What is Biomedical Engineering?

- **It is a cross-disciplinary field that incorporates**
  - Engineering
  - Biology
  - Chemistry
  - Medicine

- **Biomedical instrumentation is used to take measurements that are used in**
  - Monitoring
  - Diagnostic means
  - Therapy

Fields of Biomedical Engineering

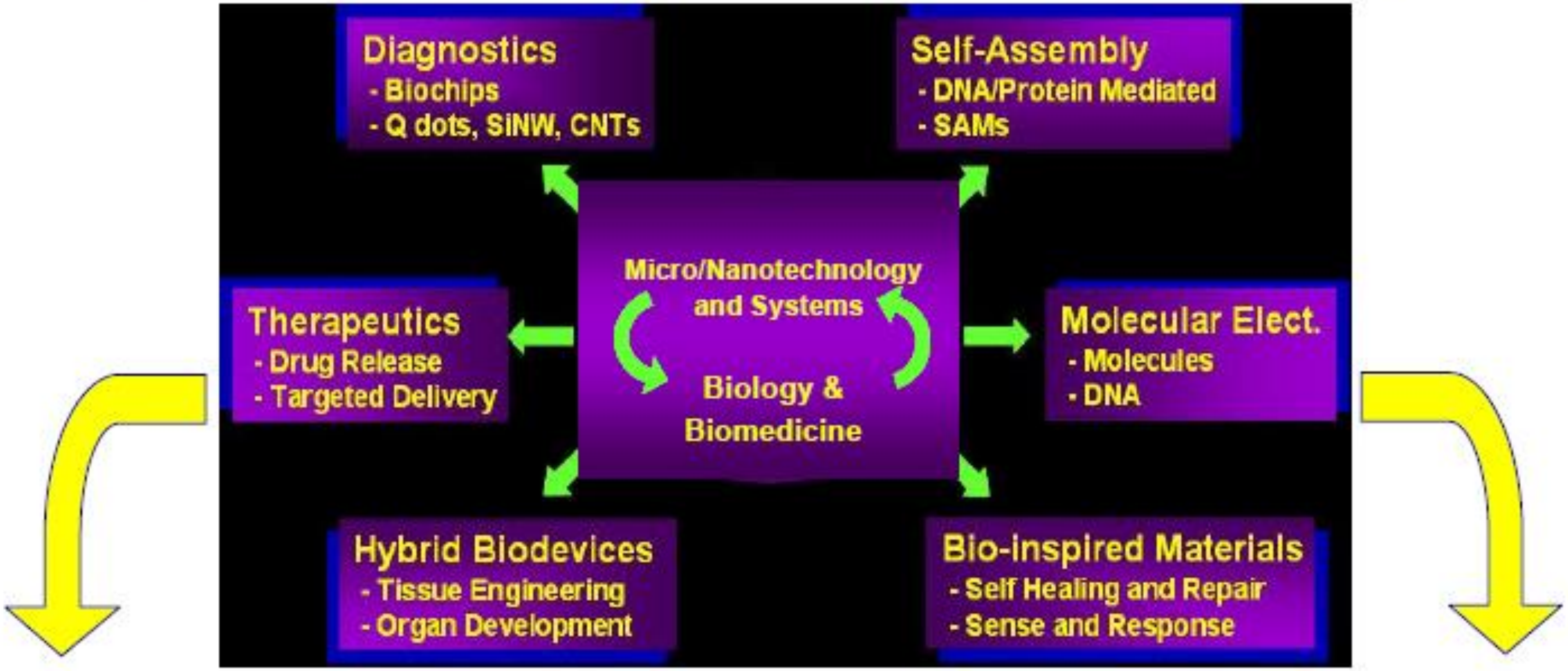
- **Bioinstrumentation**
  - Applies the fundamentals of measurement science to biomedical instrumentation
  - Emphasizes the common principles with making measurements in living cells
- **Biomaterials**
  - Application of engineering materials in production of medical devices
- **Biomechanics**
  - Behavior of biological tissues and fluids
  - Ergonomics (design principles)
- **Biosignals**
  - The mechanisms of signal production
  - Fundamental origins in of the variability in the signal
- **Rehabilitation engineering**
  - Design of equipments for disabled individuals

