Lab4MEMS II
“Micro-Optical MEMS, micro-mirrors and pico-projectors”

Photonics Pilot Line workshop.
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Lab4MEMS II: Consortia

- Italy, Malta, France, Belgium, Finland, Norway, Poland, Romania, and Austria are committed to cluster on MOEMS topics.

- Duration: 36 Months

- 21 Partners

- Total cost: ~30 MEur
L4M-II Overview
Lab4MEMS II: key-enabling technologies and new application areas

- **Lab4MEMS II** will feature the Pilot Line for innovative technologies on advanced Micro-Opto-Electro-Mechanical Systems (MOEMS).

- **MOEMS**: not just a special class of MEMS systems but it deals with MEMS merged with Micro-optics, which involves sensing or manipulating optical signals on a very small size scale, using integrated mechanical, optical, and electrical systems.

- **MOEMS** includes a variety of devices including optical switch, array of micro-mirrors, optical cross-connect, lasers and micro lens amongst others. These devices are usually fabricated using micro-optics and standard micromachining technologies using materials like silicon, molybdenum (Mo), silicon dioxide, silicon nitride (Si₃N₄), piezo coating, etc.
MEMS: Not just Motion & Environmental Sensors…

Author: Roberto Zafalon
…. MEMS are also actuators

- Piezoelectric MEMS nozzles for Industrial Printers
- Piezoelectric MEMS lens
- MEMS Speakers
- MEMS μ-Mirrors for Pico-projectors
MOEMS is a promising multi-features technology for miniaturization of critical optical systems. MOEMS could merge in micromachining, microsensors and microactuators if their processes are compatible with integrated circuits.

Miniaturization and integration of conventional optical systems will accelerate the adoption of MOEMS for many industrial products, i.e. MOEMS-actuated micro optical mirrors, 3D Laser micro-scanners, spectrometers.
1. **Pico-projector** as a response to the emergence of compact portable devices such as mobile phones, personal digital assistants, and digital cameras, which have sufficient storage capacity to handle presentation of pictures/movie or slide shows but little space and power to accommodate an attached display screen. Handheld projectors can project digital images onto a white wall or a dashboard.

2. **3D IR Scanner**, to fit into smart-phones, laptop, ultra-books and other consumer mobile devices, or into ultra-fast 3D micro-scanners for new generation’s HMI interface (games, remote control, etc.) or surveillance applications.
Lab4MEMS II: Impact

- **Lab4MEMS II** will be an add-on to the current facility, aiming to implement and optimize the industrial processes and to validate the demonstrators suitable to penetrate the market. Therefore, this Pilot Line will add on the larger manufacturing facility already in place for high volume (i.e. >100M devices/month) 3-axis MEMS accelerometers, gyroscope and other smart sensors.

- To grow the know-how on very strategic enabling technologies, combining scientific skills with design and manufacture of a wide range of smart micro-nano systems on silicon.

- **Lab4MEMS II Pilot Line** will address MOEMS for a 2016 TAM estimated:
  1. pico-projectors TAM 1,457 M$ (CAGR: 8.9%)
  2. auto-focus/zoom-actuators for mobile handsets TAM 181 M$ (CAGR: 117%)

Such a Growth Rate is remarkably larger than the global semiconductor market, anticipated to expand at a CAGR of around 6% during 2012-2015 (source: Reportlinker.com, CA, USA)
Lab4MEMS II: Technology Demonstrators

• The end-products would include precise, yet extremely low power

1. Pico-projector (ST)

2. 3D Laser micro-scanner (ST)

3. NIR microspectrometers (VTT & MEMSfab)

• The Grand Challenges empowered by Lab4MEMS II can be depicted by (not restricted to) the following list:
  • Digital life style internet-multimedia convergence
  • Energy efficiency
  • Safety in traffic and cooperative traffic management
  • Semiconductor process differentiation
  • “More than Moore” material and manufacturing
MEMS micro-mirror: What is behind?

Target

Light Plane

$Ax + By + Cz + D = 0$

Image Point

$(x', y')$

Camera

Laser & Mirror

Author: Roberto Zafalon
System Overview: Time of Flight

The light is reflected from a surface

An active illumination unit sends out light

Wanted: distance $d$ from the camera to the object

Depth (distance) captured by reflected wave phase

$$d = \frac{c}{f_{mod}} \cdot \frac{1}{2} \cdot \frac{\phi_d}{2\pi}$$

Author: Roberto Zafalon
3D reconstruction based on Structured Light

Binary coded pattern

Accurate, effective, IR light

Line code-word: 1010010

Projected over time
Actuation configuration & Modes of operation

• Depending on the application, resonant or quasi-static operation or both could be required. Different comb drive configurations can be implemented to reach the desired behavior.

In-plane comb fingers for resonant mode operation

Out-of-plane comb fingers for quasi-static mode operation
• The target platform will deal with a scanning system featuring a large projection’s range (very challenging goal to achieve a wide optical angle up to 80°) for 3D infrared.

• Innovative MOEMS micro-mirror technology to meet the long field of view projection at high incidence angle, highly reliable, small footprint, low-cost devices for consumer market.

• HMI Application Scenario for consumer. As such, for the detecting module, the platform will rely on the complementary use of a low cost image camera.