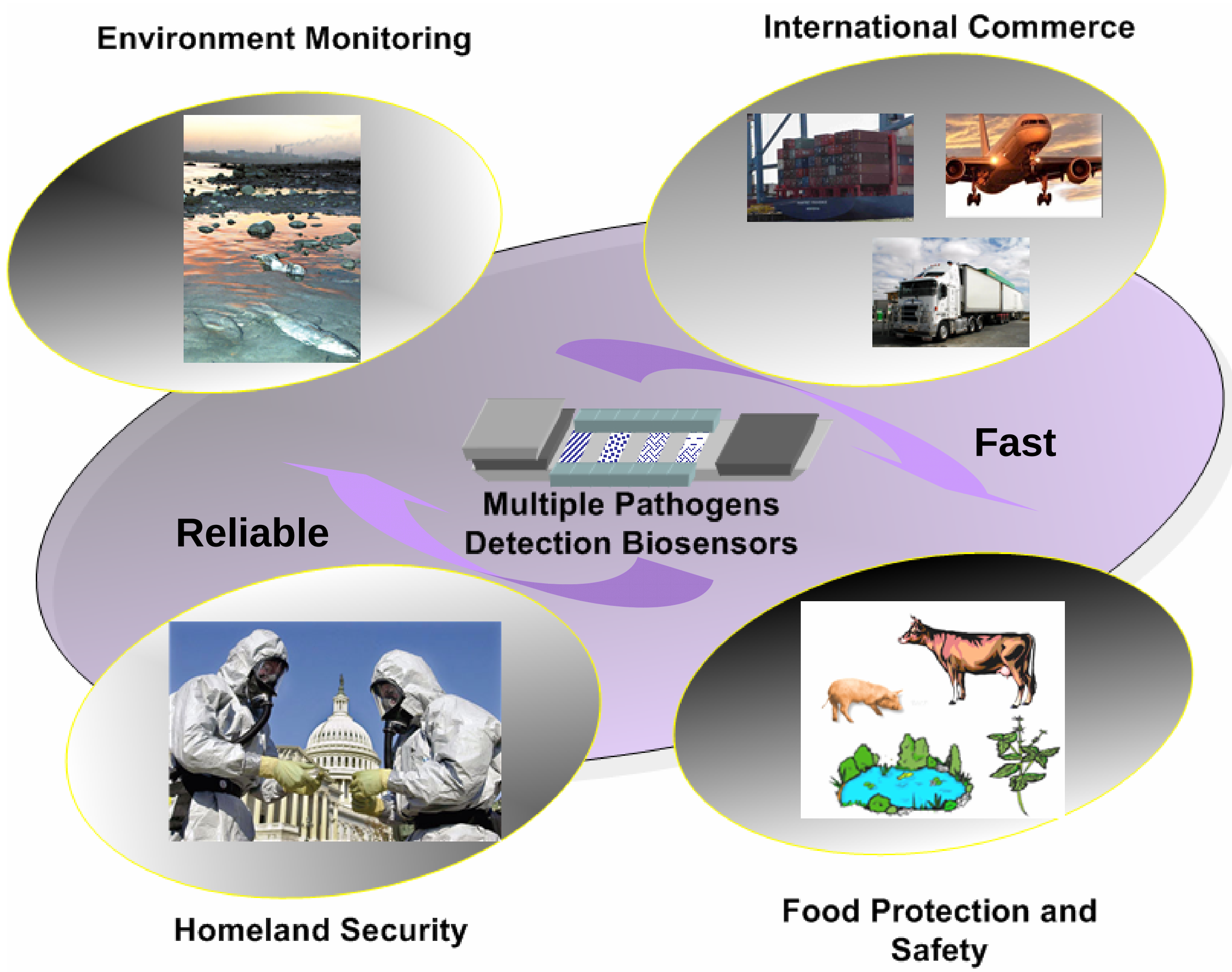
Key References

Y. Liu, S. Chakrabartty*, and E. C.Alocilja, "Fundamental Building Blocks for Molecular Bio-wire based Forward-error Correcting Biosensors", Nanotechnology, 18, (2007), 4240172.

Y. Liu, A. Gore, S. Chakrabartty*, and E. C.Alocilja, "Characterization of Sub-systems of a Molecular Bio-wire based Biosensor Device," Microchimica Acta , 2008, DOI: 10.1007/s00604-008-0950-0.

Y.Liu, S.Chakrabartty*, Factor Graph based Biomolecular Circuit Analysis for Designing Forward Error Correcting Biosensors, IEEE Transactions of Biomedical Circuits and Systems, vol. 3, no. 3, pp.150-159, June 2009

