ORGANIC ELECTRONICS
Part I Chemical Modulation

(one person's loss is another person's gain!)

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Purdue Univ. JULY 2005

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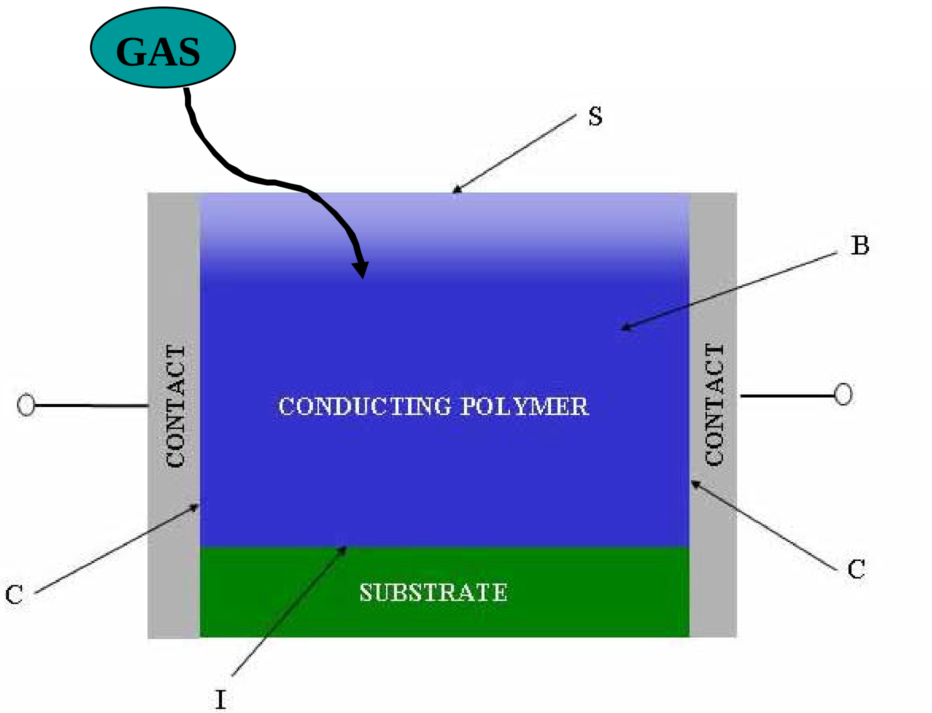
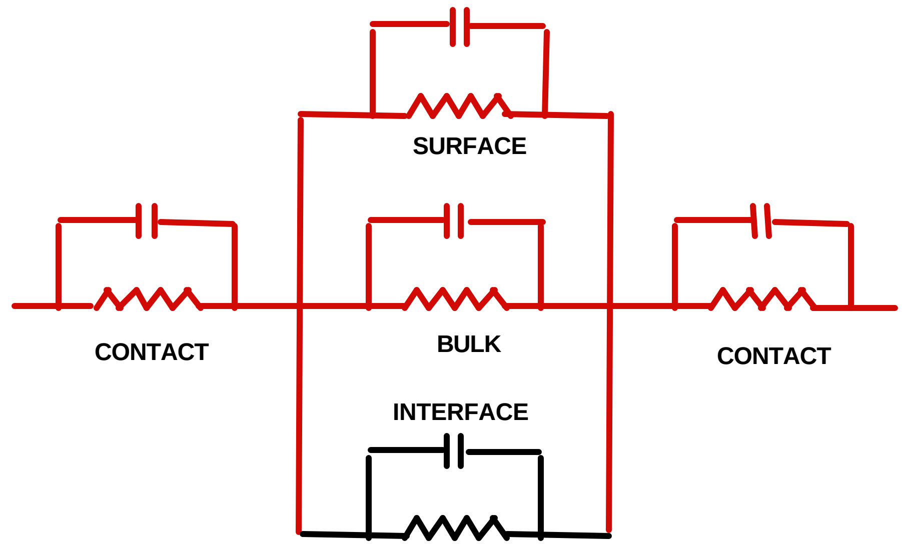
GENERALIZED ELECTROCHEMICAL SENSOR





$$Z = \bar{Z}_C dn_C + \left(\bar{Y}_S dn_S + \bar{Y}_B dn_B + \bar{Y}_I dn_I\right)^{-1}$$

where

$$Y_i = \frac{1}{Z_i} = f(C_i, R_i) \ \ and \ \ n_i \ are\ moles\ at\ node\ i$$

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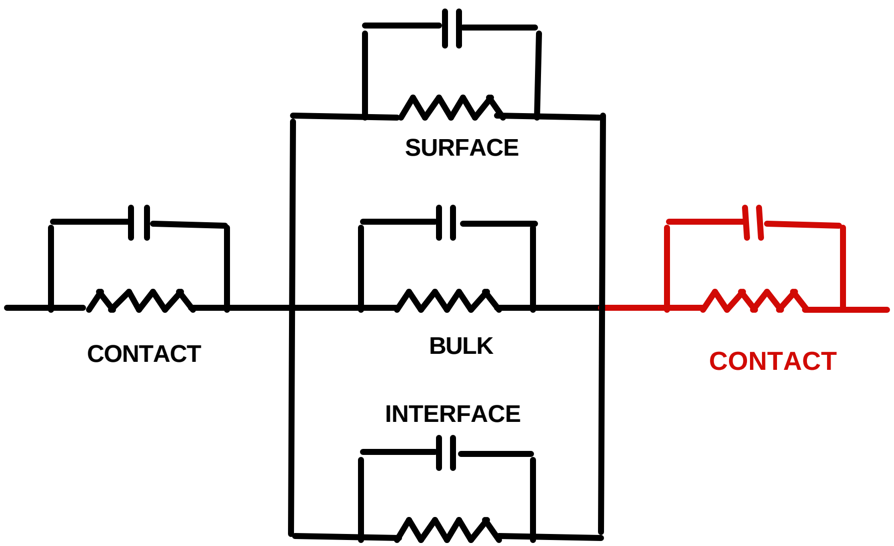
Nature Materials, 2 (1), (2003) 19-24

