Introduction to PLV Technology

SILICON
LIGHT
MACHINES

A SCREEN COMPANY

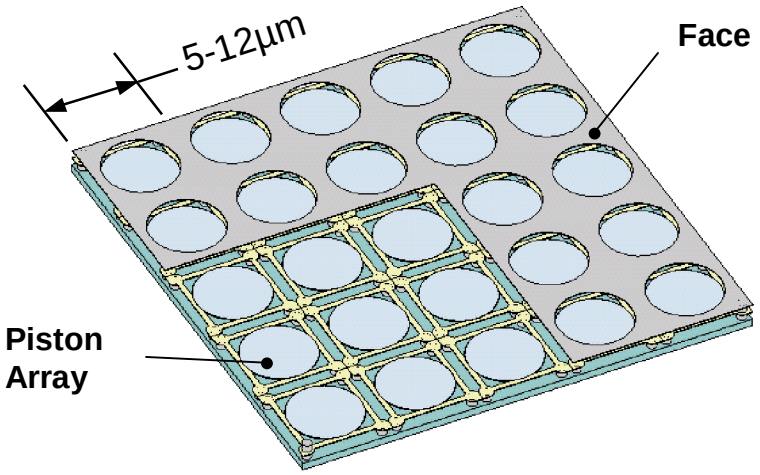
Spatial Light Modulation at Silicon Light Machines

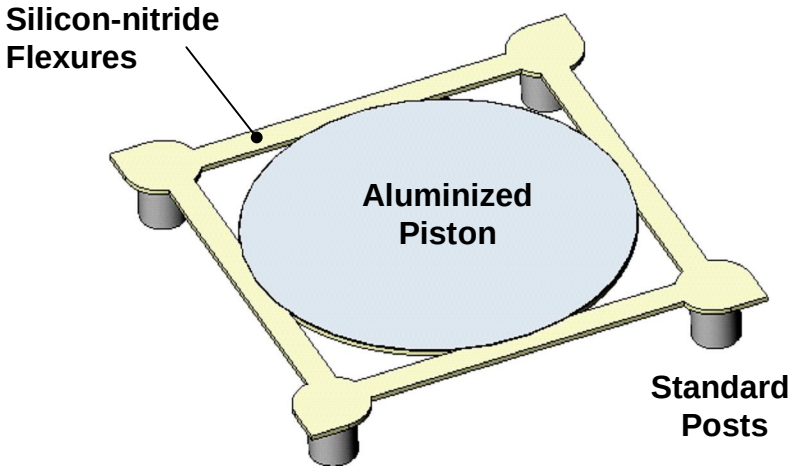
- **Grating Light Valve (GLV)**
  - Demonstrated in 1993
  - HDTV display applications in 2000
  - Computer to plate (CTP) printing in 2001
  - Long-haul telecomm, dynamic gain equalizers (DGE) and re-configurable blocking filters (RBF) in 2002
- **Planar Light Valve (PLV)**
  - Conceived, modeled, and patented in 2003
  - DARPA contract for DUV maskless lithography 2004

Planar Light Valve Technology

- Silicon Light Machines conceived a 2D analog of the 1D GLV
- New device is based same CMOS process and materials used in the proven GLV technology, but arranges pixels in a 2-dimensional, close-packed array.
- New device inherits desirable properties of GLV and extends applications where GLV could not be used.
- Different embodiments of device can provide different modulation functionality: Amplitude, Phase, or Both

Planar Light Valve (PLV)





