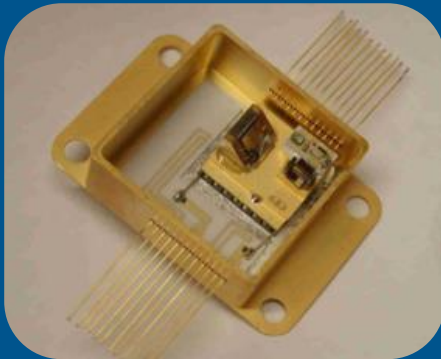
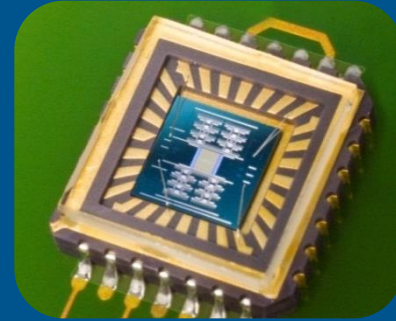


MEMS OTTICI



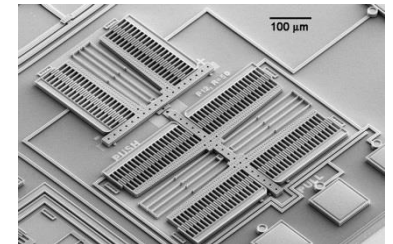
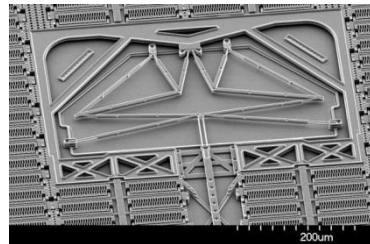
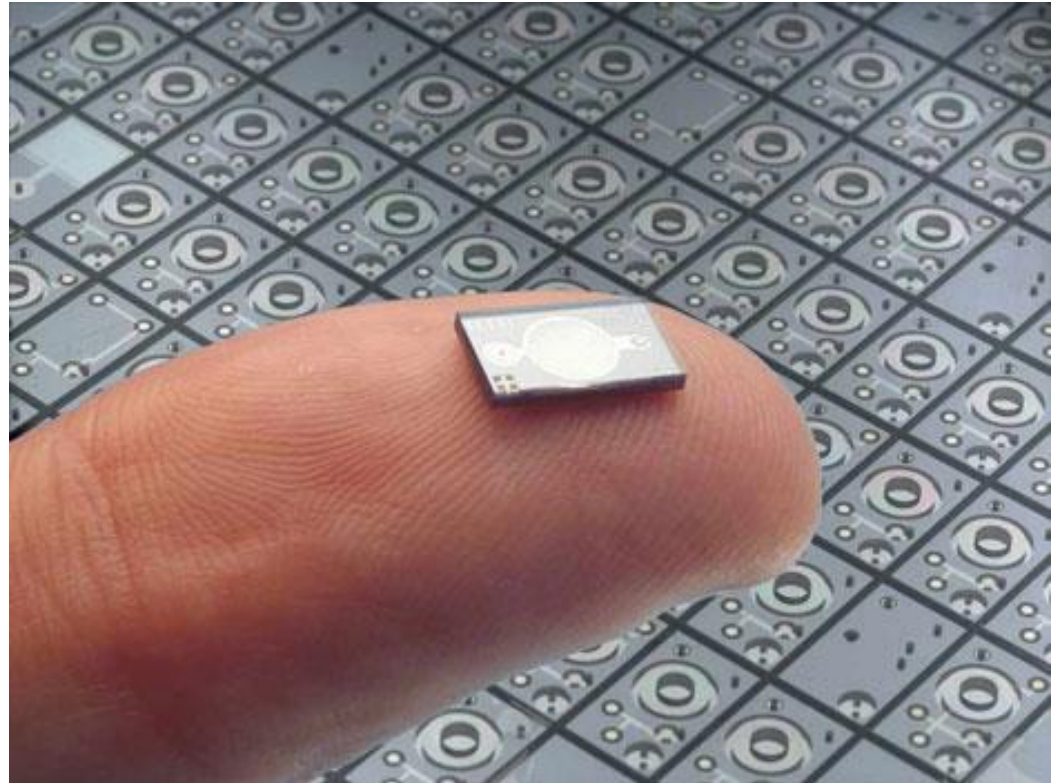
Maurizio Tormen
SUPSI, 26 settembre 2013

Outline

- MEMS
- Optical MEMS
- Optical MEMS at CSEM

What is a MEMS

M Micro
E Electro
M Mechanical
S System



MEMS – Developments and Challenges over time

1990s

Sensoror → Airbag sensor SA20 with piezoresistive beam of silicon is an international success.

~35 million sensors sold



Processing level

1990s'

2000s

Comb-drive architecture is becoming main design for inertial sensors

Texas Instruments (TI) success of DMD



MEMS level

2000s'

2010s

Packaging is becoming more important and an enabling technology.

"First MEMS" products using TSV are coming to the market



SiTime's MEMS oscillator

Packaging level

2010s'

2020s

CMOS MEMS is phasing out.
3D integration allows more functionality on the Si level.
TSV interposers and room temperature bonding create new possibilities.