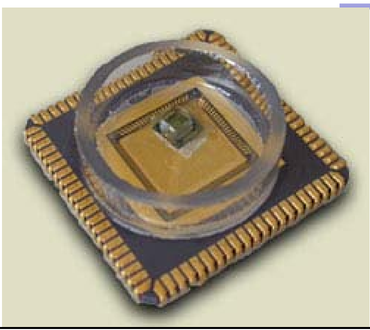
Motivation



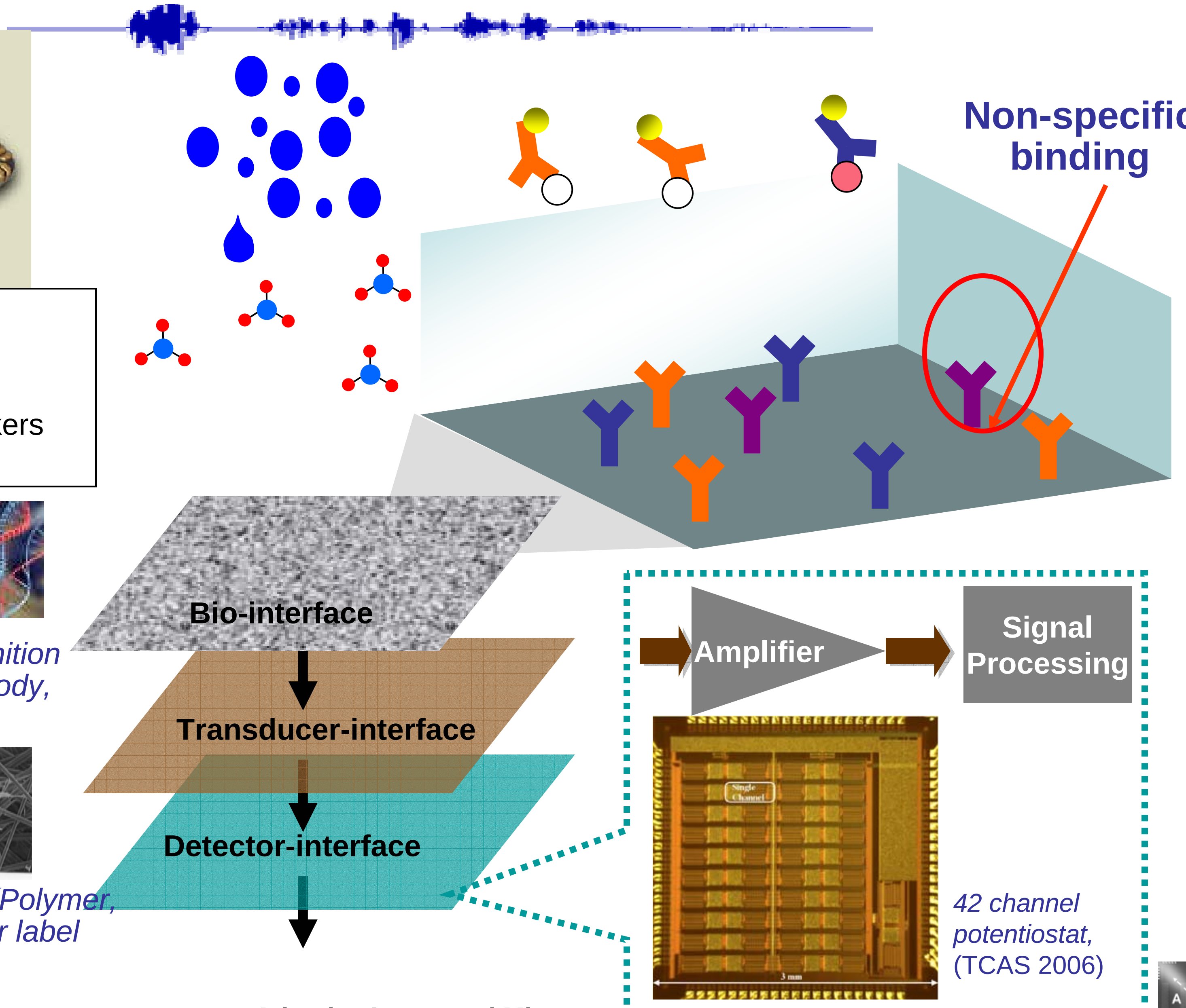
Environmental variability and non-deterministic response of bio-molecules affects reliability of biosensors.

Can forward error correction (FEC) principles be used to improve reliability of biosensors ?

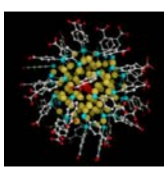
Background

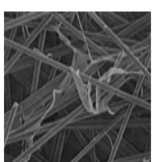


Vision: Lab-on-chip solution for rapid and reliable detection of pathogens or biomarkers in the field.



Biological Recognition layer (DNA, antibody, aptamers, ….)