AMPEROMETRIC SENSORS



RESPONSE FROM CONTACT RESISTANCE

CHARGE TRANSFER RATE
MASS TRANSPORT RATE

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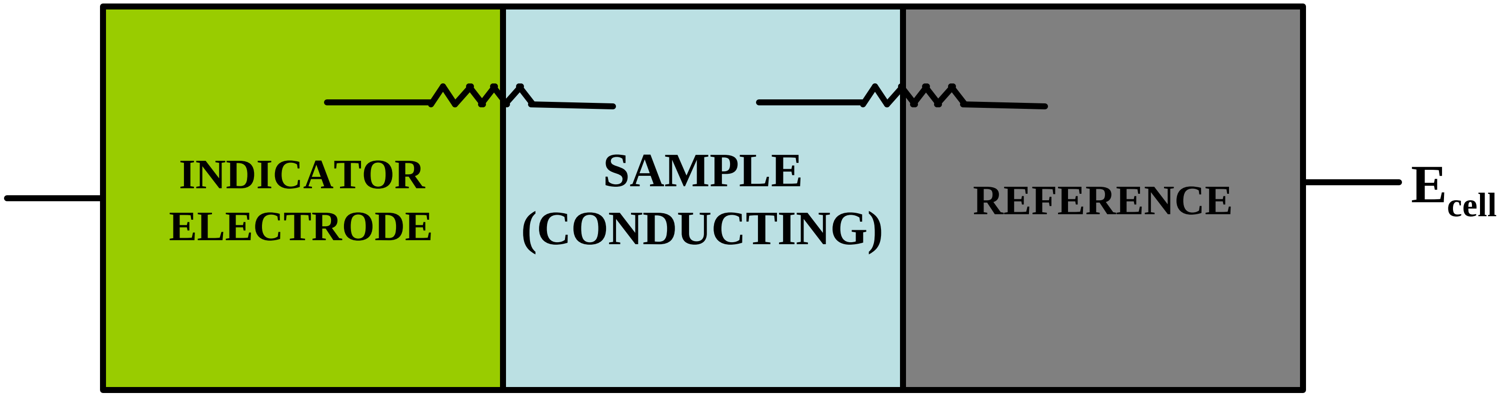
POTENTIOMETRIC



RESPONSE FROM NERNST POTENTIAL

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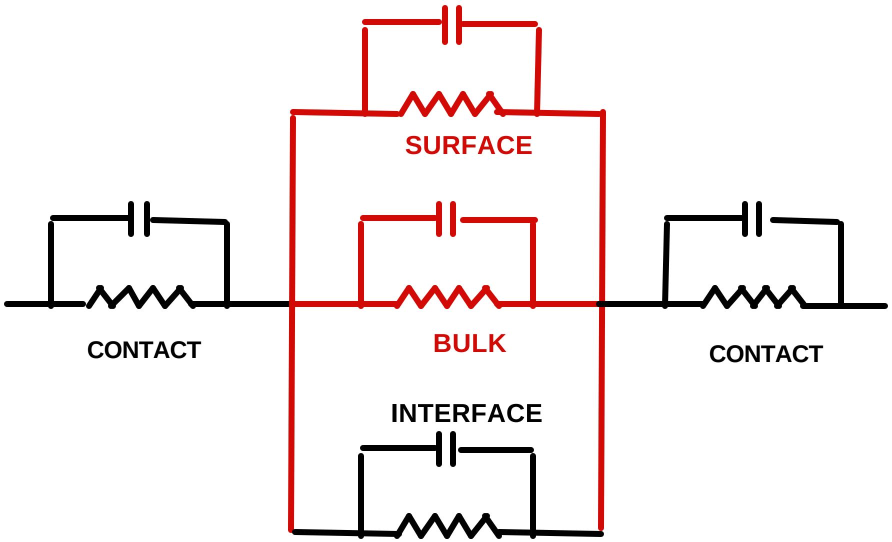
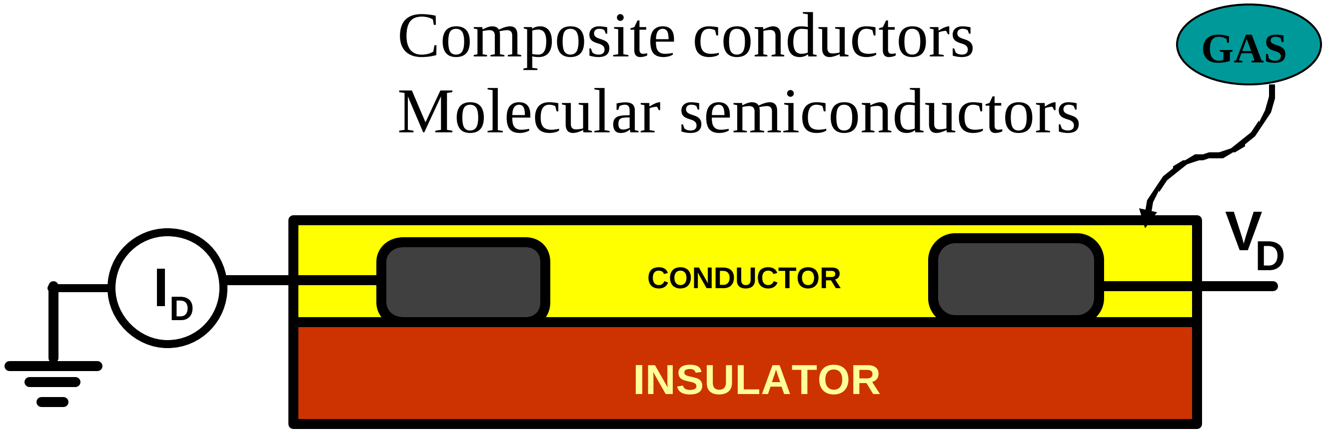
CHEMIRESISTORS



