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Scanning Micro-interferometer Array with Sub-picometer Resolution for MEMS Inspection

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Outline

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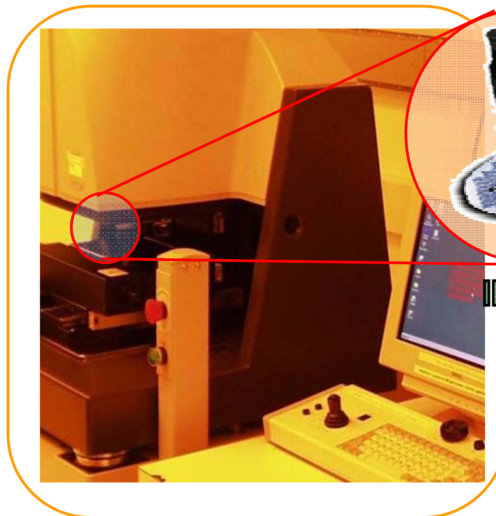
- Motivation
- Introduction to micro scanning grating interferometer (µSGI)
- Fabrication of tunable gratings
- Active tuning of grating
- Demonstration of array operation of µSGIs
- Conclusions and future work

Motivation

Lack of in-line metrology is a barrier in development of MEMS[1]

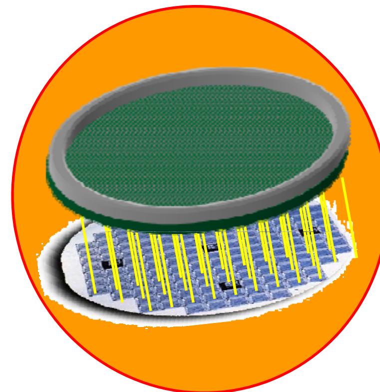
- MEMS inspection required for accurate fabrication
- Batch fabrication
- Metrology tools limited to small area inspection

