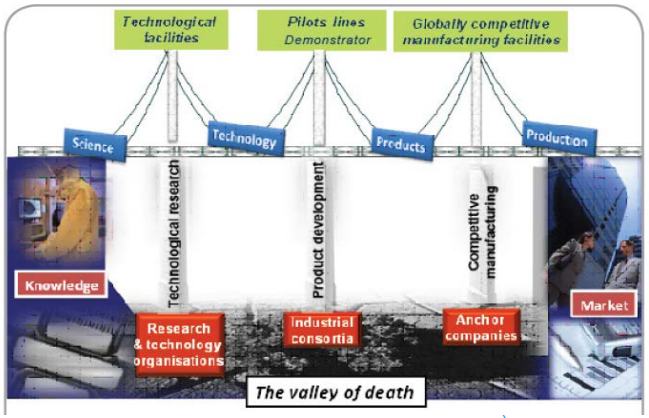
Managing the complexity of a large Pilot Line activity.



KET Conference
Brussels, April 3rd , 2014

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General Project Coordinator of
ENIAC/KET Pilot Line **Lab4MEMS**

ENIAC/KET Lab4MEMS: STMicroelectronics leads KET PL for advanced MEMS's manufacturing

- **Lab4MEMS**: 30-month project; 21 partners from 10 MS; 28 million Eur Budget.
- The project benefits from ST's MEMS facilities in Italy and Malta to establish a complete set of manufacturing competencies for next-generation devices, spanning from design and fabrication to test and packaging.
- ST assets: 900+ patents related to MEMS; more than 4 billion MEMS devices shipped so far; extensive production capabilities currently producing more than 3 million MEMS devices per day.
- The project builds upon magnetic and piezo materials to design new generation's MEMS sensors. A key target is to perfect a PZT deposition process compatible with mass production, enabling enable innovative actuators and sensors on System-On-Chip.
- Advanced packaging technologies and vertical interconnections using flip-chip, through-silicon vias and through-mold vias, enabling 3D-integrated devices for body area sensors and remote monitoring..

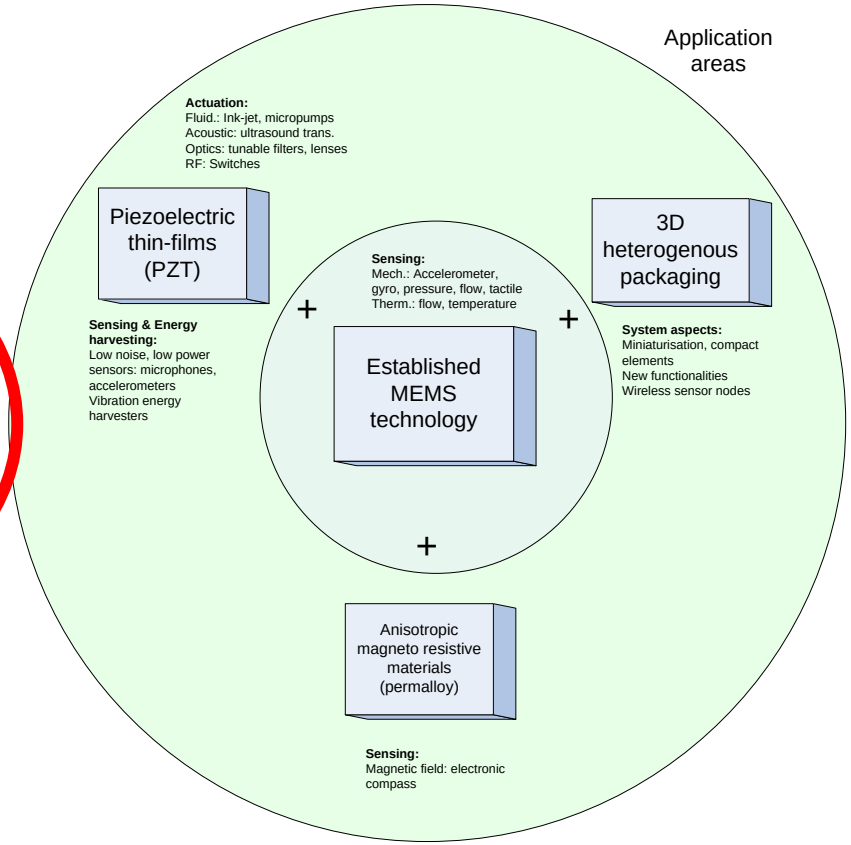
Lab4MEMS's vision : key-enabling technologies and new application areas