System level

2020s'

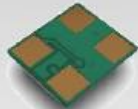
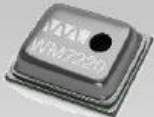
source: Yole Development

MEMS functionalities

Sensing applications

Voice / Sound

- Silicon microphones



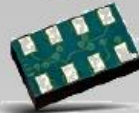
Motion / position

- Gyroscopes
- Accelerometers
- Magnetometers
- Fusion sensor combos & IMUs



Pressure monitoring

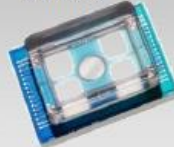
- Pressure sensors
- TPMS modules



Actuating applications

Projecting / receiving Light

- Micro-mirrors



RF related functions

- Oscillators / Resonators
- RF-MEMS switches
- FBAR / BAW filters
- SAW filters



Managing fluids

- Ink-jet MEMS modules
- Microfluidic & Bio-chips



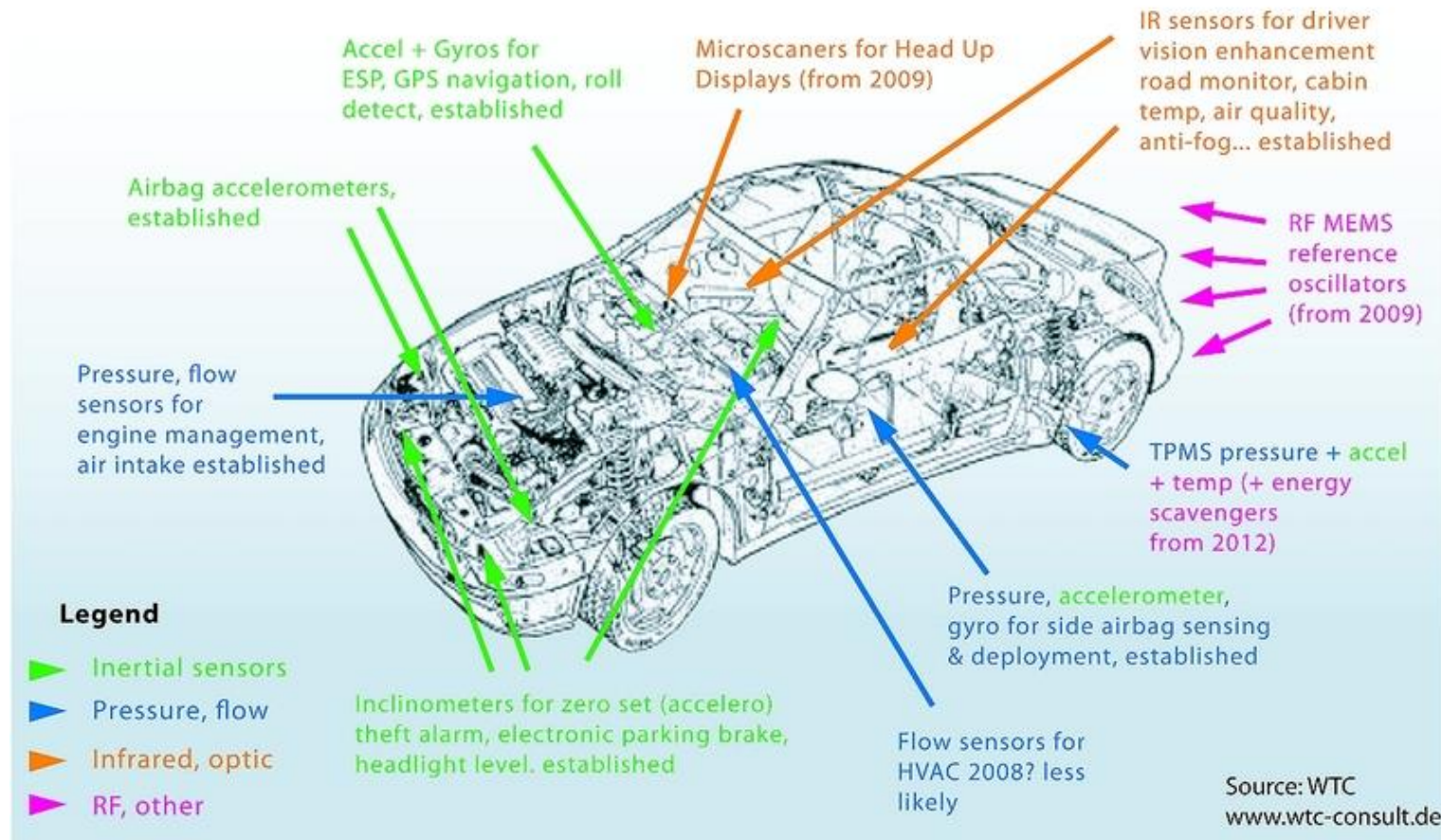
Emerging MEMS...

- μ -Displays, MEMS
- Auto-focus actuators
- IR sensing
- ...