Current Solution



Desired Solution

Array of miniaturized sensors testing in parallel

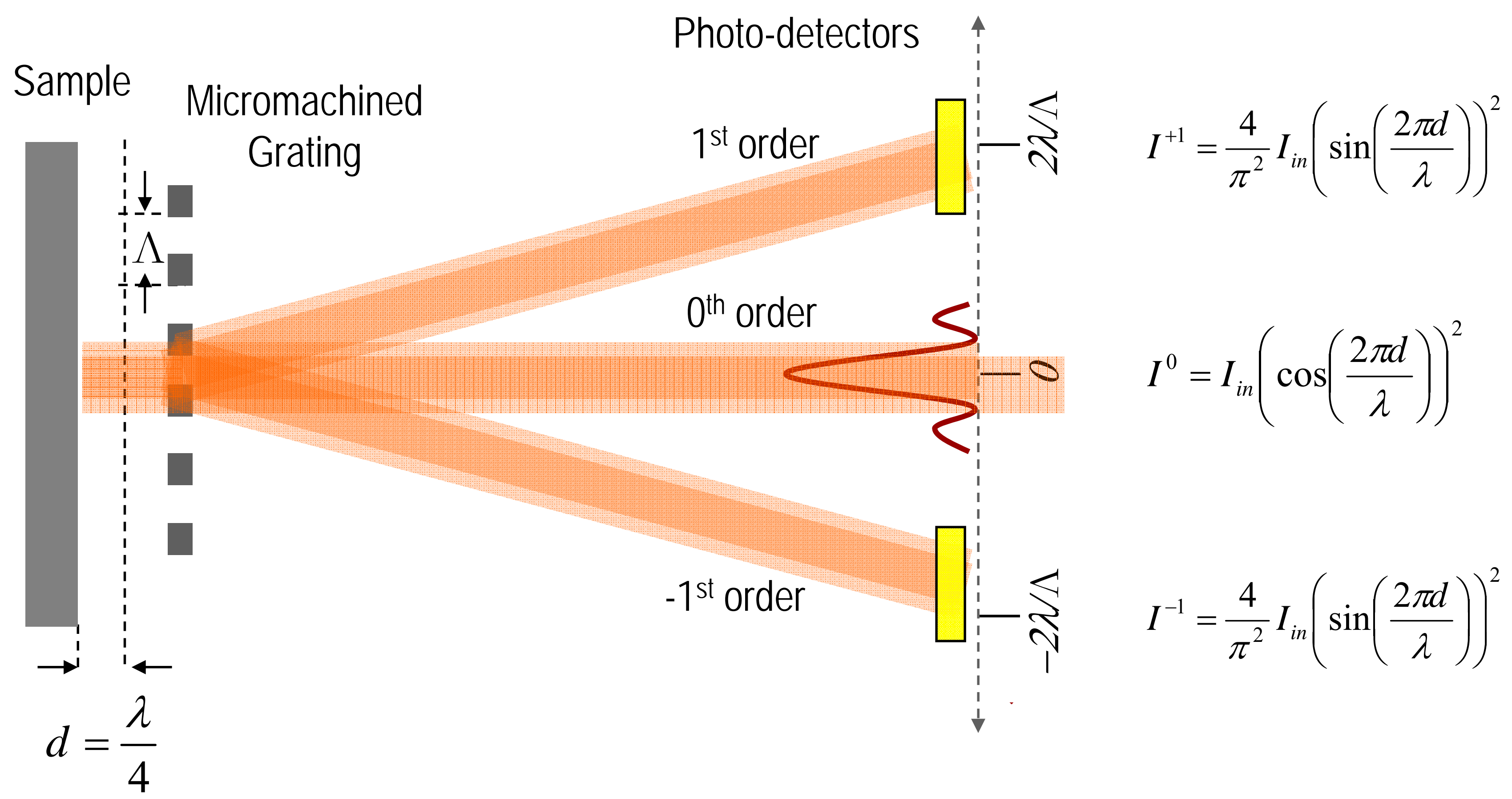


Desired characteristics

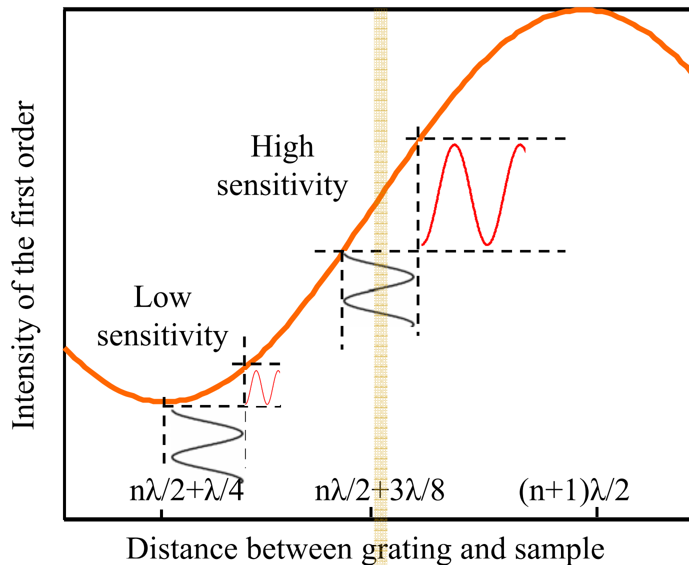
- Array operation
- Fast
- Dynamic metrology
- High resolution
- Non-contact

[1]Panetta et al,, Proceedings of ITC International Test Conference, 3-5 October, 2000, 1130-1135

Grating interferometer for miniaturization



Non-linearity in interferometers

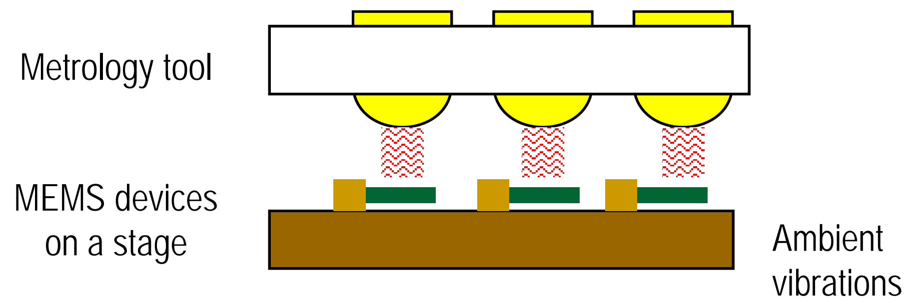


Grating

Sample

- Sensitivity of the interferometer changes depending on the position on the optical curve.
- At the saddle point sensitivity is high and the optical curve is linear.
- This is desired position of operation for high resolution metrology.