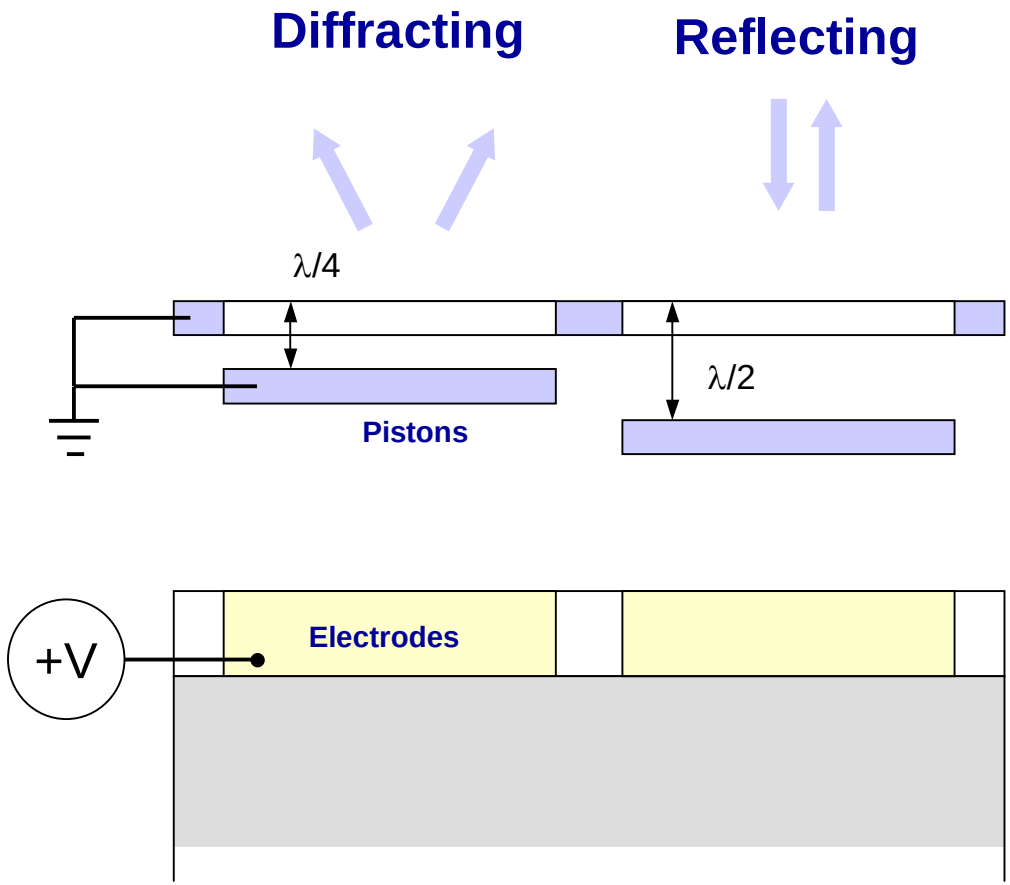
- ÅHigh contrast
- ÅAnalog gray-scale
- ÅNon-contact
- ÅBorderless pixels
- ÅHigh power handling
- ÅHigh reliability

Inherited properties of GLV

- Å2D geometry
- ÅSmaller pixel size
- ÅLarger étendue
- Å100% fill factor
- ÅVery high speed