Definitions

- **BioMEMS** are biomedical or biological applications of MEMS (micro electro mechanical systems)
- **BioNanotechnology** is biological applications of nanotechnology (science and technology of miniaturization at scales of <100nm)

BioMEMS & Bionanotechnology

Apply micro/nano-technology to develop novel devices and systems that have a biomedical impact or are bio-inspired



Novel Solutions for Frontiers in Medicine and Biology

Novel Solutions for Frontiers in Materials and Information Processing

More Definitions

- <u>Biosensors</u> are 'analytical devices that combine a biologically sensitive element with a physical or chemical transducer to selectively and quantitatively detect the presence of specific compounds in a given external environment' [Vo-Dinh and Cullum, 2000].

- <u>Biochips</u> can be defined as '*microelectronic-inspired* devices that are used for delivery, processing, analysis, or detection of biological molecules and species' [Bashir, 2004]. These devices are used to detect cells, microorganisms, viruses, proteins, DNA and related nucleic acids, and small molecules of biochemical importance and interest.

BioMEMS in Biomedical Field

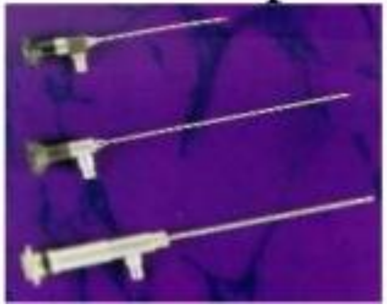
BioMEMS encompasses all interfaces and intersections of the **life science** and **clinical disciplines** with **microsystems** and **nanotechnology**.

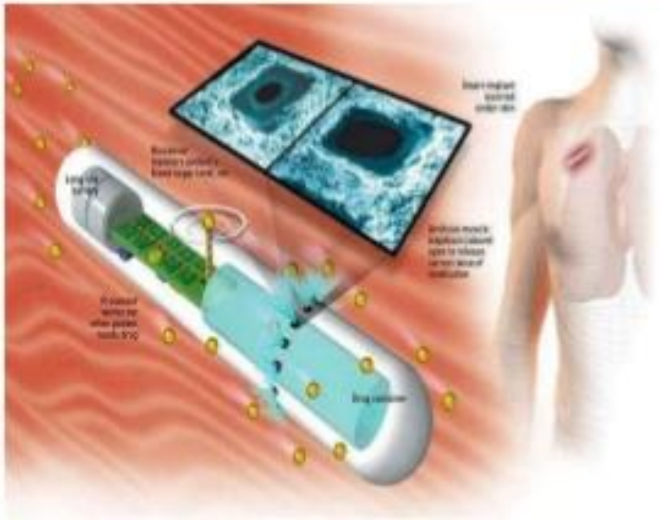
Related area:

- Micro & nanotechnology for drug delivery
- Tissue engineering, harvesting, manipulation
- Biomolecular amplification
- Sequencing of nucleic acids
- Protemics
- Microfluidics and miniaturized total analysis systems (micrTAS)
- Biosensors
- Molecular assembly
- Nanoscale imaging and integrated systems