RESPONSE FROM
SURFACE
BULK

CHEMIRESISTORS BASED ON ELECTRONIC CONDUCTORS

Materials: Conjugated polymers
Composite conductors
Molecular semiconductors



Mechanisms: Modulation of carrier numbers
Modulation of hopping distance
Modulation of carrier mobility

$$s = m_+ \mathbf{e}\,\mathbf{n}_+ + m_- \,\mathbf{e}\,\mathbf{n}_-$$

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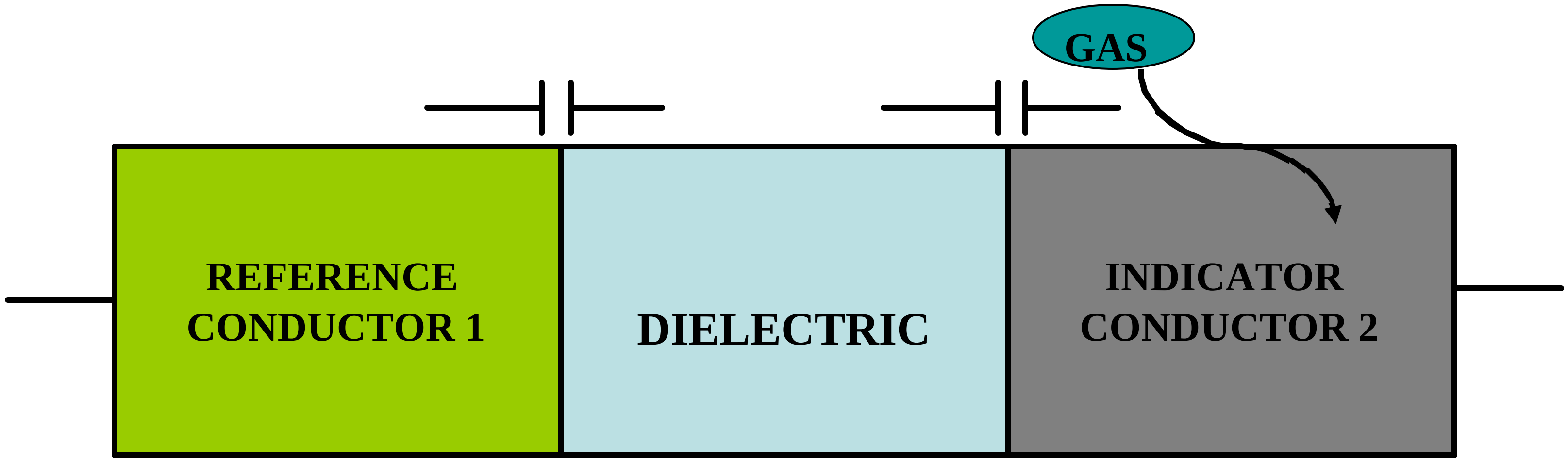
WORK FUNCTION SENSORS

Kelvin Probe

FET sensors



RESPONSE FROM

SURFACE

BULK

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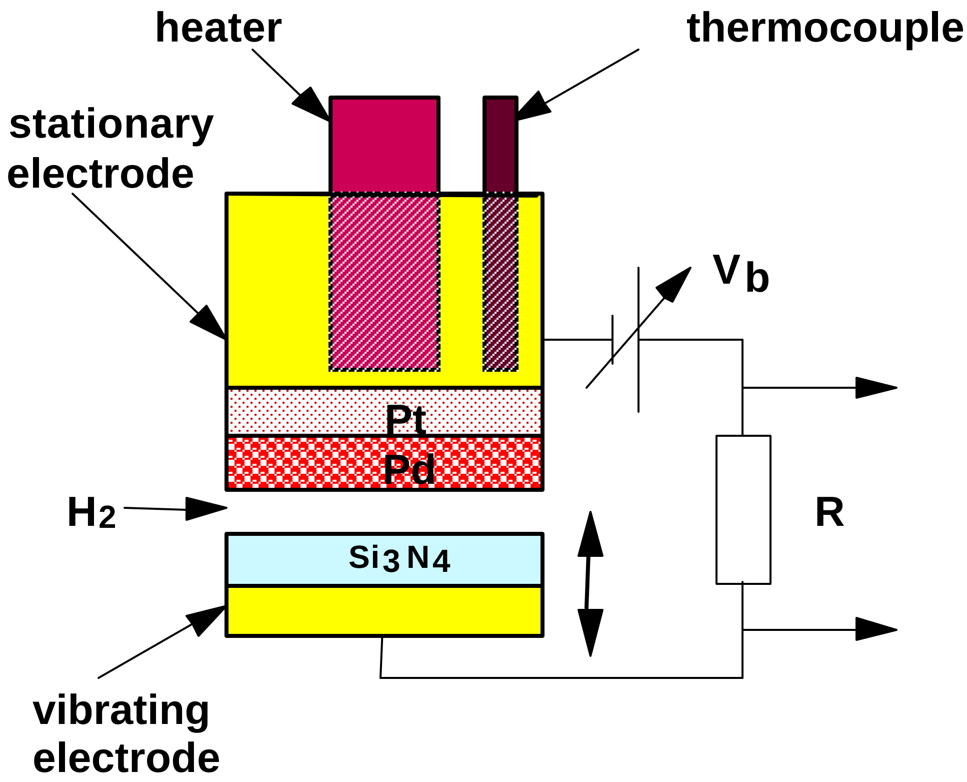
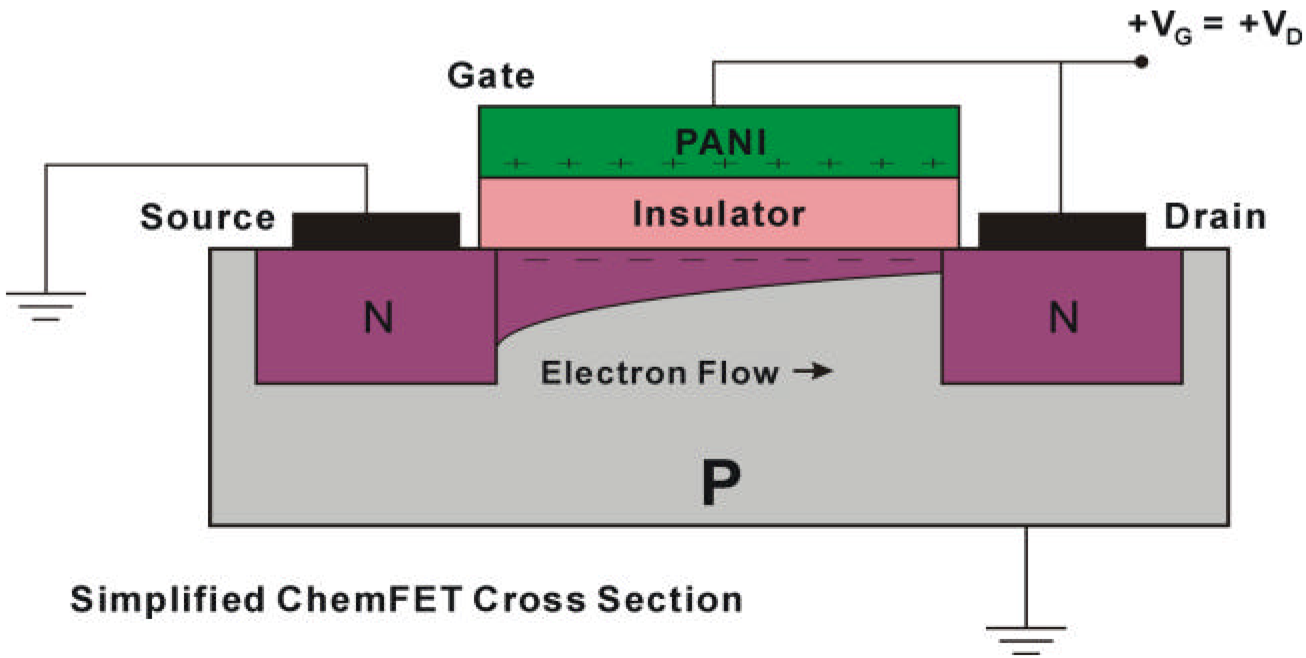
KELVIN PROBE



