Sensori per il territorio e la città intelligente

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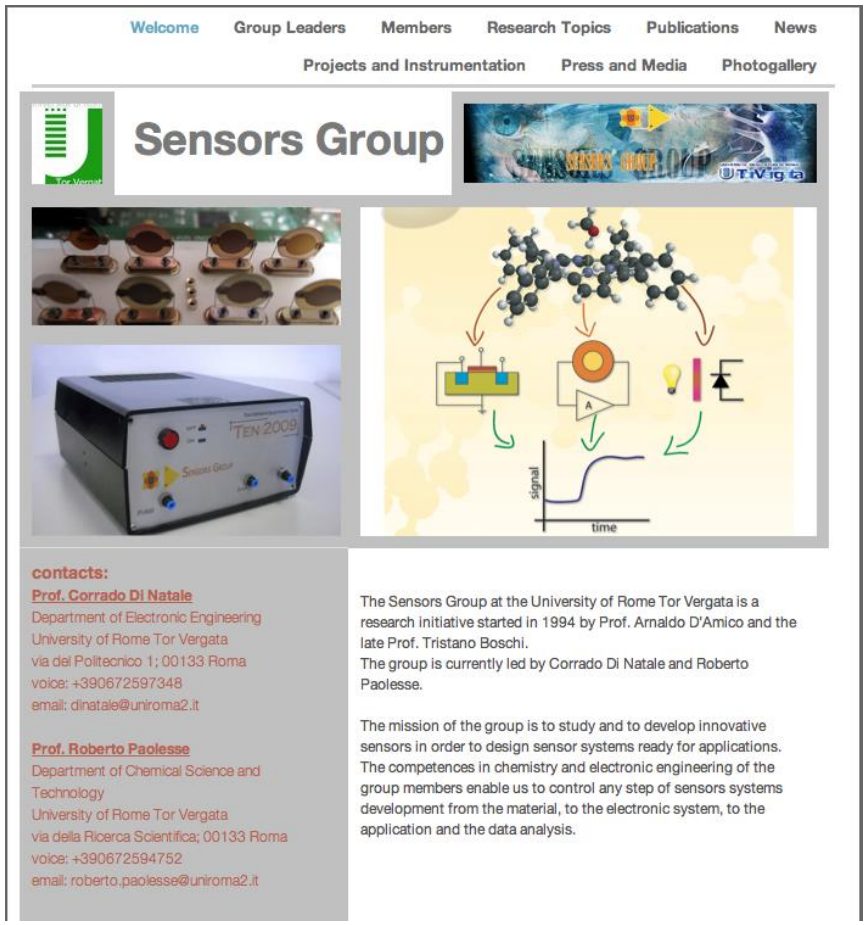


Research topics

Material science for sensors

- design and synthesis of artificial receptors:
  - porphyrinoids
  - poly-peptides
- molecular self-assembly and nanostructures
- hybrid materials:
  - porphyrins: ZnO / CNT / Graphene
- Characterization
  - Kelvin probe, AFM, optical methods

Sensors technology

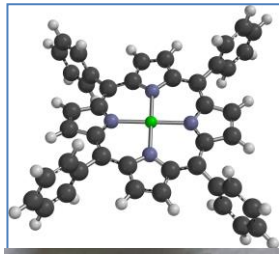
- mass, optics, impedance, ChemFET
- electronics for sensors

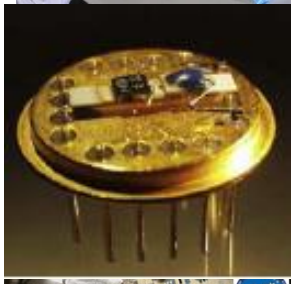
Artificial olfaction and taste

- electronic nose
- electronic tongue
- applications to food control, medical diagnosis, environmental control

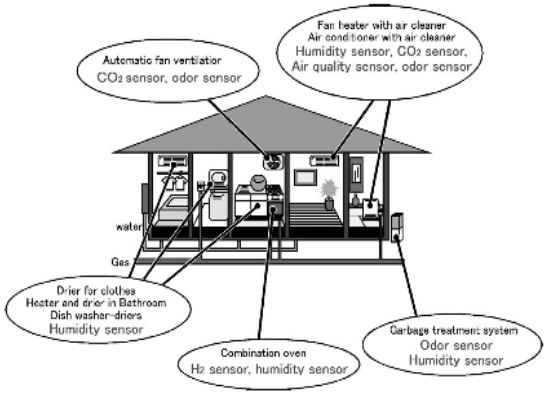
Multivariate data analysis

- chemometrics and neural networks
- QSAR modelling of chemical sensors
- Bio-inspired algorithms for artificial senses
- Data fusion
- Multispectral imaging




Sensori per……


Automatic fan ventilator
CO2 sensor, odor sensor
Fan heater with air cleaner
Air conditioner with air cleaner
Humidity sensor, CO2 sensor,
Air quality sensor, odor sensor
water
Gas
Drier for clothes
Heater and drier in Bathroom
Dish washer-driers
Humidity sensor
Combination oven
Hz sensor, humidity sensor
Garbage treatment system
Odor sensor
Humidity sensor

Strumenti di misura

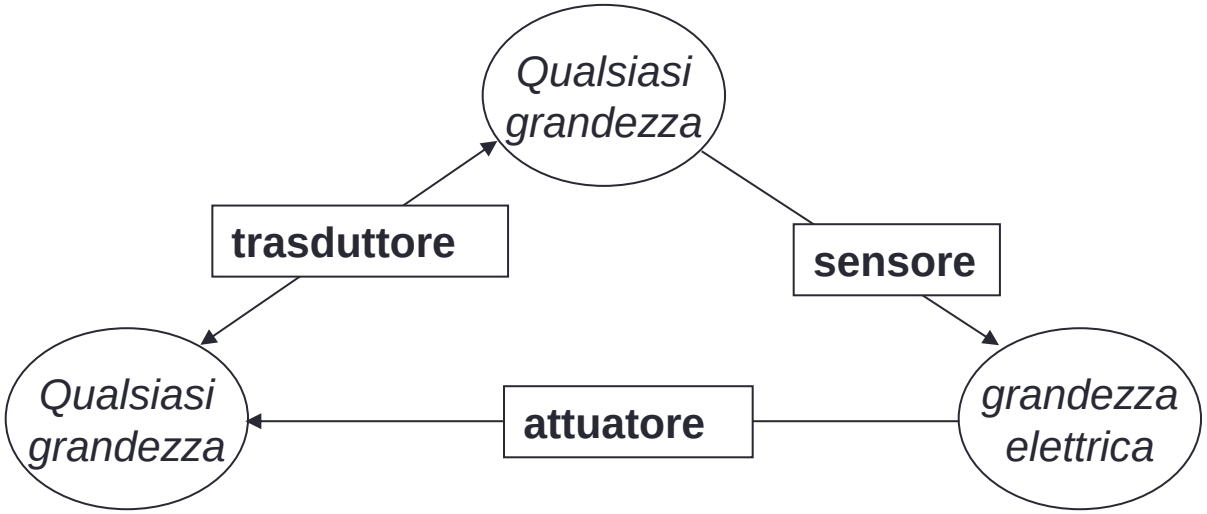
- Poche grandezze fisiche sono direttamente misurabili dai nostri sensi (lunghezza, colore, angolo,…).
- Tutte le altre per essere misurate devono essere convertite in una grandezza direttamente misurabile.

espansione termica: $\Delta T \Rightarrow \Delta L$

reazione fotochimica: $\Delta pH \Rightarrow \Delta colore$

equilibrio tra forza peso e forza elastica: $\Delta M \Rightarrow \Delta \alpha$

Trasduttori, sensori ed elettronica



- *Termometro ad espansione: temperatura lunghezza= transduttore*
- *Termistore: temperatura resistenza elettrica= sensore*
- I sensori sono componenti dei circuiti elettronici.
- Grazie ai sensori, le grandezze elettriche (corrente e tensione) acquistano il significato delle grandezze ambientali.