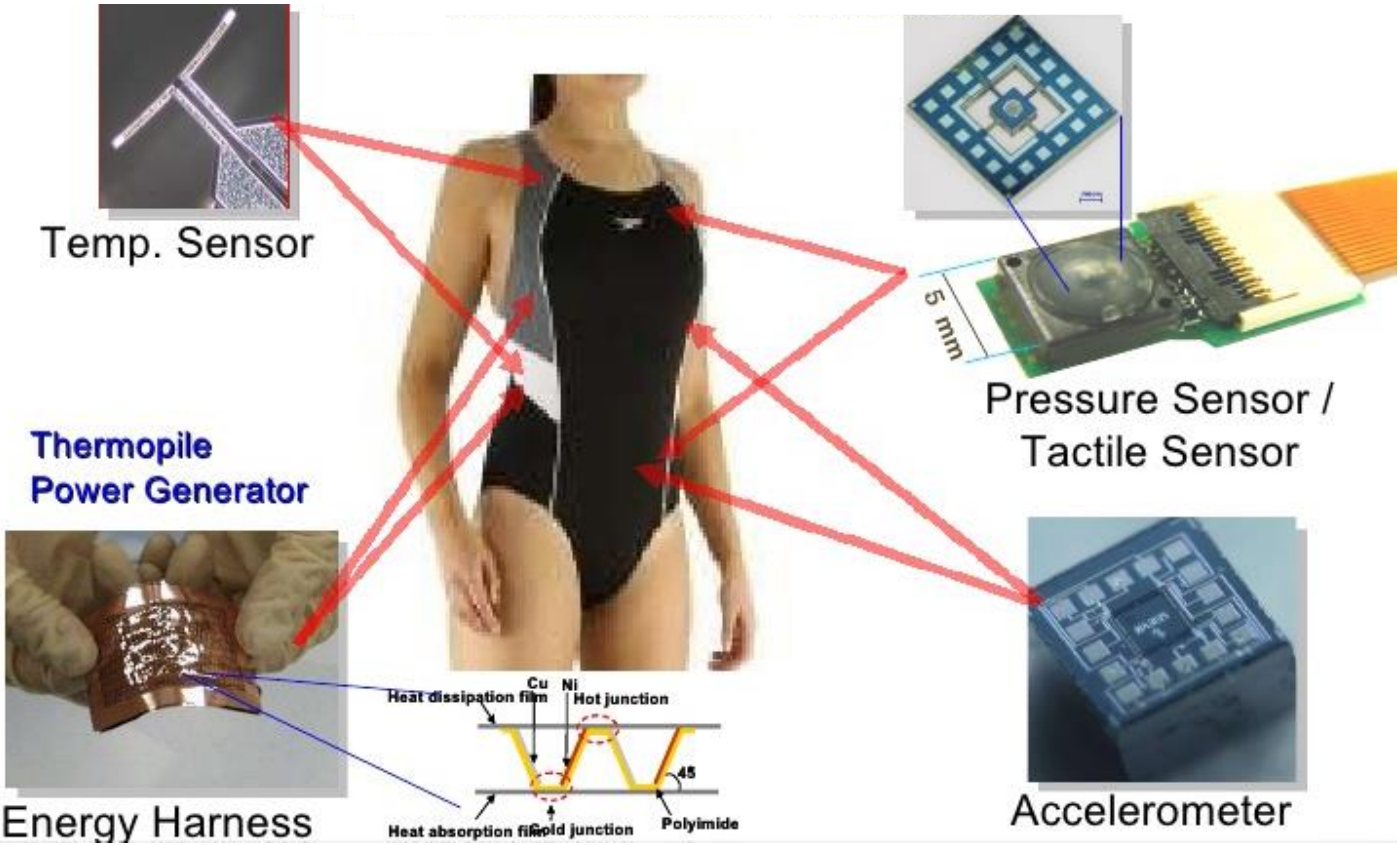
Application of MEMS

- ❑ **Bio-MEMS**
  - ➢ Lab-on-chip
  - ➢ Micro total analysis
- ❑ **Microfluidics**
  - ➢ Micro drug delivery
  - ➢ Smart pill



