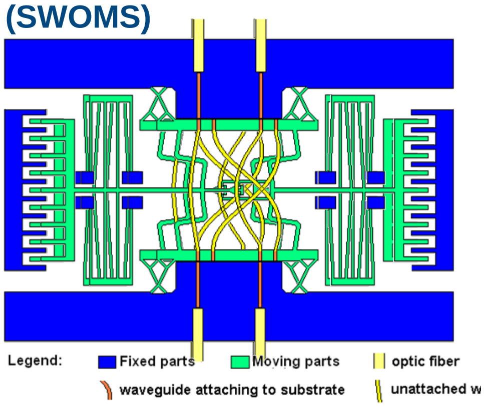
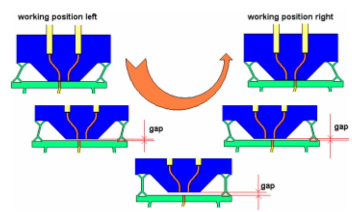
2X2 waveguide switch

- **Self-latching Waveguides Optical MEMS Switch (SWOMS)**

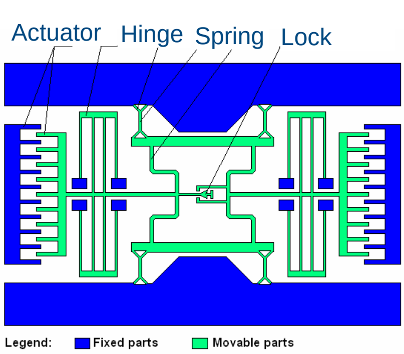


- **2×2 switch**
- **Latching**
- **Air gap-elimination**

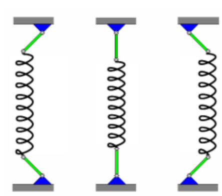


Liu HB., Chollet F., “Moving Polymer Waveguides and Latching Actuator for 2X2 MEMS Optical Switch”, IEEE/ASME Journal of MEMS, doi:10.1109/JMEMS.2009.2017073, Vol. 18, No. 3, (2009) : 715-724

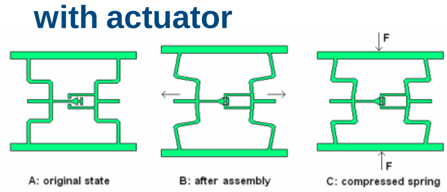
Bi-stable micro-actuator



- **Spring/hinge structure**

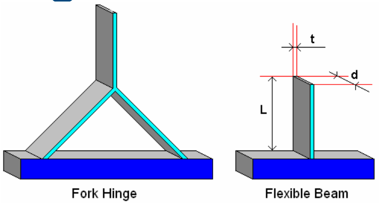


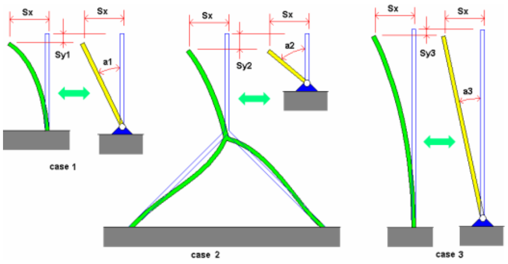
- **Compressed state obtained with actuator**



Fork hinge structure

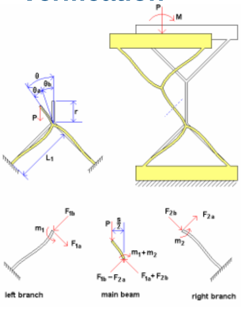
- No-gap feature needs a quasi-hinge better than a simple beam
- Novel Fork hinge structure
  - ➔ smaller
  - ➔ larger angle
  - ➔ more stable