Anal.Chem. 69 (1997) 293A

CHEMICALLY SENSITIVE FIELD EFFECT TRANSISTOR



$$I_D = \frac{Wm_m C_0}{2L}(V_G - V_T)^2$$

$$V_G = \left(\frac{2LI_D}{Wm_n C_0}\right)^{1/2} + V_T$$

$$V_G = const. + \frac{\mathrm{kT}}{2d}\ln\left(P_G + \Sigma P_j\right)$$

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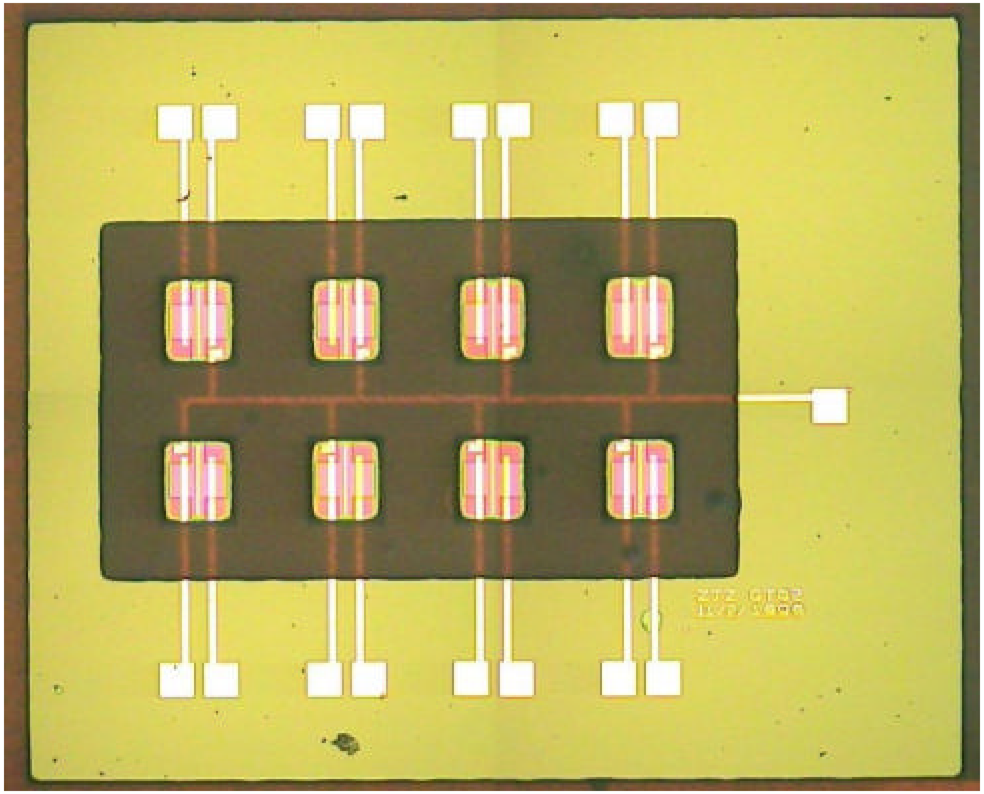
Anal.Chem. 63 (1991) 2546