- Lab4MEMS aims at introducing new classes of (non-CMOS) materials into the pilot line for innovative MEMS production

- The project will leverage on piezoelectric PZT thin-film and materials featuring Anisotropic Magneto Resistance (AMR) such as permalloy (an alloy of NiFe with very low coercivity and a good sensitivity).

- Such materials will enable a variety of new key functionalities for next generation MEMS devices

- **Lab4MEMS features Multi KET:**
  1. Micro-nanoelectronics
  2. Advanced materials
  3. Advanced Manufacturing



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Lab4MEMS: Expected Impact

- The **MEMS** PL is based in Agrate (IT), on 200 mm wafer. Once in operation, it will process >600 wafers/week.
  - ST-I fits a new set of R&D equipments for PZT and AMR, as part of a larger manufacturing facility already in place for high volume (i.e. >100M devices/month) 3-axis MEMS accelerometers and gyroscope.
  - This strategy will increasing the know-how on very strategic enabling technologies, combining scientific skills with the ability to design and manufacture a wide range of smart systems on silicon.
- The **Packaging** PL is based in Kirkop (Malta)
  - ST-M integrates a new set of R&D equipment for flip chip, vertical interconnections (Through Silicon Vias and/or Through Mold Vias) and Wafer Level Package, as part of a larger back-end manufacturing facility for high volume MEMS products.

KET PL: Challenges & Opportunities

- Although a large political endorsement from the EC and all the main MS, the level of public funding on KET until today is much lower than claimed.
- On the industrial side, not easy to mobilize ~1BEur/Y investment in manufacturing facilities and equipment, with the target of receiving 30-45% grants on depreciation, 3 to 5 years later
- KET is more “SME friendly” instrument
  - closer to real supply chain, products and market

Why public funding?

- Although the industrial roadmap for the Pilot Line was decided earlier, the ENIAC public money helps to speed up the investment plan and to compensate the risk of “market slip”. In addition, partnering with EU’s top notch RTOs and SMEs give a competitive edge, not achievable out of EU collaborative programmes.

- Public Funding allows to:
  - Alleviate the financial burden
  - Motivate the company to invest on high-tech manufacturing

- Issues are:
  1. Non homogeneous and sometimes colliding industrial policies among MS’s. On the JTI this translates into a pletora of national procedures and contracts to sort out along the whole project’s duration: This overhead in fully in charge of the coordinator.
  2. Largelly unadequate level of public funding to sustain the capex investment

Lessons learned

- Lessons learned (positive or negative)
  - KET is a good paradigm-shift to recovery and augment the industrial manufacturing capacity on high-tech.
  - Remove the cattle grid of multiple NGAs from each different National PA! Only the JU-GA should apply (enforced): same rules, same eligibility criteria, same funding rates across the MS.
  - Facilitate funding “across boundaries”
  - Use the JU funding to guarantee pre-payments at start time.

- In principle, ESIF can complement H2020 (based on RIS3). Still, with a huge bureaucracy and unpredictable times!

- Don’t ask the Project to have as many independent WorkPackages as participating Regions or, even worse, to make a “best-coverage” financial puzzle of the Work Plan!