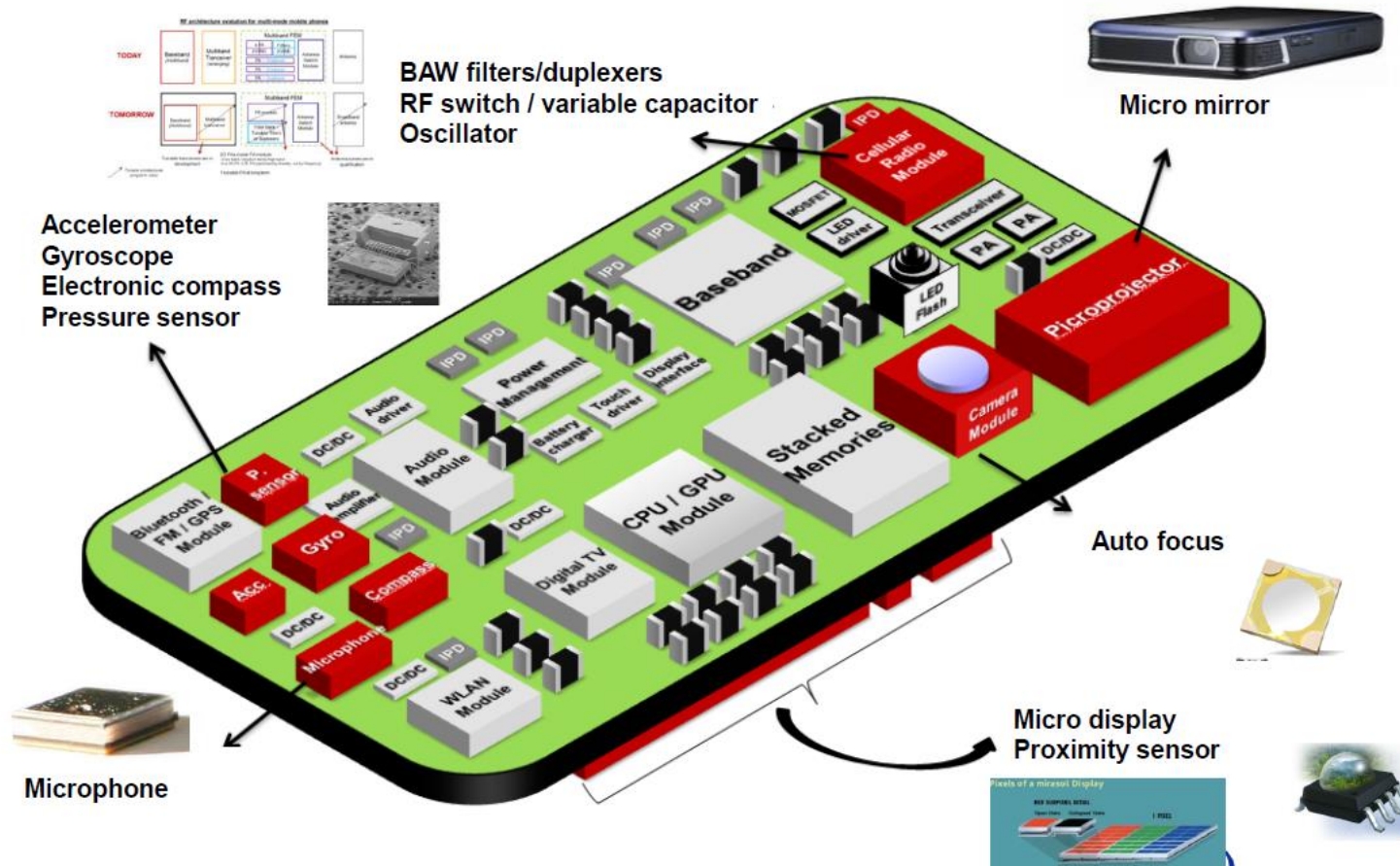


MEMS are present in our daily life

Applications for MEMS in automobiles

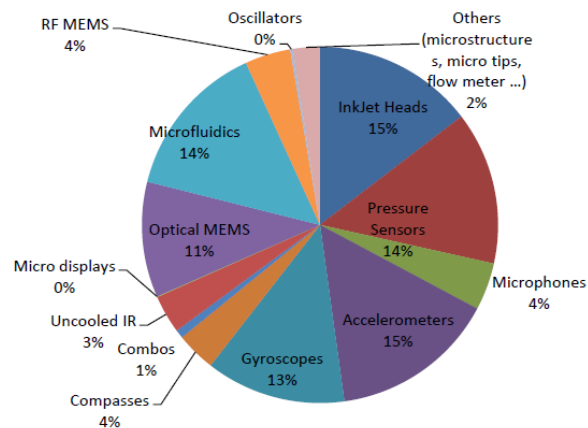


MEMS are present in our daily life

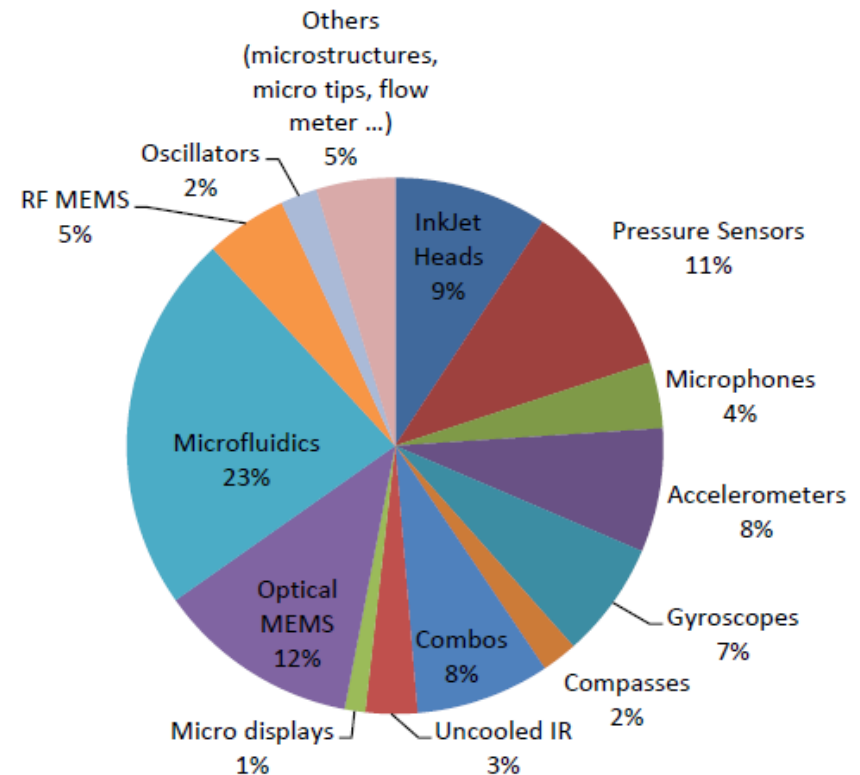


MEMS – Market & Products

2011 MEMS Market Value
Breakdown
(TOTAL \$10,2B)



2017 MEMS Market Value
Breakdown
(TOTAL \$21B)



What is an Optical MEMS

Optical

M **Micro**

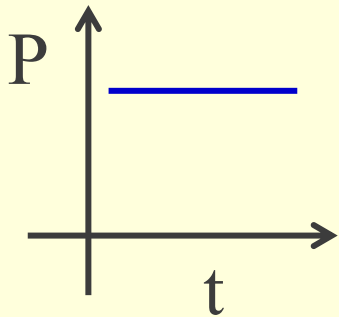
E **Electro**

M **Mechanical**

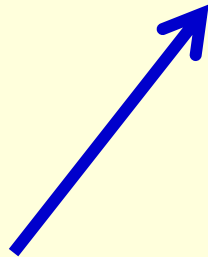
S **System**

Optical properties managed by Optical MEMS

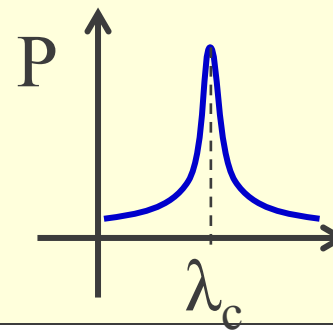
1. Power



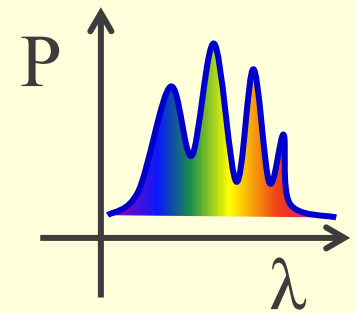
2. Direction



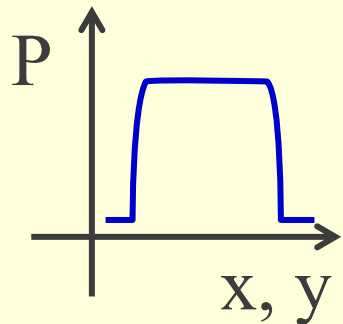