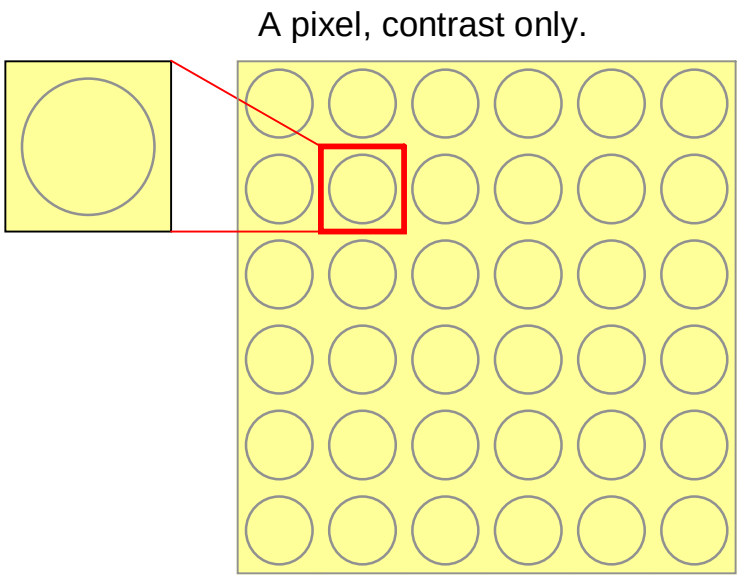
New properties of PLV

PLV Cross-Section

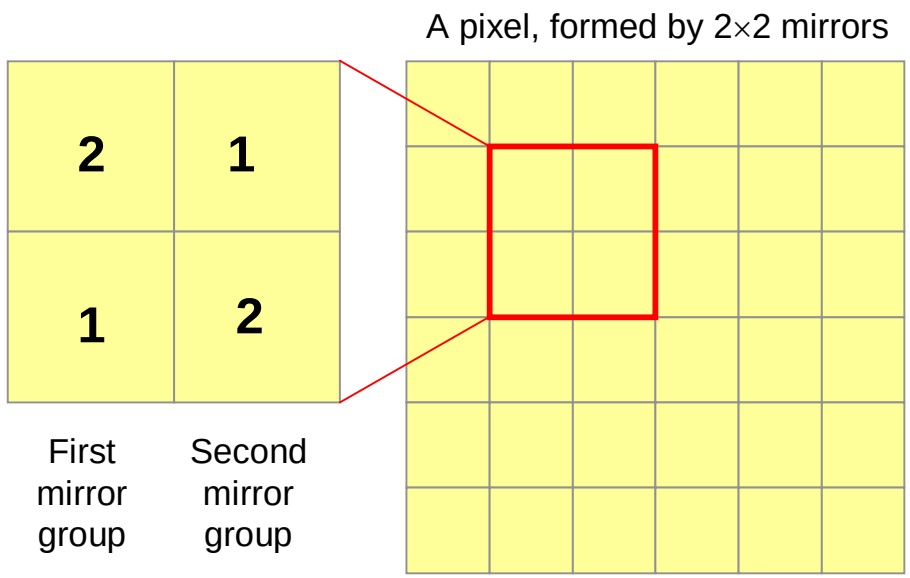


- Device changes from reflective state to scattering state by deflection of the MEMS pistons through quarter wavelength.

Amplitude or Phase Modulation



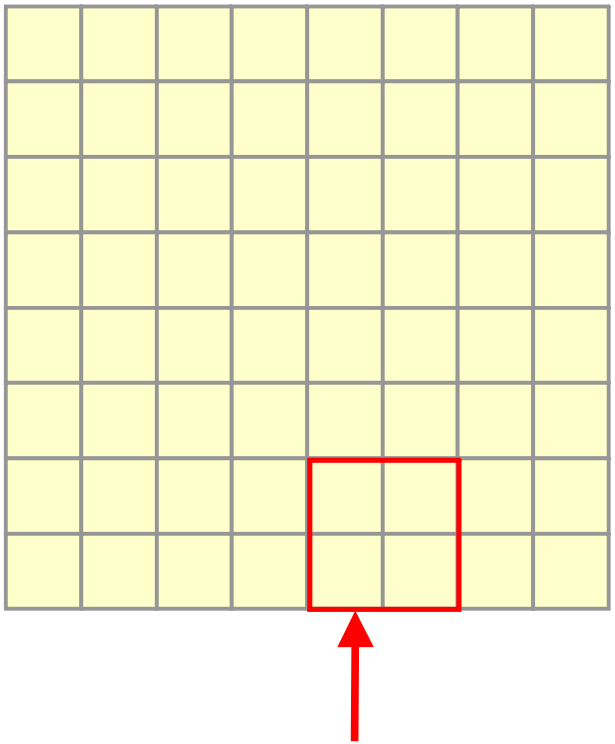
(a) Amplitude Modulator



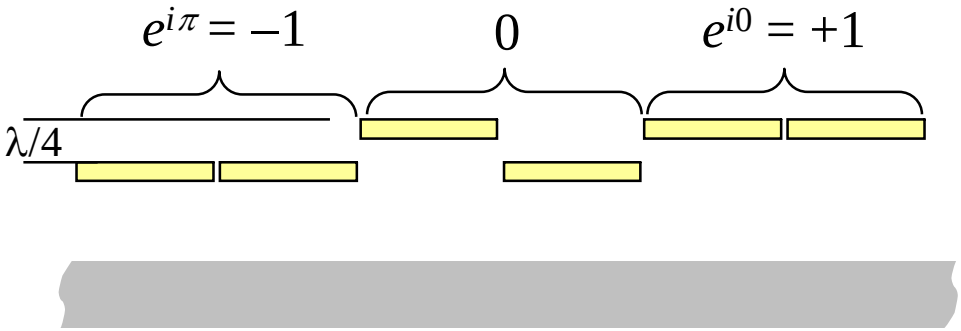
(b) Amplitude+ Phase Modulator

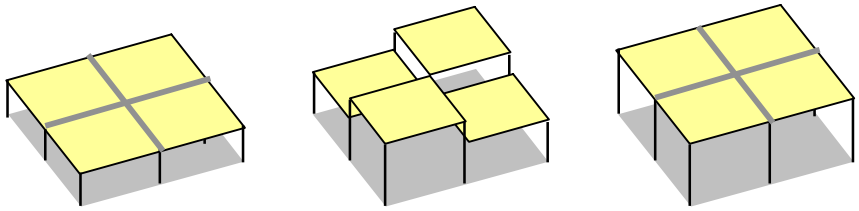
- **The piston structure of the PLV can support different embodiments depend on application requirement.**
- **By altering the piston-faceplate design, the PLV can be straightforwardly modified into a phase modulator.**

