EPFL

EDMI Microsystems and Microelectronics

MICRO-614: Electrochemical Nano-Bio-Sensing and Bio/CMOS interfaces

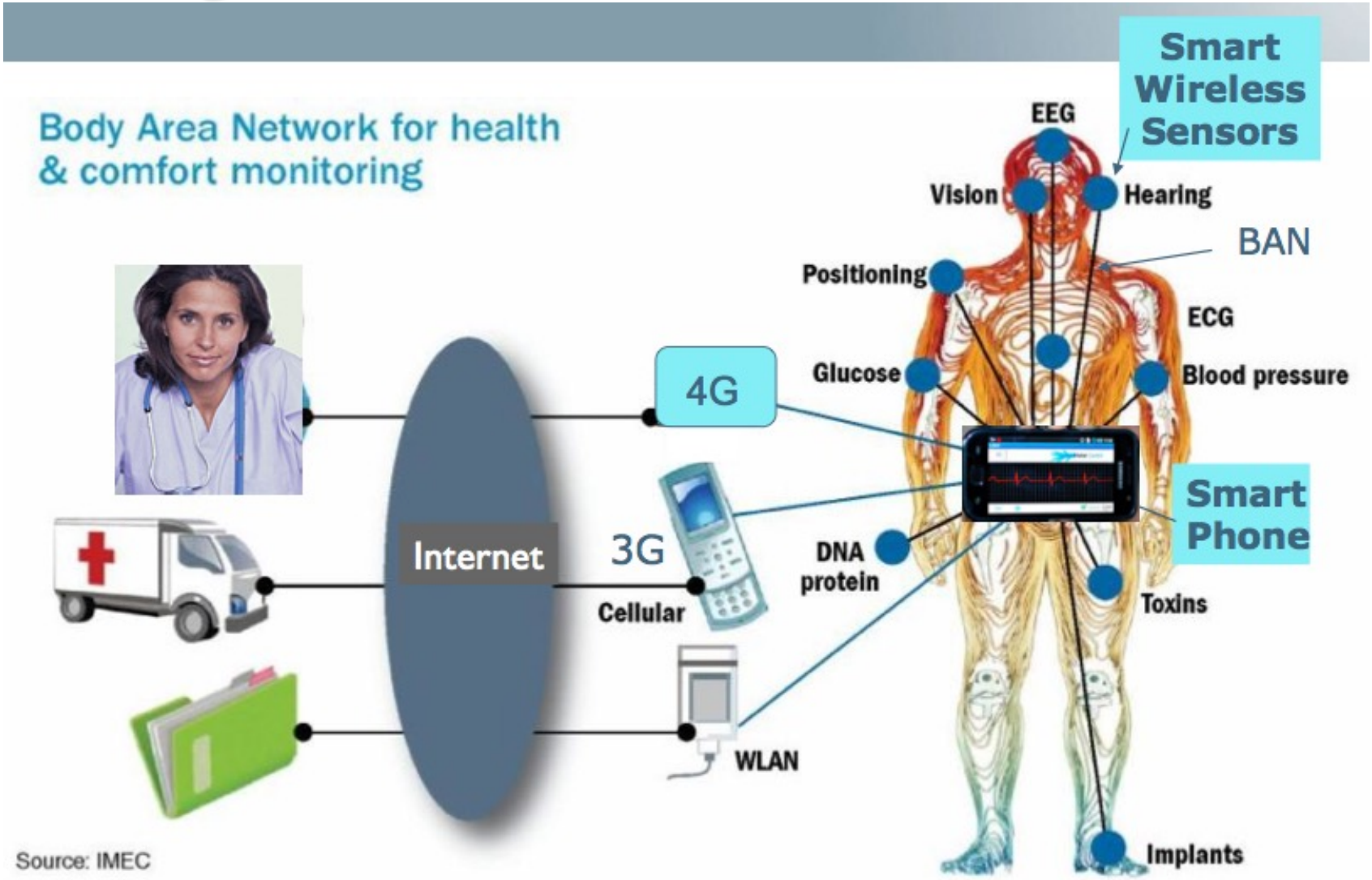
Lecture #1 - Introduction

Human Metabolism Monitoring by Electrochemical Sensing: Present & Future!

The Time' forecast on Human++

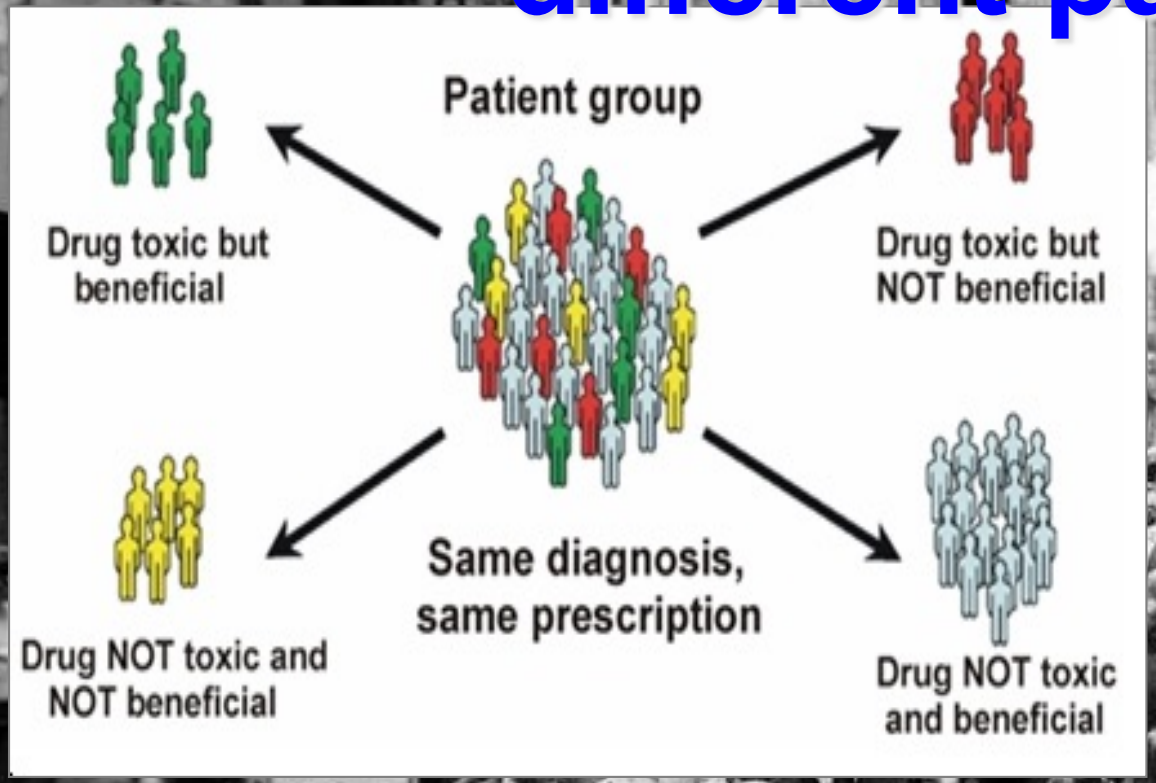
[TIME, February 2011]