3. Wavelength



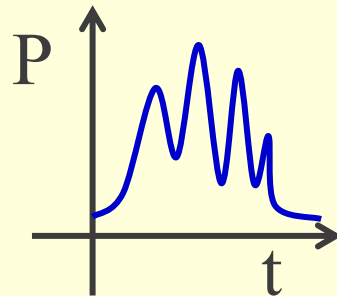
4. Spectrum



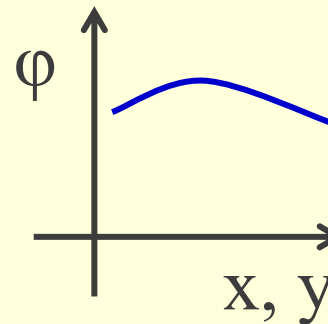
5. Beam shape



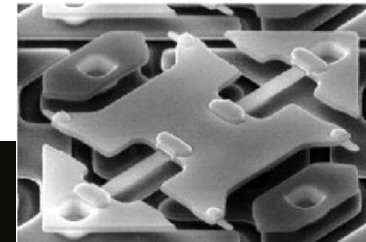
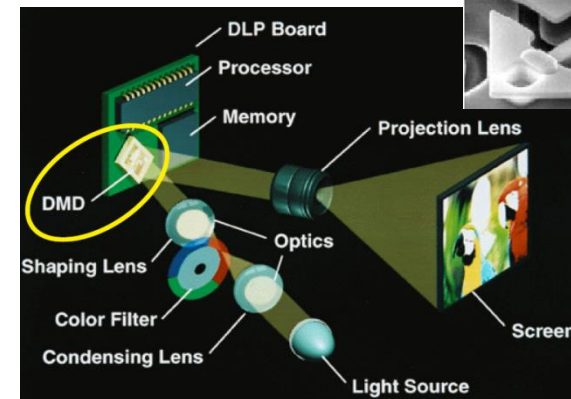
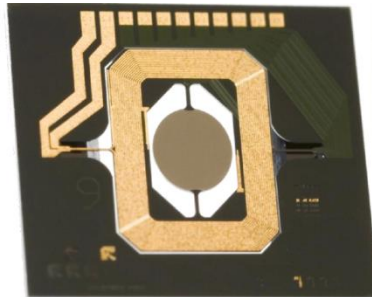
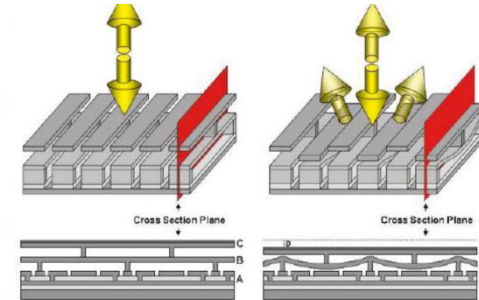
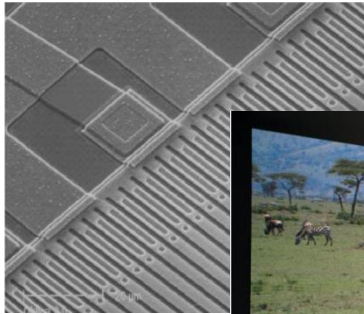
6. Pulse shape



7. Wavefront



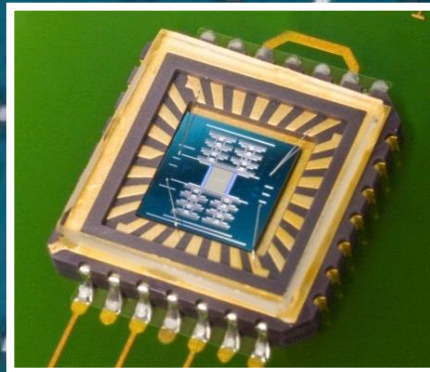
Examples of Optical MEMS in the market



Exactly the same chip
for all applications

Mini-series production
demonstrated
Mass-production possible

Operation in Visible,
near-IR and mid-IR

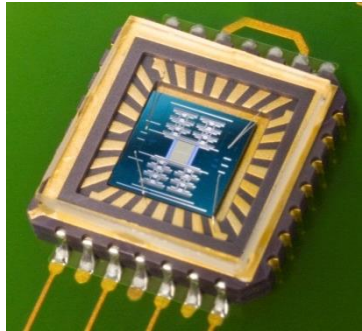


Several demonstrators
realized

Passed severe shock tests
(> 3000 g)