Sensori come dispositivi elettronici

- **Resistenze**
  - *termistori, fotorivelatori, magnetoresistenze, strain gauge, sensori di gas…*
- **Induttanze**
  - *Sensori di posizione, sensori di campo magnetico…*
- **Condensatori**
  - *Sensori di posizione, sensori di umidità…*
- **Diodi**
  - *Fotodiodi, sensori di campo magnetico,…*
- **MOSFET**
  - *Sensori di campo magnetico, sensori di ioni in soluzione, sensori di gas…*
- **Potenziale elettrico**
  - *Sonde di Hall (sensori di campo magnetico), Elettrodi iono-selettivi,…*
- **Forza elettromotrice (f.e.m.)**
  - *Termocoppie, celle fotovoltaiche, celle elettrochimiche (ioni e gas),…*

I sensi naturali

Luce
fotoni con λ=400-700 nm

Suono
onde di pressione con f=10-10^3 Hz

Odore
alcuni composti volatili

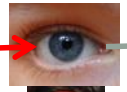
Pressione
temperatura
carica elettrica

Gusto
Alcune molecole in soluzione

Percezione, associazione memoria

comunicazio
ne della
esperienza

Associazione, mem



Esperienza sensoriale
acquisita

La rivoluzione scientifica

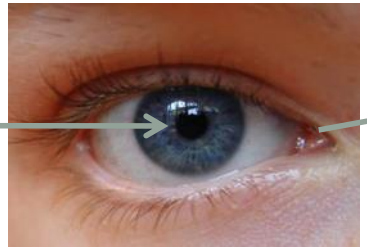
il dominio della vista

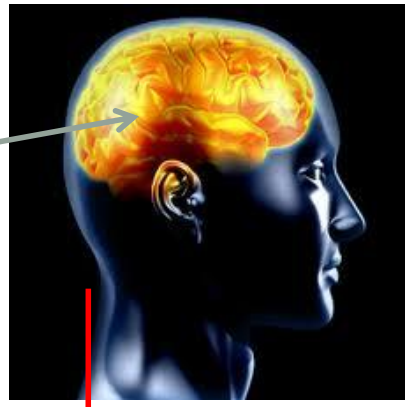
Percezione, associazione memoria

Radiazione IR, UV, radio
Luce e immagini
Suono
Campo magnetico
Pressione
Forza
Termperatura
Potenziole elettrico
odore
……

Strumenti di misura

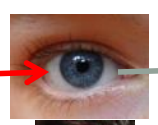
DISPLAY





comunicazione della esperienza

Associazione, memo



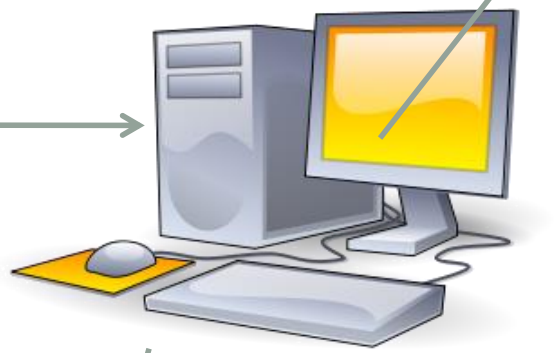
Esperienza sensoriale acquisita

Rivoluzione digitale

Radiazione IR, UV, radio, x
Luce e immagini
Suono
Campo magnetico
Pressione
Forza
Termperatura
Potenziole elettrico
odore
……

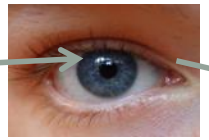
SENSORE

processamento, conservazione



Percezione, associazione me

comunicazione digitale della esperienza sensoriale

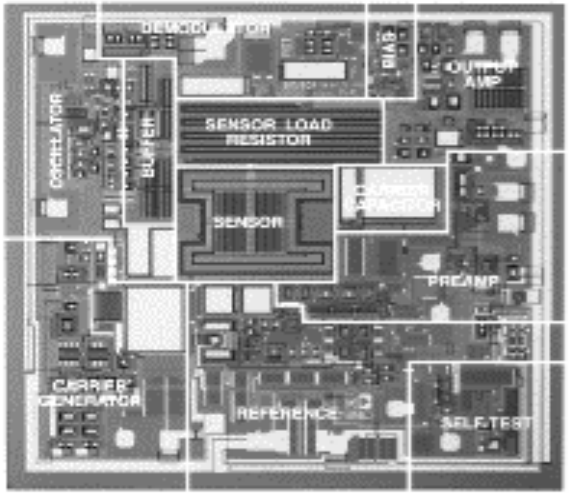


Percezione, associazione mem

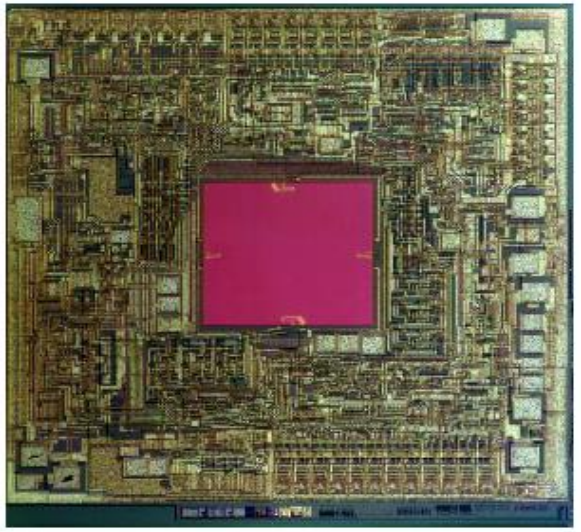
Sensori integrati

- Le tecnologie della microelettronica consentono di realizare dei sistemi meccanici integrati con I sistemi elettronici
  - MEMS (Micro Electro Mechanical Systems)

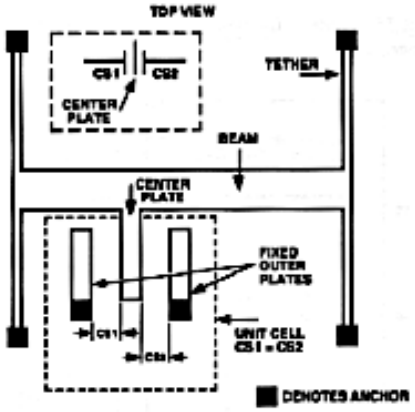
accelerometro

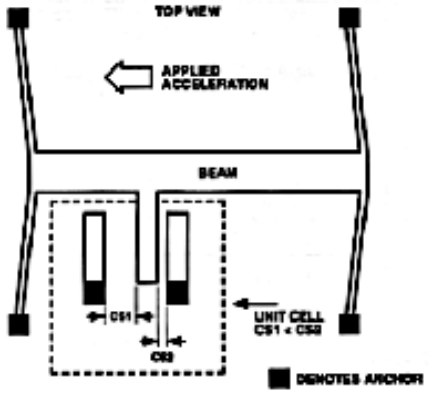


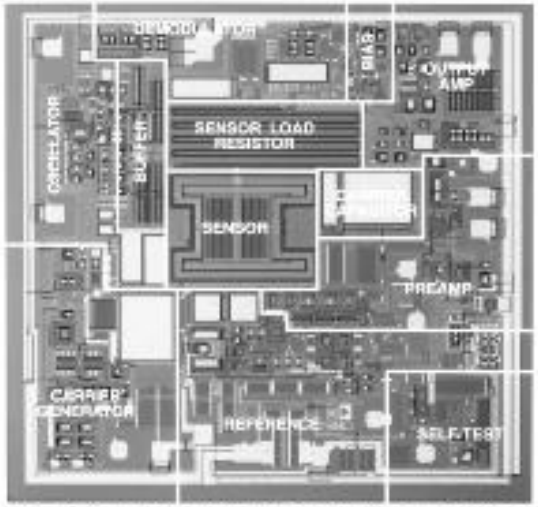
sensore di pressione



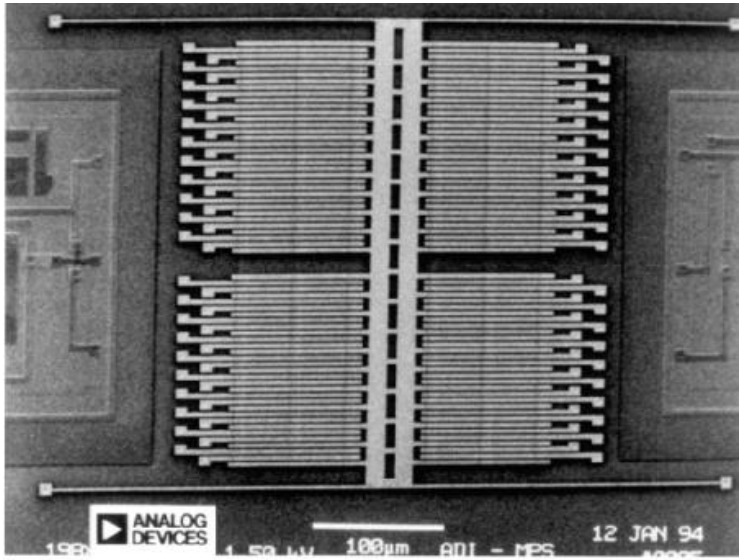
Accelerometro integrato
ADXL50 per airbag controller