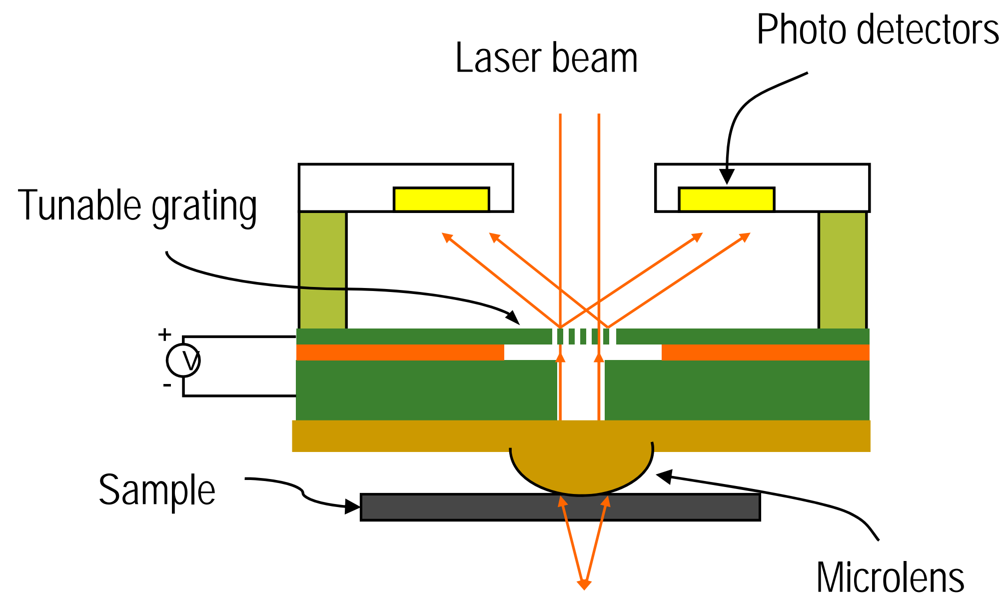
Need for active surface tracking in array operation