2 granted patents
1 pending patent

MEMS tunable grating

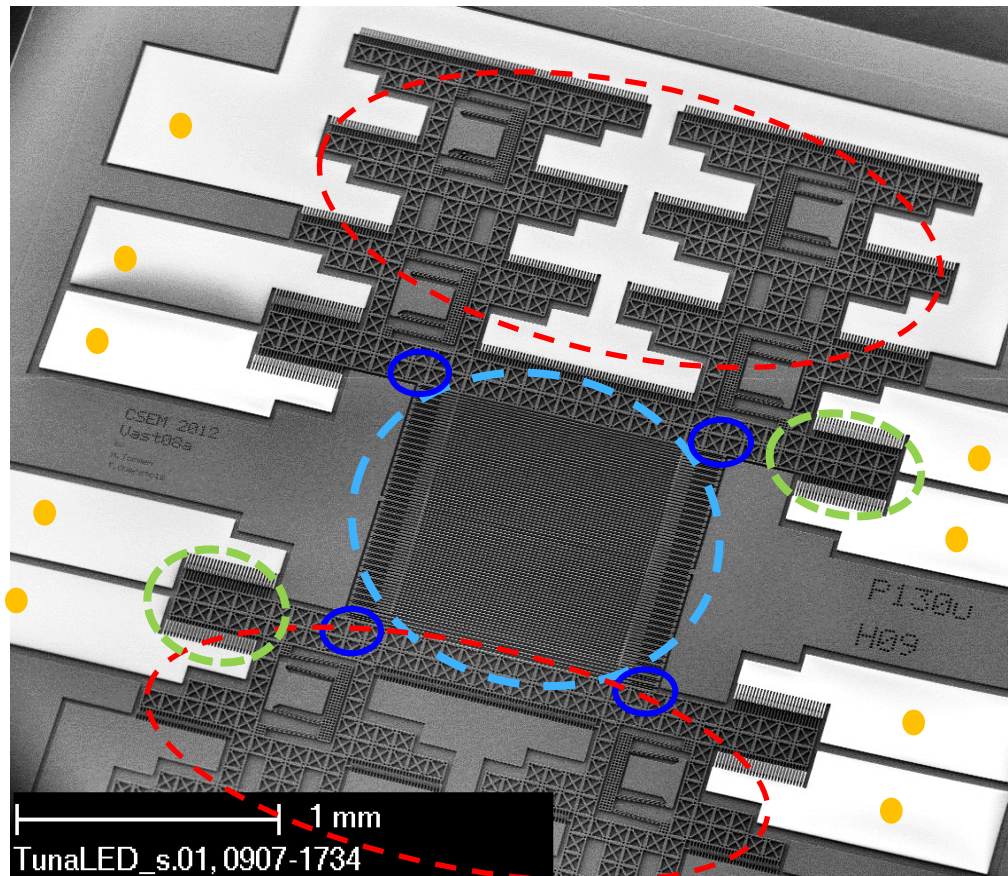


Chip size
5mm x 5mm

Grating size
1mm x 1mm

Blaze angle
54 deg

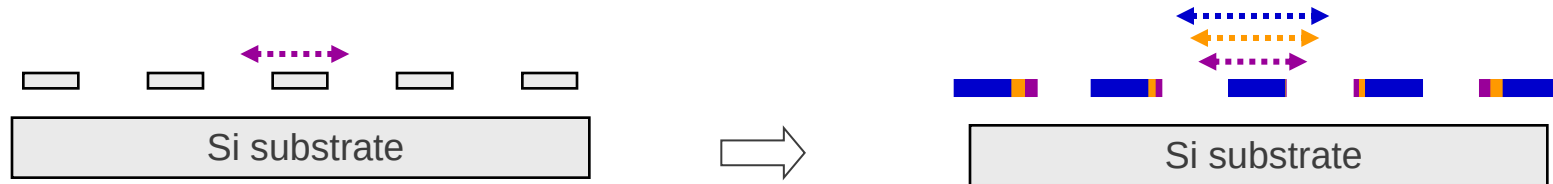
Encoder
differential comb



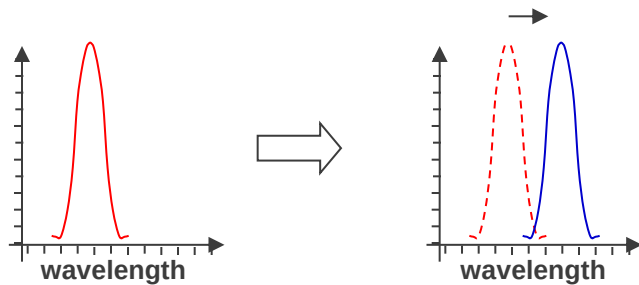
-  Optical grating
-  Anchor points
-  Comb actuators
-  Encoder
-  Pads