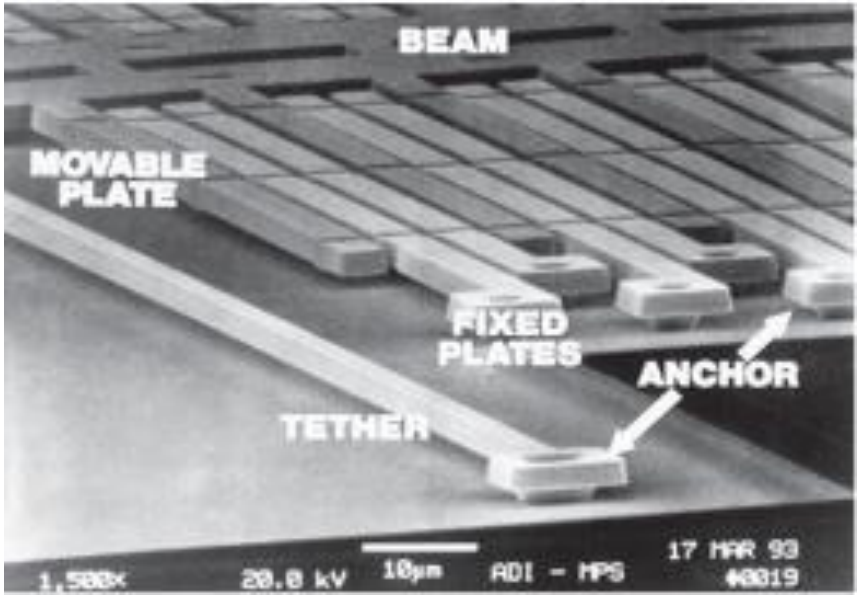




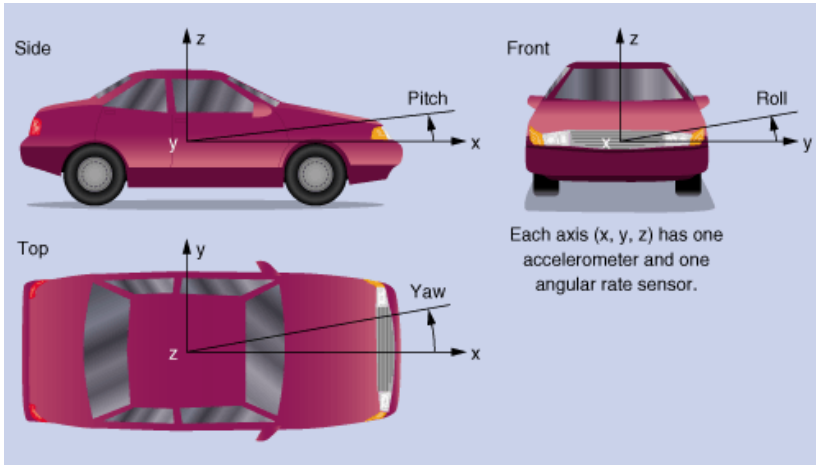


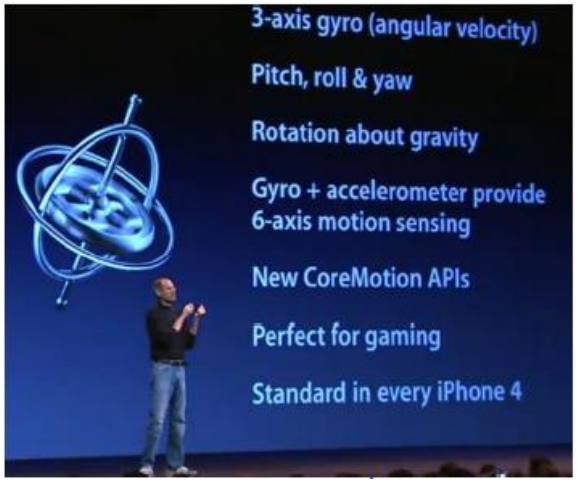
Analog Devices' ADXL-50, the industry's first surface micromachined accelerometer, includes signal conditioning on chip.





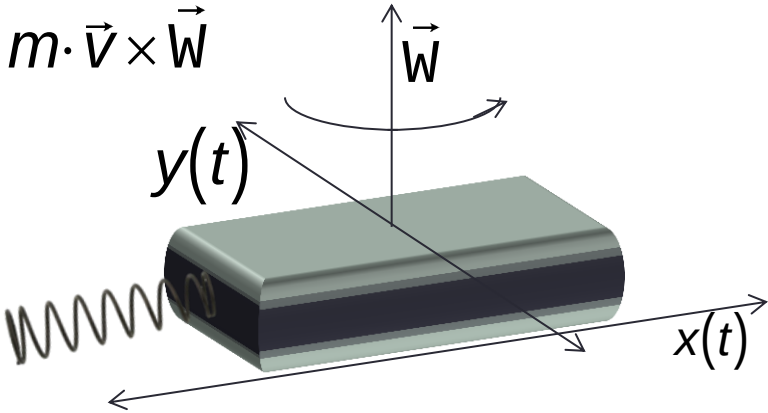
Giroscopio
Sensore di velocità angolare



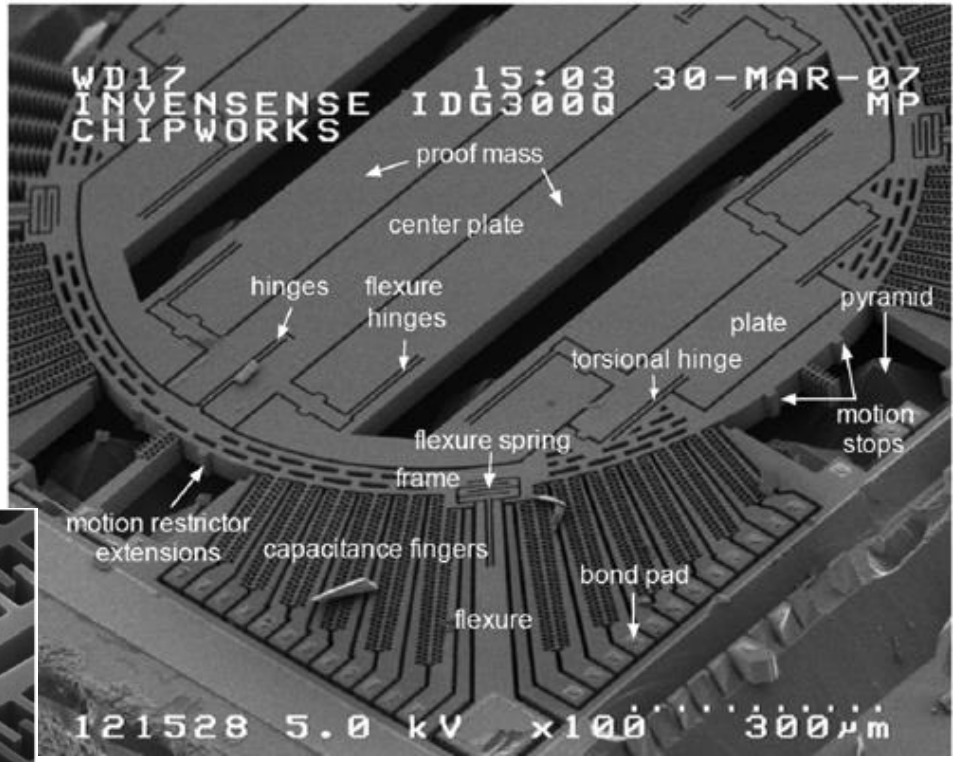


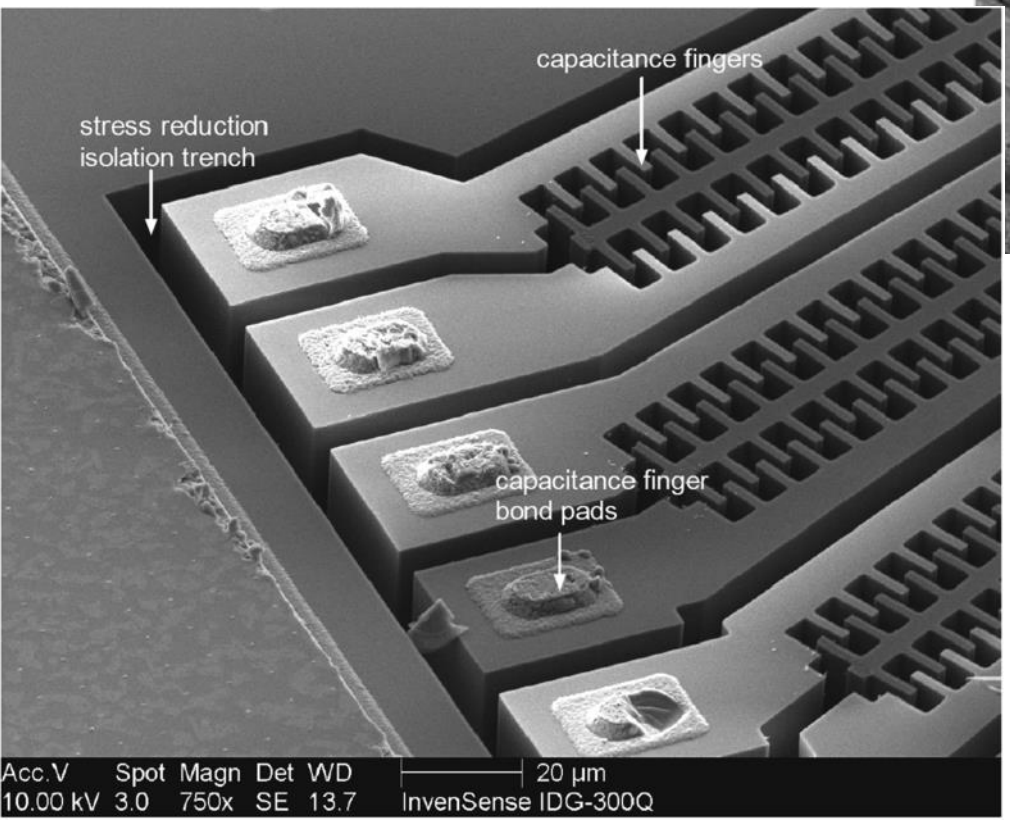
Il giroscopio si basa sulla forza di coriolis: che agisce su una massa M con velocità v in un sisema di riferimento che ruota con velocità angolare Ω