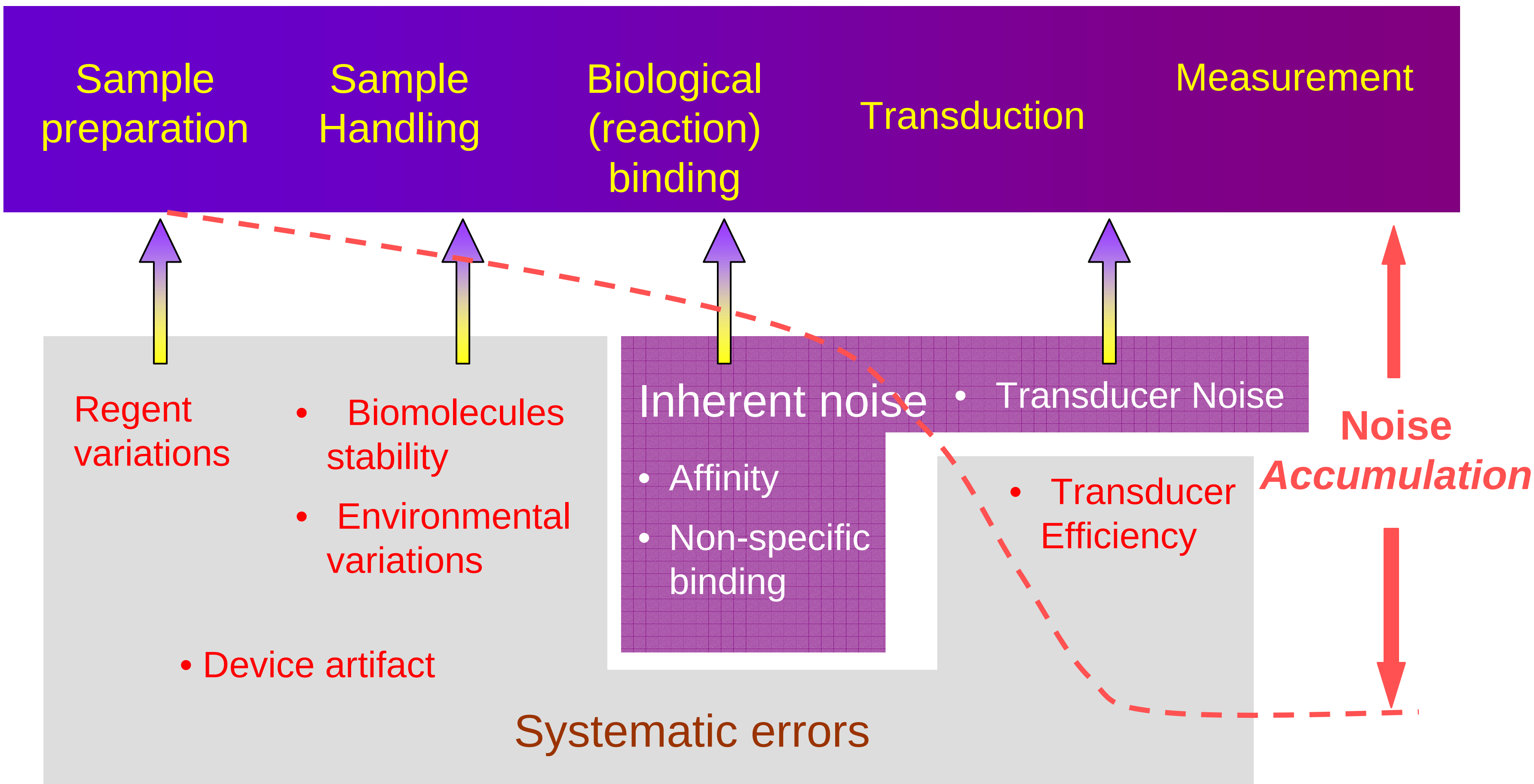




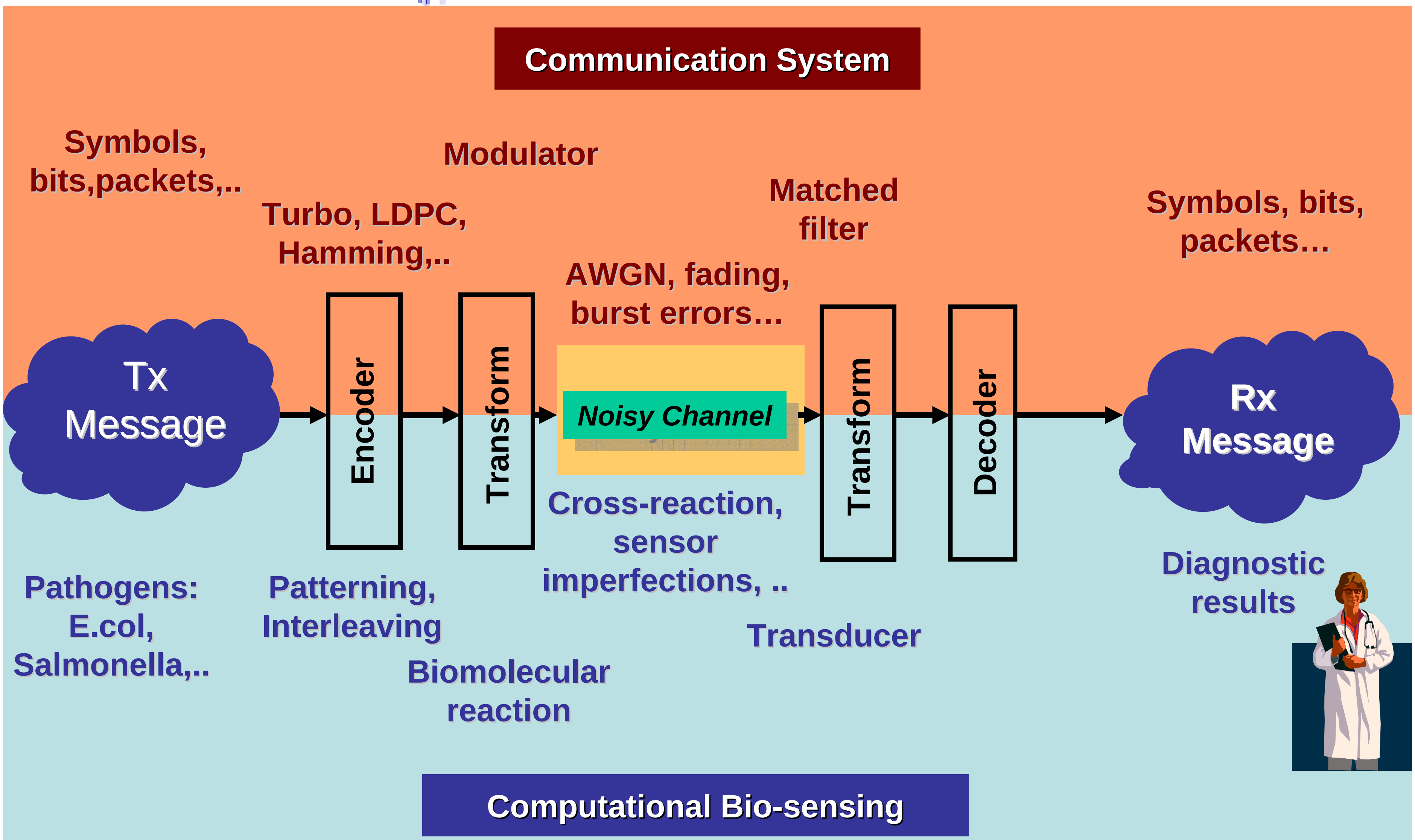
Label or transduer (Polymer, nanoparticles,….) or label free