Fully-Connected Human++



Courtesy, Hugo De Man (IMEC)

Different outcomes for different patients

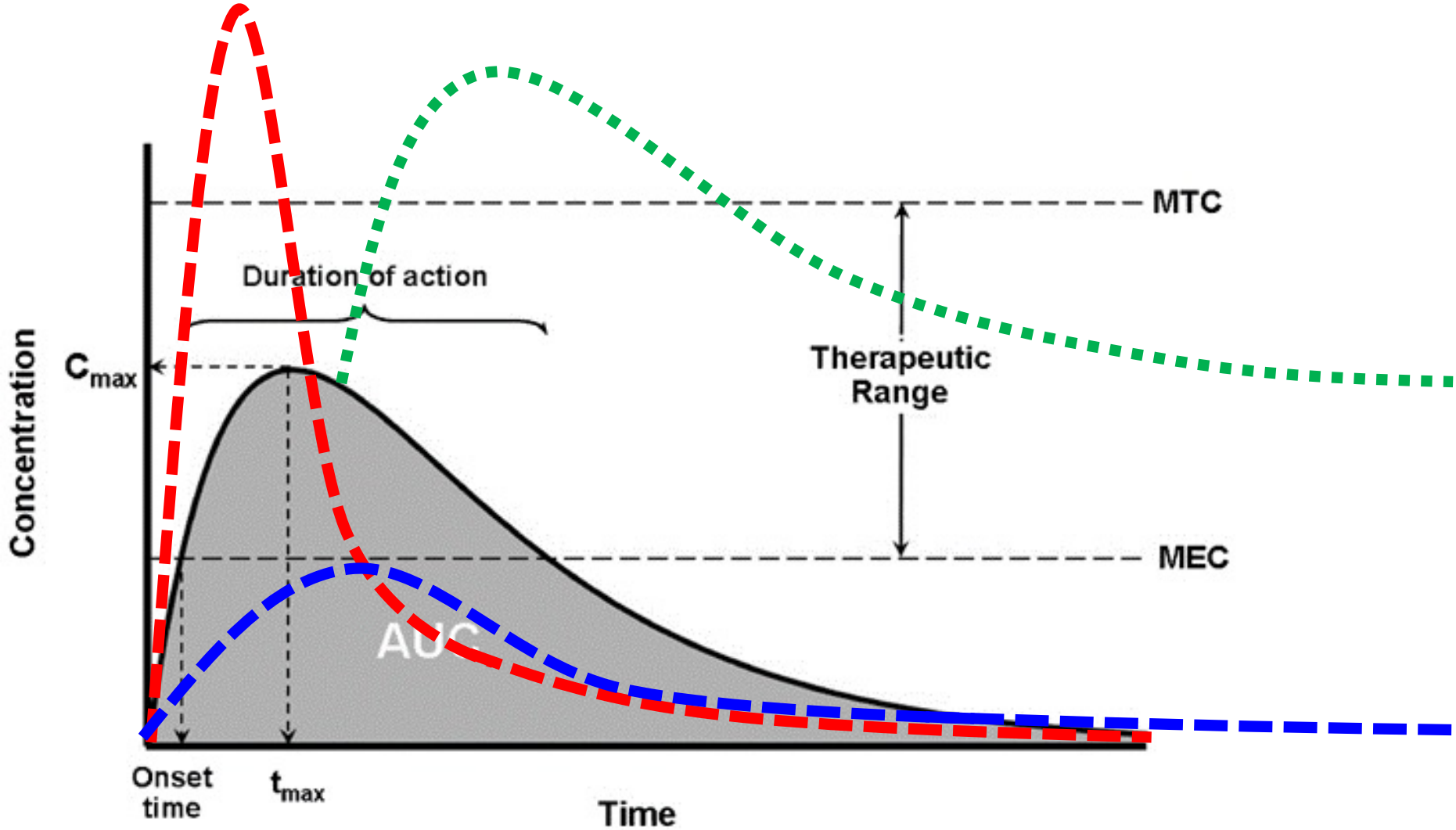


Therapeutic area	Rate of efficacy with standard drug treatment
Cancer (all types)	25%
Alzheimer's disease	30%
Incontinence	40%
Hepatitis C	47%
Osteoporosis	48%
Rheumatoid arthritis	50%
Migraine (prophylaxis)	50%
Migraine (acute)	52%
Diabetes	57%
Asthma	60%
Cardiac arrhythmias	60%
Schizophrenia	60%
Depression	62%

For depression, the data apply specifically to the drug class known as selective serotonin reuptake inhibitors.

Source: Brian B. Spear, Margo Heath-Chiozzi, and Jeffrey Huff, "Clinical Application of Pharmacogenetics," *Trends in Molecular Medicine* (May 2001).