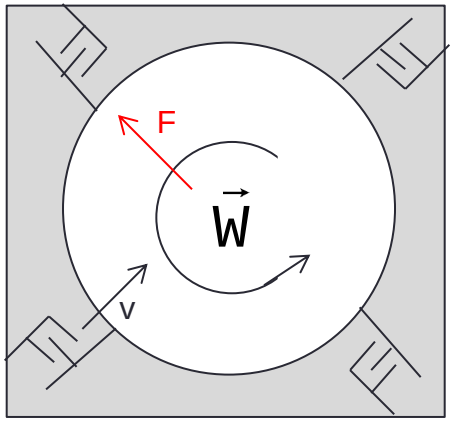
$$\vec{F} = 2 \cdot m \cdot \vec{v} \times \vec{W}$$



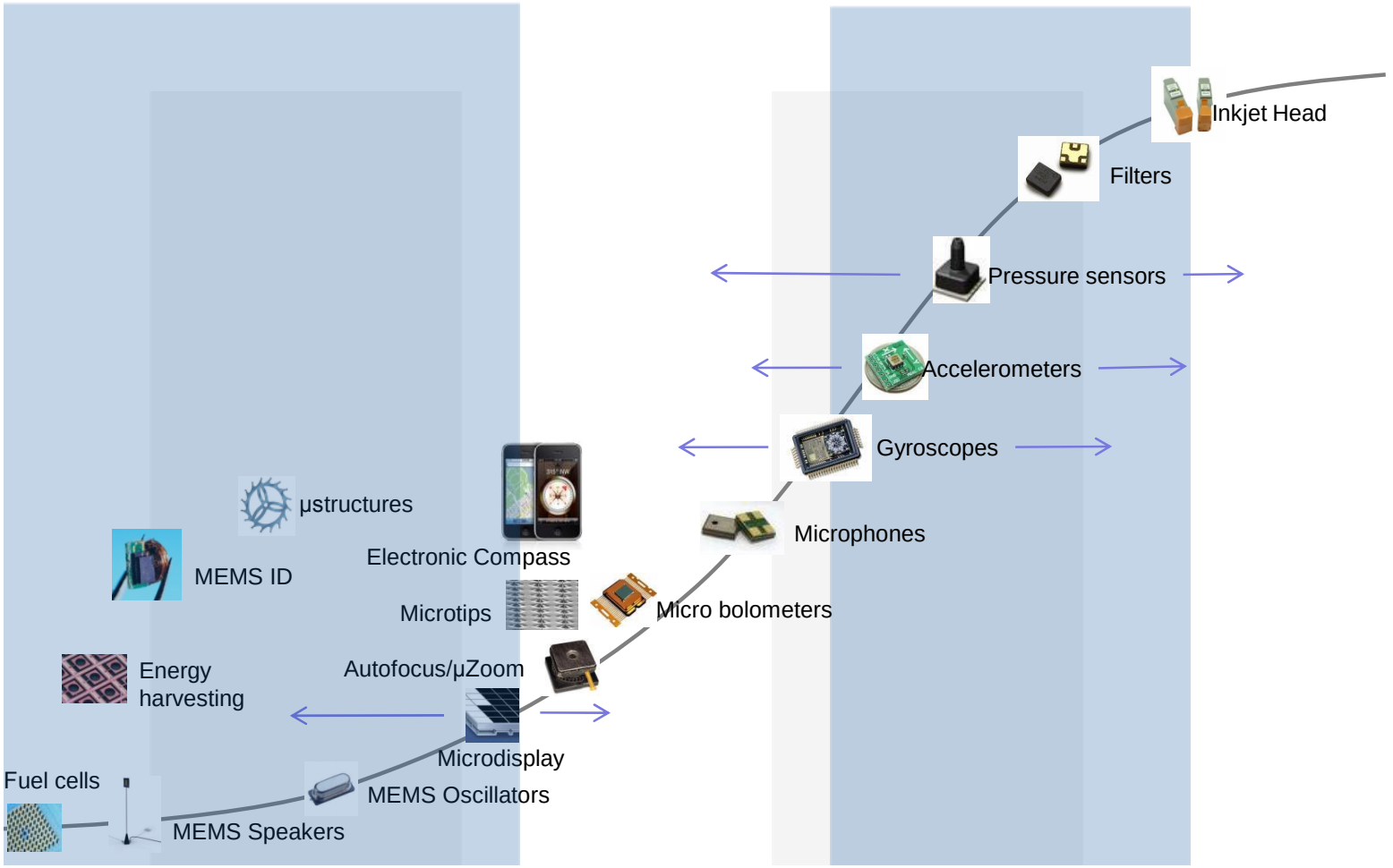
Giroscopio integrato



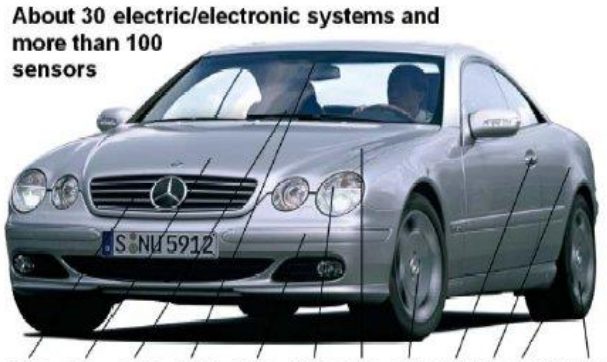




MEMS state of the art

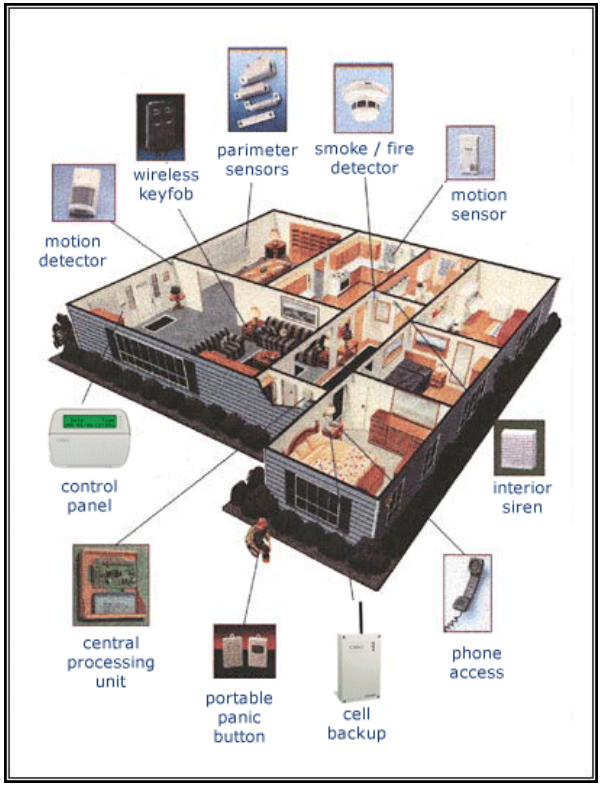


sensori ubiqui



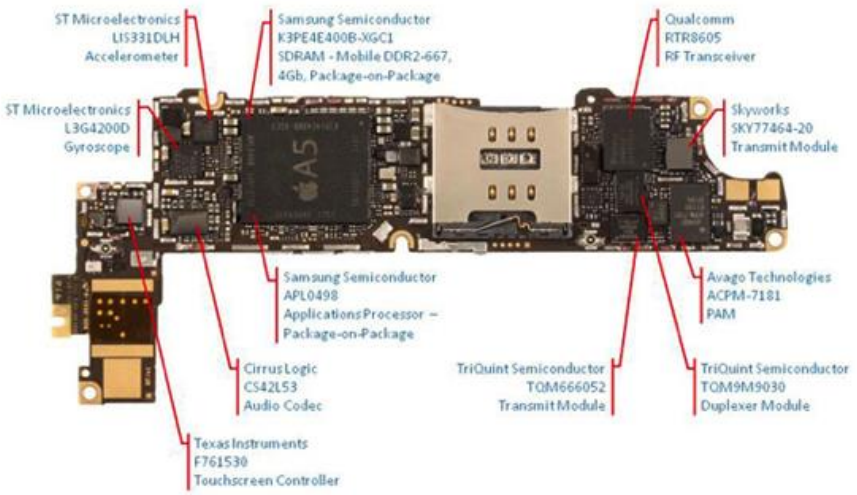
System	Abb.	Sensors			
Distronic	DTR	3	Common-rail diesel injection	CDI	11
Electron. controlled transmission	ECT	9	Automatic air condition	AAC	13
Roof control unit	RCU	7	Active body control	ABC	12
Antilock braking system	ABS	4	Tire pressure monitoring	TPM	11
Central locking system	ZV	3	Elektron. stability program	ESP	14
Dyn. beam levelling	LWR	6	Parktronic system	PTS	12

