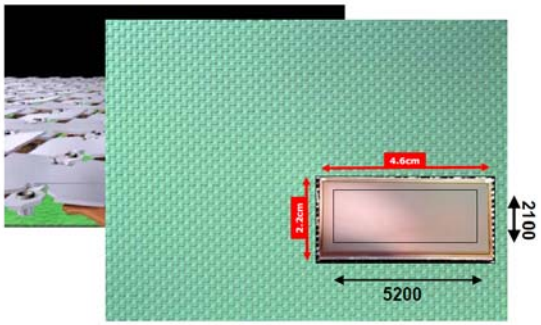
CMOSIC 上 SiGe ミラーアレイ

Ann Witvrouw

Exhibit #3: 11 megapixel micro-mirror array with 8 µm pitch made in poly-SiGe above standard 0.18µm analog-CMOS wafers fabricated by NXP, featuring 6 interconnect levels.

11MPixel micro-mirror array

- To be used as SLM (Spatial Light modulator)

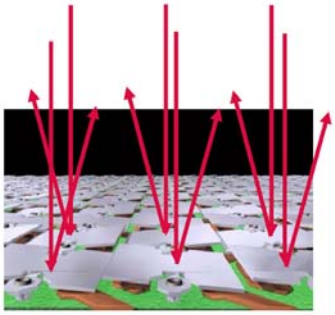


Project together with ASML, Bruco, NXP, Philips Appl. Tech.

11MPixel micro-mirror array: *application*

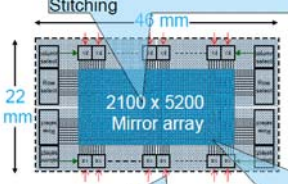
Spatial Light Modulator:

- Light is deflected by each mirror to create image
- Applications: video projection, mask writing, maskless imaging

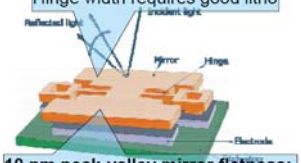


Micro-mirror array: *Chall...*

11M mirrors
MEMS + CMOS integration
Yield impact
Stitching



8x8 µm² pitch mirrors
Well controlled layer thickness
Hinge width requires good litho



10 nm peak-valley mirror flatness:
Stress control of mirror
Measure 11M mirrors with <10 nm accuracy

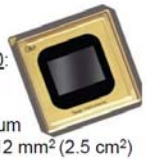
6 kHz update rate
600 Gbit/s data requires > 2500 (analog) wires

10 µrad global flatness
CMP optimized in CMOS & MEMS
Cleaning challenge (# part./cm² ≤ 1 of 0.8µm)

Additional challenges:
Reliability: 10 years (1E+12 tilt cycles)
Assembly of delicate chip

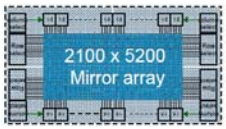
Micro-mirrors: *State-of-the art*

TI DLP Discovery 4000:
1920x1080 (2M)
Digital
Mirror Pitch 10.8 µm
Mirror Area 21 x 12 mm² (2.5 cm²)
<www.dlp.com



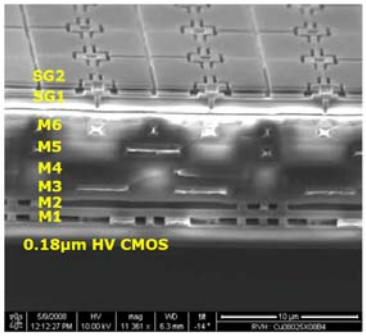
Fraunhofer SLM:
2048x512 (1M)
Analog
Mirror Pitch 16 µm
Mirror Area 33 x 8mm² (2.6 cm²)
<www.ipms.fraunhofer.de

This work:
5200x2100 (11M)
Analog
Mirror Pitch 8 µm
Mirror area 42 x 17 mm²
(7 cm²)



Micro-mirrors: *processing*

SiGe is chosen to achieve required mirror specs including reliability at CMOS-compatible T



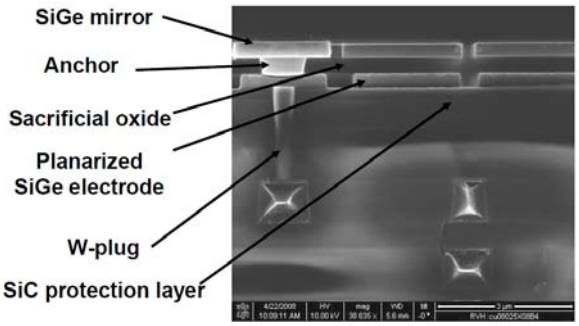
SiGe-based micro-mirror module

← Planarised interface

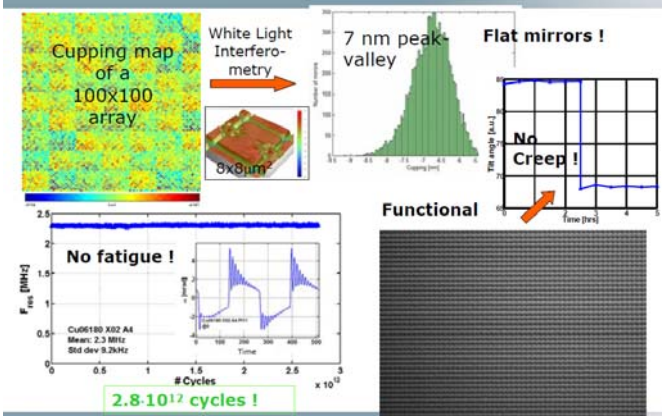
0.18 µm analog CMOS with 6 metal levels (from NXP)

< L. Haspeslagh et al. , Proc IEDM 2008

Micro-mirrors: *processing*



Micro-mirrors: *functional & reliability analysis*



Micro-mirrors: *packaging and testing*

Packaging and assembly
A. Witvrouw et al, Proc. MEMS09

Imaging results: J. Lauria et al, Microel. Eng. 86, 569–572 (2009)

Mirror performance after packaging
123648 mirrors tested

Item	Specification	Results
Good Mirrors %	/	99.5 %
Mean Cupping	< 10 nm	5.4 nm
Residual Piston	< 1nm	< 1 nm

Direct imaging:
3 mirror contact holes