Actuator design

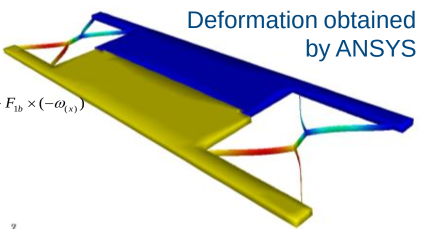
- Analytical formulation of simplified model and numerical verification



$$
\begin{cases}
(F_{1b} - F_{2a}) \times \cos 45^\circ = (F_{1a} + F_{2b}) \times \cos 45^\circ \\
(F_{1b} - F_{2a}) \times \sin 45^\circ + (F_{1a} + F_{2b}) \times \sin 45^\circ = P \\
P \times \frac{s}{2} = m_1 + m_2
\end{cases}
$$

$$
\begin{cases}
\frac{d^2 \omega_{(x)}}{dx^2} = \frac{M_{(x)}}{E_{45} I} \\
M_{(x)} = m_1 - F_{1a} \times (L_1 - x) + F_{1b} \times (-\omega_{(x)}) \\
\theta_{(x)} = \frac{d\omega_{(x)}}{dx} \\
\omega_{(0)} = 0 \\
\frac{d\omega_{(0)}}{dx} = 0 \\
\omega_{(L_1)} = \Delta\omega \approx 0
\end{cases}
$$

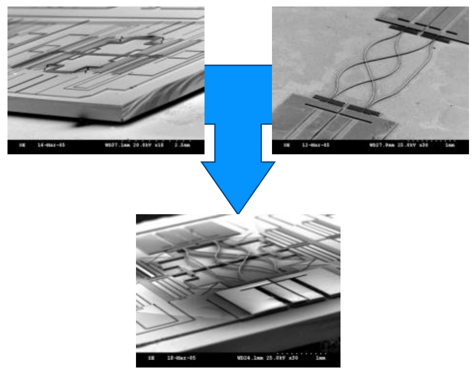
Deformation obtained by ANSYS



- Error is less than 7% and validate the use of the analytical model for the design

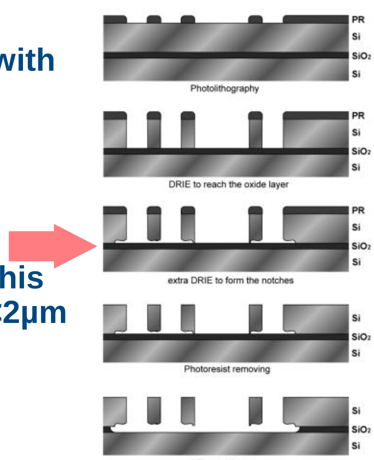
Switch fabrication

- **Switch is an opto-mechanical device and will use hybrid fabrication technique**
  - ➔ silicon actuator
  - ➔ polymer waveguide
  - ➔ final assembly
- **Allows separate optimization of both structures**



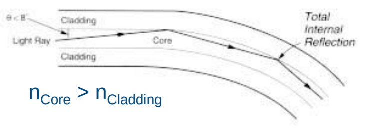
Actuator fabrication

- **Improved SOI/DRIE process with notching release**
  - ➔ PR mask patterning
  - ➔ DRIE etching
  - ➔ DRIE notching
  - ➔ (Wet release)
- **High success yield even for this huge system (5x6 mm) with <2µm springs**

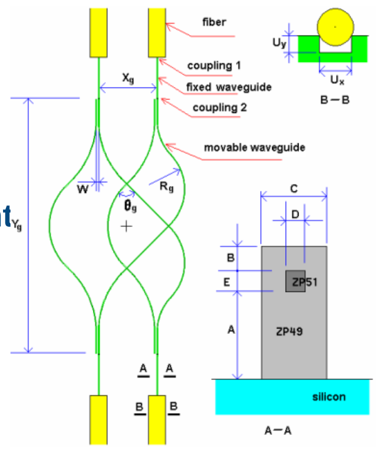


Deformable polymer waveguide

- **Polymer as waveguide**
  - ➔ Transparent
  - ➔ Wide refractive index range
  - ➔ Easy to process
  - ➔ Easy to deform
- **Fluorinated polymers present low absorption in the NIR**