Tunable grating function



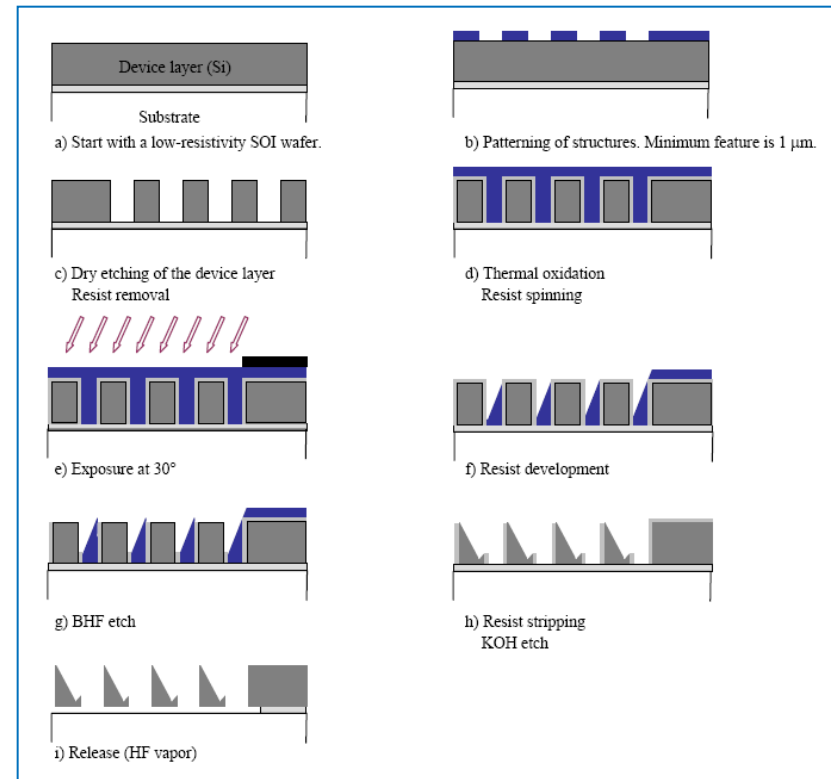
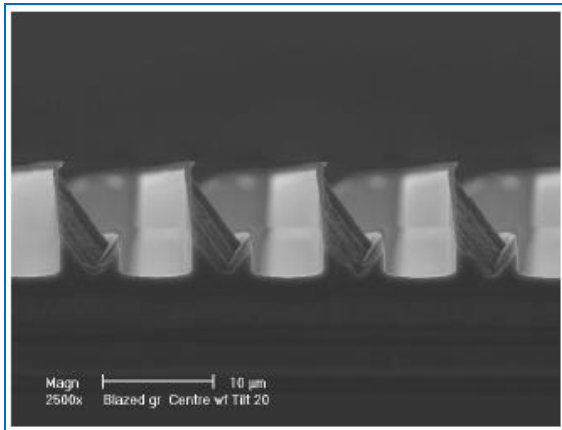
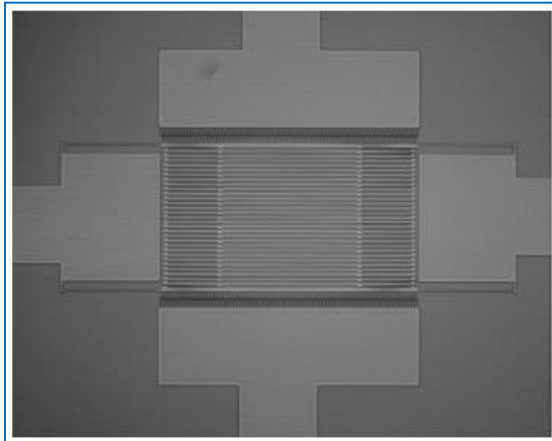
Technique: grating stretching
Advantage: continuous tuning



Applications

- Tunable filters
- External Cavity Lasers
- Spectrometers

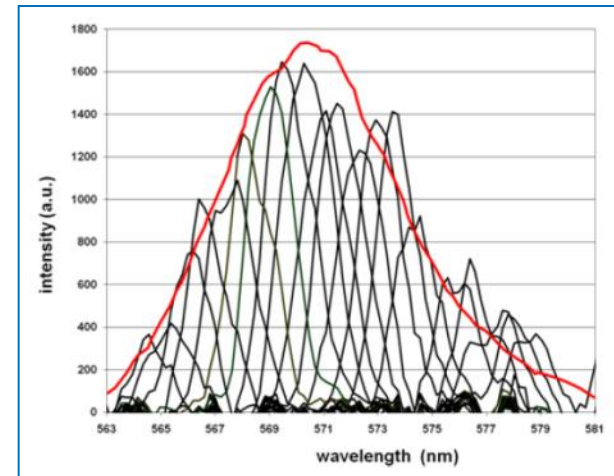
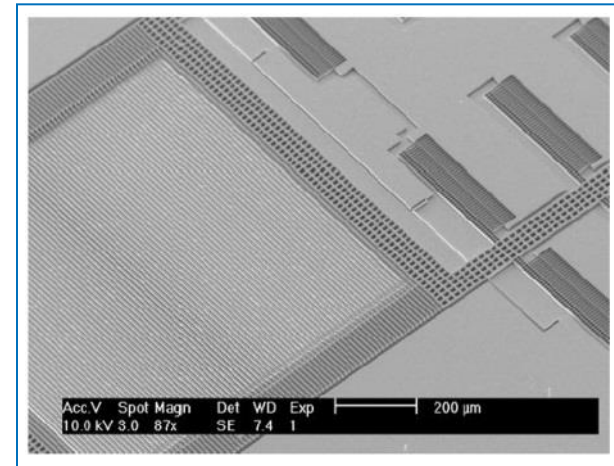
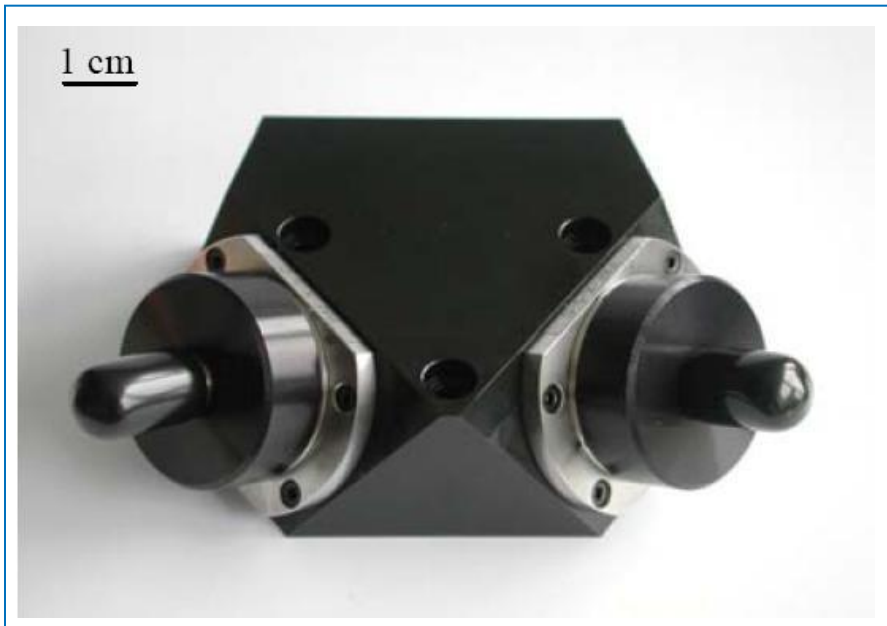
2006 – Concept & Process



Maurizio Tormen, R. Lockhart, P. Niedermann, T. Overstolz, A. Hoogerwerf,
J-M. Mayor, J. Pierer, C. Bosshard, R. Ischer, G. Voirin, and R. P. Stanley

