

CSEM Technologies that make the difference

Dr. Marc Schnieper

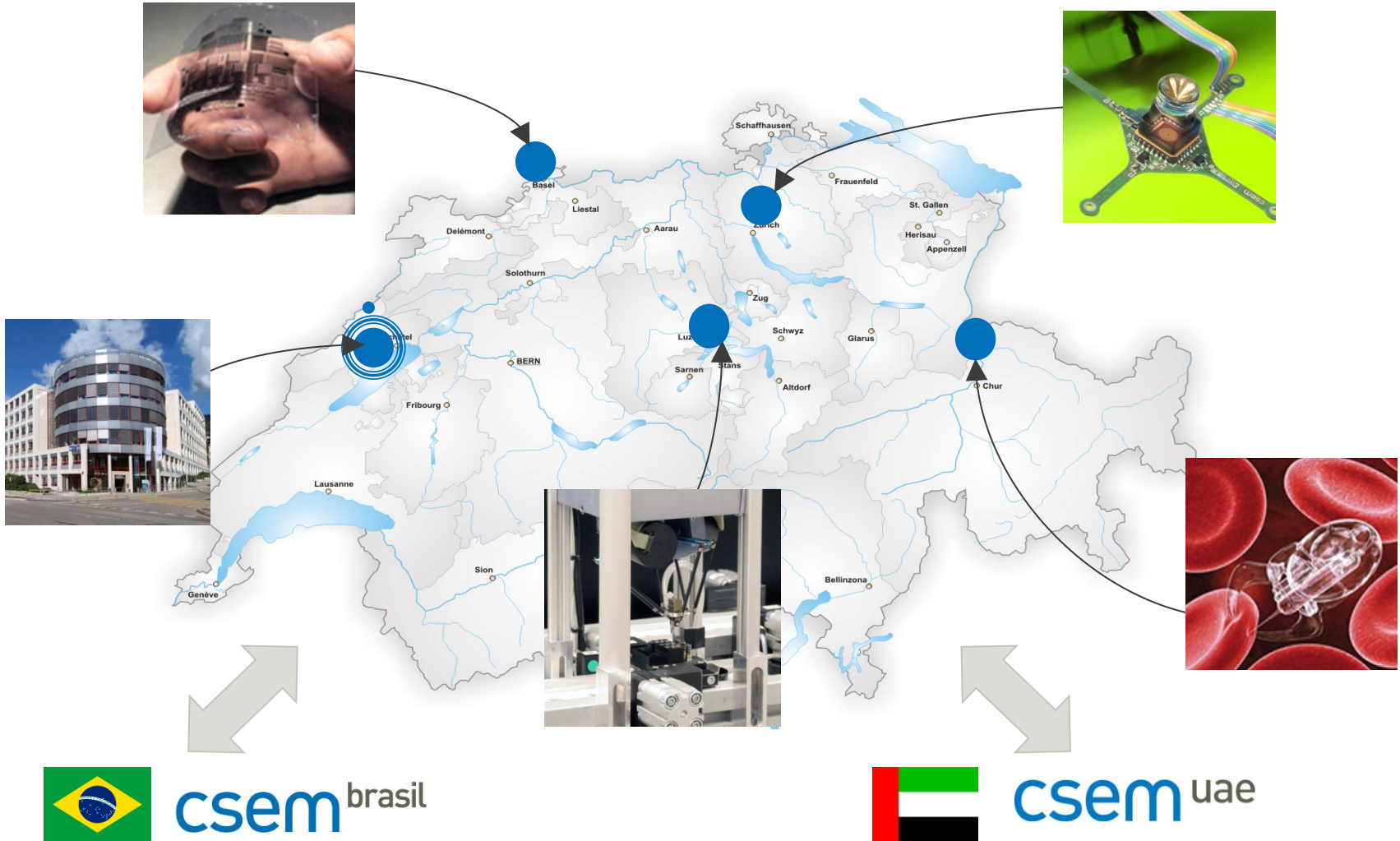
Biophotonics , March 19th, 2014



1984 • 2014
YEARS **30**

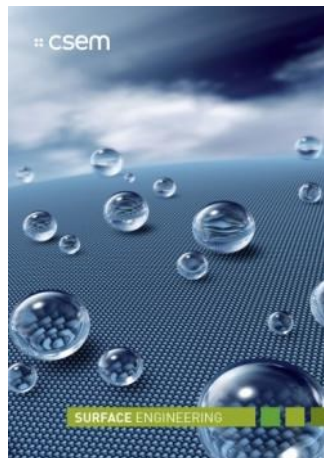
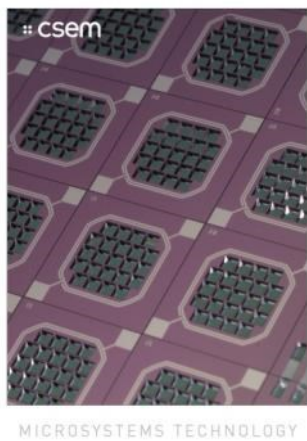
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Closer to industry ...