Figure 1: Car functions and the respective sensors (source: based on DaimlerChrysler)

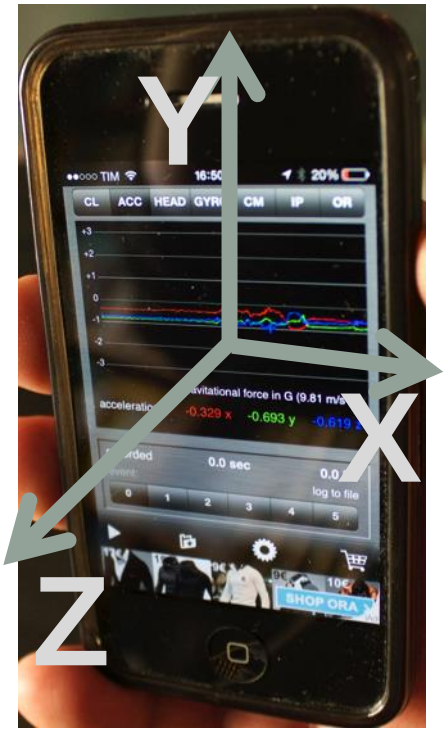


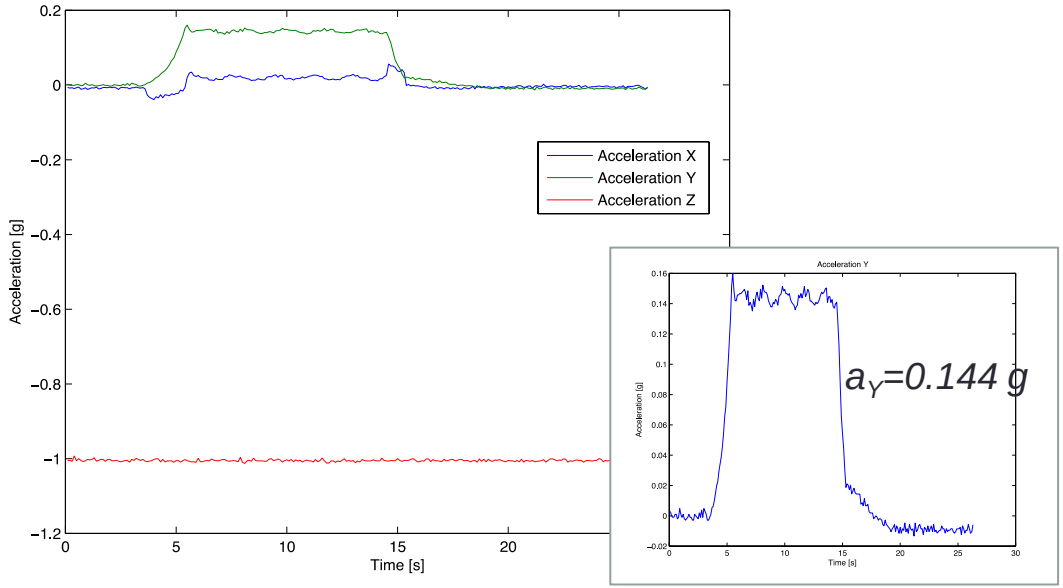
Apple iPhone 4S 16GB

Disassembly – Main PCB, Top

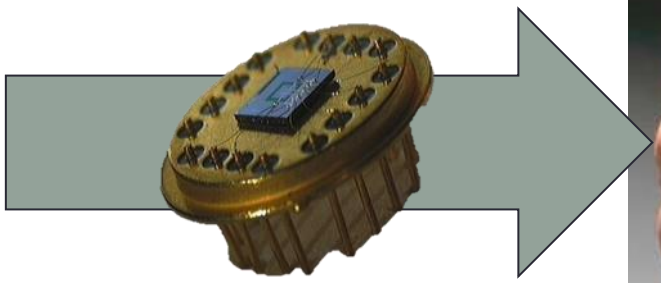


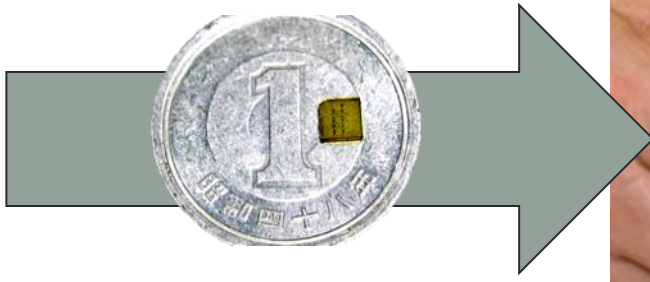
Source: IHS



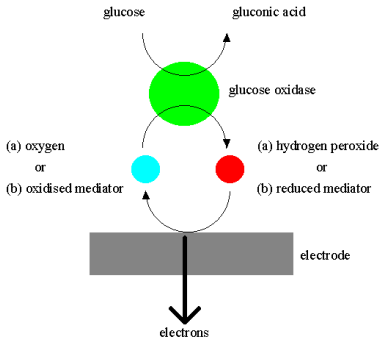


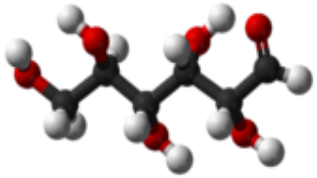
Personal analyzer





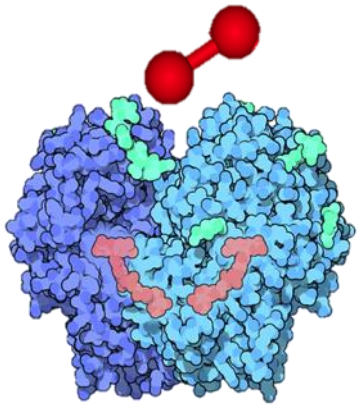
Glucose meter





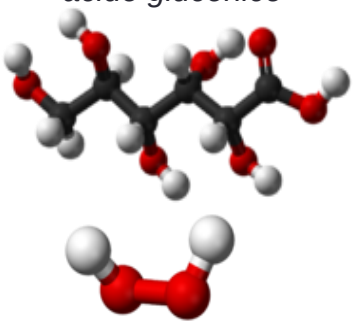
glucosio

O_2



glucosio ossidasi

acido gluconico

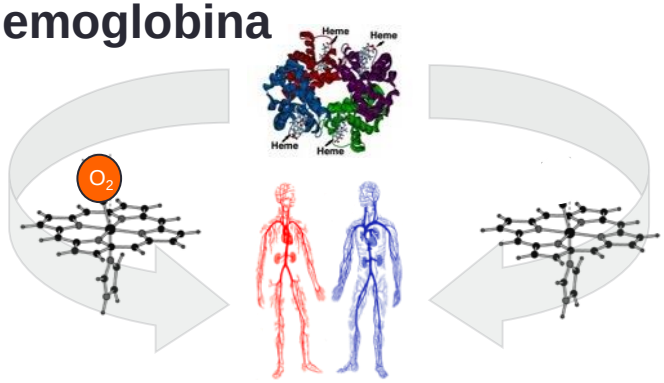


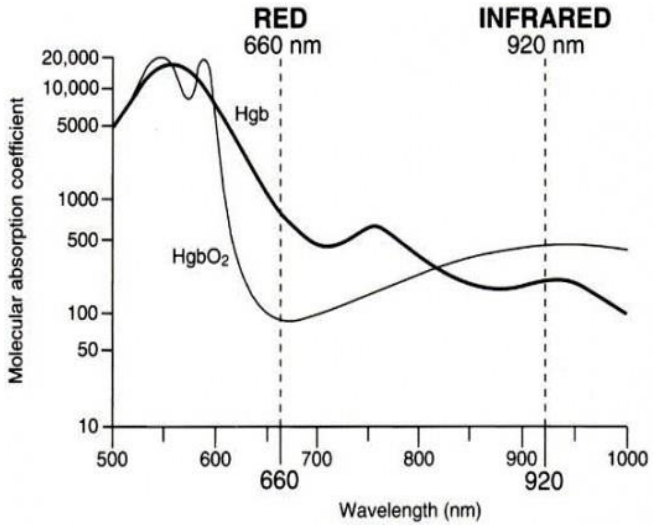
H_2O_2

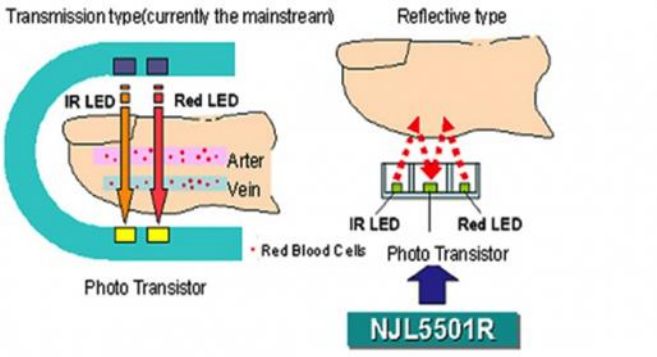
Mediatori ottici

Molecole che cambiano lo spettro di assorbimento in conseguenza del legame con un analita.