Lessons Learned from the Past

- Signal Amplification at the bio-molecular level significantly improves the sensitivity of the biosensor.



Communication model for reliable bio-sensing

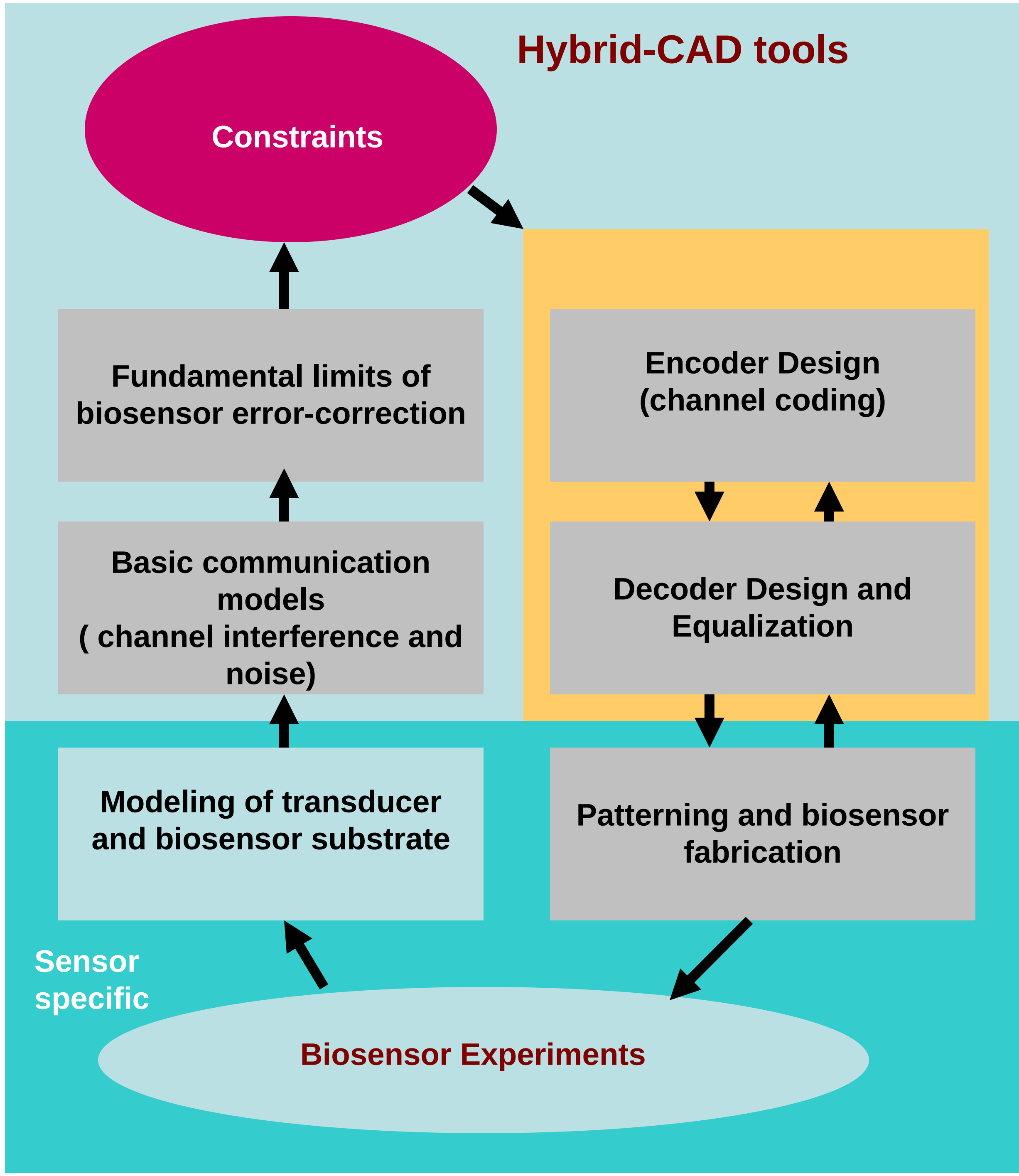


The "Big" Picture

Virtual biosensor: Alleviate cumbersome experimental cycles and protocols.