Amplitude and Phase Modulation



1 pixel with
2 × 2 pistons





Reflecting state,
π phase-shift

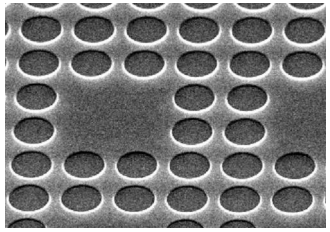
Diffracting state

Reflecting state,
0 phase-shift

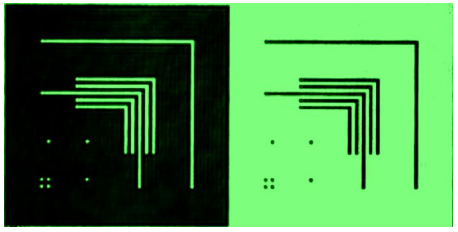
- **Using this PLV structure, a single pixel can assign arbitrary amplitude and phase.**

PLV Development Summary

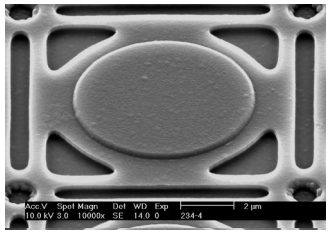
Static PLV



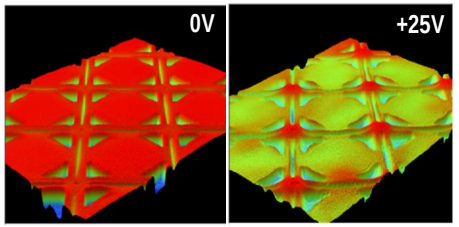
- Static (non-MEMS) PLV surface
- Single etch depth
- Demonstrate 500:1 contrast
- 532nm images generated



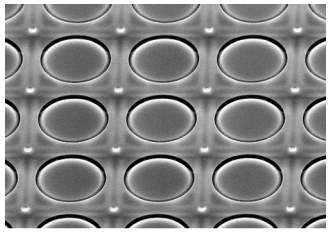
Piston s Only



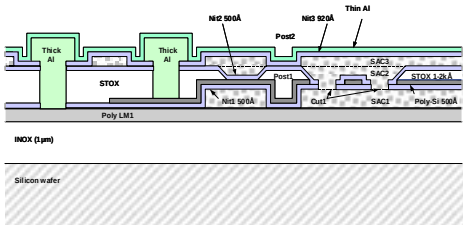
- Piston MEMS layer only
- Used existing GLV process
- Piston mechanics validated
- Light modulation results



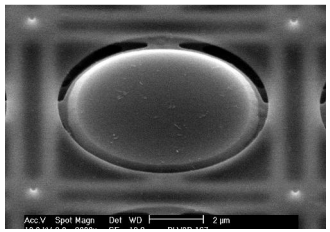
Non-electrical PLV



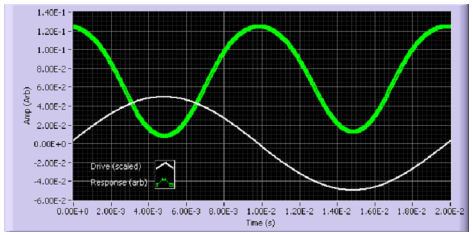
- Non-electrical device
- First double-layer device
- Piston + face plate
- No piston conductor



