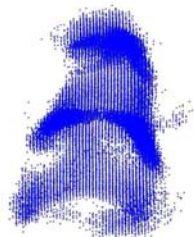
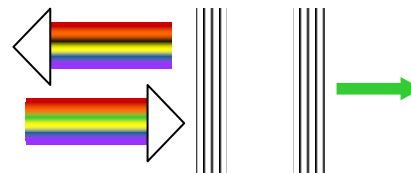


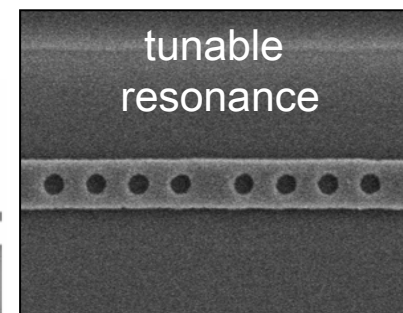
# 3D Optical Systems group: research summary



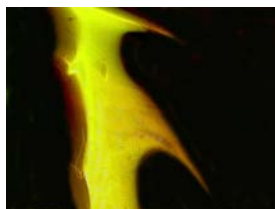
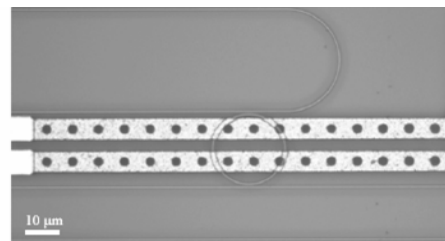
tomography



switchable resonance

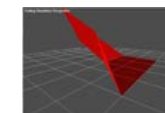
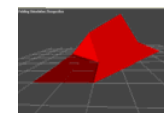
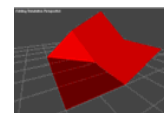
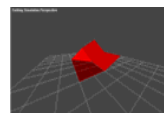
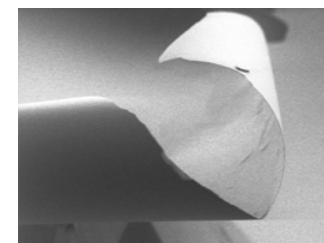
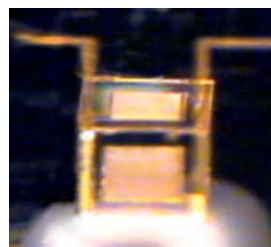