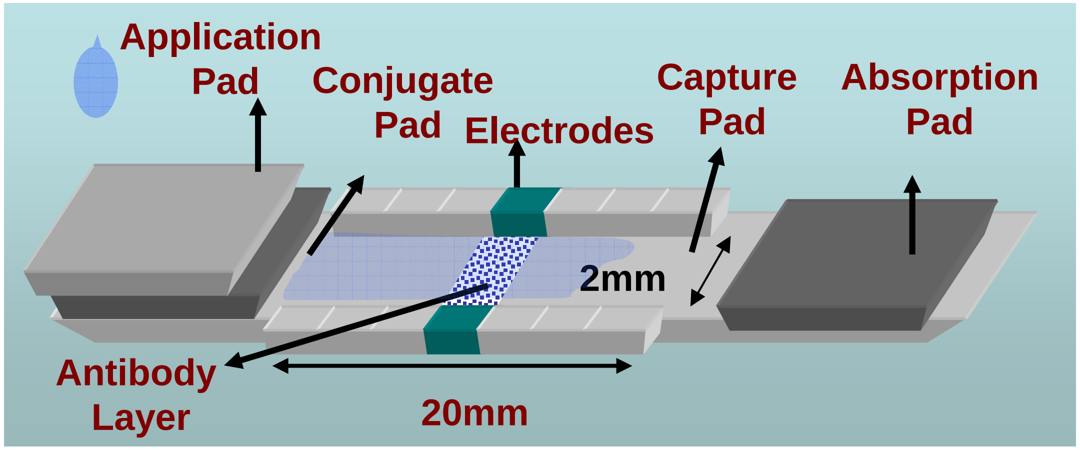
For a given substrate of fixed size how many pathogens can be detected reliably at a specified error rate ?

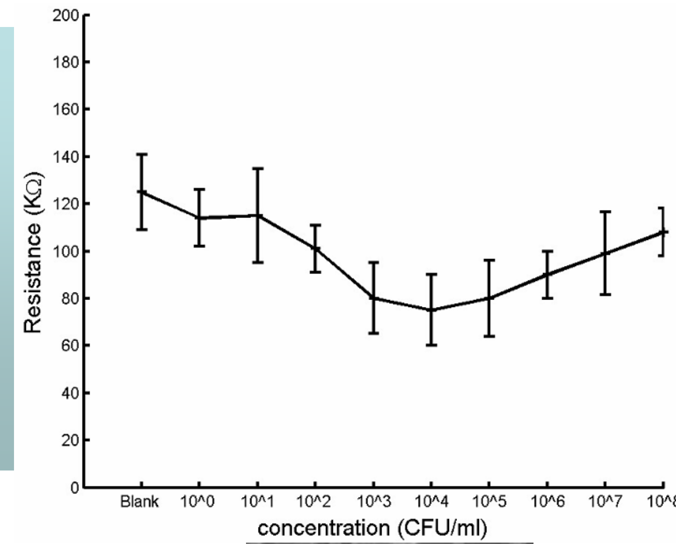
Can new encoding-decoding principles be discovered by using CAD models ?

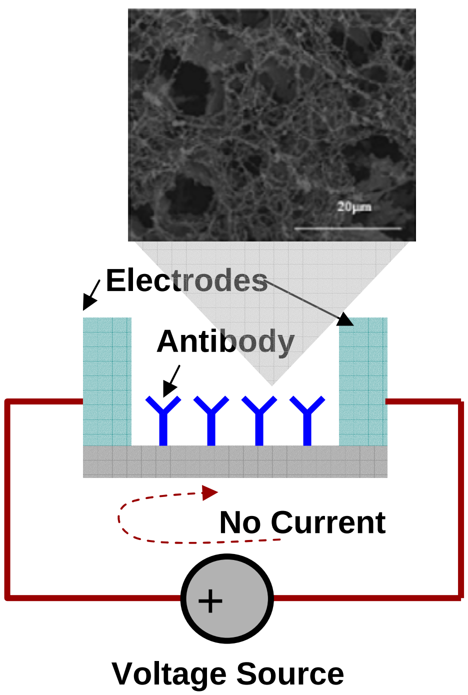


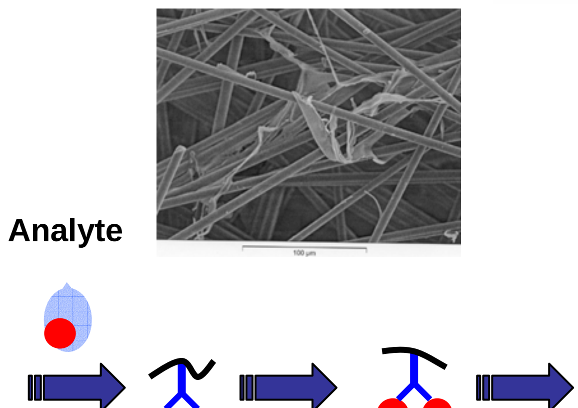
Case Study I: Membrane based biosensor

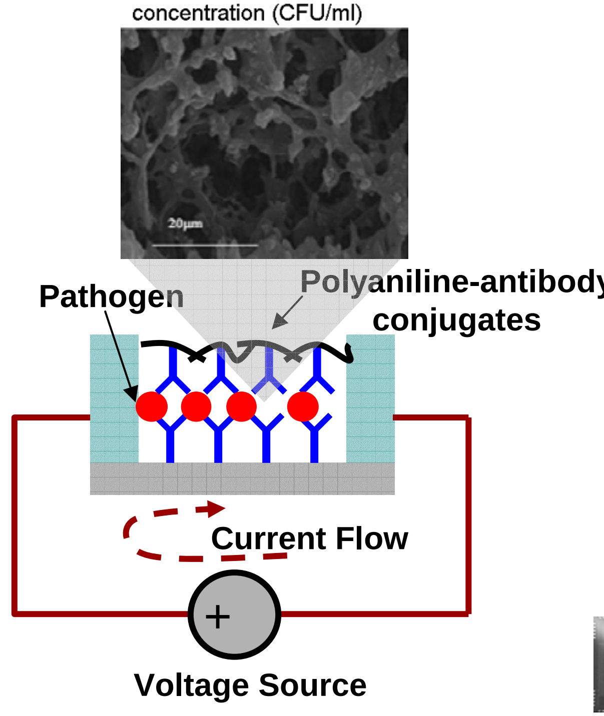
(Tahir, Alocilja, chakrabartty, 2003,2005,2006)