CSEM's technology programs

- MEMS
- Surface engineering
- Systems
- Ultra-low-power integrated systems
- Photovoltaics



Markets and successes

Consumer markets

- 8% Consumer goods
- 9% Safety & traceability
- 10% Telecom & semiconductor

Growing Industry

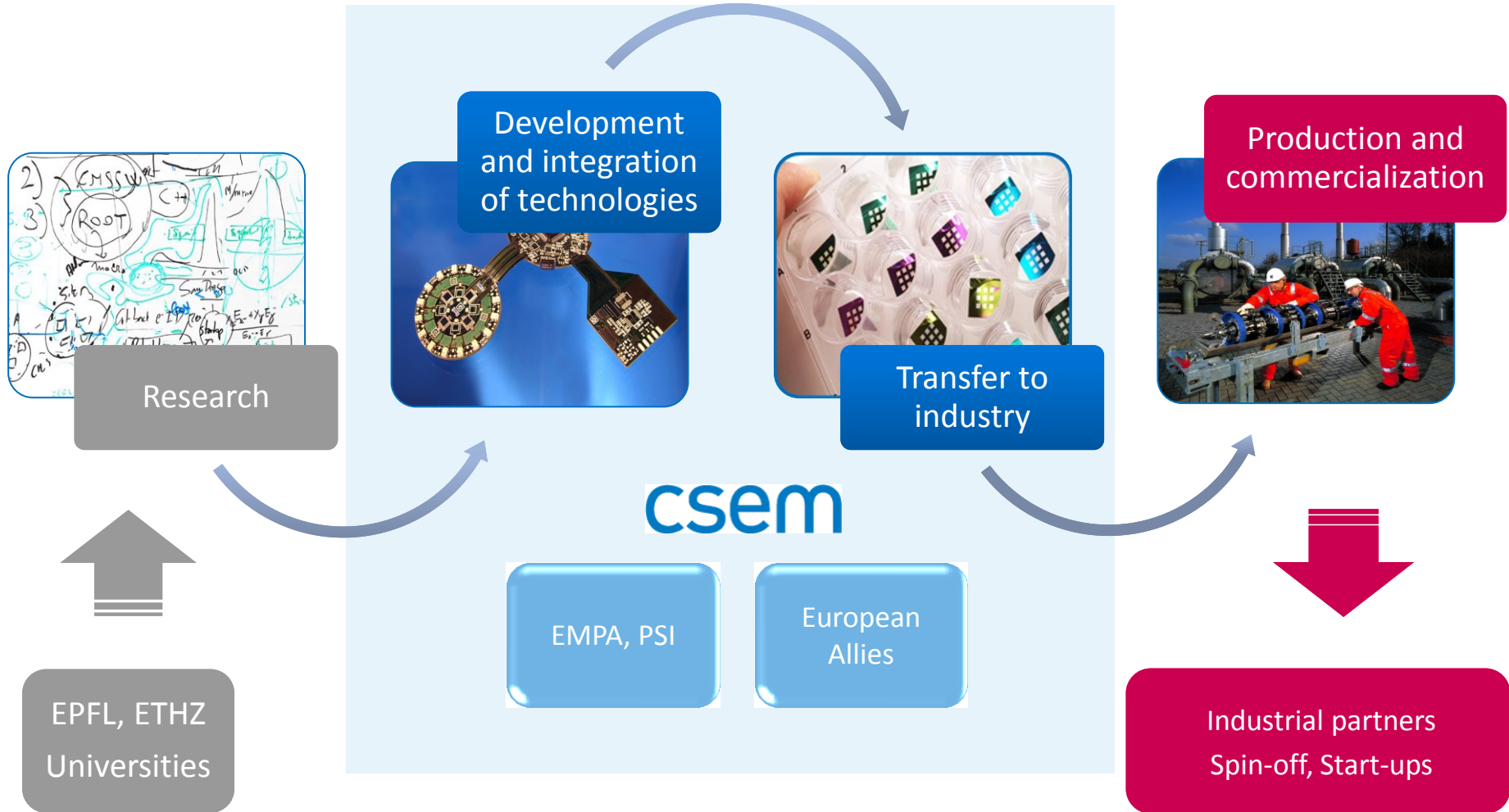
- 6% Cleantech & transportation
- 12% Biomedical & lifestyle