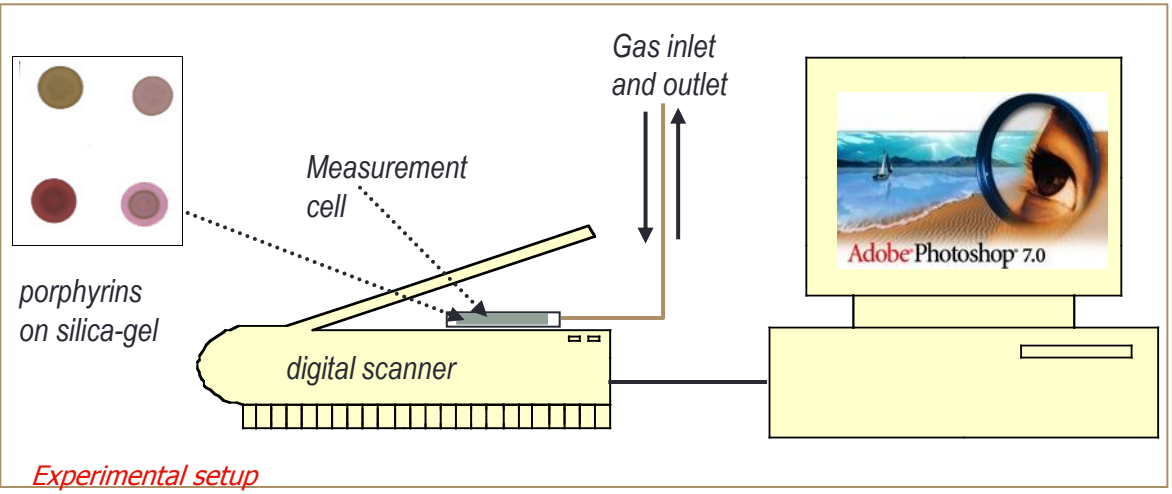
Esempio:
emoglobina



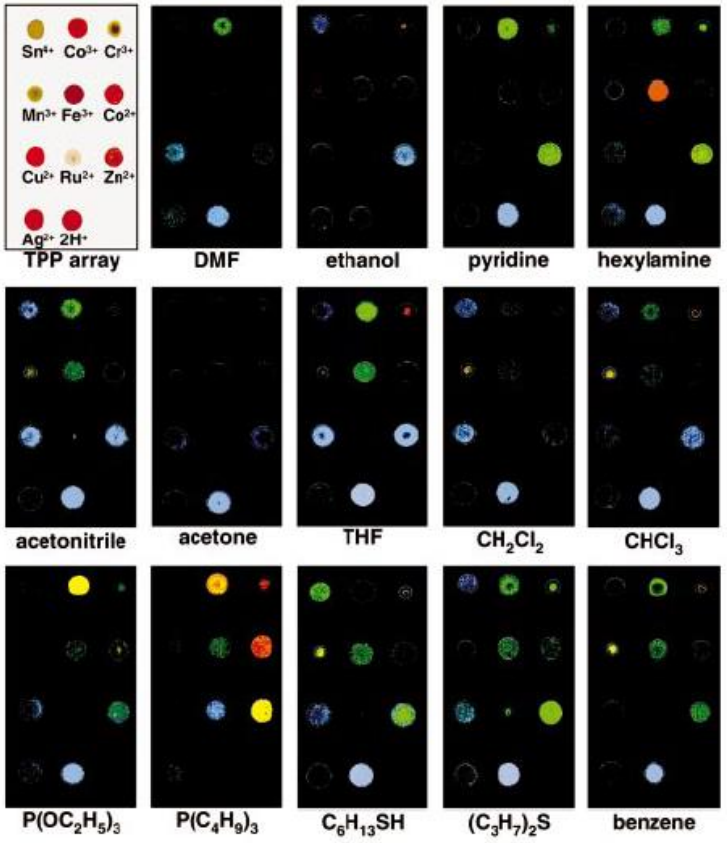




Colorimetria con scanner digitali

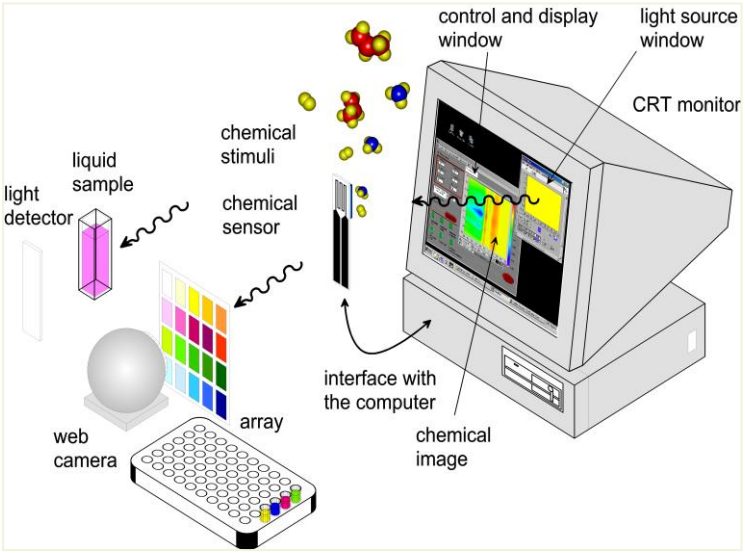


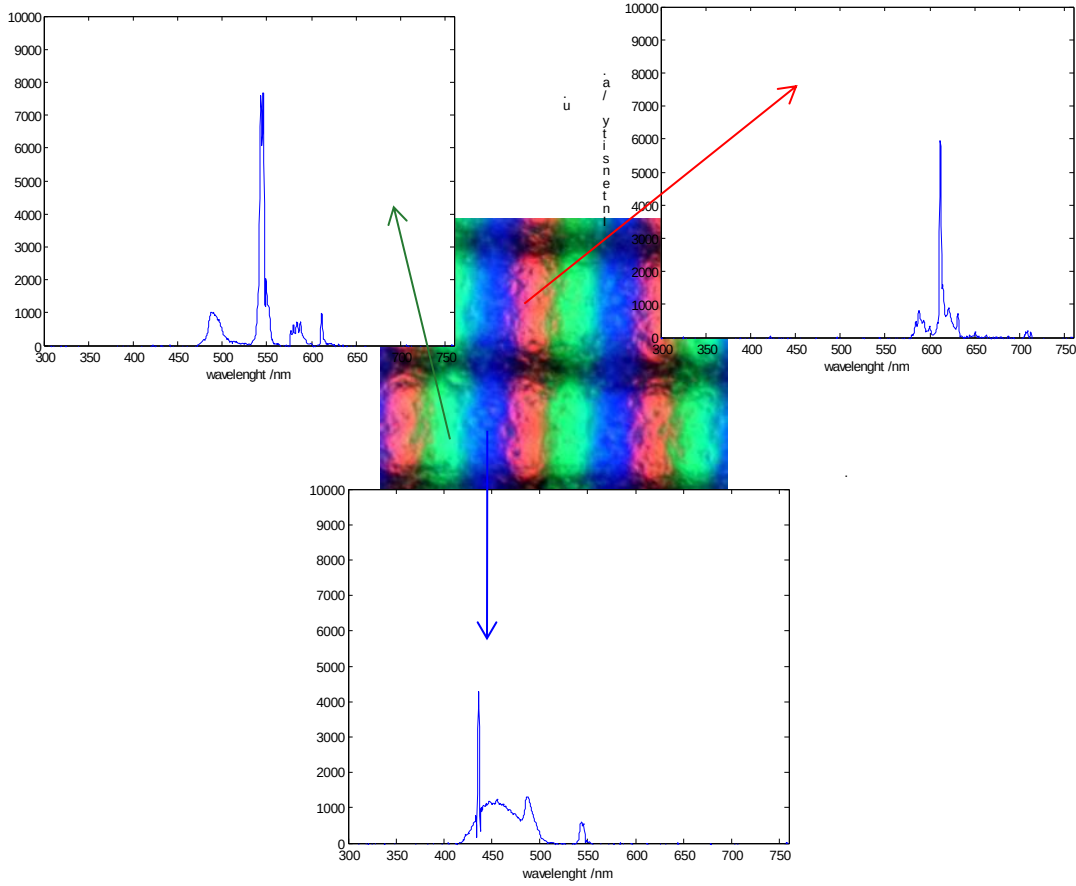
Experimental setup



Suslick et al. , Nature. **2000**