Lab4MEMS: two-fold Demonstration strategy

1. **Proof-of-concept** ***:*** A suite of intermediate demonstration vehicles will be delivered and assessed at midterm, to prove the actual feasibility of initial device solutions, wafer substrates, process steps, tools or equipments.

2. **Final Technology Demonstrators** : From the *"proof-of-concept"*, the work-flow will then converge and optimize a set of four Tech Demonstrators intended to become the main flagship vehicles to demonstrate the KET Pilot Lines.

   Lab4MEMS *Final Technology Demonstrators:*

   a. Print-head for industrial printers, piezo actuated

   b. Micro-electric scavenger, by mechanical/vibration energy

   c. AMR magnetic sensor

   d. 3D MEMS packaging

Proof-of-concept designs

1. ENERGY HARVESTERS

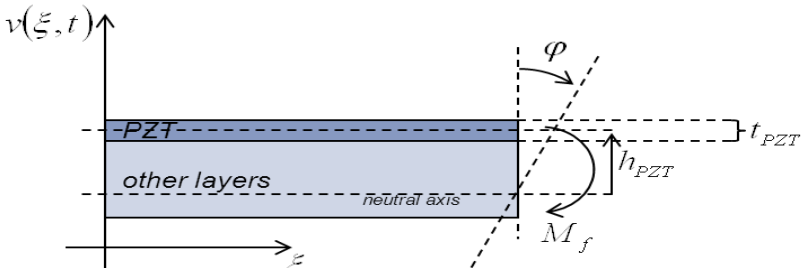
2. ULTRASOUND TRANSDUCERS

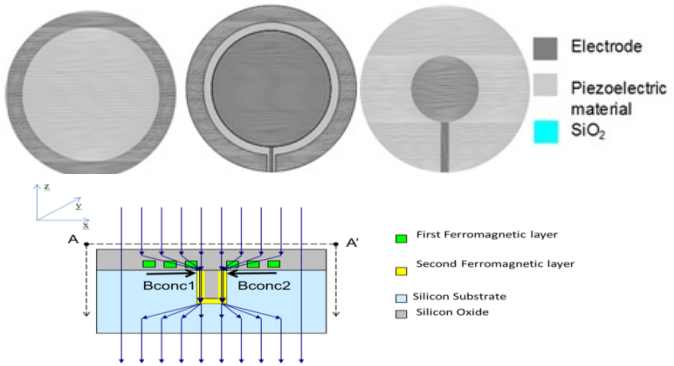
3. MAGNETOMETERS

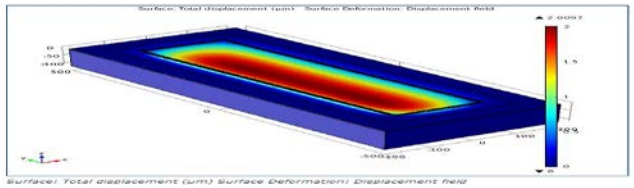
4. PRINT-HEADS

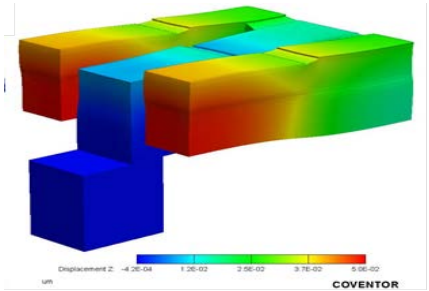
5. RF MEMS

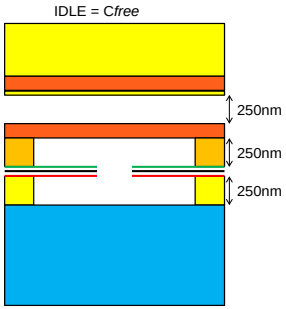
6. TEST STRUCTURES

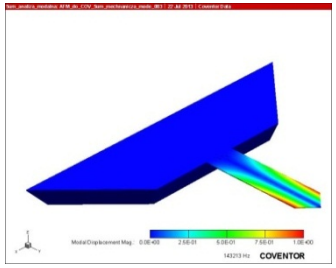












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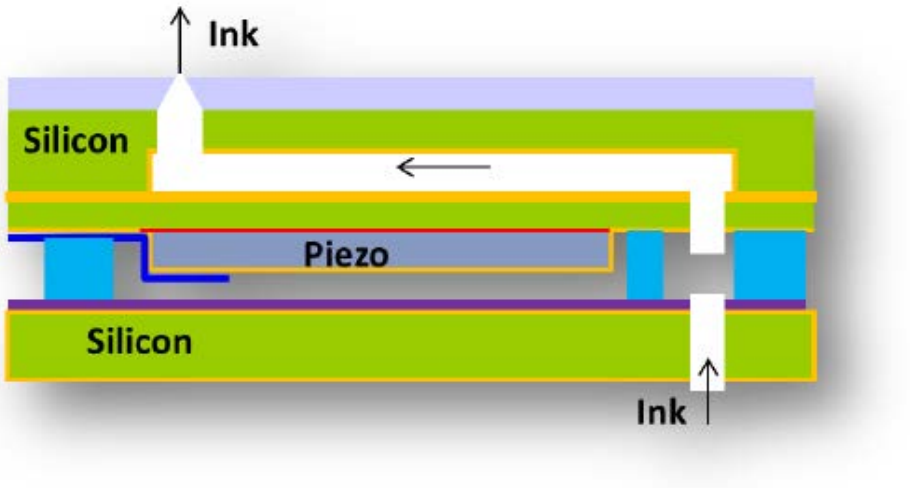
Piezo print-head for industrial printers

Fully integrated print-head for professional piezoelectric inkjet printers:

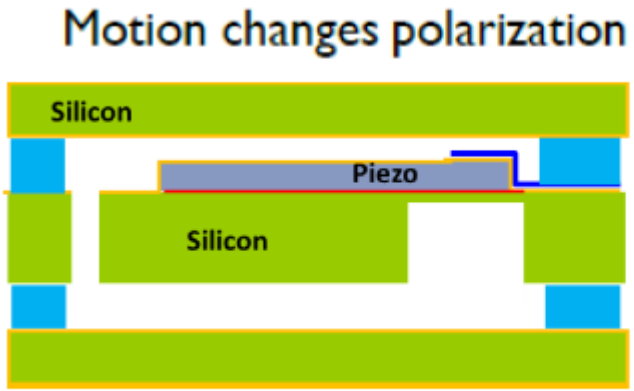
- Very high nozzles density (1200 dpi) by 55 um nozzle physical pitch;
- High frequency of droplet firing (up to 100KHz)
- Droplet volume down to 3 pL and flight speed of 10 m/s
- Compatibility with wide set of aqueous, curable, UV and wax inks
- High reliability: up to 10^{11} fired droplets before head maintenance
- Operating temperature in the range -40C to 85C
- Fabrication process compatible with size scaling and design customization
- Low manufacturing cost (current for bulk-piezo printheads is ~0.5 $/nozzle)



Technology demonstrators – b.

Micro-electric piezo scavenger, powered by mechanical/vibration energy

- Multiple piezoelectric sources, combining the individual power sources yet minimizing loss
- From the mechanical pressure to the power manager's output: Total yield > 90%
- Run on a battery-less platform
- The intrinsic consumption of the multisource <1 uW requiring few 10 nA for the power management and for any single source
- Face with irregular vibrations, using algorithms handling active power conversion, using subthreshold asynchronous electronic control
- Active operation control handling: circuits detect in real-time 0-voltage and 0-current conditions to operate with a large variety piezo source and transducers.