Established industry

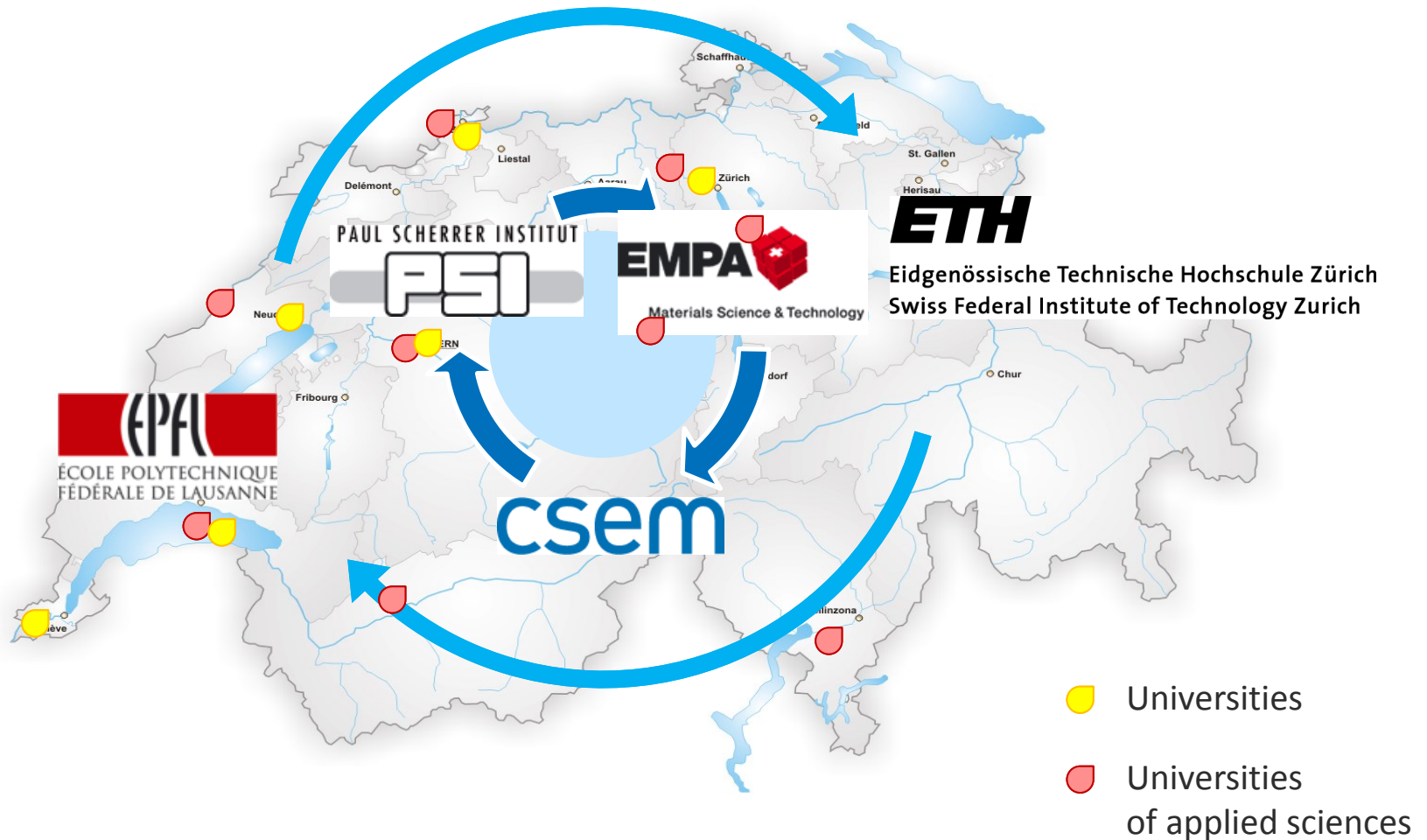
- 21% Watchmaking
- 16% Space & scientific instrumentation
- 18% Automation & industrial control



CSEM's positioning



CSEM's national network



CSEM Mutu



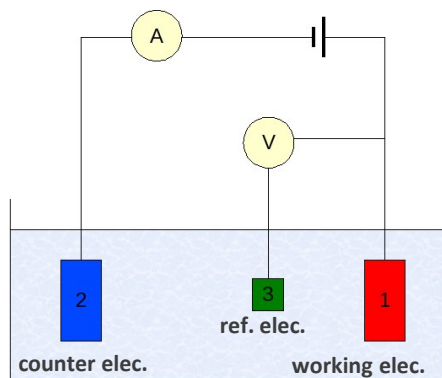
Printable Bio Sensors

Sensing principles

Electrochemical Sensors

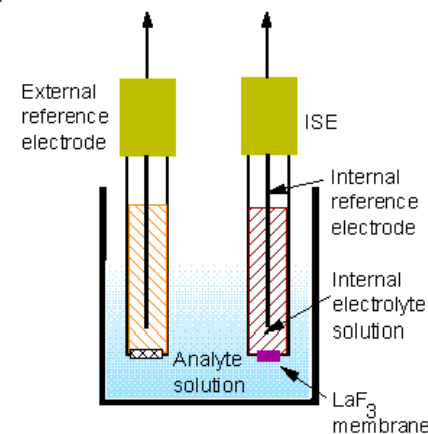
Amperometric / Voltammetry

- Detection of ions in a solution based on electric current or changes in electric current
- Current monitoring → measure of the electron transfer of chemical reaction
- Uses reference electrode, working electrode, and counter electrode.
- Fixed potential between working electrode and reference electrode

