1. PUBLISHABLE SUMMARY

The main objective of the project MicroPAdS was 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 more or less easily fabricated by adapting 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 allow a large amplification of the range (up to 5times more than that 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 (Fig. 4).

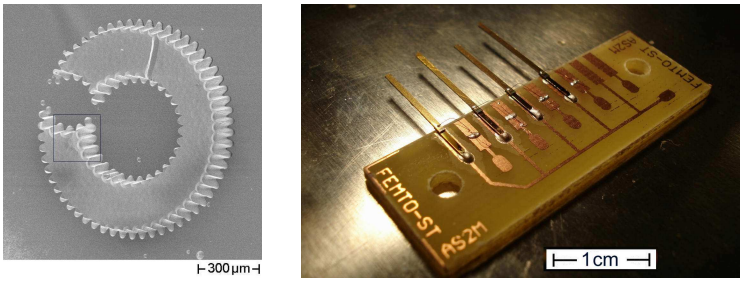

Fig1. A micro-gear based on piezoMEMS (left). Some cantilever structured piezoMEMS (right).

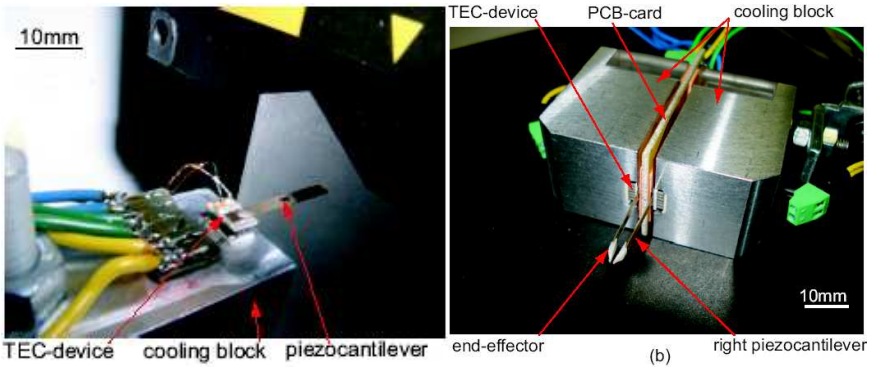

Fig2. A hybrid thermo-piezoelectric microactuator (left). A hybrid microgripper (b).

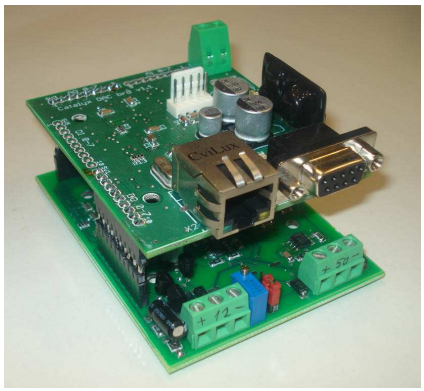

Fig3. An electronic board that is used for the self-sensing and measurement and for the control of piezoelectric microactuators.

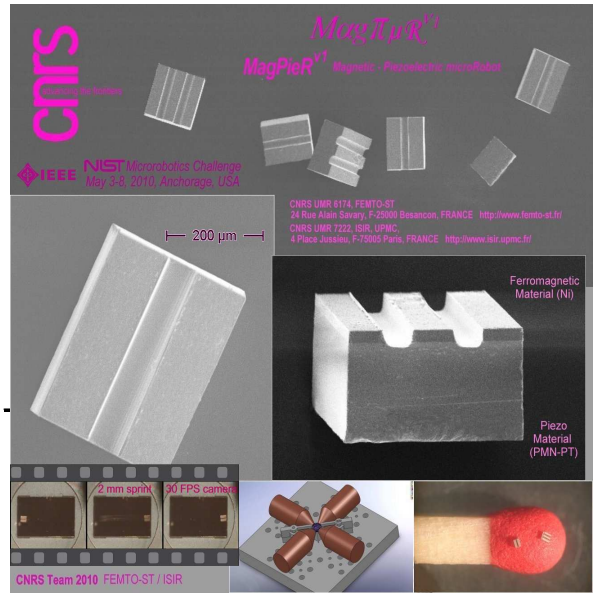

Fig4. The MagPieR microrobot that brokes the 2mm sprint World Record with a time of 32ms at IEEE NIST Mobile Microrobotics Challenge held at Anchorage on the 4th of May 2010.

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