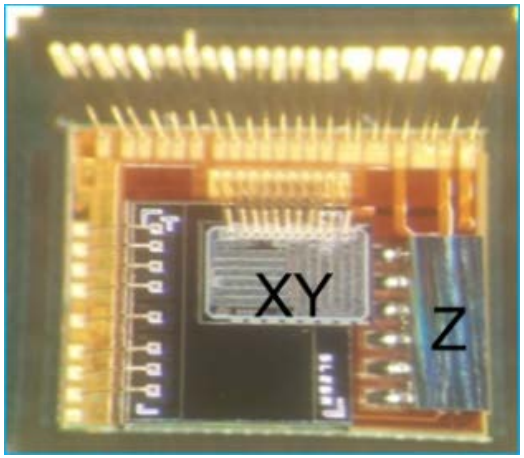


Vacuum Wafer-level packaged die

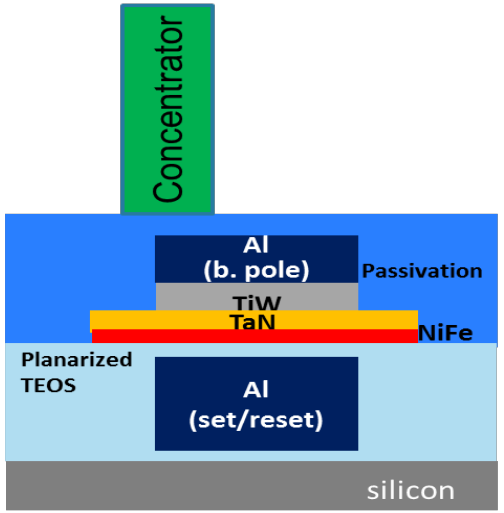
Technology demonstrators – c.

AMR 3-axis magnetic sensor

- Demonstrate new ways to get reliable and less expensive assembly of the vertical Z-axis on magnetometers.
- Assembly of magnetometer with a 3-axis MEMS gyroscope
- Integration of magnetic materials in MEMS nano-structures



Today's plane integration with two magnetic devices. The goal is to integrate the three axes onto the same chip.