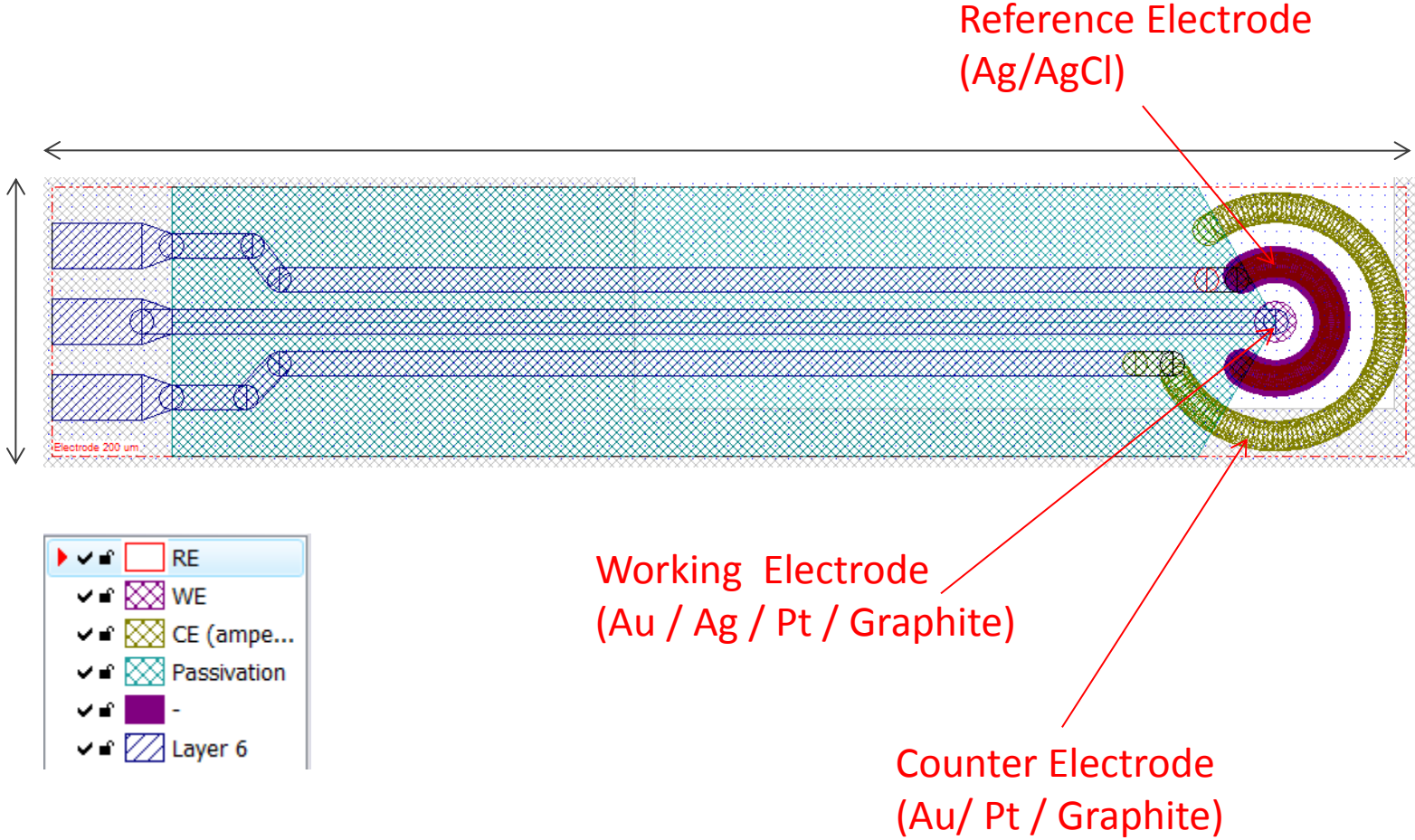


Potentiometric

- Converting a recognition process into a potential signal, proportional to the concentration of species generated in the recognition event.
- Based on Ion Selective Electrodes (ISE)
- High-impedance measurement
- Can measure both positive and negative ions



Generic Layout for Screen-Printed ISE or Amperometric Sensors



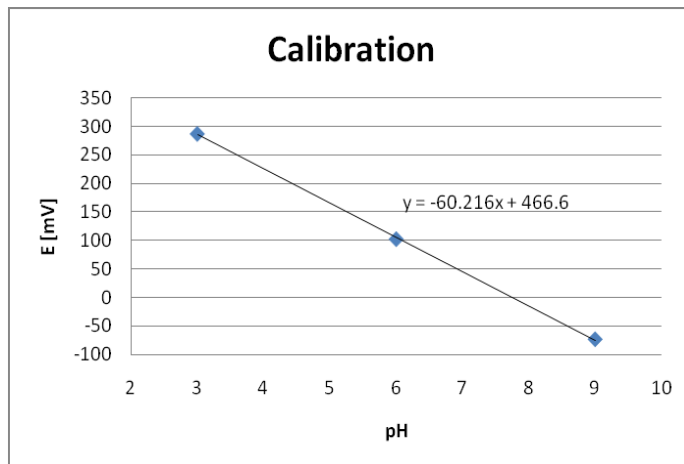
Electrochemical monitoring

- **Ion-selective electrodes:** *potentiometric detection of*
 Na^+ , K^+ , Ca^{2+} , Mg^{2+} , NH_4^+ , NO_3^- , pH,
- **Enzymatic sensors:** *amperometric detection of*
glucose, lactate, glutamate.
- **Immunosensors:** *enzyme-linked-based immunoassay.*
Chronoamperometric
detection of amylase.