OFET/IGFET TEST PLATFORM



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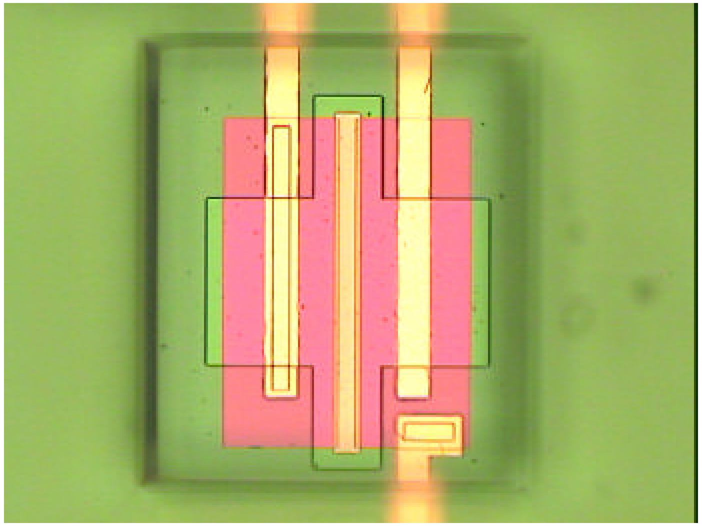
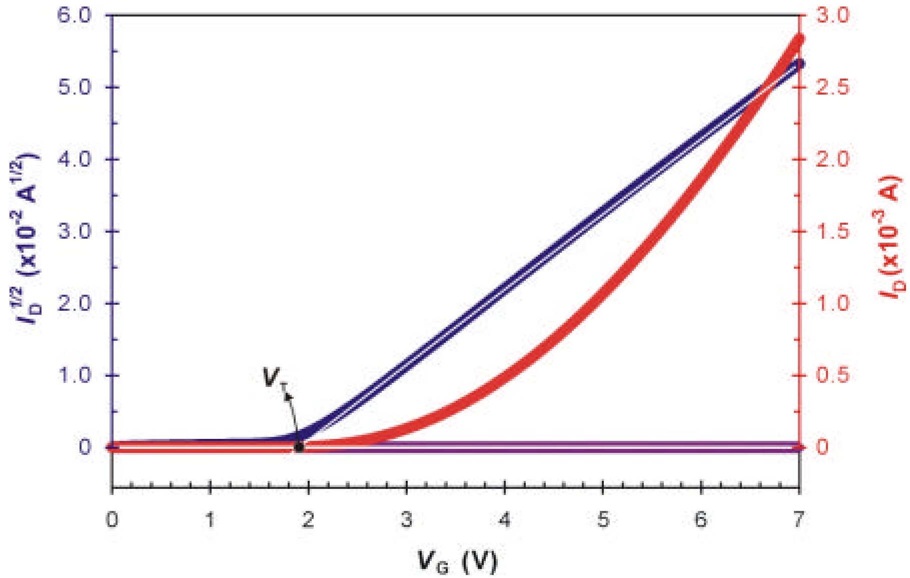
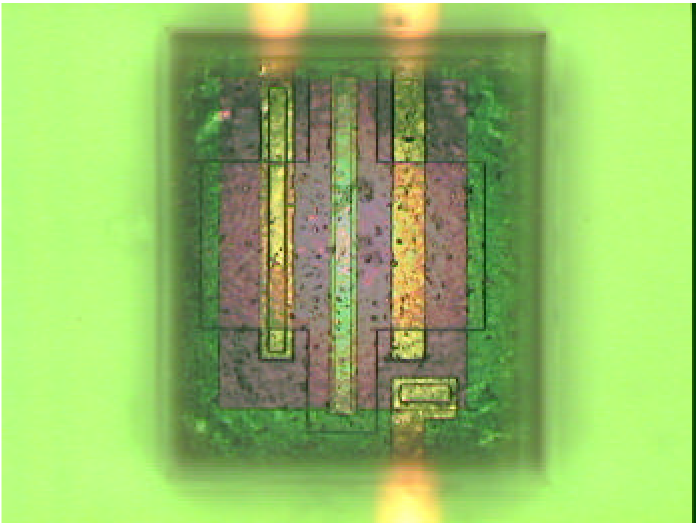
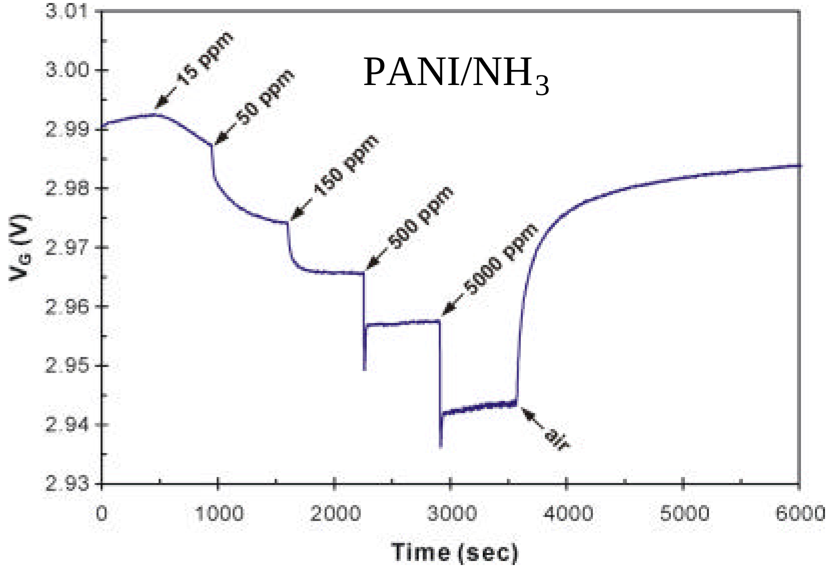
J.Phys.Chem.B. 108 (2004), 9042-9047