Patients' metabolism drive the Drugs effect in time!



Course Motivation: From Labs to Hands

- 100.000 $ (machinery)
- 1.000 $ the single μ-array

Labeled

Label-Free

- 50 $ (machinery)
- 0.05 $ the single strip

Bayer HealthCare

Next step: the future already begun

Glucose Personal Diagnostics on our iPhones

Next step: the future already begun

Glucose Personal Diagnostics on our Skin

The Pancreas Functions

IN-put Signals

Bile aceids

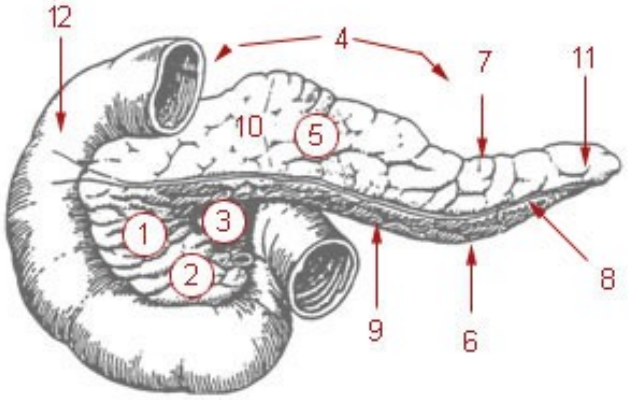
pH

Syrinic proteases

Glucose

Glycagone pancreatic

.....



OUT-put Signals

insulin

Lipase

Fospholipase A

Cholesterol estarase

Endopeptidase

Esopeptidase

Elastase

Ribonuclease

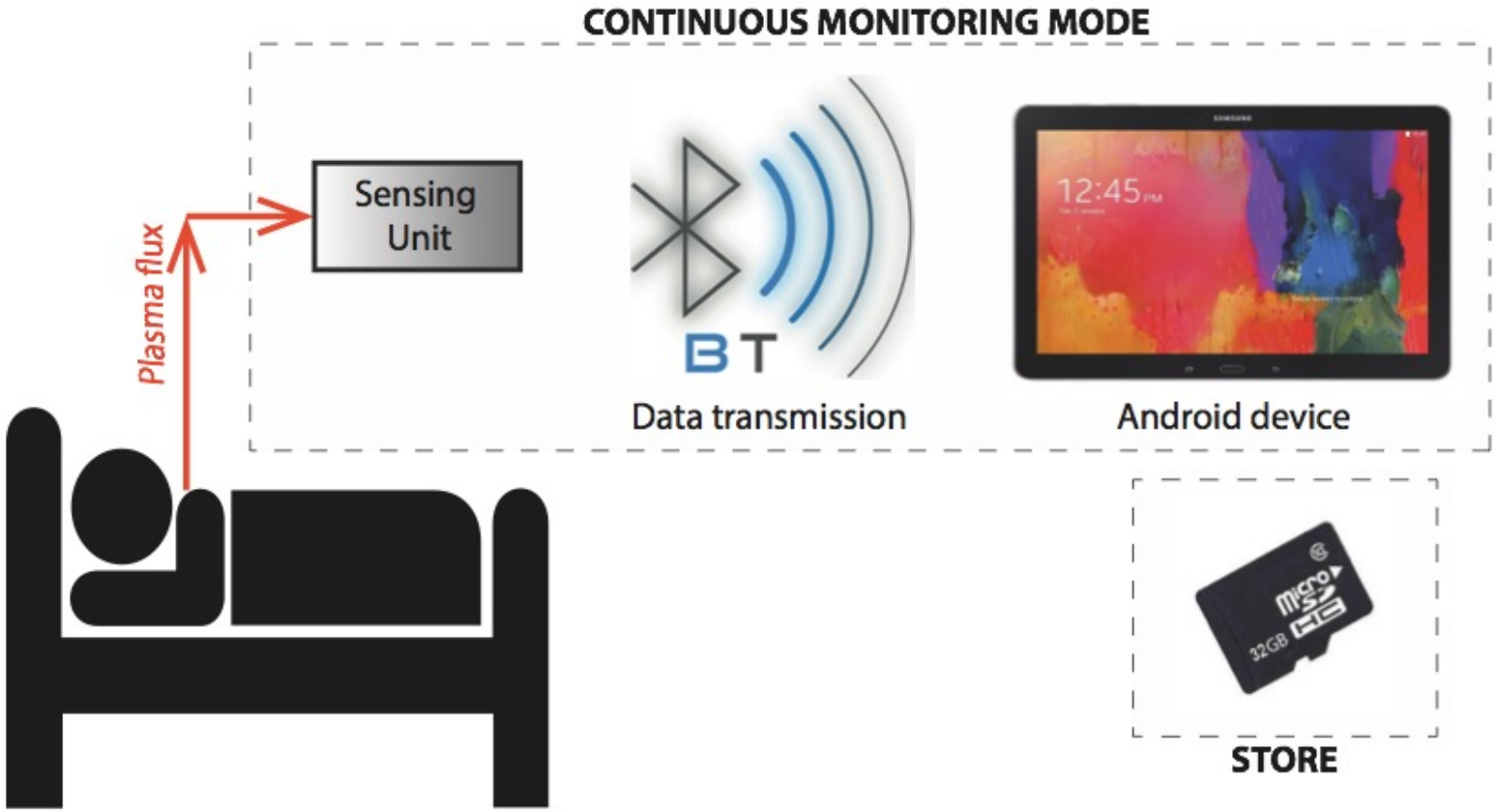
Enterochinase

.....