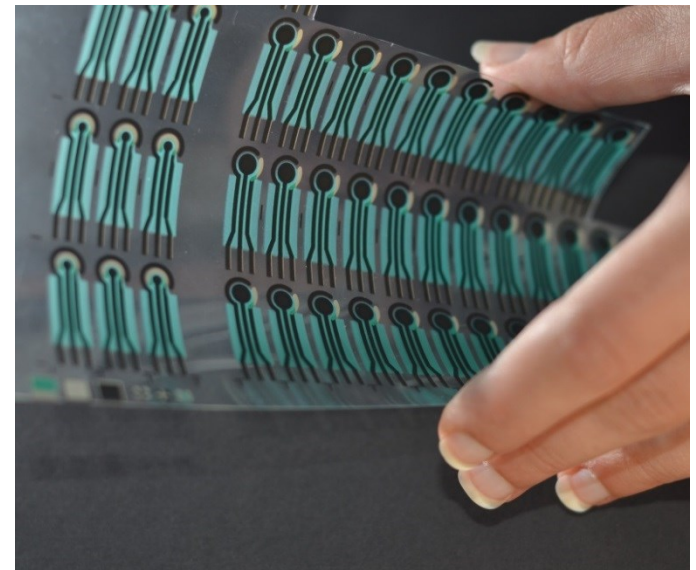


Ion-Selective Electrodes

- Analytes: Na^+ , K^+ , Ca^{2+} , Mg^{2+} , NH_4^+ , NO_3^- , pH, ...
- Characteristics: (sensitivity, selectivity, detection limit, ...)
→ comparable to commercial ISE
- Semi-disposable: functional lifetime between 1 week and 2 months



Response of pH sensors on screen-printed substrates



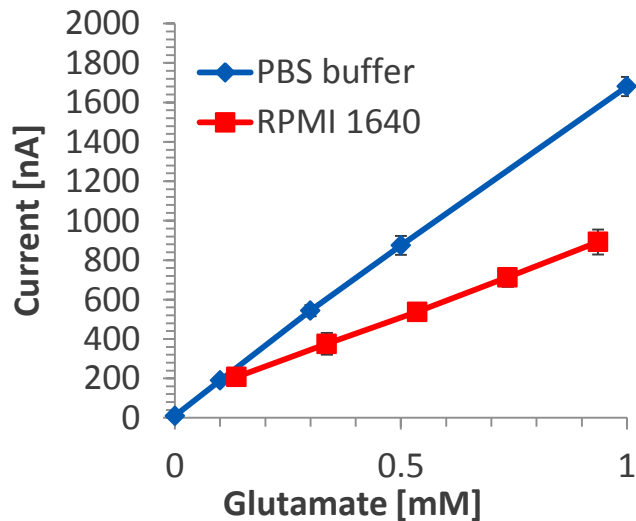
Screen-printed electrodes, @ CSEM

Enzymatic sensors

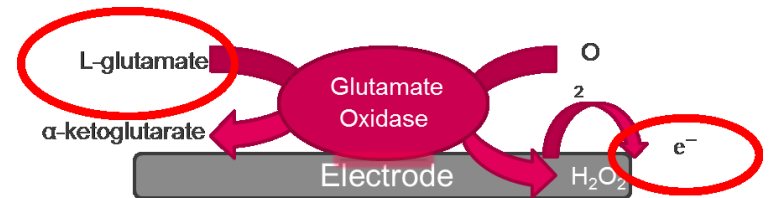
- Analytes: *glucose, glutamate, lactate.*
- Semi-disposable: *functional lifetime up to several months, depending on the sensor type*



Glutamate detection:



Glutamate calibration curves in buffer and cell culture medium



In PBS:

- Detection limit: 10 μ M
- Linear response from 10 μ M to 3 mM
- Response time: seconds
- Initial sensitivity: ca. 1600 nA/mM
- Lifetime: over 100 days

Screen printed sensors

Enzymatic sensors



Wireless monitoring
of parameters in cell cultures



Target: Glucose & Lactate sensors
for bio-reactors

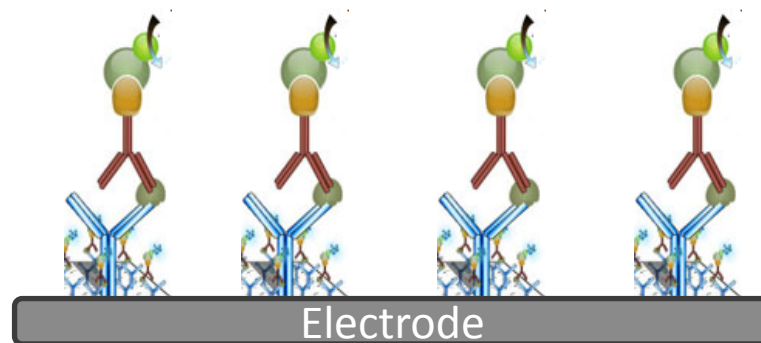


Electrochemical sensor integrated into cap

Electrochemical immunoassays

- Sandwich immunoassay on:

Screen-printed graphite substrates,
on polymer

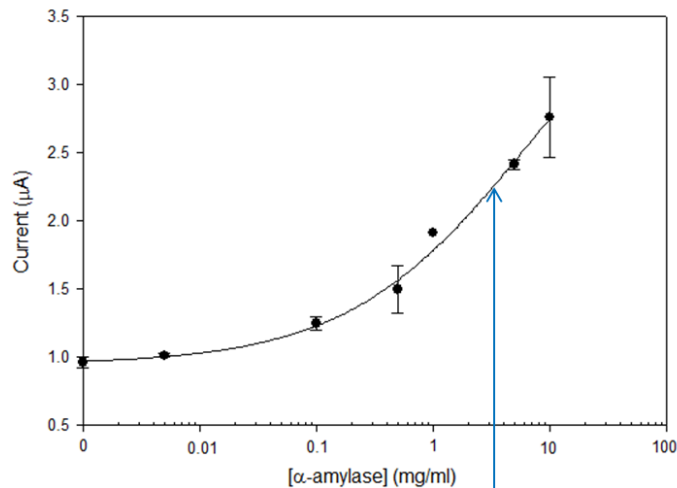


Electrochemical immunoassays

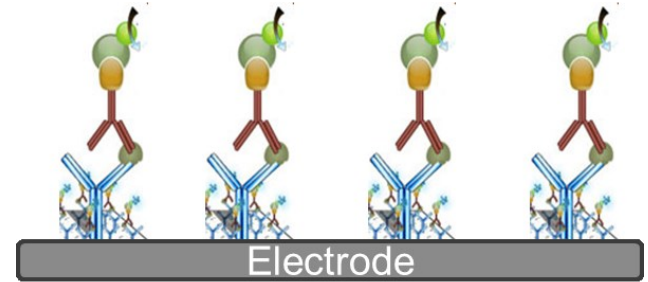
- Sandwich immunoassay on:

Screen-printed graphite substrates, on polymer

Calibration curve of α -amylase



Human average
2.64 mg/ml



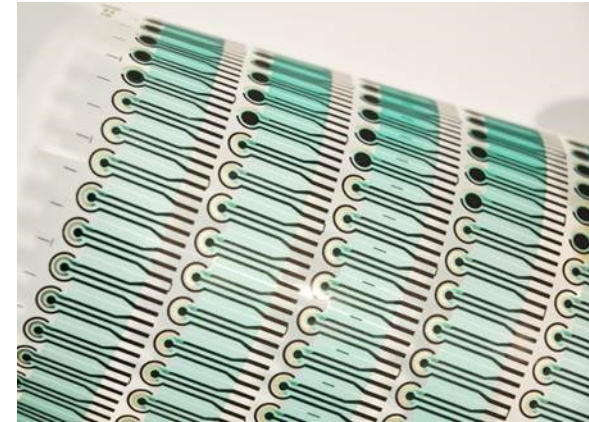
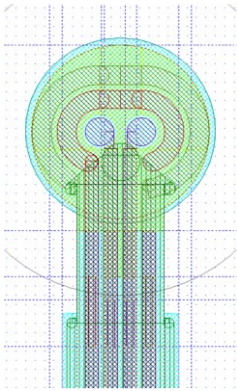
Primary & secondary antibodies