Schematic of parallel Operation of µSGI

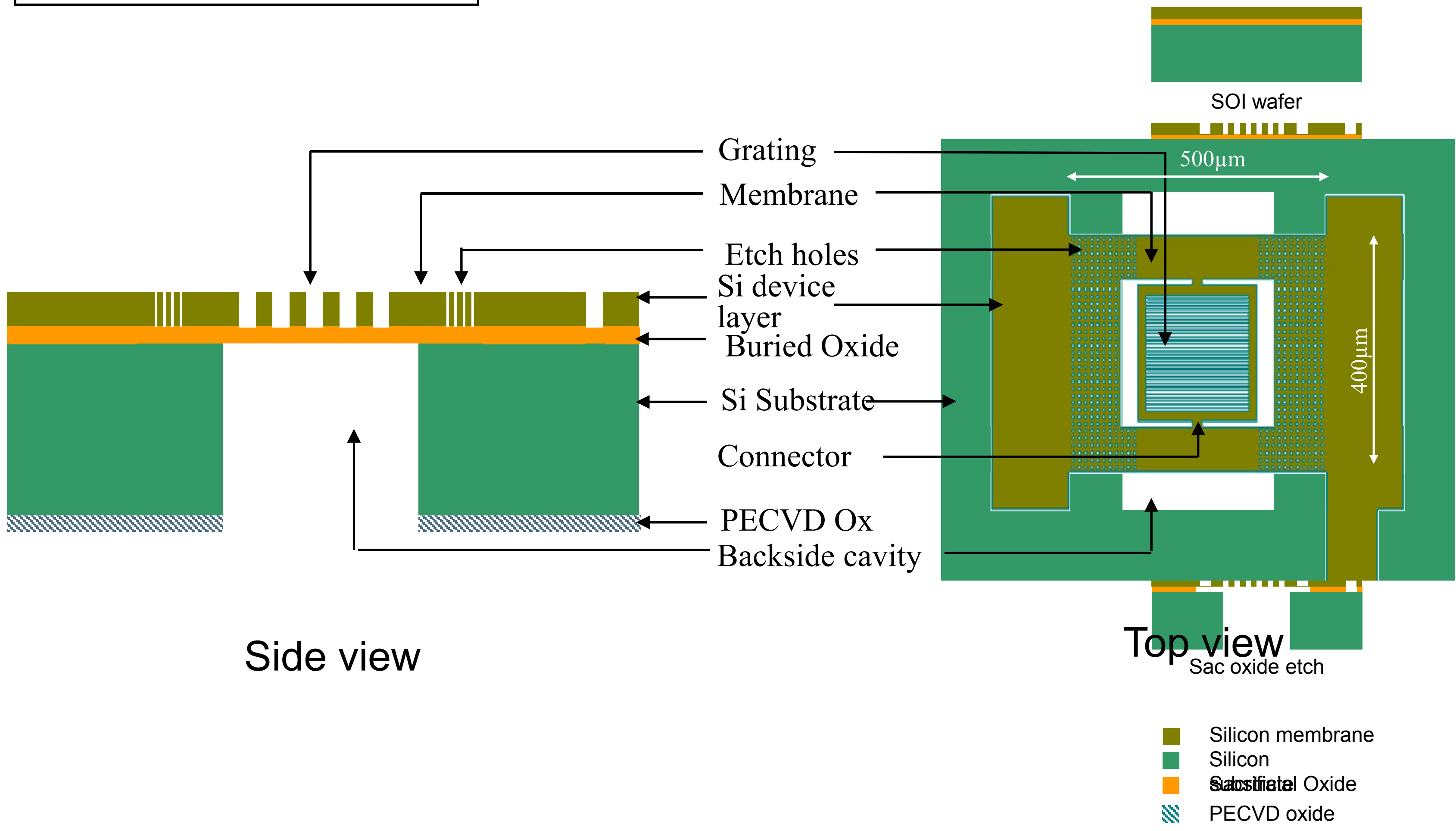
- The micro-interferometer array needs to actively tune the distance between sample and each of the gratings for maximum sensitivity.
- Error in initial positioning, scanning a sample with tilt, ambient vibrations can cause change in position (Freq < 1kHz)
- Dynamic motions of MEMS under observation are at higher frequencies.

Micro scanning grating interferometer (μSGI)



Schematic of μSGI
(Miniaturized assembly)