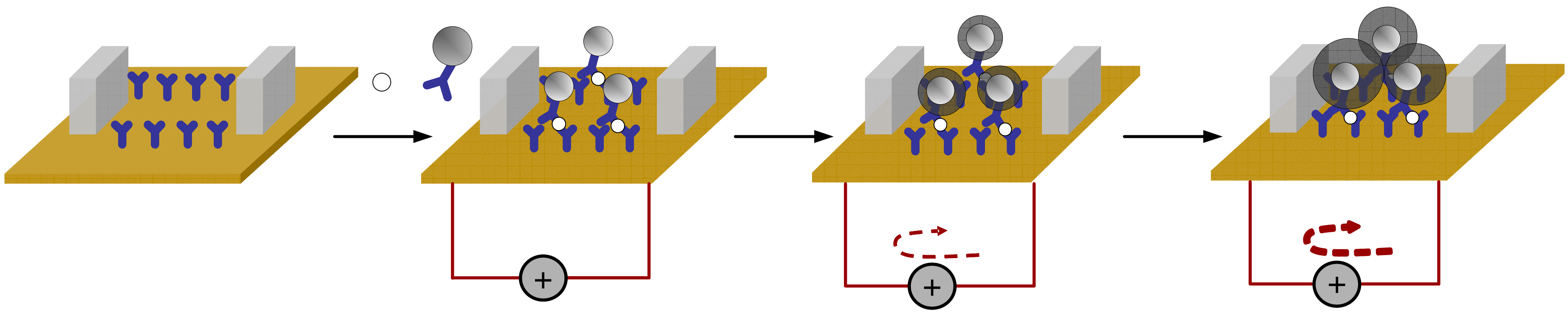








Case Study II: Silicon Biosensors

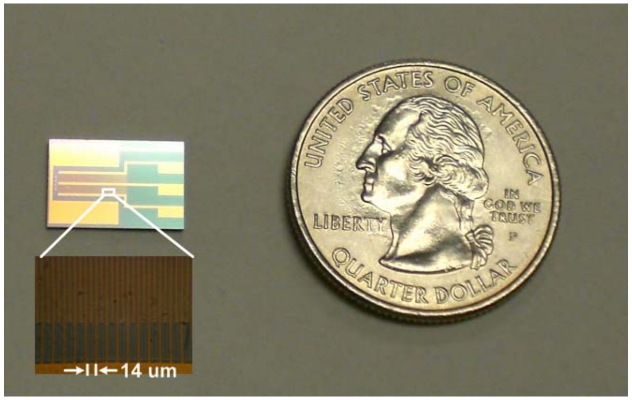


- The gold nanoparticles act as a catalyst and reduce silver ions into metallic silver in the presence of a reducing agent (hydroquinone). [3-5]

- The reduced silver deposits on the gold surface, thus enlarging the size of the gold nanoparticles.

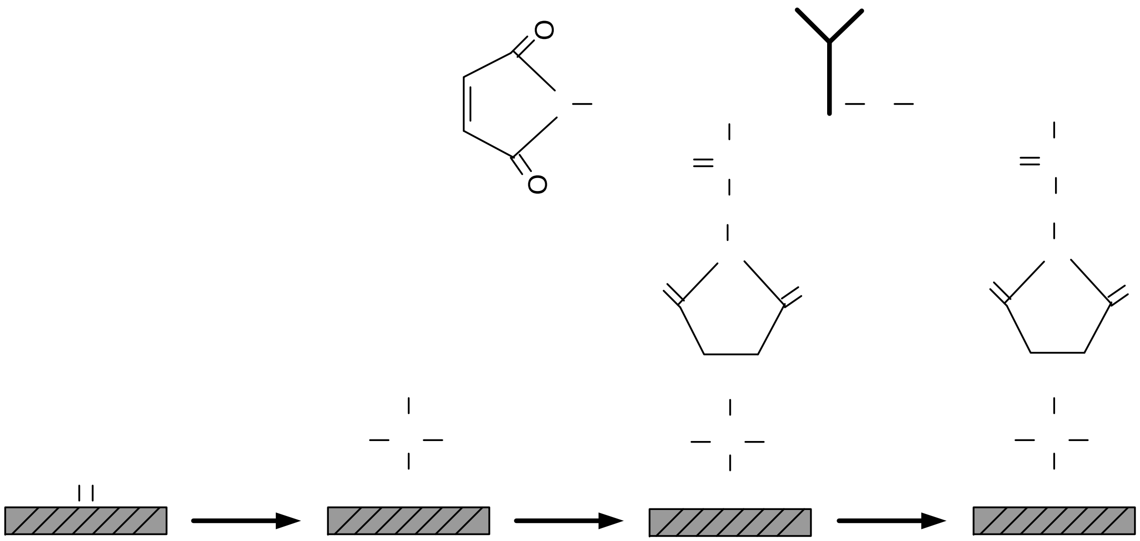
Antibody-
conjuga
Au

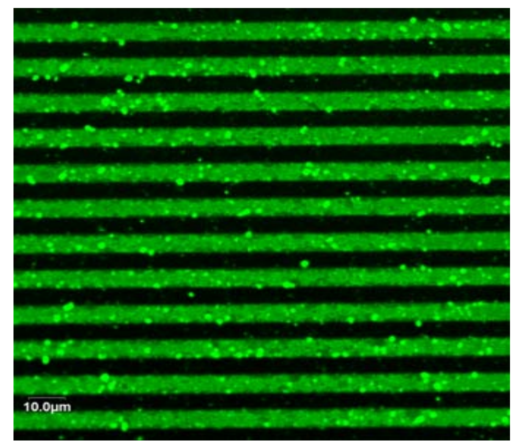
Biochip and Surface Functionalization



- Photolithograph: 5 nm titanium and 50nm gold layer
- Each electrode finger has a length of 750 um, a width of 3 um and inter-electrode spacing of 4 um.