Intensive-Care-Units (ICU) Monitoring

The present monitoring scenario foresees lot of independent devices and input/output interfaces

Lab-on-a-chip for ICUs



F. Stradolini, *et al., IEEE Sensors Journal 16(2016) 3163 - 3170*

Monitoring scenario where the main parameters of the patient are continuously displayed on an Android mobile device

The full connected system

The whole system with the Android™ interface that allows connectivity too

One Interface for Remote Monitoring of Patients in Intensive Care Units

Image | Bam Labs

The whole system with the Android™ interface that allows connectivity too

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A subcutaneous biosensor chip to revolutionize tomorrow's medicine

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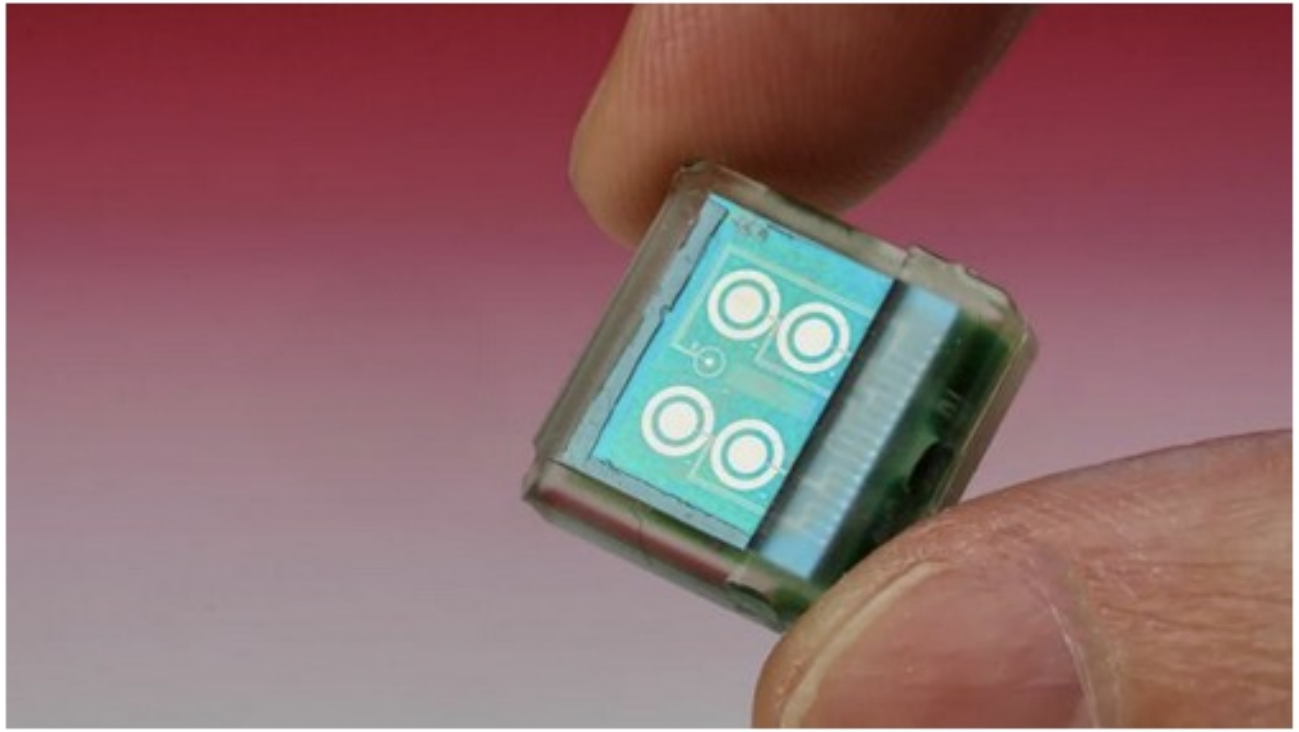


(c) S.Carrara

The microchip implants that let you pay with your hand

By Katherine Latham
Business reporter

April, 11th , 2022

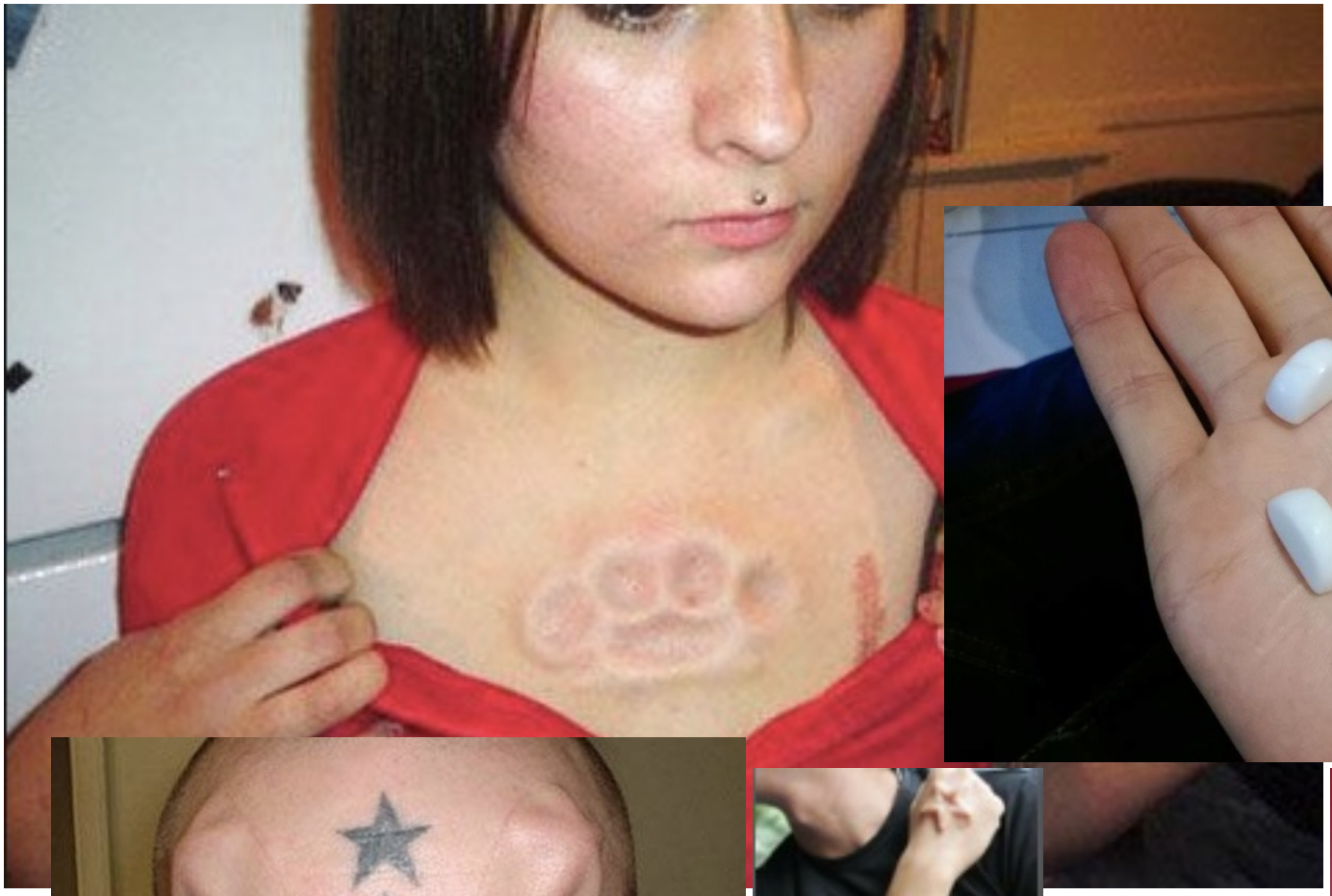
An x-ray showing a Walletmor implant, which are injected into a person's hand after a local anaesthetic