Fabrication of the μSGI tunable gratings



Fabrication results

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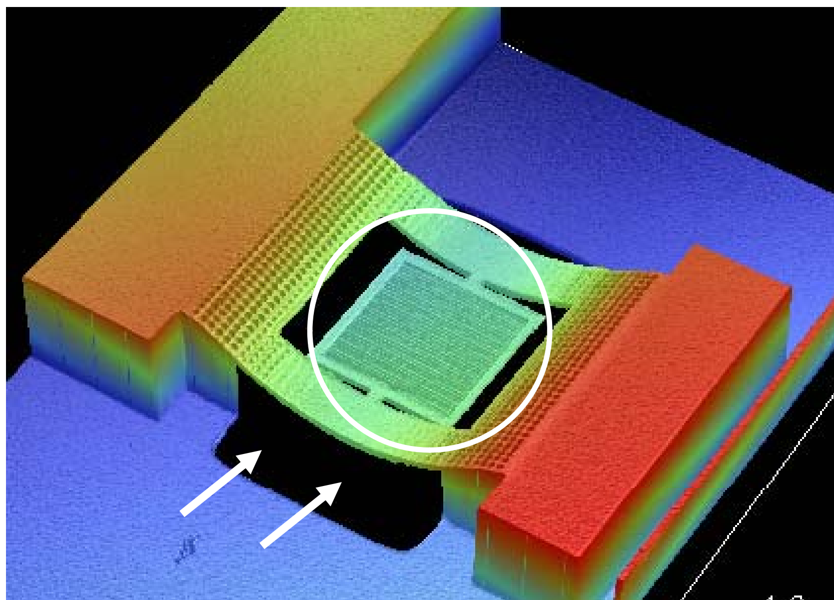
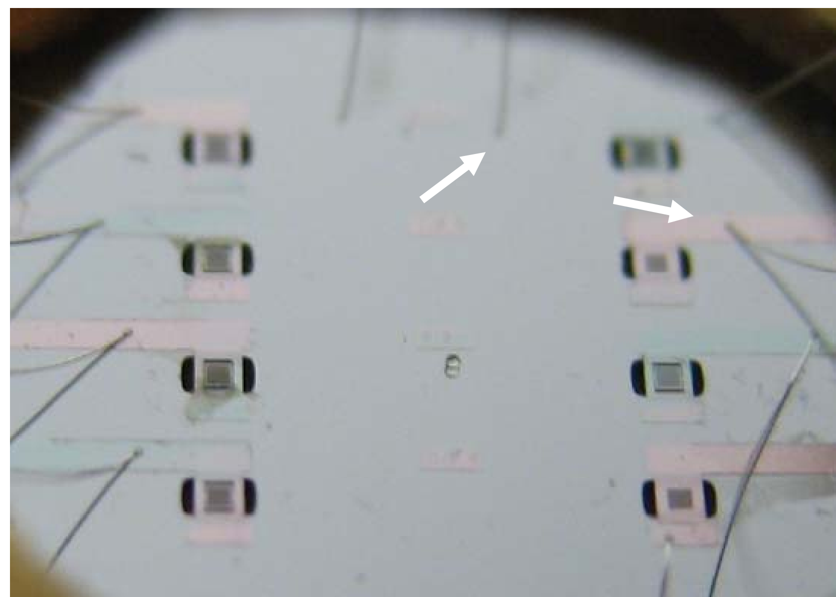
- Flat grating – good optical performance
- Backside cavity – low squeezed film damping, no optical interaction with substrate
- Conductive Silicon – avoids metal electrodes, simple fabrication
- Gratings show 500nm range and 50kHz bandwidth