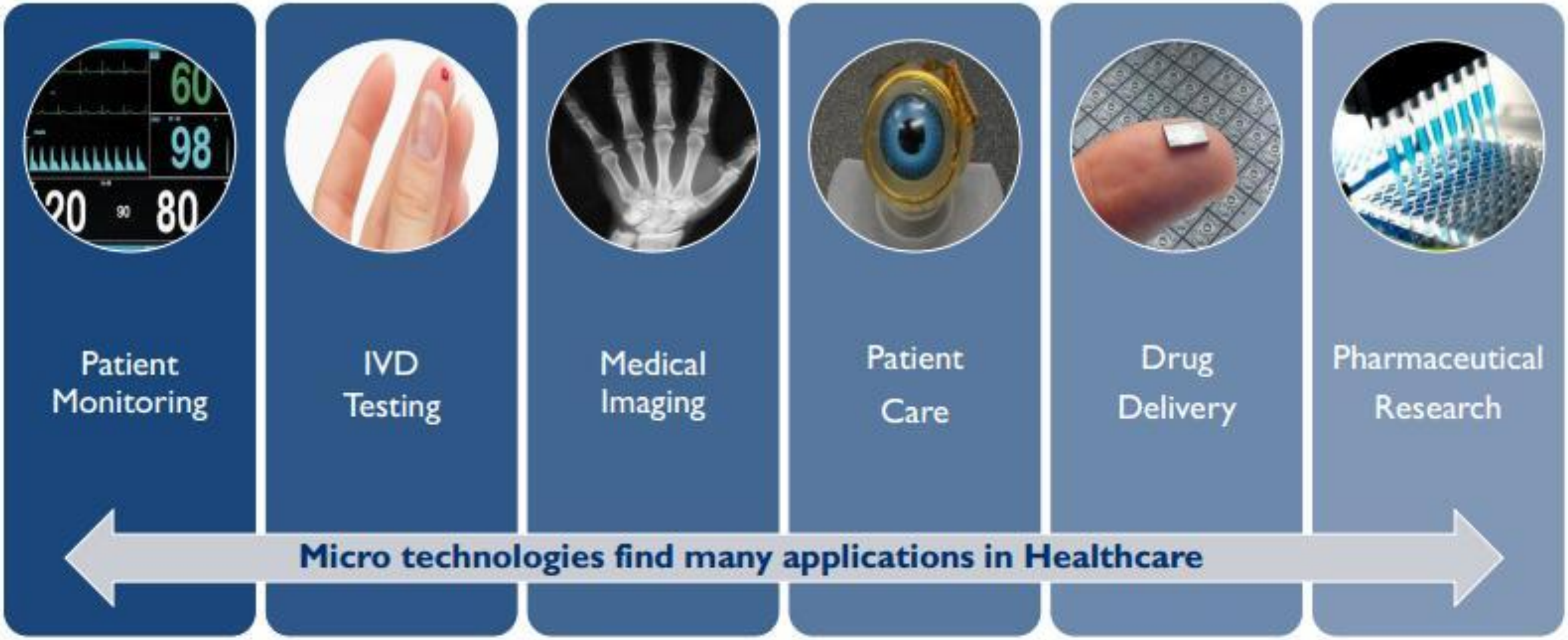


Application of MEMS into Garment



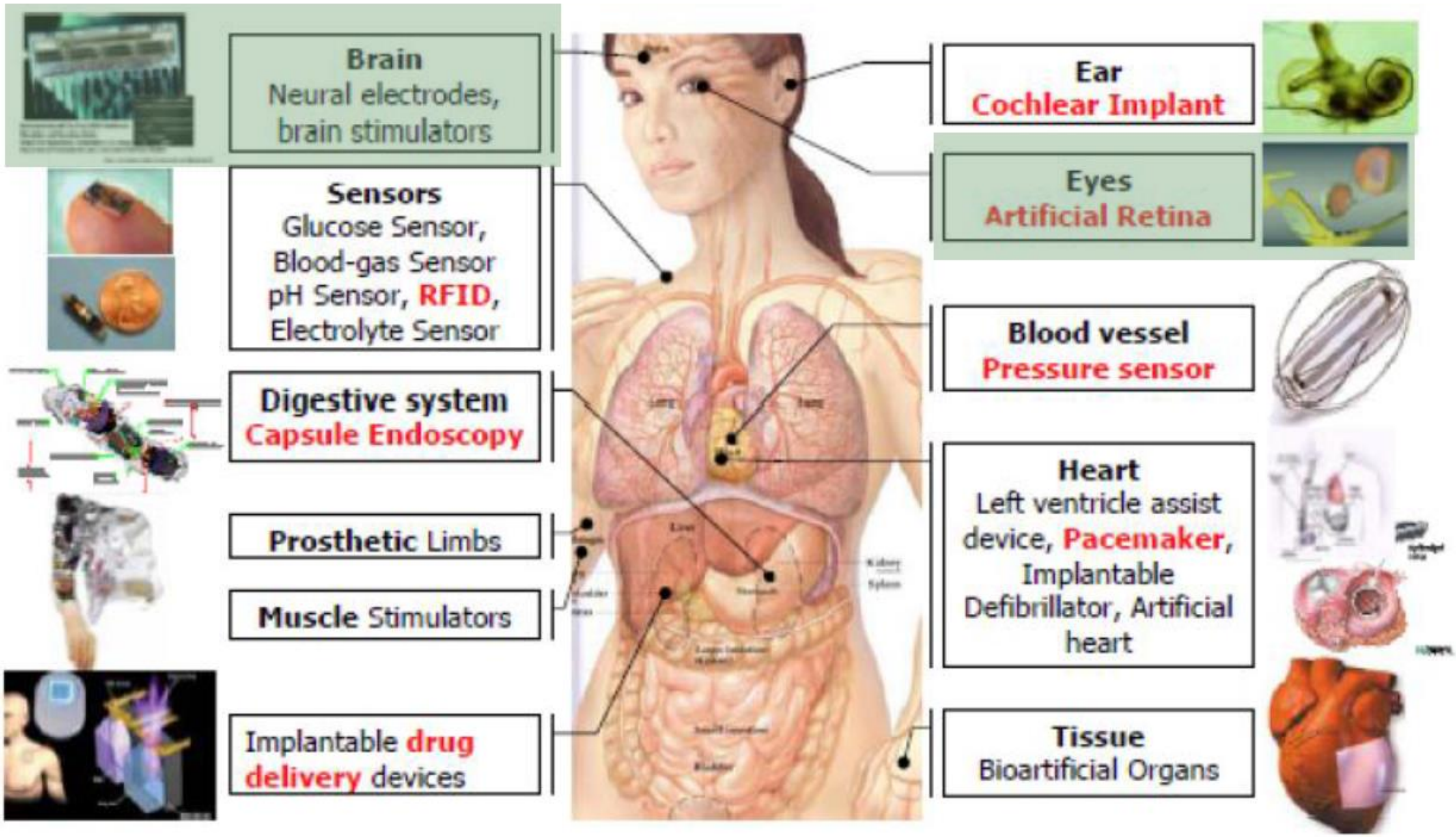
Biomedical Applications

MEMS impact in Healthcare

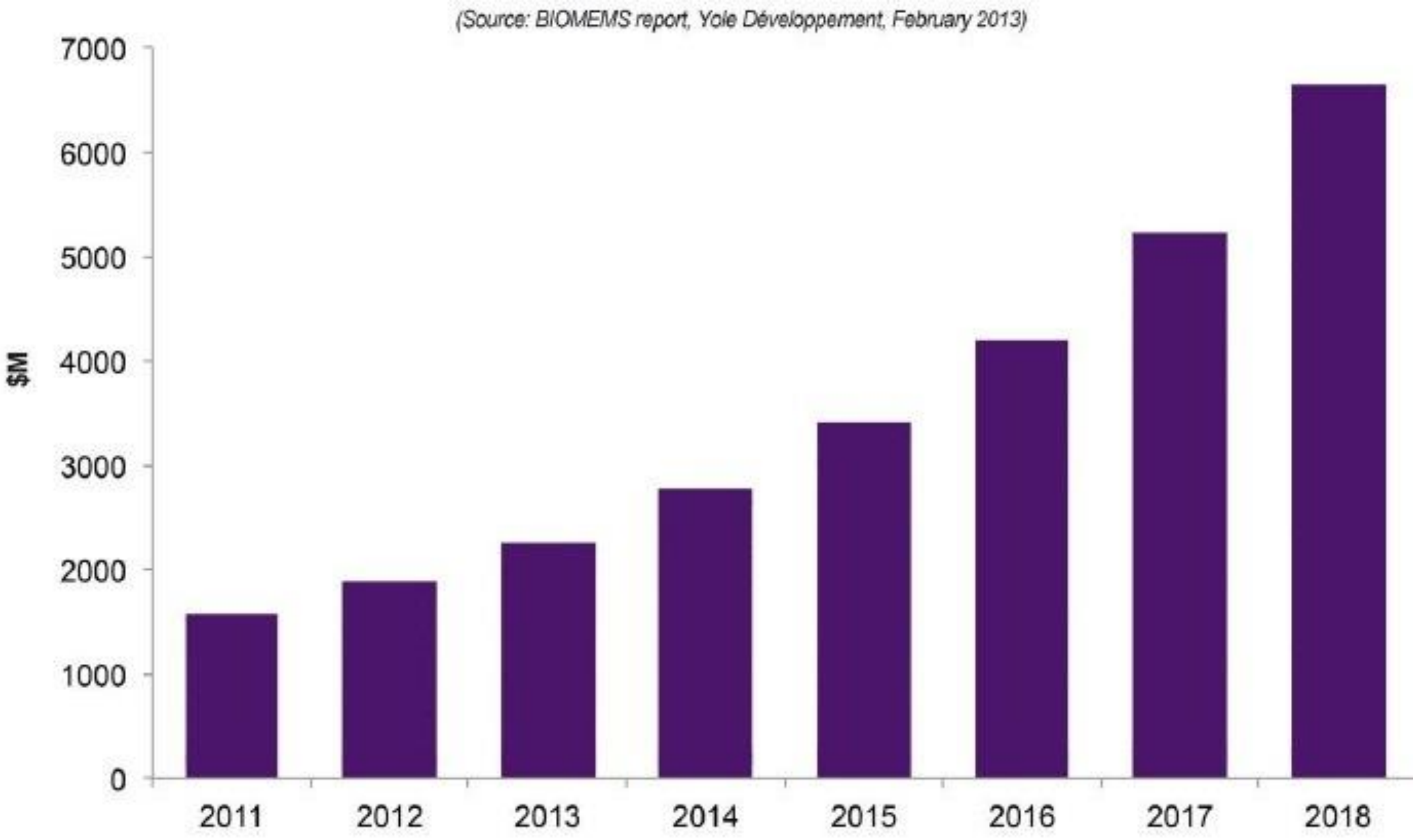


In vitro diagnostics (IVD) are tests that can detect diseases, conditions, or infections. Some tests are used in laboratory or other health professional settings and other tests are for consumers to use at home.

BioMEMS Applications



BioMEMS & Microsystems
for life science market (in M$)



Constrains of BioMEMS

- **Materials requirements**
  - Biocompatibility
  - Mechanical compatibility
  - Chemical resistance

- **Polymer MEMS**
  - ***Advantage***
    - Biocompatible and biodegradable
    - Better mechanical shock tolerance
    - Low cost
  - ***Disadvantage***