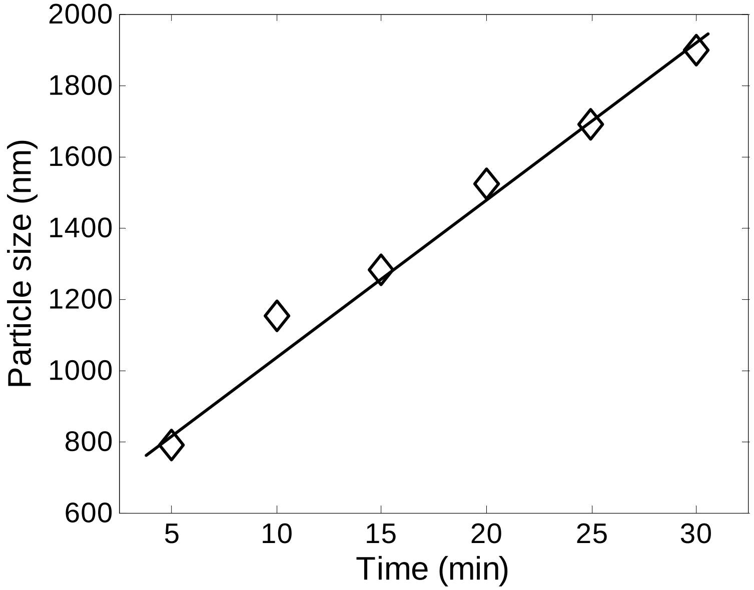
Surface functionalization



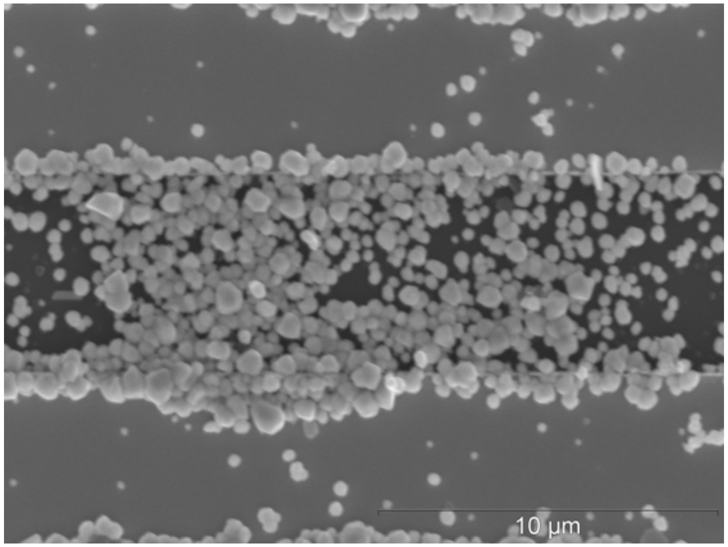


FITC labeled bovine IgG only immobilized to the silicon dioxide surfaces

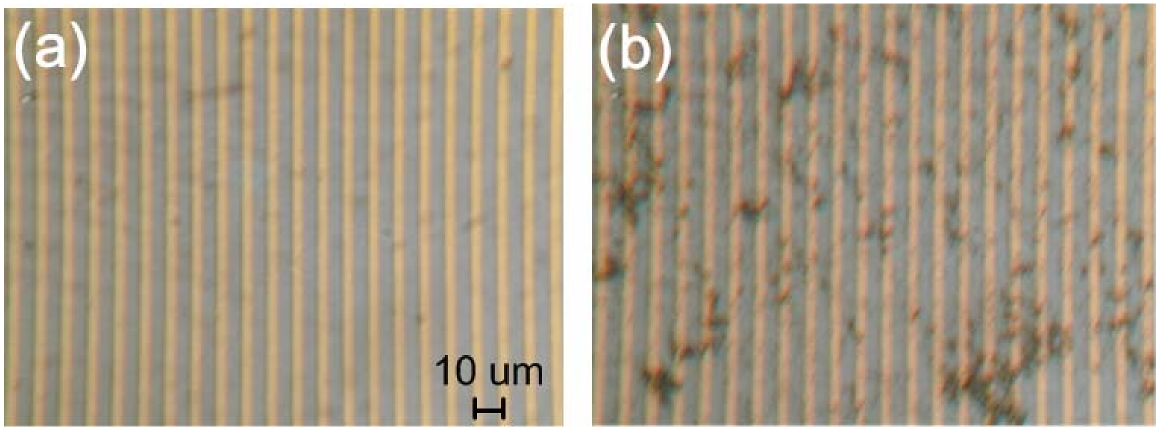
Verification of the Principle



The relationship between the particle size and the silver enhancing time.



