MOEMS for space applications:
Micromirror arrays for Universe and Earth Observation

Frederic Zamkotsian[1], Yves Petremand[2], Patrick Lanzoni[1], Sébastien Lani[2], Michel Despont[2], Sylwester Bargiel[3], Nicolas Passilly[3], Nadège Courjal[3], Michel Lenczner[3]

[1] LAM, Marseille, France; [2] CSEM, Neuchâtel, Switzerland, [3] FEMTO-ST, Besançon, France

frederic.zamkotsian@lam.fr

Keywords: micromirror arrays, space instruments, Universe Observation, Earth Observation

Micro-Opto-Electro-Mechanical Systems (MOEMS) could be key components in future generation of space instruments. In Earth Observation, Universe Observation and Planet Exploration, scientific return of the instruments must be optimized in future missions. MOEMS devices are based on the mature micro-electronics technology and in addition to their compactness, scalability, and specific task customization, they could generate new functions not available with current technologies. Breakthrough instruments could be based on this new family of components. We propose large micromirror arrays (MMA) for designing new generation of instruments [1] [2].

In Universe Observation, multi-object spectrographs (MOS) are powerful tools for space and ground-based telescopes for the study of the formation and evolution of galaxies. This technique requires a programmable slit mask for astronomical object selection; 2D micromirror arrays are perfectly suited for this task.

In Earth Observation, removing dynamically the straylight at the entrance of spectrographs could be obtained by using a Smart Slit, composed of a 1D micro-mirror array as a gating device.

We are currently engaged in a European development of micro-mirror arrays, called MIRA, exhibiting remarkable performances in terms of surface quality as well as ability to work at cryogenic temperatures. MMA with 100 x 200 μm^2 single-crystal silicon micromirrors were successfully designed and fabricated using three wafers and two wafer-level bonding steps (fusion and thermo-compression bonding). In first generation devices, individual micromirror surface deformation is as low as 10nm Peak-to-Valley (PtV) at room temperature, and below 30nm PtV at 162K. No broken micromirrors were observed on the final devices demonstrating the quality of the fabrication process. Improved contrast has also been implemented by minimizing gaps around the micromirrors. 1D and 2D arrays (Fig. 1) are built on wafer with Through Wafer Vias in order to allow routing of the device on wafer backside, foreseeing integration with dedicated ASICs. They have been tested at room temperature and at cryogenic temperature, showing their ability to work in space environment [3].

Challenges for designing, modeling, realization and characterization of micromirror arrays for space instrumentation will be presented as well as applications for Universe and Earth Observation. 2D MIRA prototype demonstrates the ability of such MOEMS device to work as objects selector in future generation of MOS instruments both in ground-based and space telescopes. 1D MIRA is the perfect candidate for the Smart Slit concept, a dynamical slit at the entrance of spectrographs for Earth Observation.

Micromirror arrays are also foreseen for a wide range of applications in space instruments, including optical communications in space, LIDARs, compressive sensing instruments.

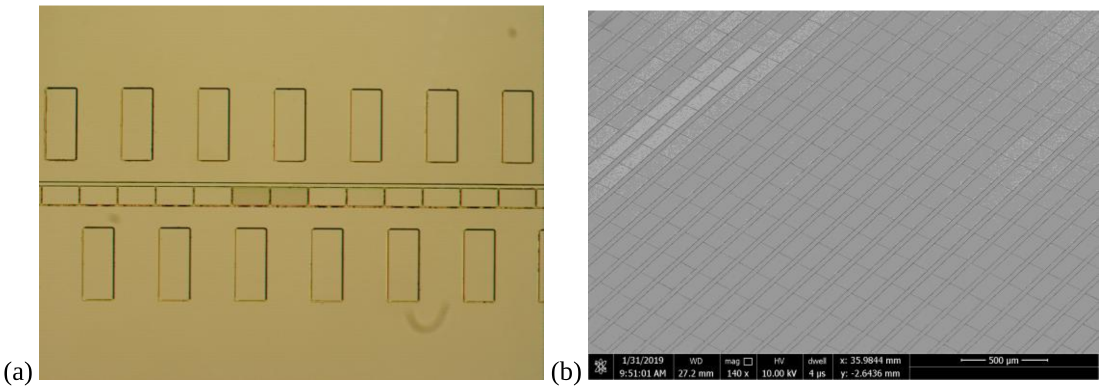

Figure 1: MIRA devices, 1D array (a), and 2D array (b).

[1] F. Zamkotsian, P. Lanzoni, N. Tchoubaklian et al. "BATMAN @ TNG: Instrument integration and performance" in Proceedings of the SPIE conf. on Astronomical Instrumentation 2018, Proc. SPIE **10702**, Austin, USA (2018), https://doi.org/10.1117/12.2315222

[2] Frederic Zamkotsian, Arnaud Liotard, Patrick Lanzoni, T. Viard, " Optical MEMS in space instruments for Earth Observation and Astronomy", *Proceedings of the SPIE conference on MOEMS 2013*, Proc. SPIE **8616**, San Francisco, USA, (2013)

[3] Frederic Zamkotsian, Yves Petremand, Patrick Lanzoni, Sébastien Lani, Rudy Barette, Branislav Timotijevic, Michel Despont, "Large 1D and 2D micro-mirror arrays for Universe and Earth Observation", *Proceedings of the SPIE conference on MOEMS 2019*, Proc. SPIE **10931**, San Francisco, USA, (2019), https://doi.org/10.1117/12.2513287