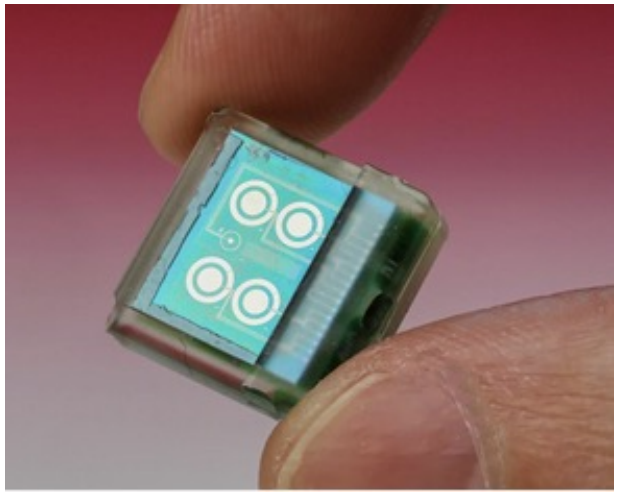
For many of us, the idea of having such a chip implanted in our body is an appalling one. **but a 2021 survey of more than 4,000 people across the UK and the European Union found that 51% would consider it.**

Chips under the skin?
See video on Moodle!

[EuroNews, June 2015]

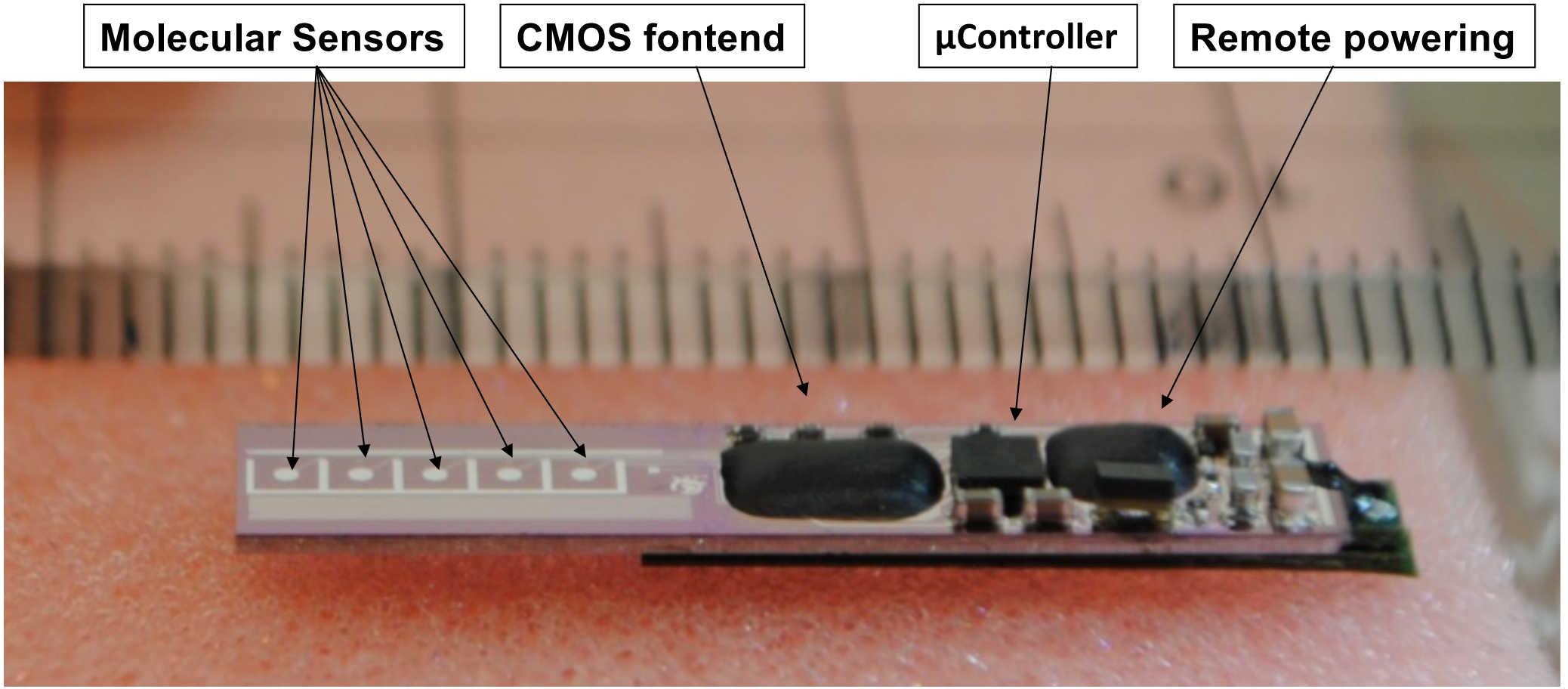
Under the skin for body sculpting





Enhancing human being

Size and Shape to be injectable as a Needle?