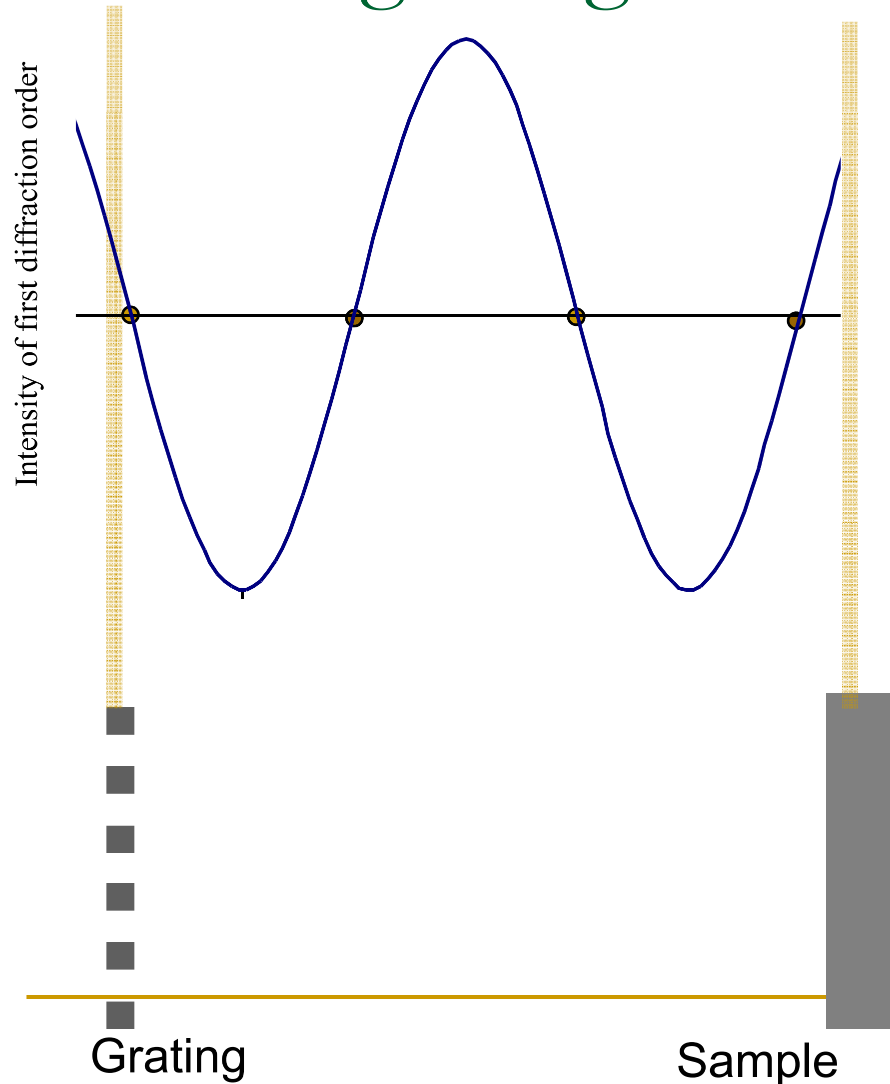


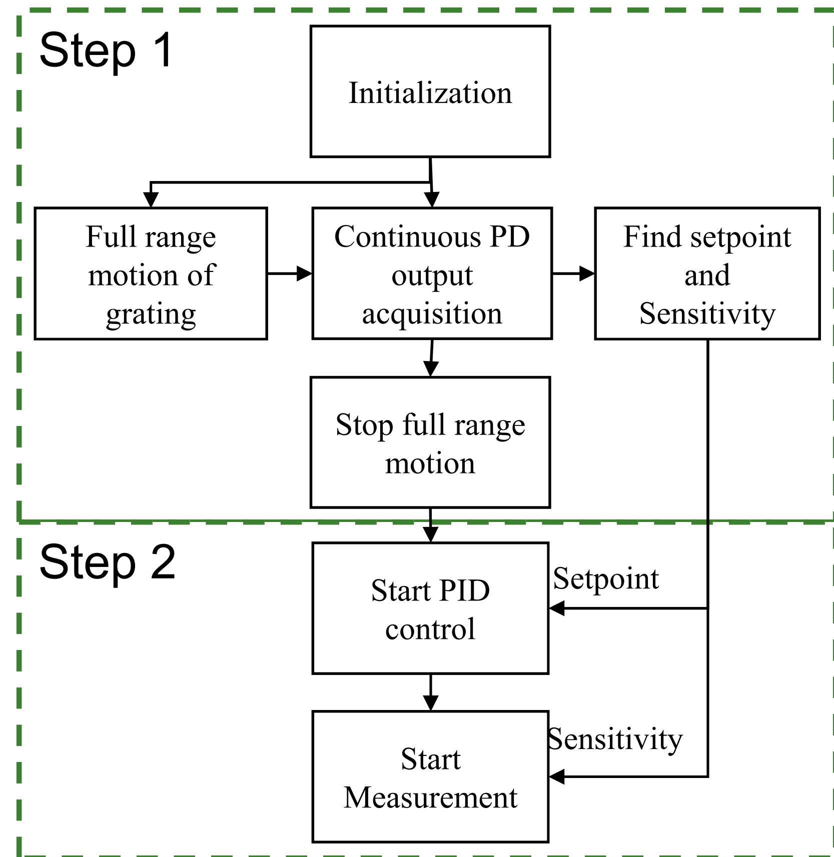
Electrostatically actuated tunable grating