Detection limit: 26 $\mu\text{g/ml}$

Sensitivity: 1.39 mg/ml

Screen printed electrochemical sensors

- flexible, disposable electrochemical sensors for biotech labs

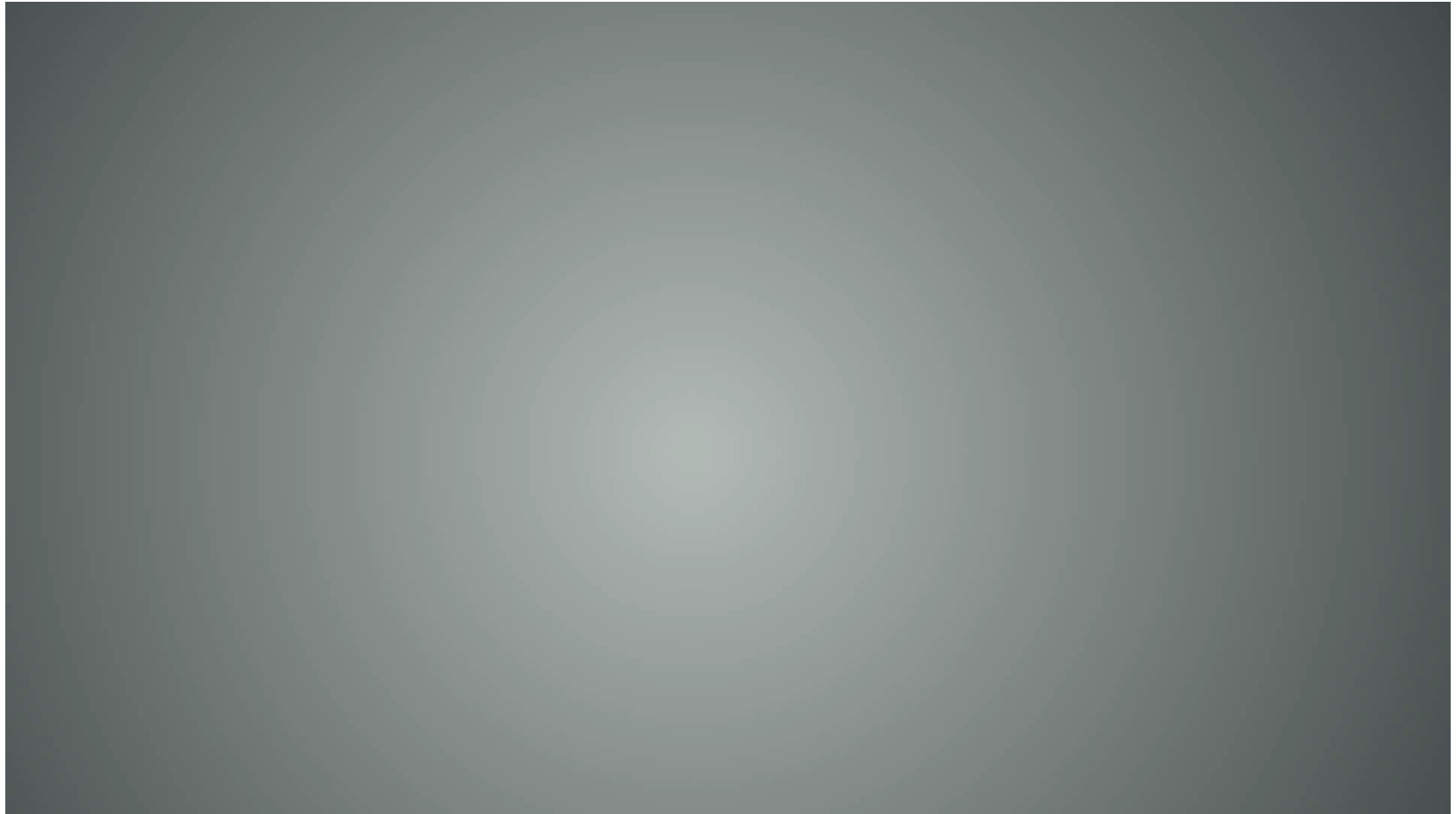


- Design Cle-Win & simulations Comsol, Femlab,
- Screen printing; alignment ($< 50\mu\text{m}$), pressure control & automated squeegee
- Dicing / packaging
- Bio-functionalization



Screen printed sensors

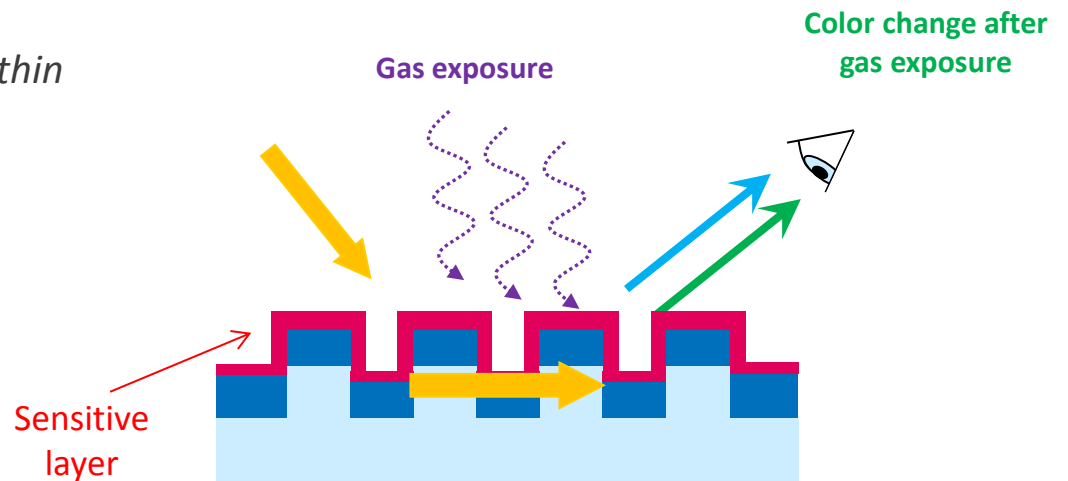
Screen printed electrochemical sensors



Optical Sensors

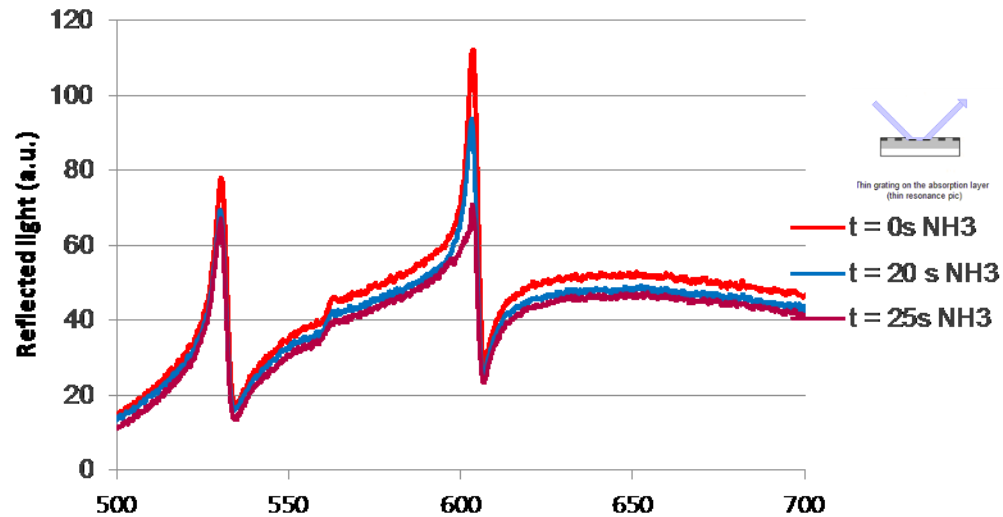
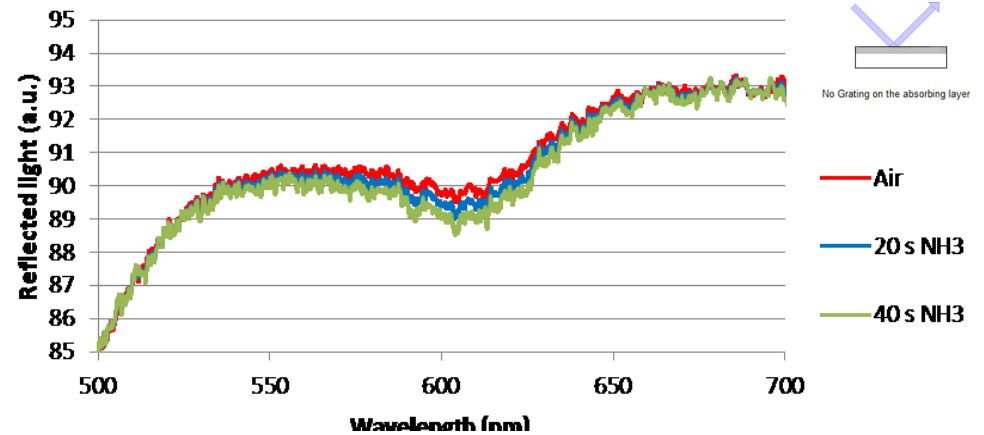
Combination of dye thin films and waveguide gratings