The IC has been fabricated in UMC 0.18 technology and interfaced to the passive multi-panel platform

ECG monitoring by Medtronic

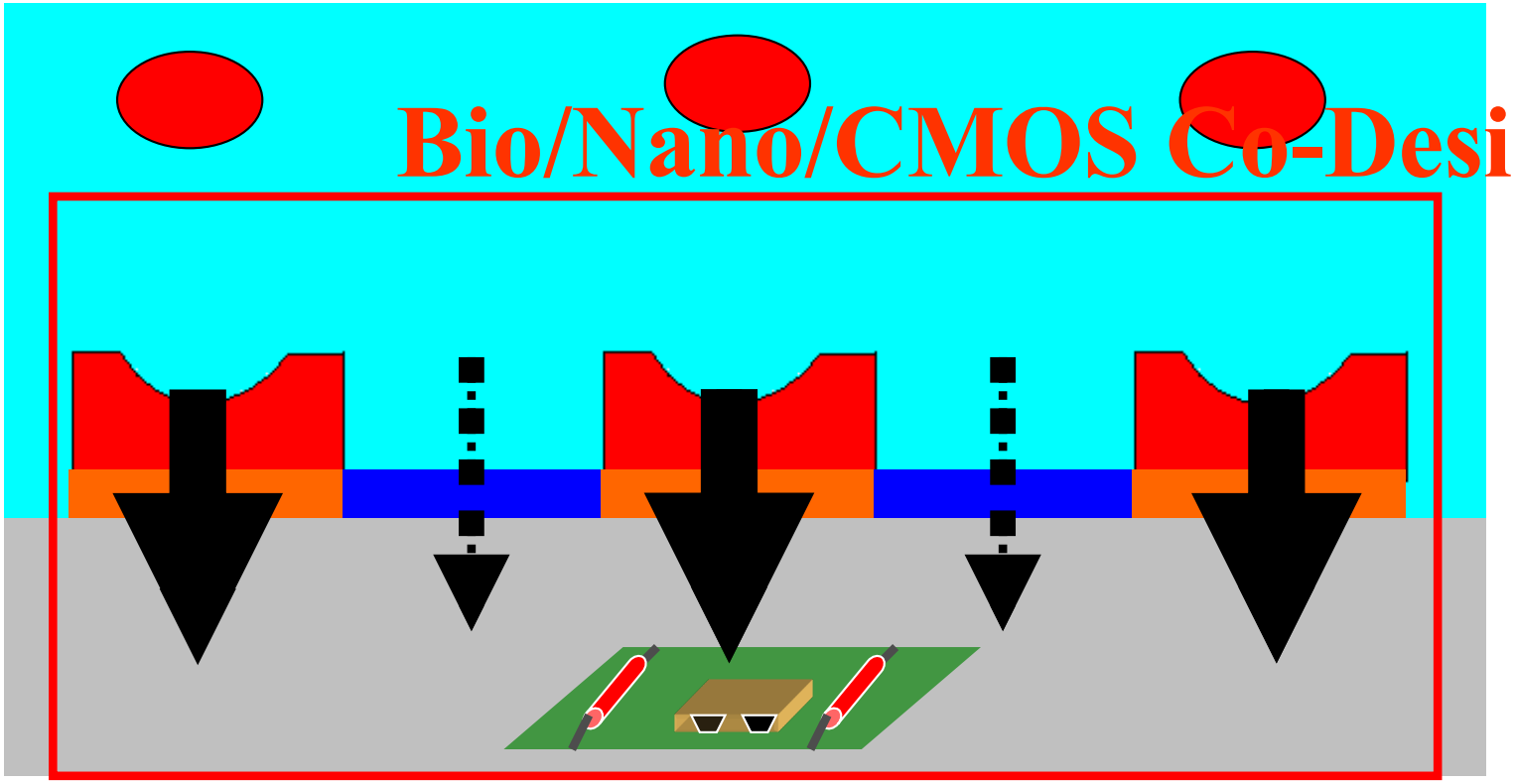
Mark Phelps by Medtronic, and the Reveal LINQ™ system

Toward Ultrasensitive Biosensors:

1. Fully integration of Biomolecules to assure specificity
2. Fully integration of Nano-structures to assure sensitivity
3. Proper CMOS frontends to assure
   (i) Correct Voltage driving
   (ii) Precise Current measurements,
   (iii) Reliability in Temperature and pH