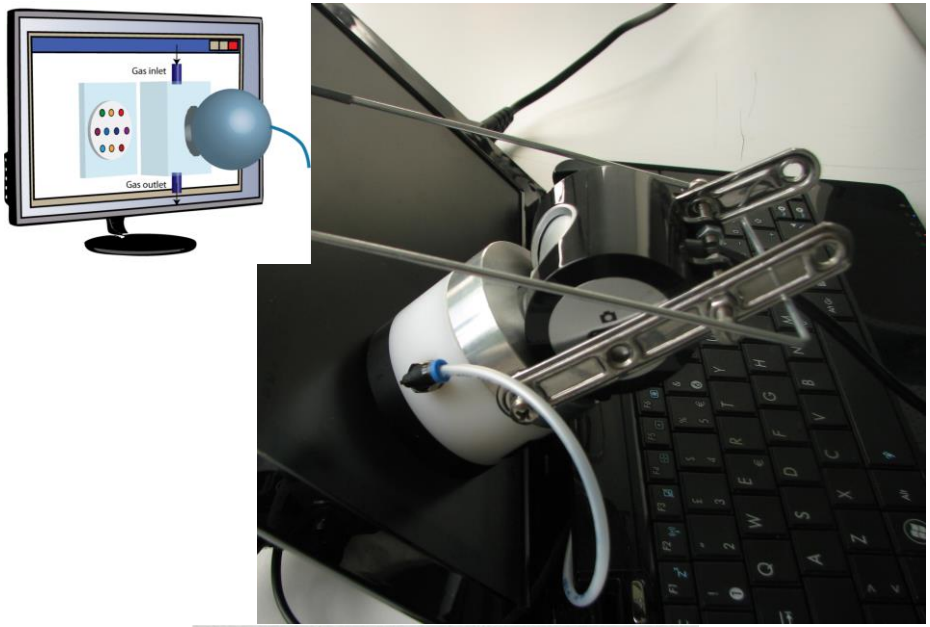
Computer Screen Photoassisted Technology

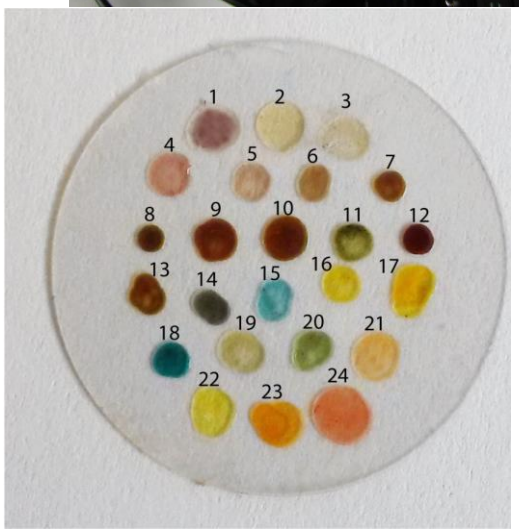


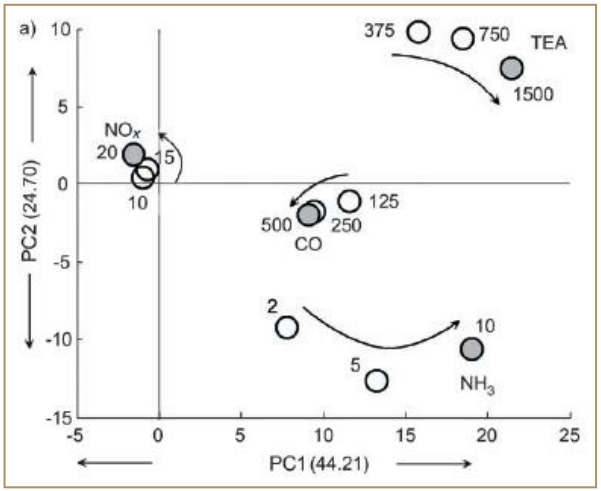


Filippini and Lundström, Chem. Comm. **2002**

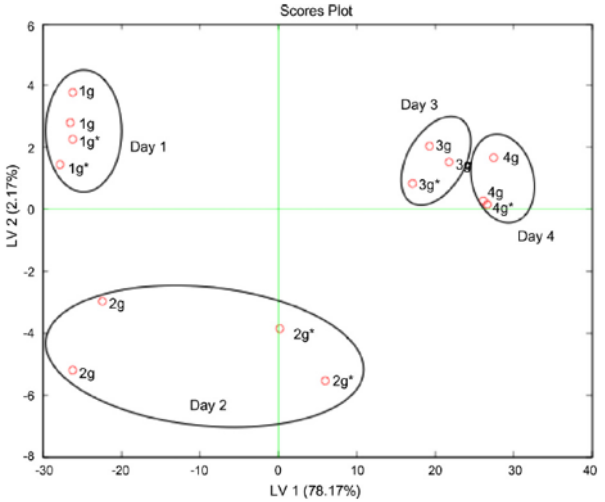
Analisi chimica con matrici di indicatori naso elettronico





