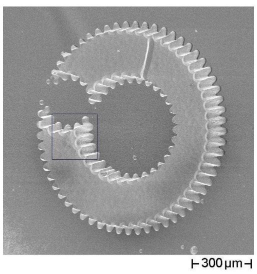
1. FINAL PUBLISHABLE SUMMARY REPORT

The main objective of the project MicroPAdS is to develop innovative centi/millimeter active structures integrating on the same piezoelectric material both the actuating and the sensing functions, with control laws enabling the achievement of micro/nanometric resolution and high bandwidth (some hundreds of Hz). To achieve these objectives, the project were split into several multidisciplinary tasks:

- Research of newer materials and different microfabrication technologies to treat them, for high performances actuators and sensors dedicated to the micro and nano-scale. We derived that PMN-PT Piezoelectric materials combined with silicon would be very promising to develop high performances and embarkable Microsystems. These PMN-PT/Silicon Microsystems, called piezoMEMS, can be easily fabricated using existing microtechnologies (laser, reactive ionic etching, saw dicing…) allowing therefore the batch fabrication. Fig.1 presents some examples of fabricated elementary piezoMEMS.
- Design of cantilevered microactuators and microgrippers for micromanipulation and microassembly of micrometric size objects mainly based on a mix of thermal and piezoelectric principles (called hybrid thermopiezoelectric actuator). These innovative microactuators allows a large amplification of the range (up to 5times more than of classic piezoatcuators) by maintaining the high resolution of positioning. Result: one patent is pending. Fig.2 presents a hybrid thermo-piezoelectric microactuator and a developed hybrid microgripper.
- The development of embedded measurement systems for piezoelectric microactuators by employing the self-sensing technique. The developed technique, based on a convenient electronic scheme and an observer technique, allows the use of a piezoelectric Microsystems as an actuator and sensor at the same time. Results: major improvement of signals, reduction of system costs, possible applications for AFMs microscopy. As shown in Fig.3, the self-sensing technique allows a considerable reduction of space of the measurement and control of the Microsystems since the datagate and the sources are both embedded in one electronic board.
- Development of microrobotics. We designed and successful tested a mobile microrobot actuated based on the combination of magnetic and piezoelectric effects. Result: we participated to the annual competition of micro/nanorobotics held at IEEE ICRA conference May 2010 in Alaska. Place: 1st place and world record award for the 2mm dashed challenge. Fig4 presents the MagPieR mobile microrobot.



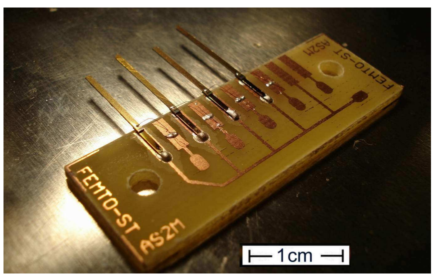


Fig1. A micro-gear feature etched by inductively coupled plasma in PMN-PT material (left). Some PiezoMEMS cantilevers structured of PMN-PT material on Silicon wafer (right).

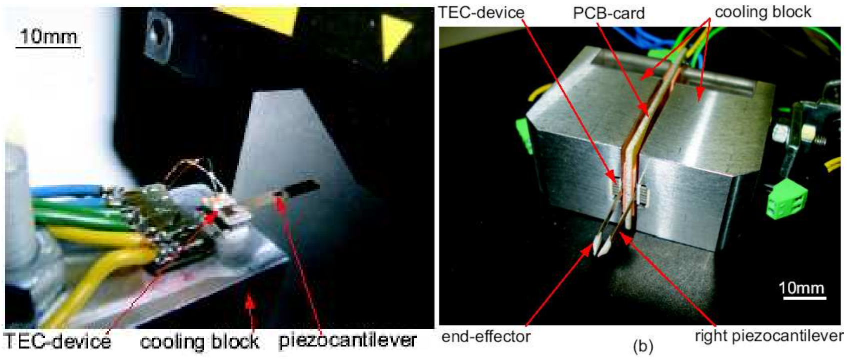


Fig2. A patented hybrid thermo-piezoelectric microactuator (left). A hybrid microgripper (b).

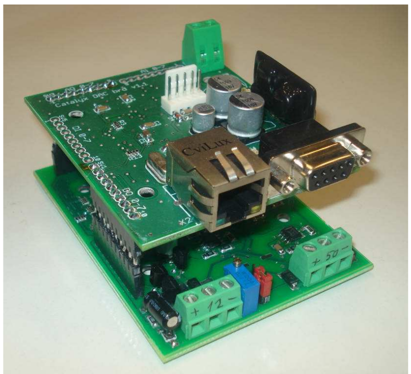


Fig3. A custom-designed electronic board that is used for the self-sensing and measurement and for the control of piezoelectric microactuators.

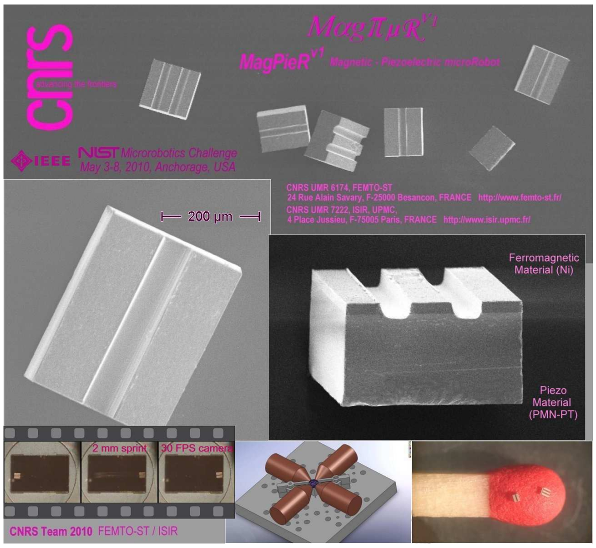


Fig4. The MagPieR microrobot that broke the 2mm sprint World Record with a time of 32ms

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