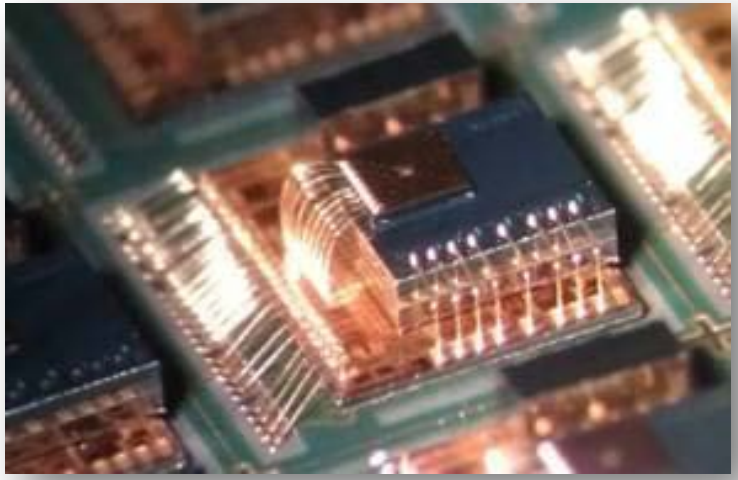


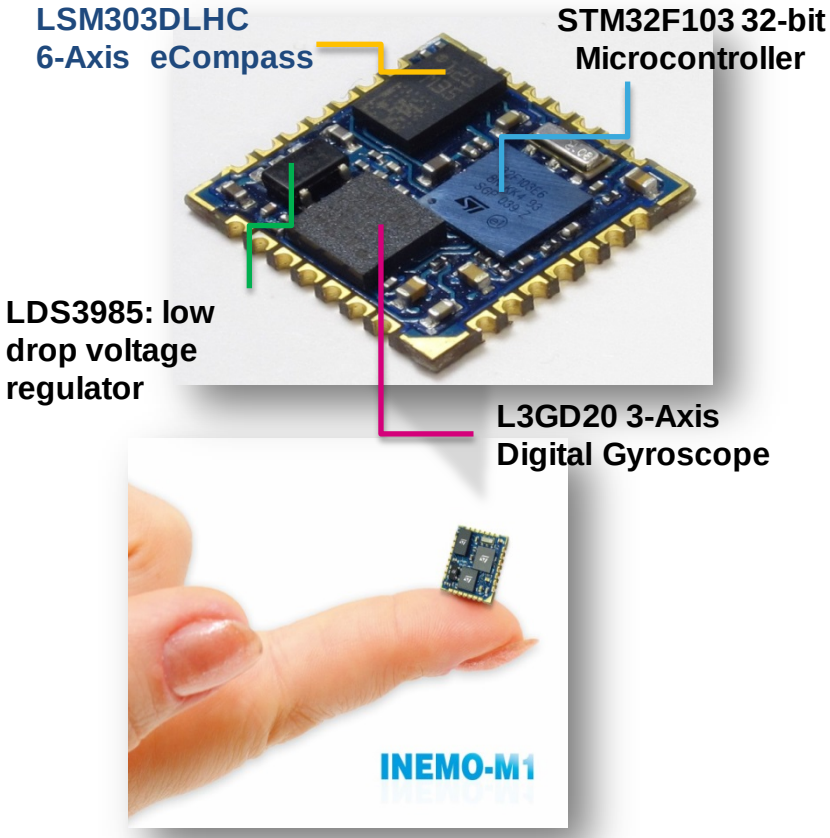
Cross-section for planar AMR vertical-axis based on electroplated concentrator.

Technology demonstrators – d. (1)

3D MEMS packaging

- 3-axis magnetometer assembled together with a 3-axis MEMS gyroscope and 3-axis accelerometer
- Integration of magnetic materials in MEMS nano-structures





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Technology demonstrators – d. (2)

New Advanced 9-Axis Motion/Position Sensor allows Smaller, Smarter Electronics

- Enhanced performance
  is almost 35% smaller th
- Adds new features to ge
- Small size and battery e
  technology, will drastica
  devices.

> MEMS

STMicroelectronics targets smaller, smarter electronics with new advanced 9-Axis movement/position sensor

Jan 9th, 2014

Highest integration utilizing latest MEMS technology boosts performance and efficiency while squeezing size for smart mobiles and next-generation wearable devices.

Send to a Friend

STMicroelectronics (NYSE: STM), a global semiconductor leader serving customers across the spectrum of electronics applications with more than 900 MEMS-related patents and patent applications worldwide, has revealed its most advanced module for 9-axis movement and position sensing in next-generation mobiles and tiny wearable devices.

Delivering enhanced performance with reduced power demand, in a 3.5mm x 3mm outline, which is almost 35% smaller than previous generations, the LSM9DS1 module supports the context awareness needed for features such as gesture controls, indoor navigation, and augmented reality. Its small size and battery efficiency, achieved by using ST's latest low-noise sensor technology, enhance the usability and comfort of wearable devices by reducing bulk and extending battery life between charges. In addition, greater positional resolution enhances the stability and precision of applications such as smart-TV remotes, game controllers, and wearable sports or medical sensors.

"*This tiny, high-performance 9-axis module leverages our latest MEMS technology to enable a wide variety of position-sensing and movement-tracking applications in next-generation mobile and wearable devices,*" said **Benedetto Vigna**, Executive Vice President and General Manager Analog, MEMS & Sensors Group, STMicroelectronics. "*With 30% higher magnetometer resolution, 20% lower power and a footprint more than one-third smaller than other devices, designers have extra freedom to establish new form factors and improve stability and performance.*"