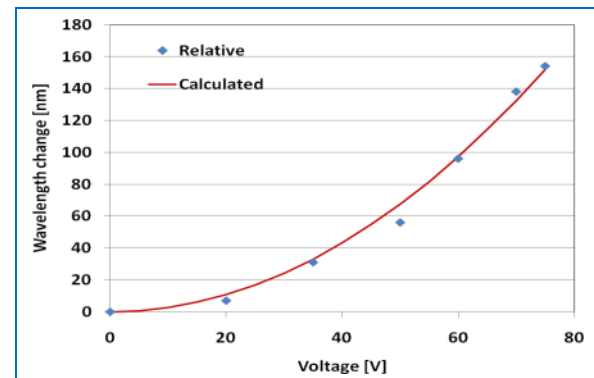
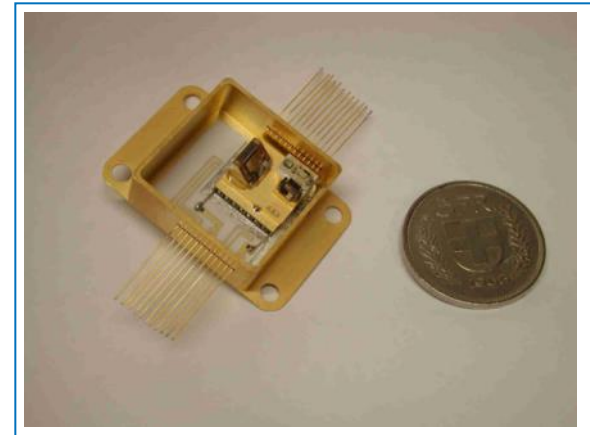
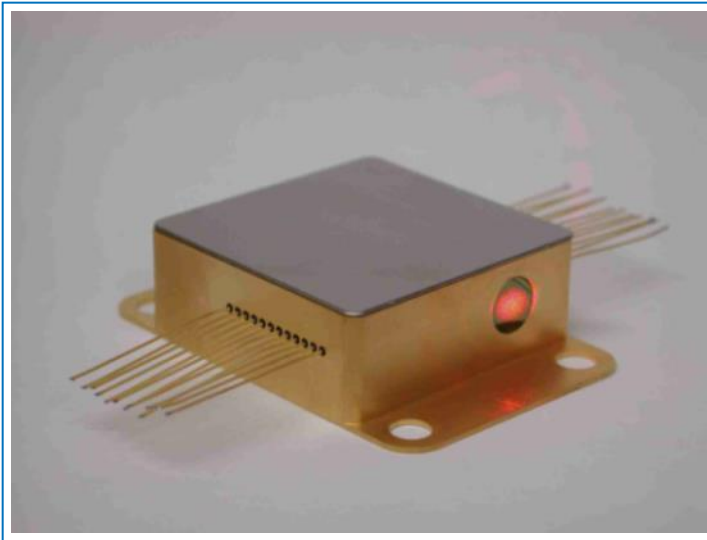
CSEM (Swiss Center for Electronics and Microtechnology),

2008 - Monochromator

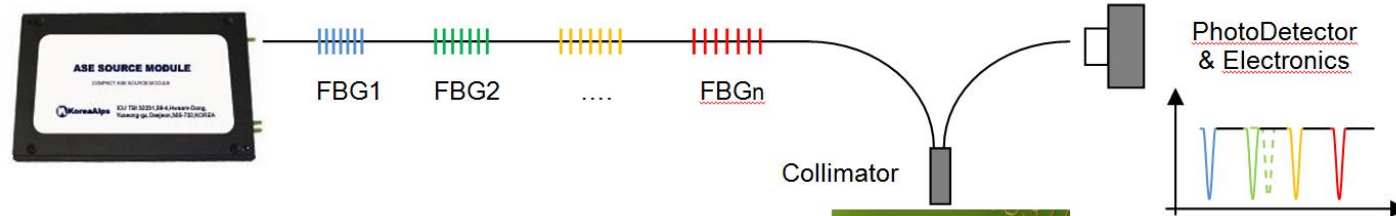
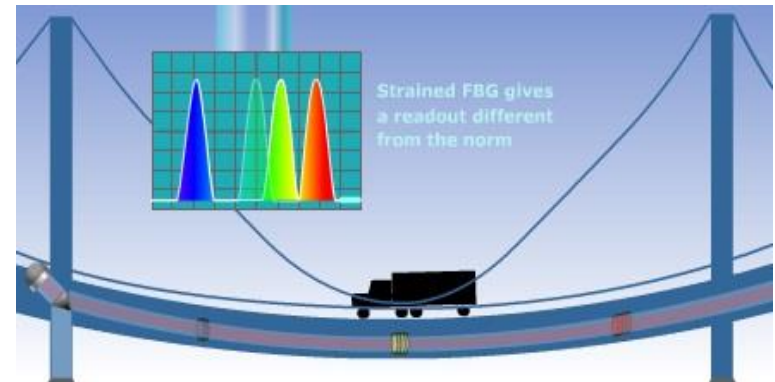
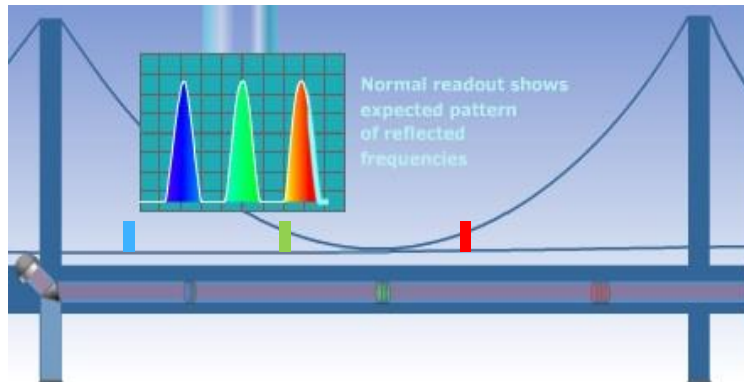