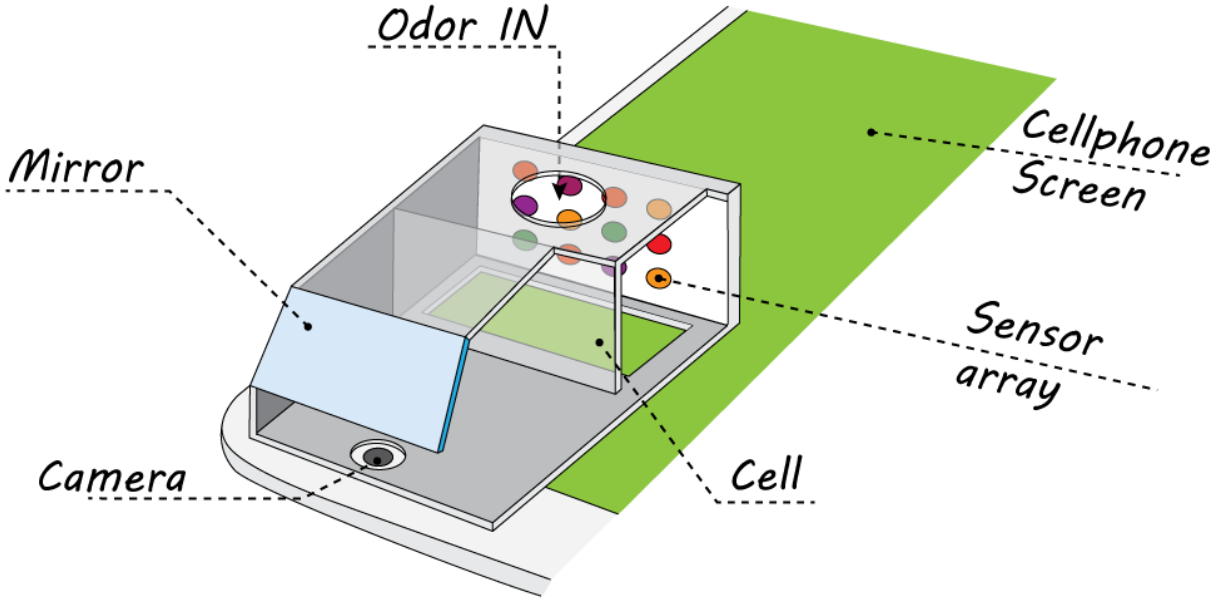


Filippini et al. Angew Chemie Int. Ed. , **2006**



Di Natale et al. Anal. Chim. Acta , **2007**

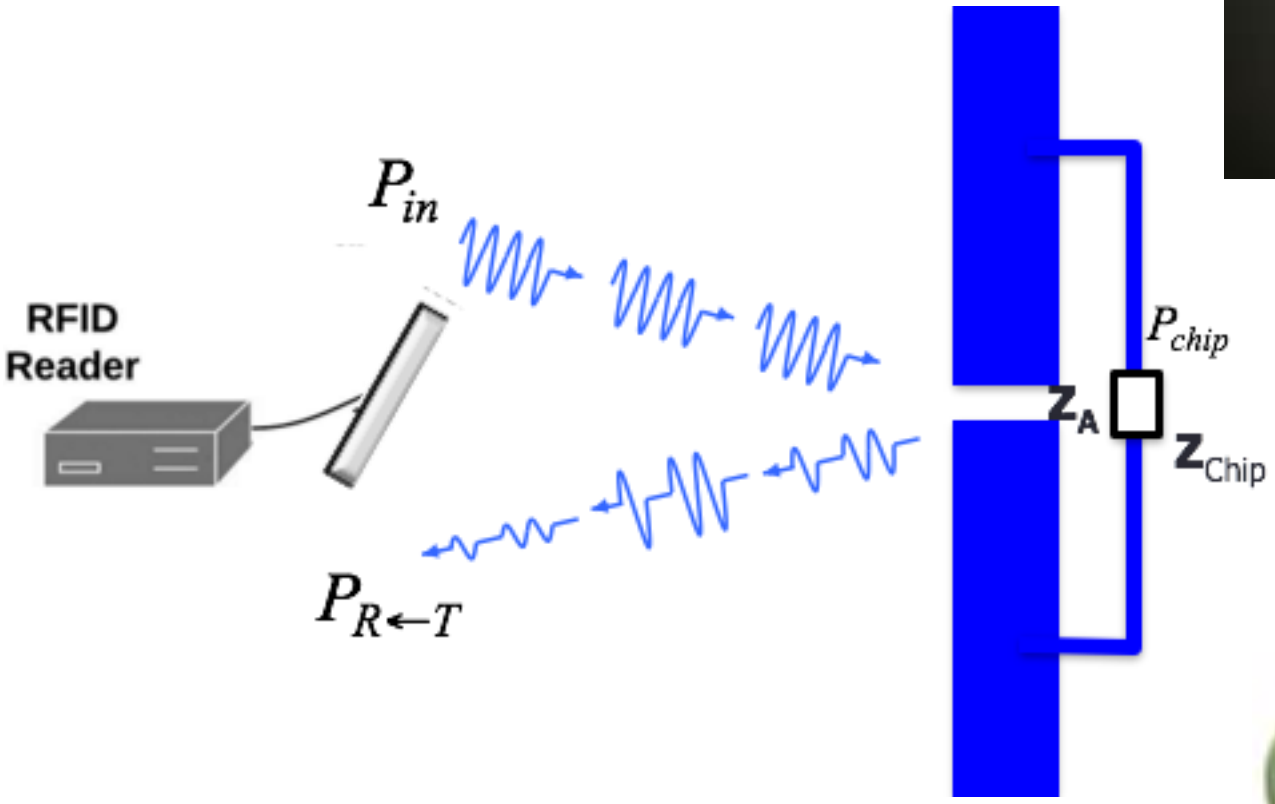
CSPT on a cellphone

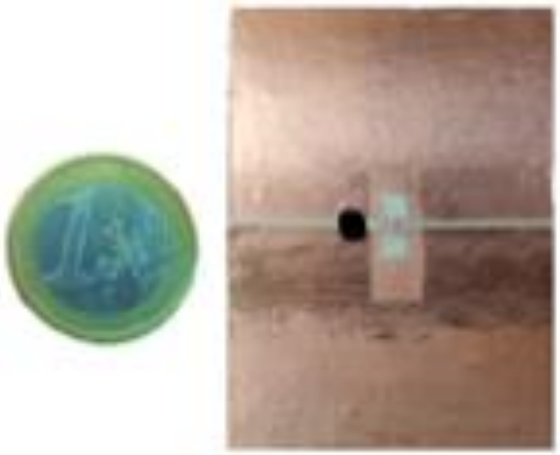


useful area

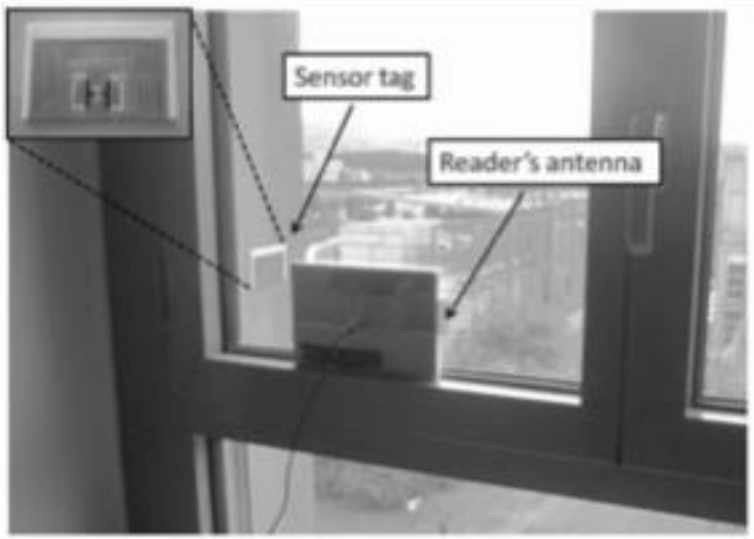
camera

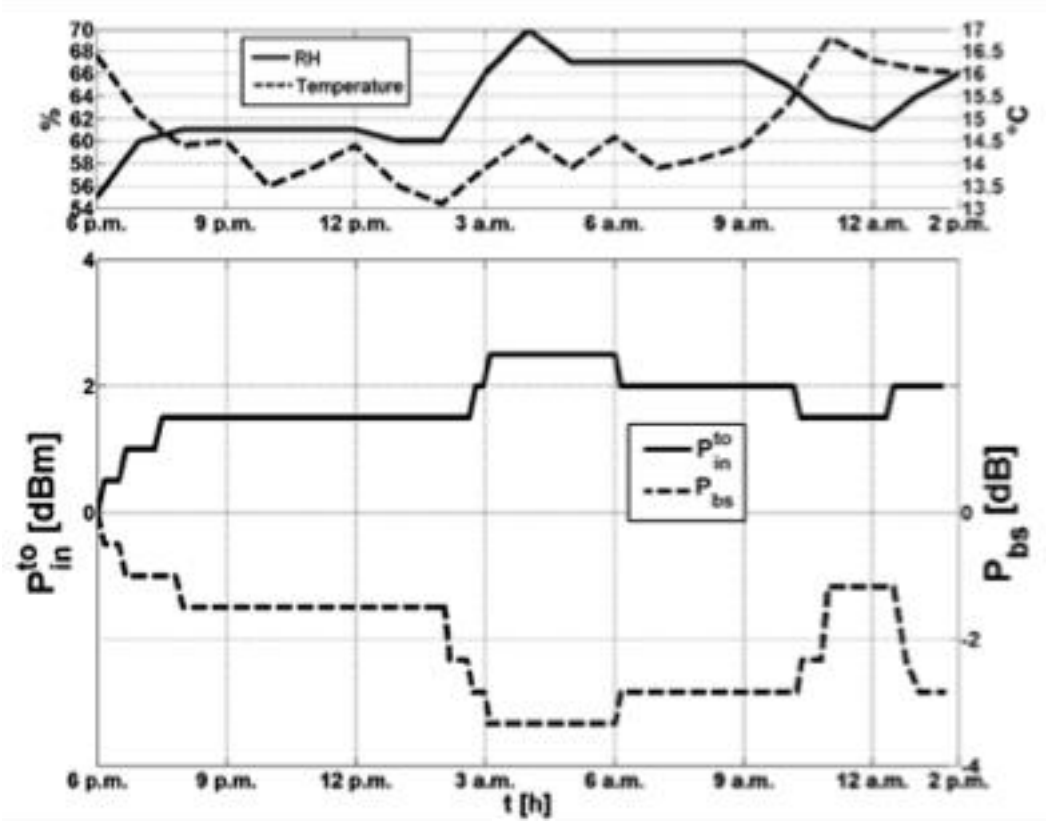
RFID technology





RFID sensors
real-time humidity monitoring





Manzari et al. IEEE Sens J, 2012

Conclusioni

- I sensori moderni sono componenti elettronici.
- L'elettronica e le telecomunicazioni offrono un supporto senza precedenti all'utilizzo dei sensori e alla diffusione e alla fruizione delle informazioni sensoriali.
- Questo sviluppo comporta la distribuzione delle capacità analitiche ai singoli individui.
- La "smart city" è il luogo degli "smart citizens" che possono controllare. direttamente lo stato del proprio ambiente a cominciare dal proprio corpo.
- La sensorialità è necessaria all'intelligenza.
  - *Nihil est in intelectum nisi prius fuerit in sensu*