- *Sensing concept:*
 - *Combines a resonant structure with a thin film dye*
 - *Enhance the optical changes of a dye thin films (absorption)*
 - *Longer interaction with the dye thin film by in-coupling light in the waveguide*



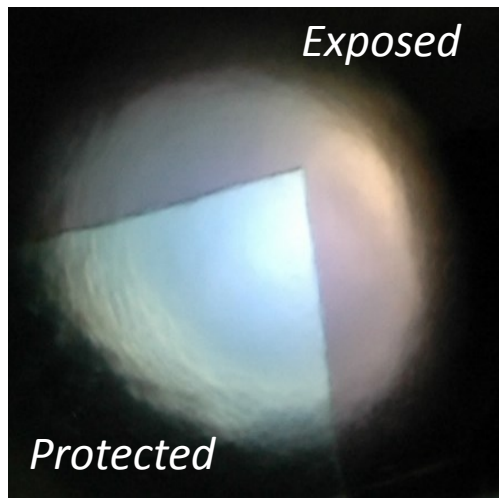
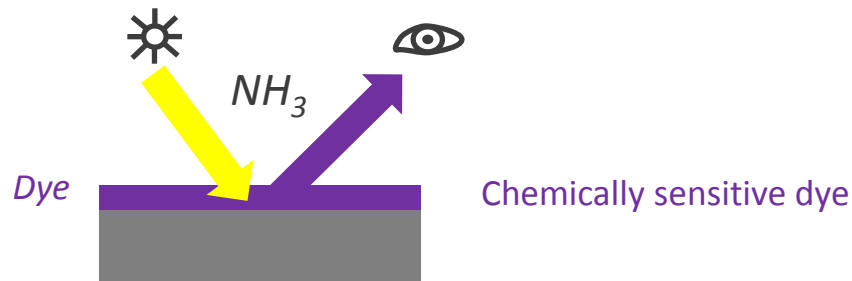
Amonia sensor (NH₃)

- *BCP sensitive layer for NH₃ sensing:*
 - Absorption without nanostructures
 - Absorption with nanostructures
- *Absorption enhanced at the resonance wavelengths*
- *Higher sensitivity by factor 100*

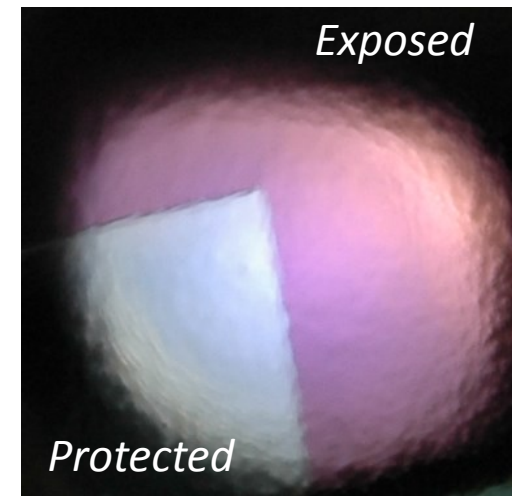
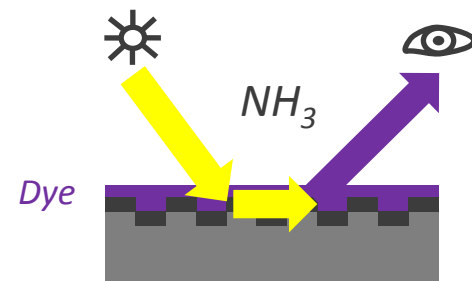


NH₃ gas sensing gratings

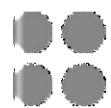
- Color of a chemically sensitive dye enhanced by a resonant grating
- Enhanced sensitivity for detection of dangerous gases (e.g. NH₃)



Without grating: low contrast



With grating: high contrast



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Thank you for your attention.