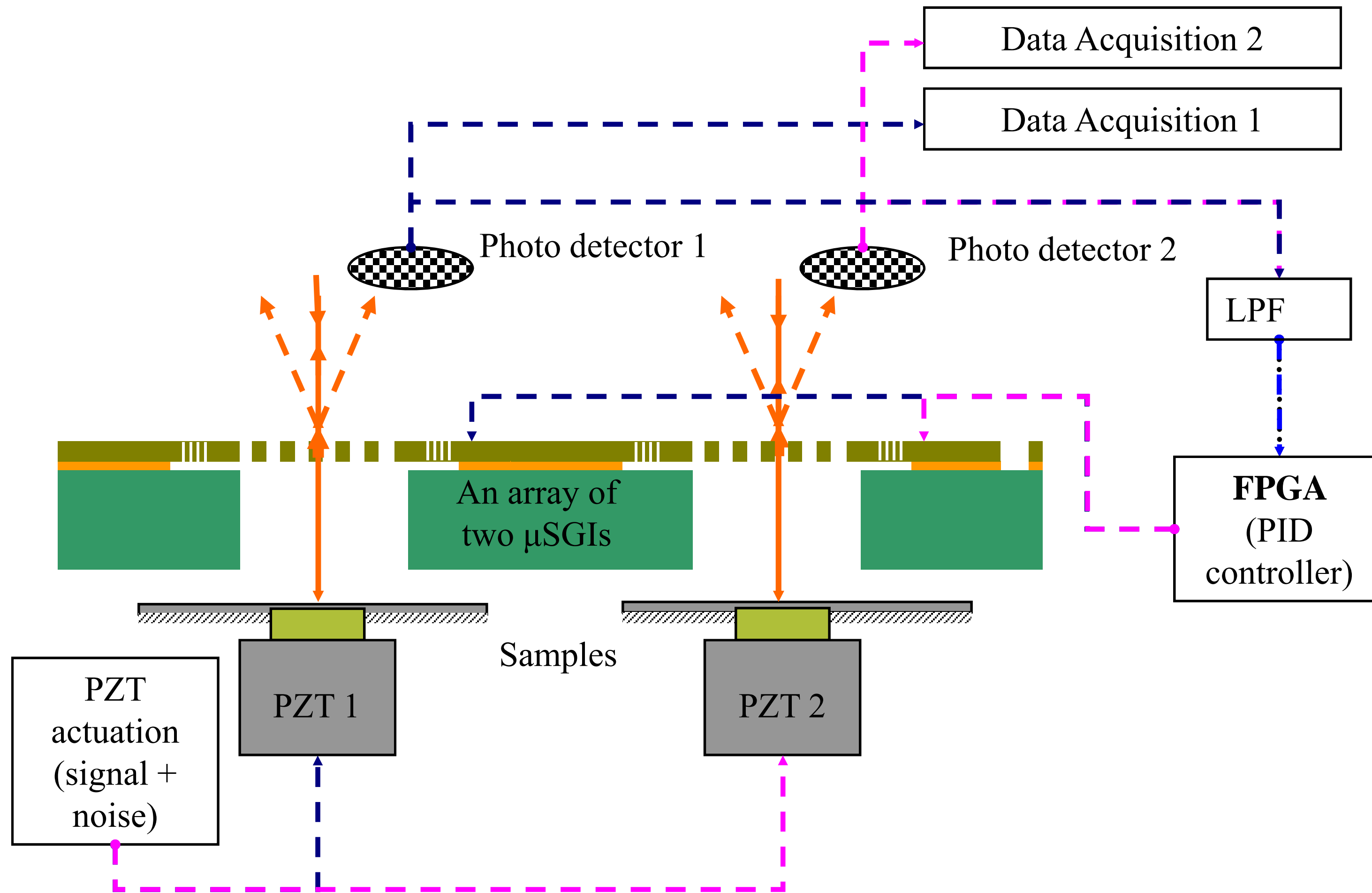
Array of tunable gratings fabricated on a chip and wire-bonds to the electrodes