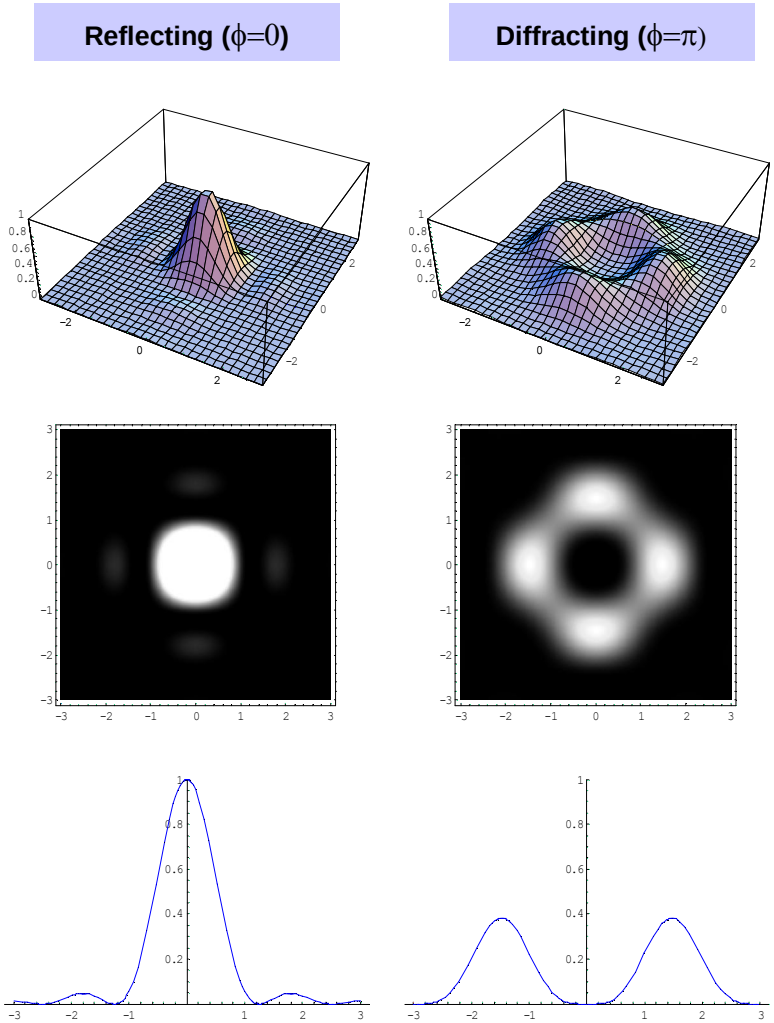
Electrically Active PLV

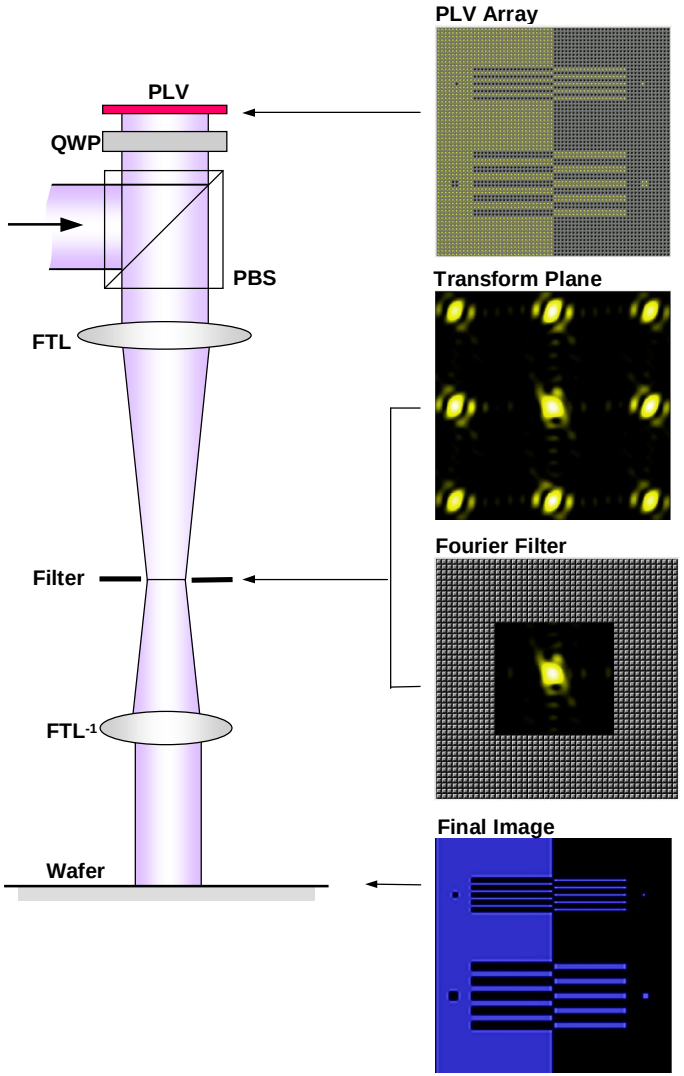


- First electrically active PLV
- Integrated membrane conductor
- Successfully demonstrated 9/05
- Design learning rolls into PLV1



Optical Response & Imaging






Thank You