Chemical Sensing with PANI-ChemFET

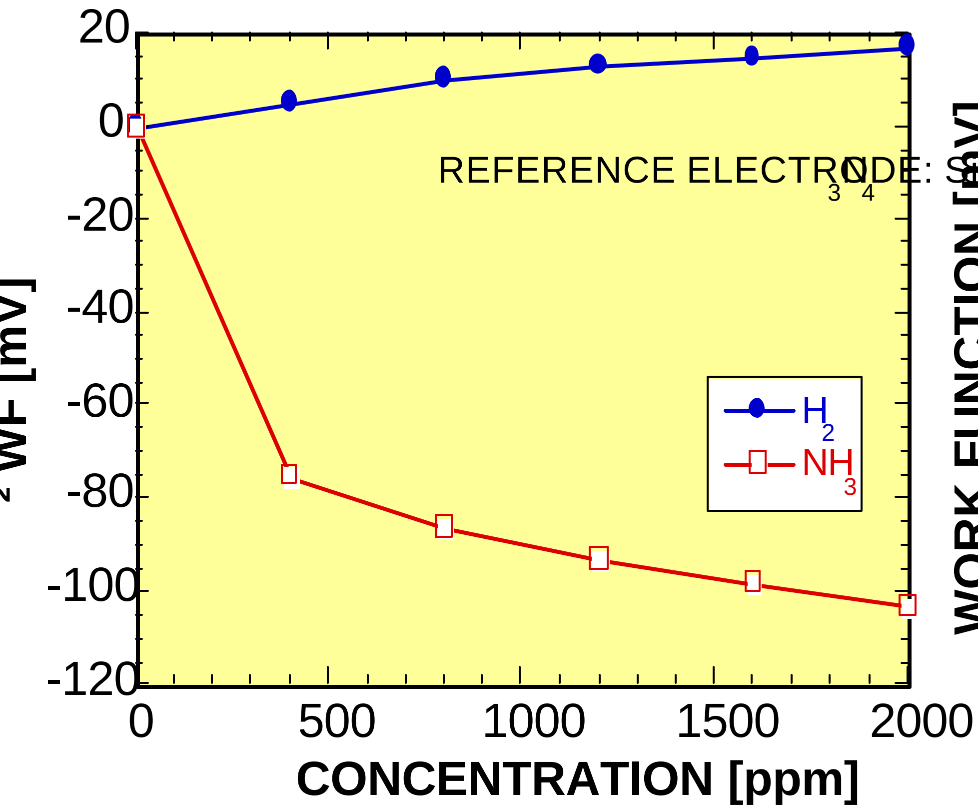




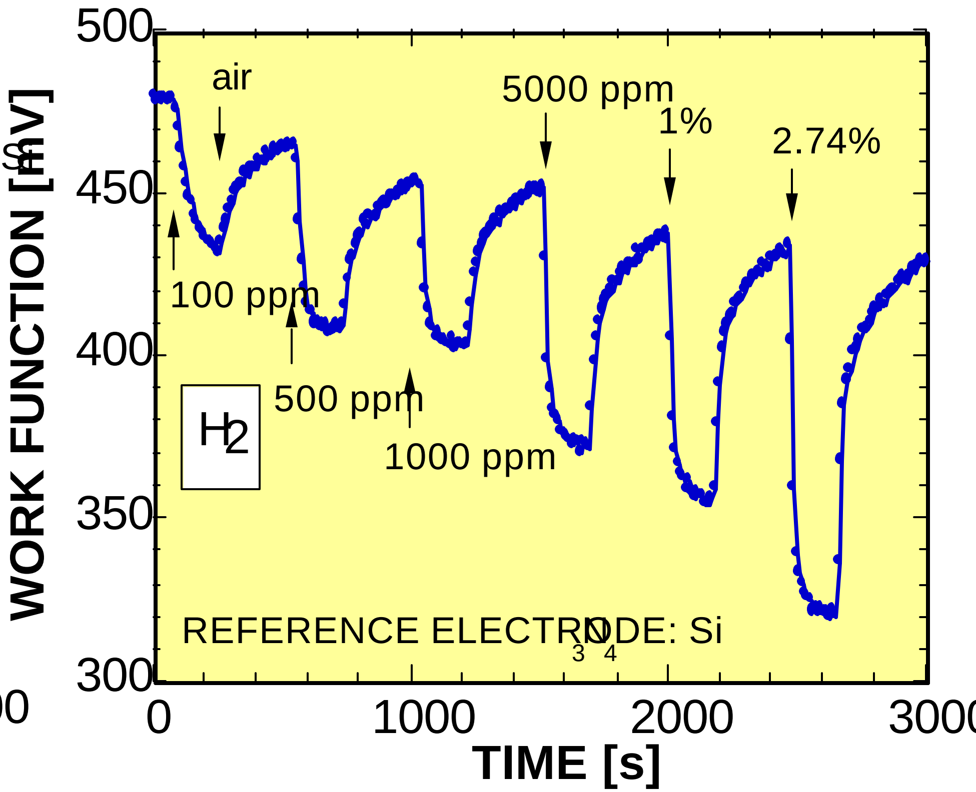




PANI in air at 120 °C



PANI-PVA with Pd clusters in air at 90 °C.



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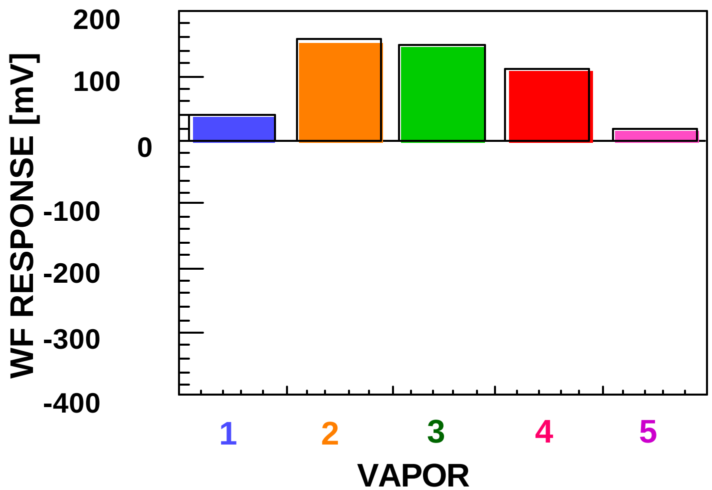
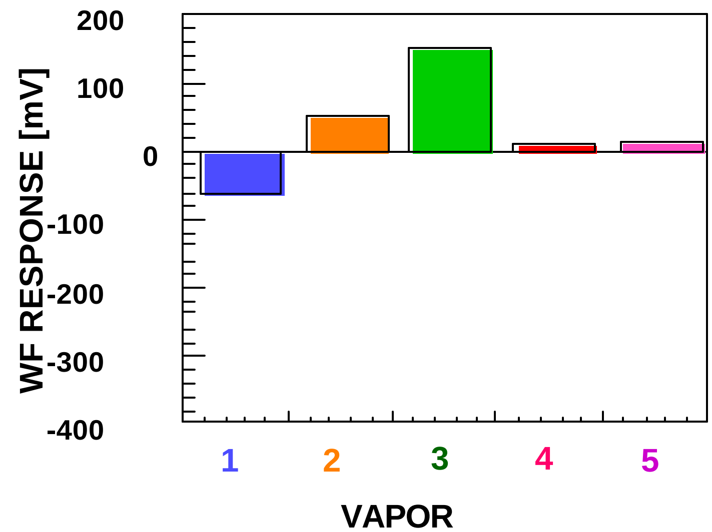
EFFECT OF INITIAL WORK FUNCTION ON SELECTIVITY