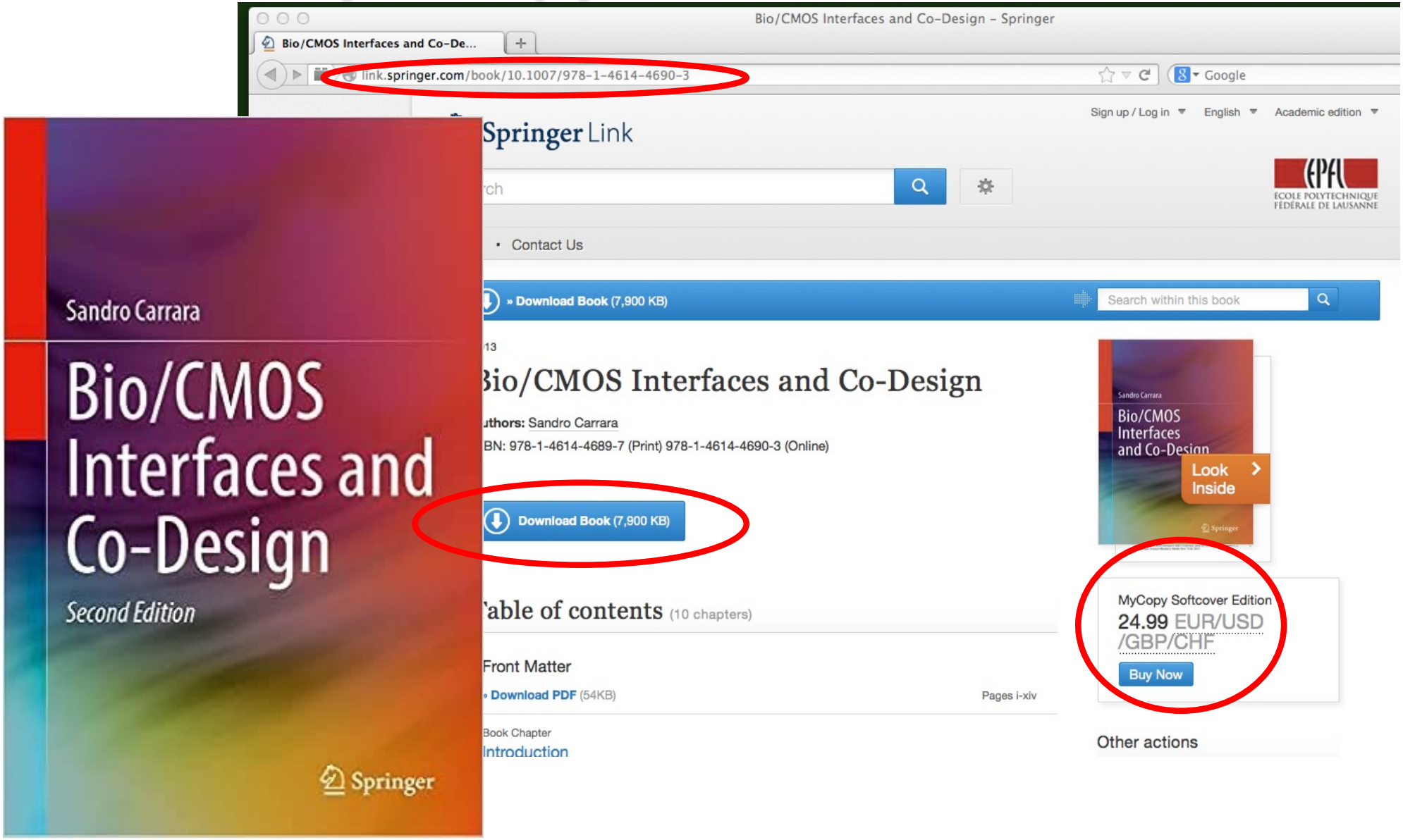
Bio/Nano/CMOS Co-design !

CMOS/Sample interface

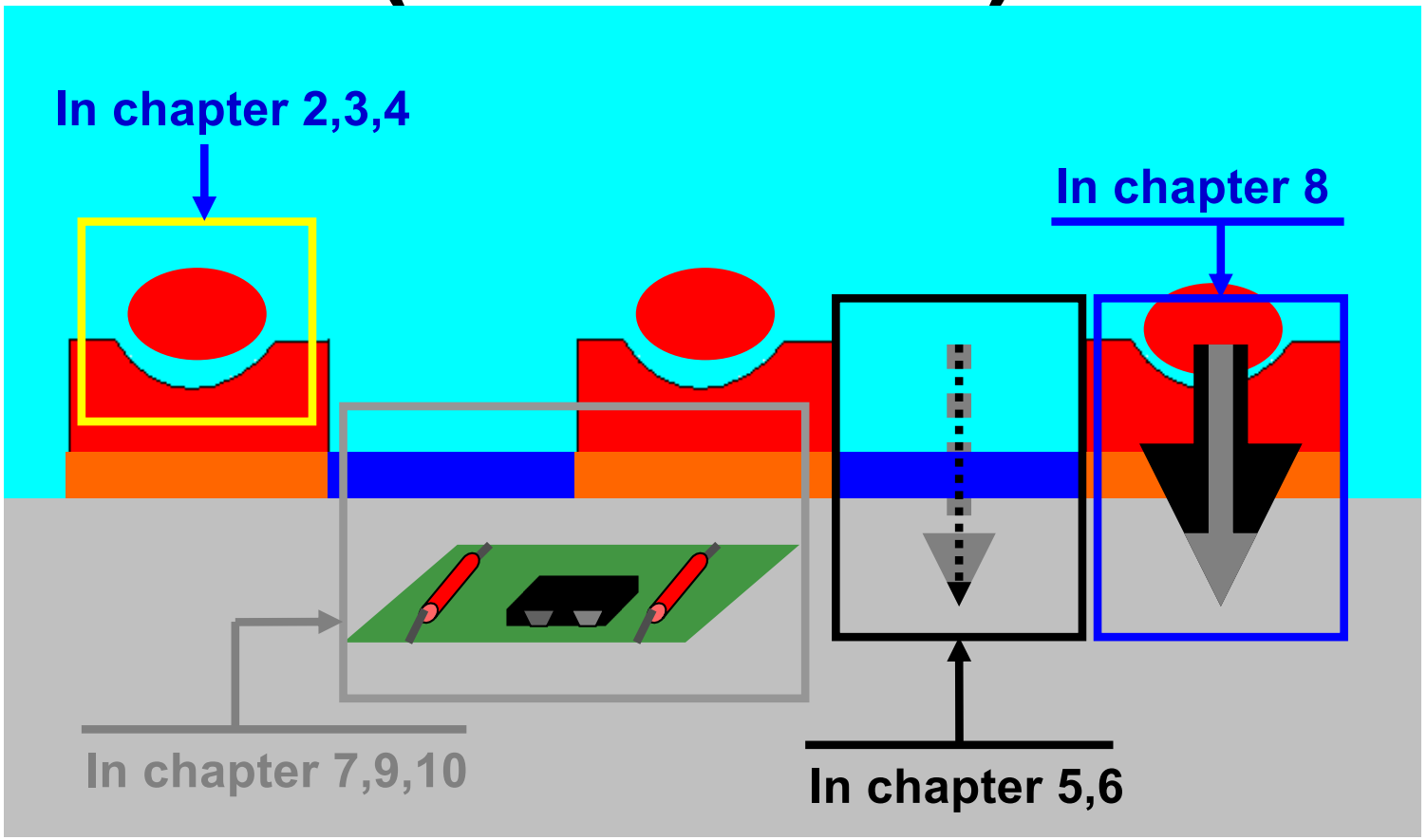


The interface between the CMOS circuit and the bio-sample needs to be deeply investigated and organized