    - Mechanical properties change dramatically over a narrow temperature range (low glass transition temp. and melting point)
    - Gas/moisture permeable, will need hermetic packaging

Biocompatibility: definition

- "Biocompatibility" is the ability of a material to perform with an appropriate host response in a specific application (Williams, 1987).

- Examples of "appropriate host responses" include
  - the resistance to blood clotting,
  - resistance to bacterial colonization, and
  - normal, uncomplicated healing.

Biocompatibility: in other words

- The ability of a material to elicit an appropriate biological response in a specific application by **NOT** producing a toxic, injurious, or immunological response in living tissue.
  - Strongly determined by primary chemical structure.

Biomedical Applications

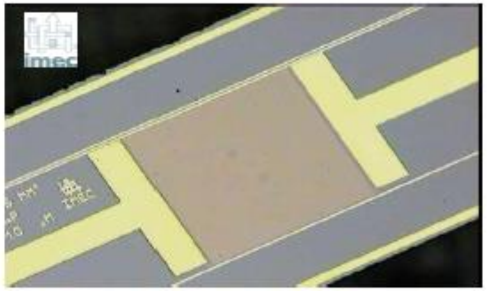
- Usually in the form of pressure sensors
  - Intracranial pressure sensors
  - Pacemaker applications
  - Implanted coronary pressure measurements
  - Intraocular pressure monitors
  - Cerebrospinal fluid pressure sensors
  - Endoscope pressure sensors
  - Infusion pump sensors
- Retinal prosthesis
- Glucose monitoring & insulin delivery
- MEMS tweezers & surgical tools
- Cell, antibody, DNA, RNA enzyme measurement devices

Blood Pressure sensor on the head of a pin

Biomedical Applications

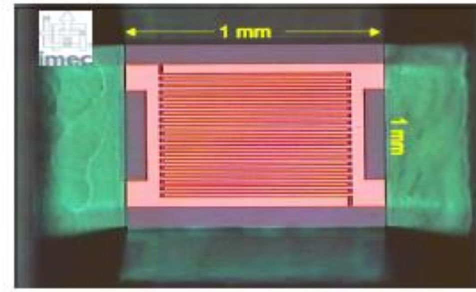
- Laboratory Diagnostic Tools:
  - Microsensors & Microactuators,
  - Lab-on-a-Chip Devices (LOC),
  - Micro Total Analysis Systems (μTAS),
  - DNA and Protein Microarrays.
- Individualized Treatments
- Tissue Scaffolding Devices
- Medication Delivery Devices
- Minimally Invasive Procedures
- Platform for Nanomedicine Technologies
- Homeland Security