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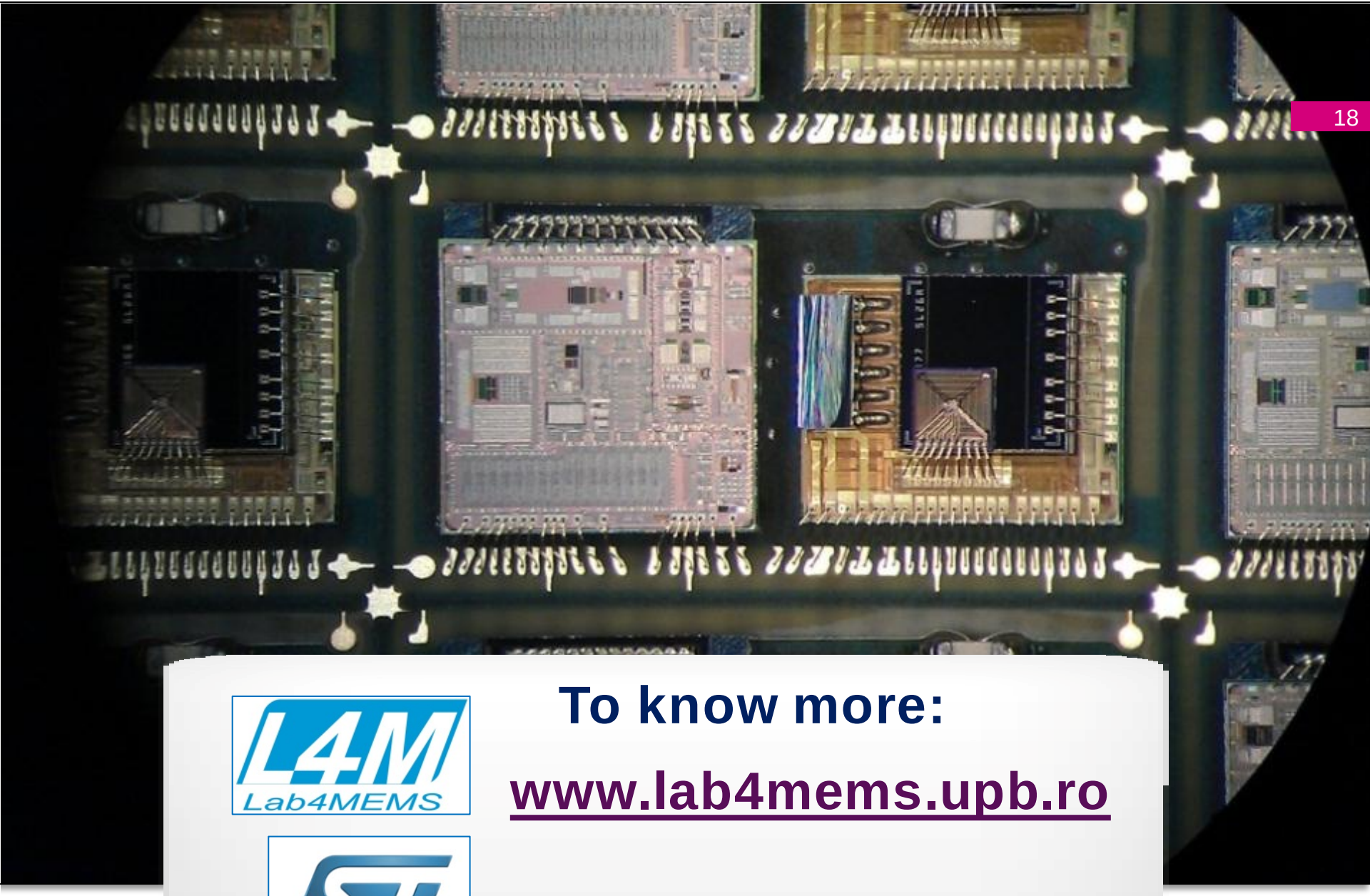

To know more:

www.lab4mems.upb.ro

www.st.com/mems

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