Active surface tracking algorithm for the tunable grating

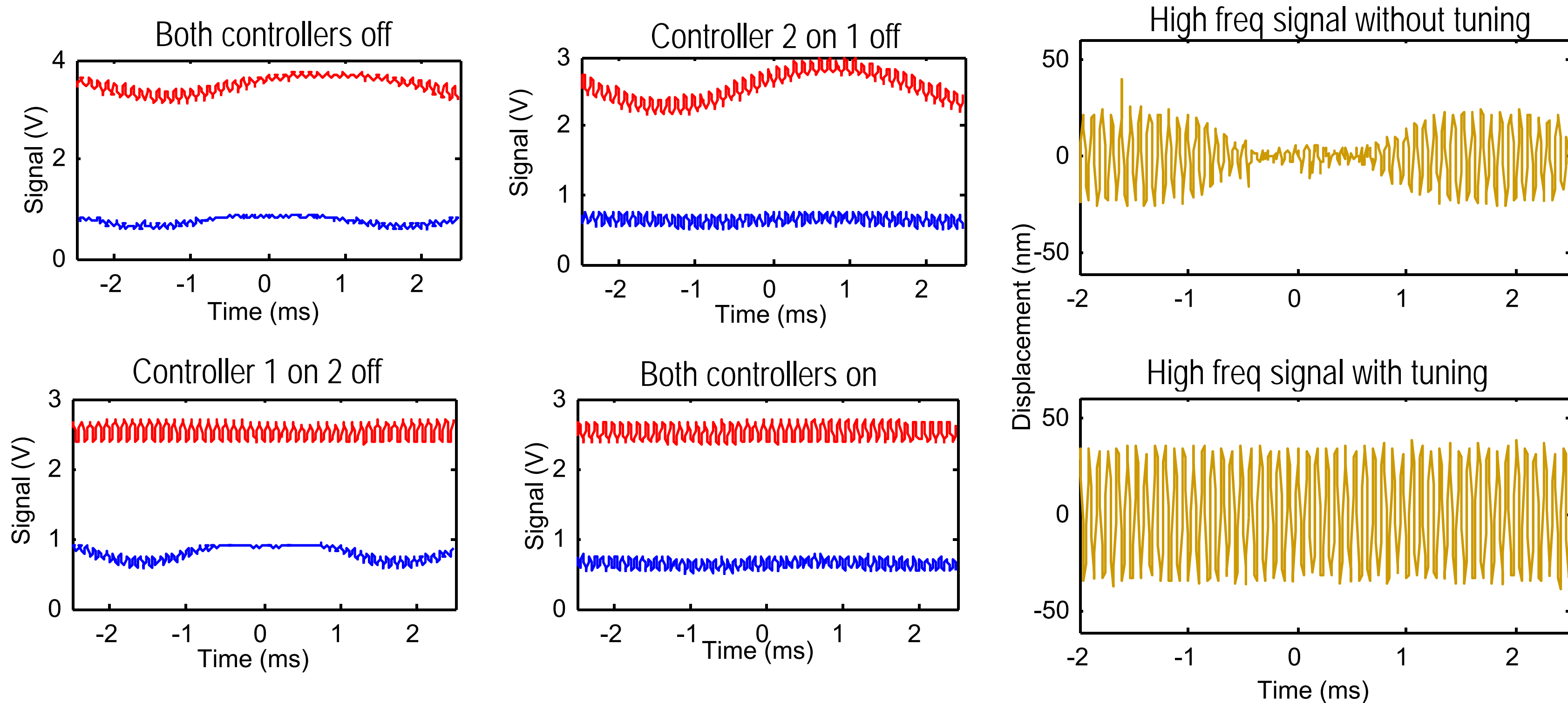




Experimental setup for array operation



Array operation results



Demonstrates

- Independent, parallel, simultaneous operation
- Active surface tracking at ~100Hz
- Sub-picometer resolution

Conclusion

- The μSGI technology may have significant impact on the growth of MEMS
- Tunable gratings fabricated in SOI substrate
- Active tuning algorithm developed and run in parallel on an FPGA
- Array operation of μSGIs demonstrated
- Future work –
  - Non-linearities in control
  - miniaturization of optical source
  - Lens, photo-detector and source integration

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