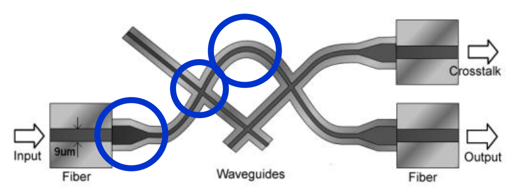


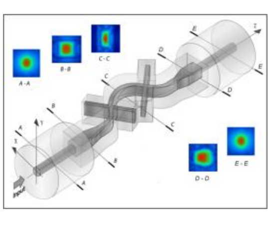
$n_{Core} > n_{Cladding}$



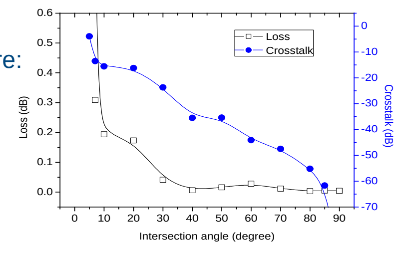
Waveguide optimization

- **Input/output taper dimension**
- **Intersection angle**
- **Radius of curvature**
- **Performed with 2D/3D BPM**



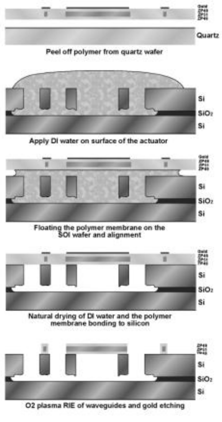


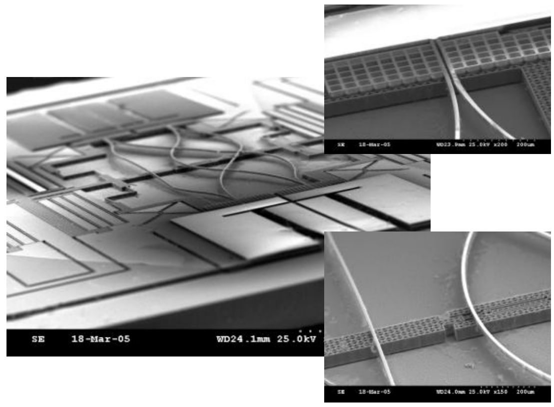
Optimized structure:
- loss: 0.12 dB
- crosstalk: -49 dB



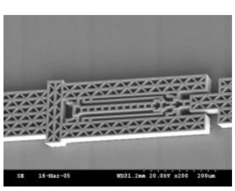
Switch assembly

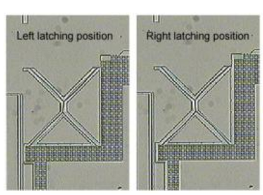
- **Water based assembly**



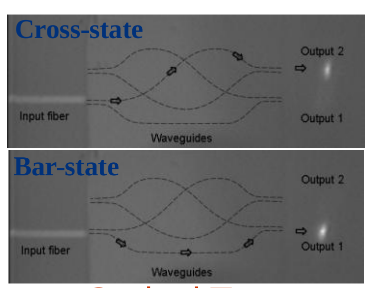


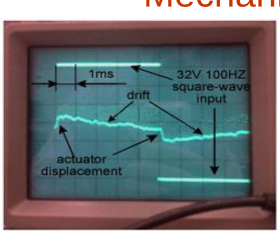
Switch characterization





Mechanical Test





- **Assembly**
- **Switching**
  - V<36V
- **Latching**
- **Switching speed**
  - <0.5ms

Optical Test

- **Loss components**
  - Scattering 2.88dB/cm
  - Bending 0.25dB/cm
  - Intersection 0.1dB
  - Coupling 0.2dB
- **Average 2.6dB**