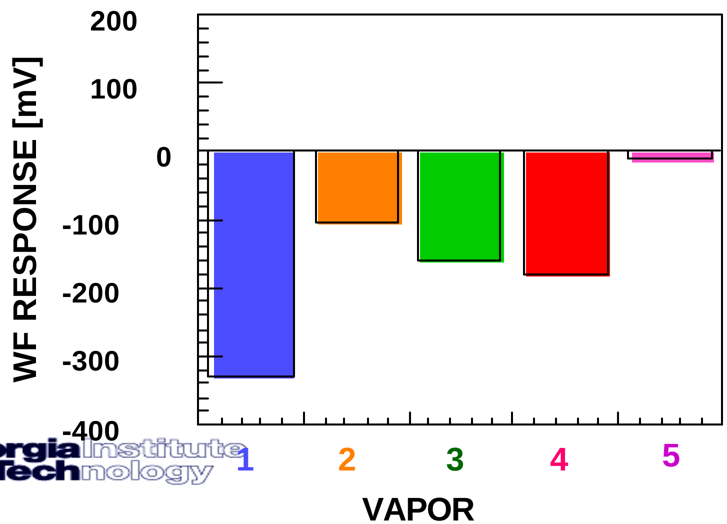
$WF_{initial}$ = 60 mV



$WF_{initial}$ = 210 mV



$WF_{initial}$ = 590 mV



1 METHANOL

2 CHLOROFORM

3 DICHLOROMETHANE

4 ISOPROPANOL

5 HEXANE

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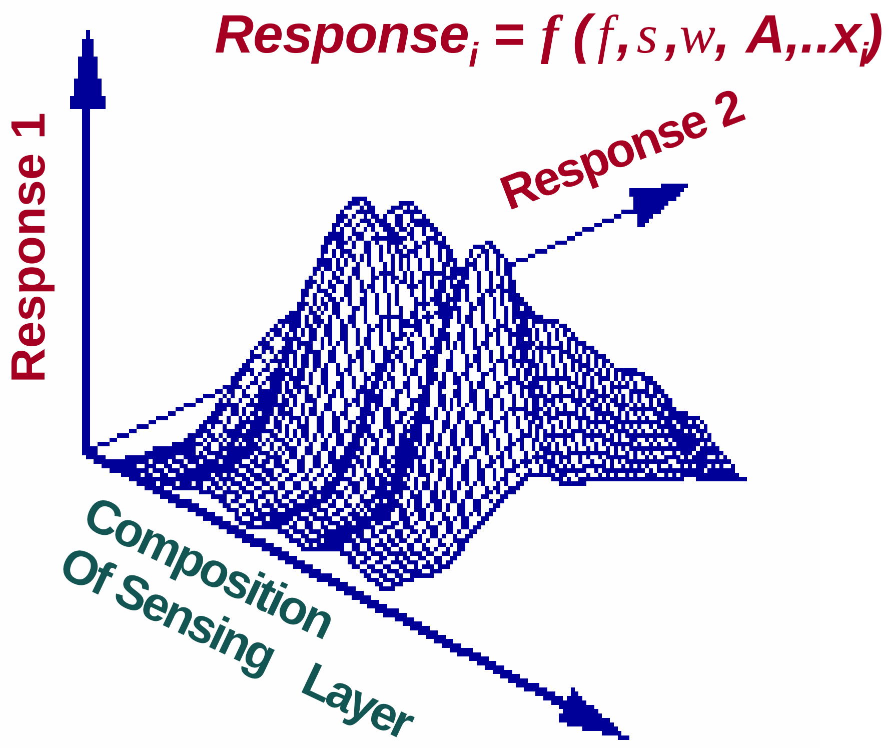
Accounts Chem. Res. 31 (1998) 241-248

Higher Order Chemical Sensors

(Extending the Feature Space in Chemical Sensing)

ENVIRONMENTAL
- detection limit
- selectivity
- stability
- dynamic range

PROCESS CONTROL
- speed
- robustness
- safety
- stability



Cost of obtaining the information must not be higher than the consequences of not having that information

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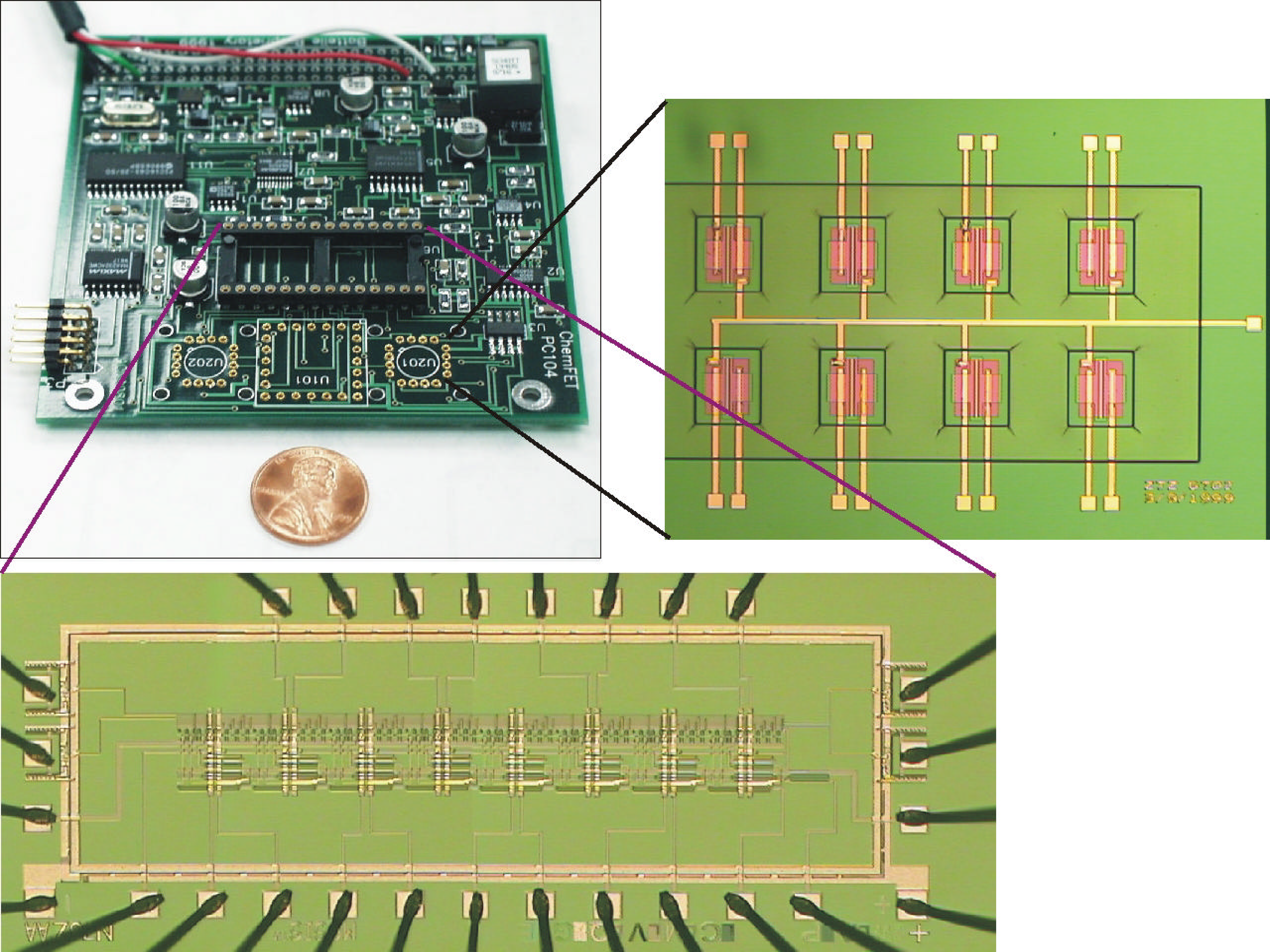
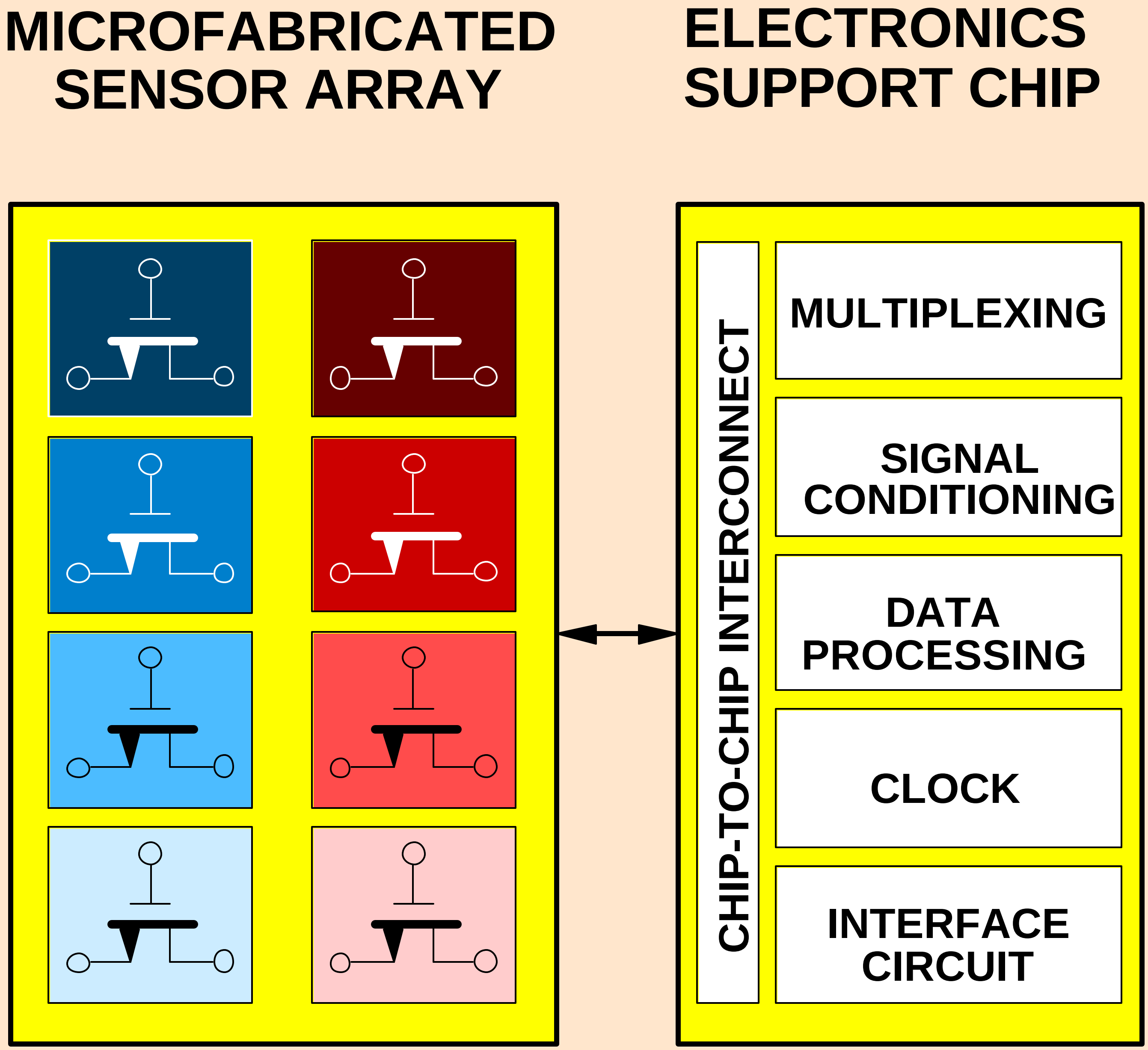