SEM image of the bridge formed by enlarged gold particles.

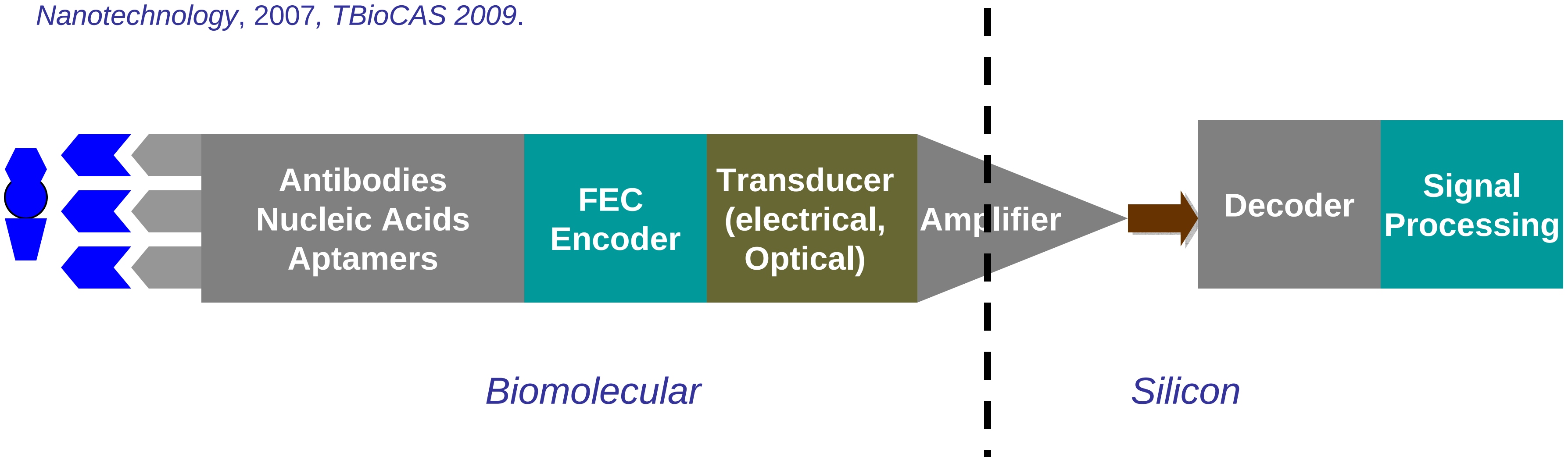


Microphotographs for the biochip active surface. (a) before silver enhancement (b) 35 min after silver enhancement.

Designing the Encoder-Decoder

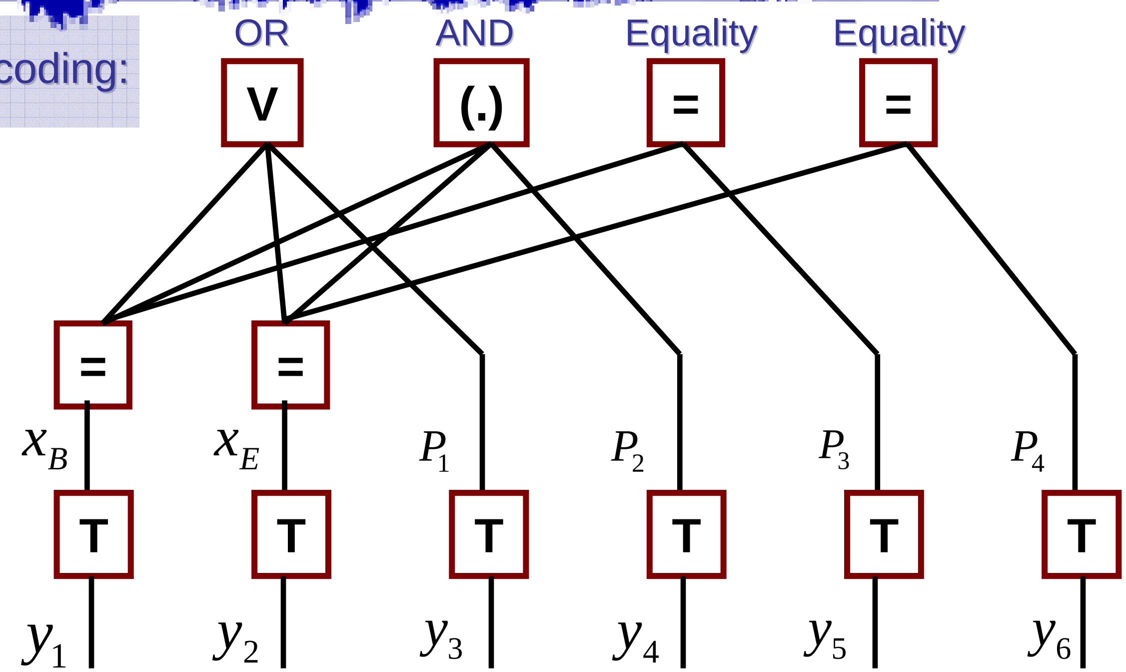
Forward error-correction biochip

Nanotechnology, 2007, *TBioCAS 2009*.



Factor graph model of an FEC biosensor

Factor Graph Based Decoding:



Likelihoods

Measurements

Likelihood of E.coli given the measurement vector

$$f(x_E; y_1, y_2, y_3, y_4, y_5, y_6)$$

Likelihood of Bacillus given the measurement vector

$$f(x_B; y_1, y_2, y_3, y_4, y_5, y_6)$$