Specialized Sensors

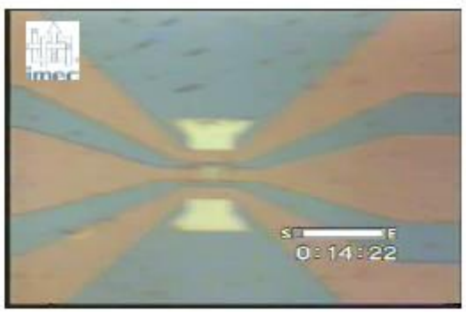


Sub-µm IDEs
(proteins, DNA)

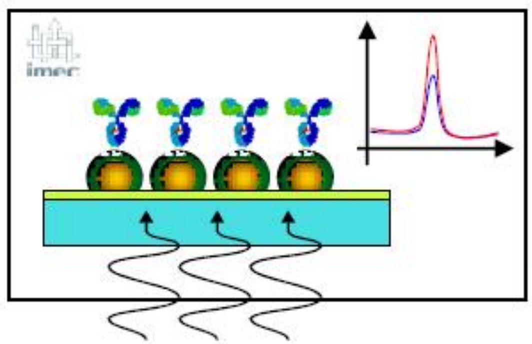
Surface Acoustic Wave
(proteins)



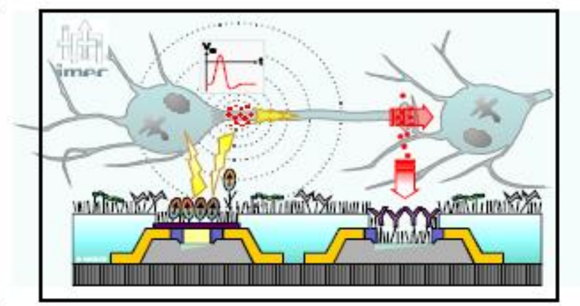
Polymer FETs
(pH, glucose)



Magnetic-bead Biosensor
(proteins, DNA)



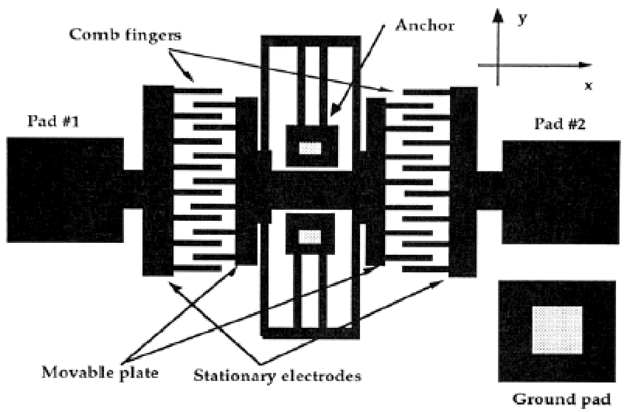
Transmission Plasmon Biosensor
(proteins, DNA)



GaAs MESFETs
(neurons, proteins)

Actuators

- Valve control and pumping
- Positioning and alignment of detectors
- Dispensing of medications
- Harnessing chemical, electrostatic, electrostrictive, piezoelectric, magnetic, thermal and optical phenomenon



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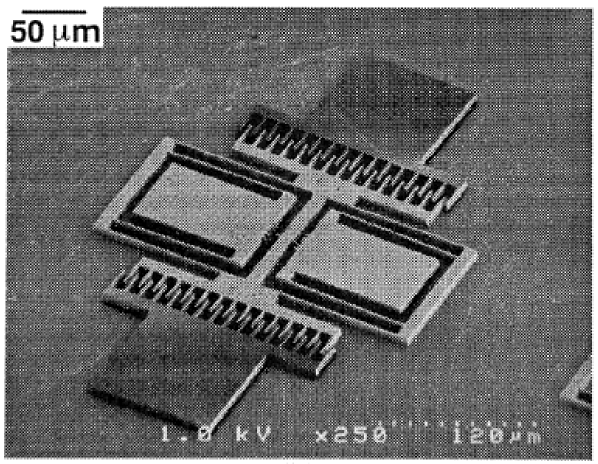

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