ChemFET
PC104
U202
U101
U201


MICROFABRICATED
SENSOR ARRAY
ELECTRONICS
SUPPORT CHIP
CHIP-TO-CHIP INTERCONNECT
MULTIPLEXING
SIGNAL
CONDITIONING
DATA
PROCESSING
CLOCK
INTERFACE
CIRCUIT

ARRAY OF CHEMICAL SENSING ARRAYS

OBJECTIVES

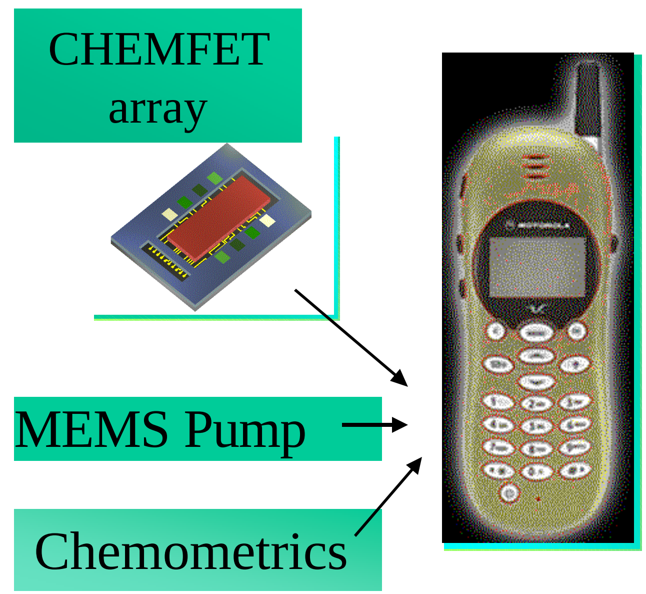
- Combine advanced sensing and modern communication technology
- Develop library of interchangeable sensing modules for targeted applications
- Construct “superarray”

APPROACH

- Develop solid state sensing array platform
- Design sample delivery systems
- Optimize chemometric package

APPLICATIONS

- Personal hygiene
- Health care monitoring
- Personal safety
- Remote environmental monitoring
- Military monitoring
- Veterinary medicine



TAKE-HOME MESSAGES

- "ORGANIC ELECTRONICS" EXPOSED TO ENVIRONMENT BECOMES ELECTROCHEMICAL SENSOR
- SENSING PROPERTIES CAN BE TUNED ELECTROCHEMICALLY OR CHEMICALLY
- SILICON/SILICON OXIDE/NITRIDE SYSTEM IS IMMUNE TO ENVIRONMENTAL CHANGES

THANK YOU!

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