2010 - Tunable laser

Maurizio Tormen, CSEM, Rue J. Droz 1, Neuchatel 2002, Switzerland, Robert Lockhart, Branislav Timotijevic, Thomas Overstolz, Ross Stanley, Jorg Pierer, Real Ischer, Guy Voirin



2011 - Wavemeter

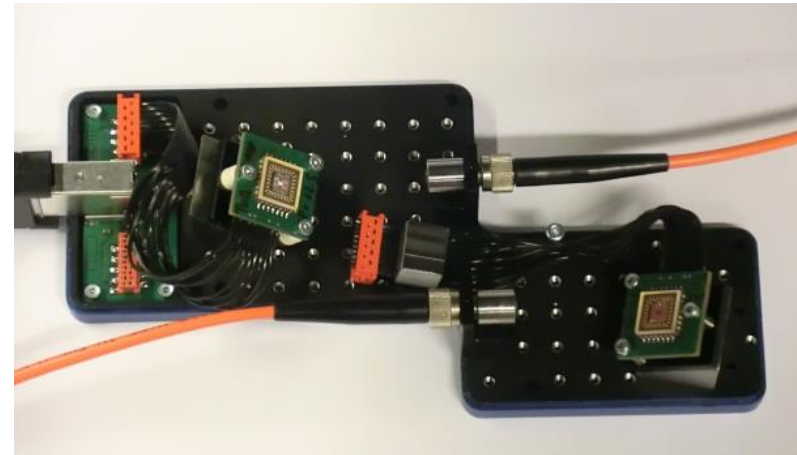
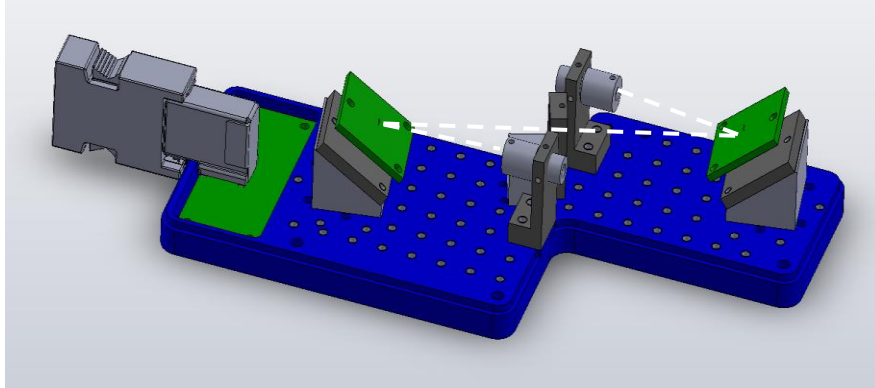


MEMS Wavemeter

What is your idea?

Accurate wavelength determination is key for the correct functioning of complex systems, such as in the biomedical or the construction domain. For example, the stress and deformation inside a building, a bridge or an airplane wing can be

2012 – Double stage monochromator



Optical module

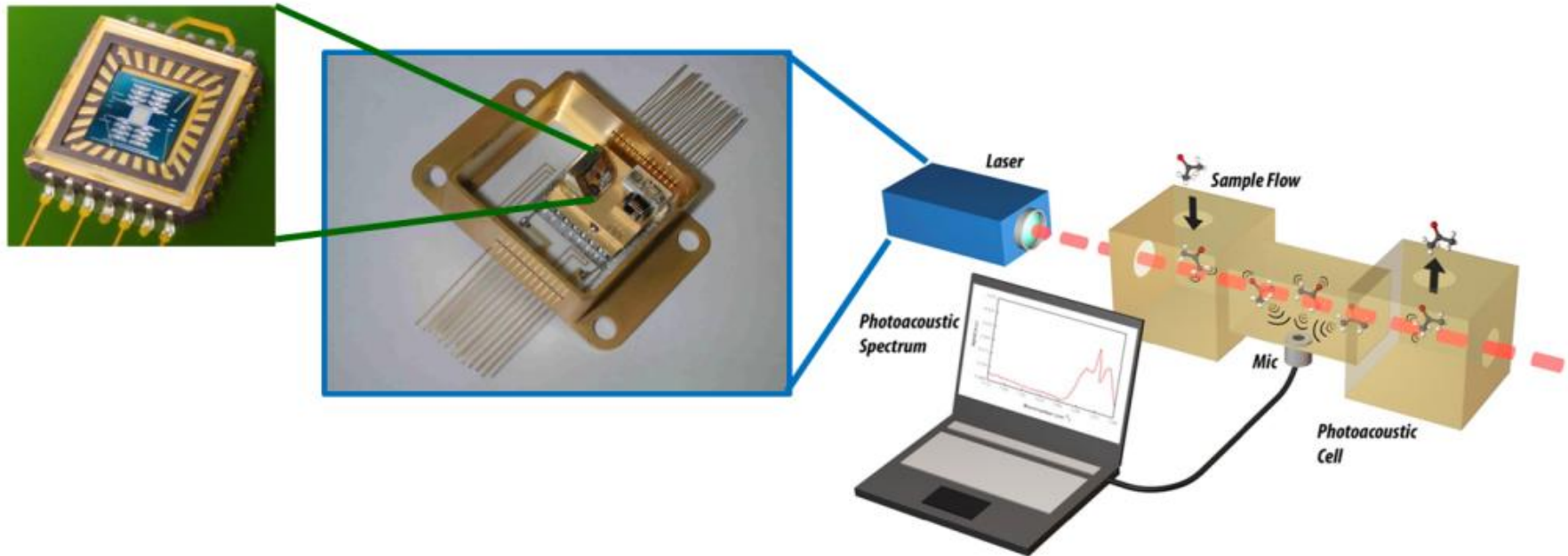


Electronics

(to drive 4 optical modules)

2013 – Photo-acoustic Spectroscopic System

Development of in Photo-acoustic Spectroscopic System based on Tunable Quantum Cascade Laser modules, mounting CSEM MEMS gratings.



THANK YOU