Get you copy of the Textbooks

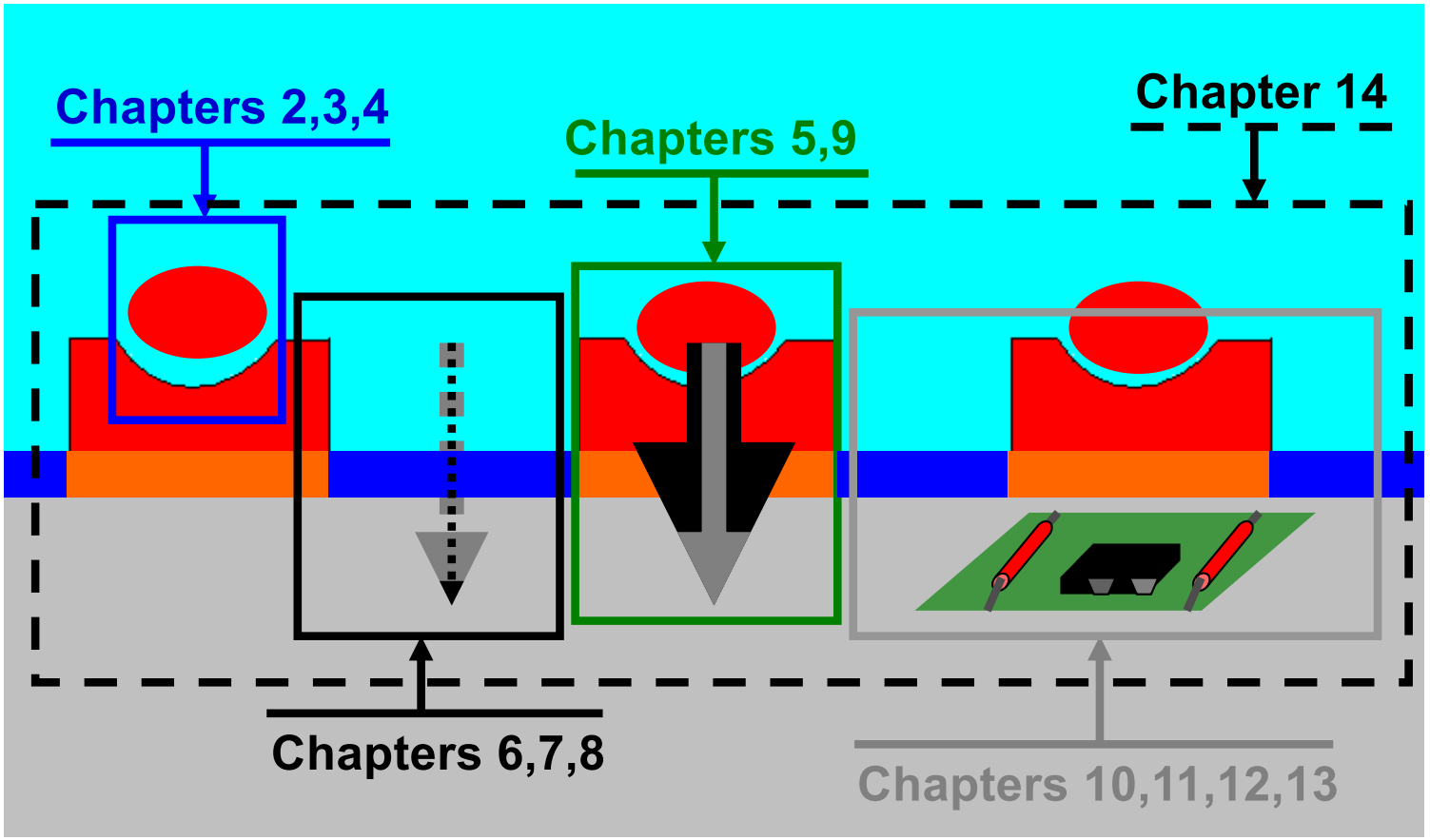


Bio/CMOS interface book (1st Edition)



Introduction to Personal electronics, Distributed Diagnostics, and Bio/CMOS interfaces in Chapter 1

Bio/CMOS interface book (2nd Edition)



Introduction to Personal electronics, Distributed Diagnostics, and Bio/CMOS interfaces in Chapter 1

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MICRO-614: Electrochemical Nano-Bio-Sensing and Bio/CMOS interfaces

Course outline

1. Intro about Metabolism Monitoring
2. Bio 1 metabolites, Peptides, Proteins & DNA
3. Bio 2 Probes/targets interaction
4. Bio 3 Detection principles
5. Bio 4 Amperometric Biosensors

Bio

6. Nano 1 Functionalization: Methods & Models
7. Nano 2 Characterisation by RM, SPR, SEM, AFM
8. Nano 3 Preventing ET
9. Nano 4 Enhancing ET
10. Nano 5 Memristive Sensing

Nano

11. CMOS 1 in Constant Bias
12. CMOS 2 in Scanning Voltage
13. CMOS 3 for DNA: Capacitive & Amperometric
14. CMOS 4 Memristive Sensing
15. CMOS 5 Beyond implantable & wearable

CMOS

To fruitfully follow the course