tunable resonance



3D optics

## Integrated optics ( $\approx 2D$ )

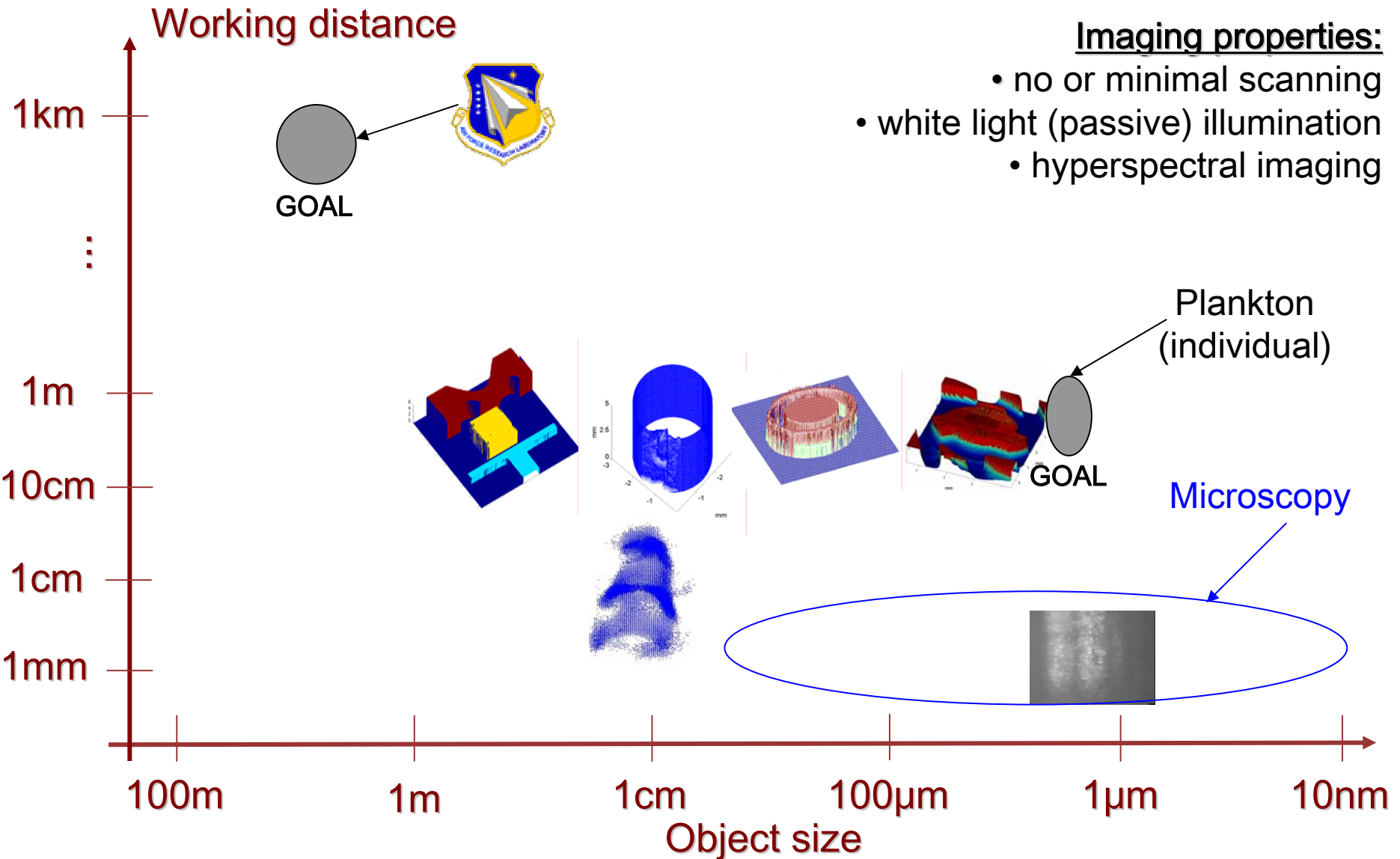


## 3D nanomanufacturing

3D *via* 2D + folding: nanostructured origami

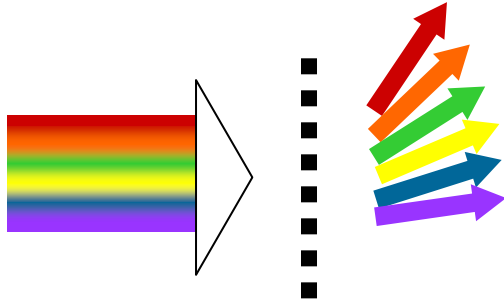


# 3D optics for imaging



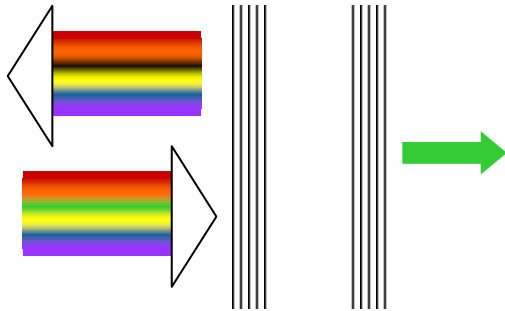
# Integrated optics with micromechanical switching/tuning

~2002-2003



diffraction grating separates colors into a rainbow

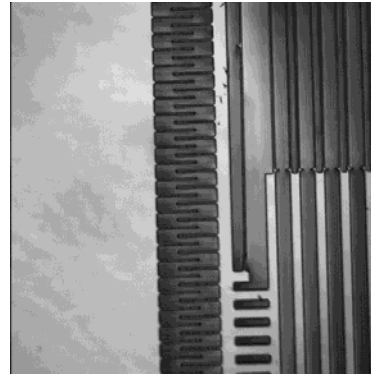
~2003-2004



Fabry-Perot cavity transmits one color (resonant), reflects the rest  
*emphasis on integrated optics*

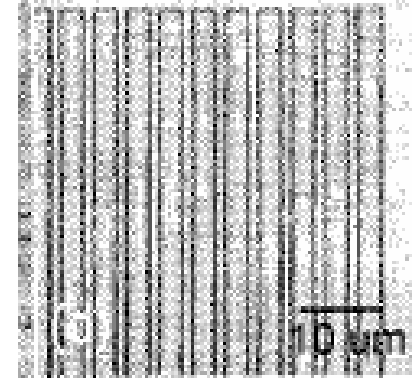
diffraction gratings with continuously tunable period

(1)



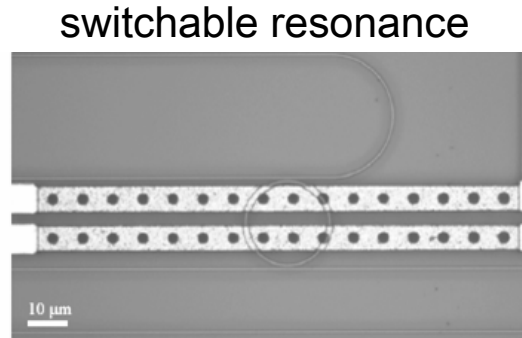
electrostatic comb drive / parallel plate actuation

(2)



piezoelectric thin film actuation

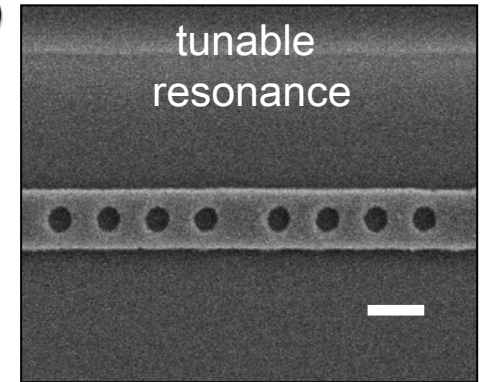
(3)



switchable resonance

ring resonator with high-index contrast waveguides

(4)



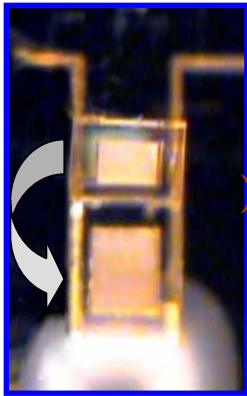
cavity with photonic crystal reflectors

Collaborators: Sang-Gook Kim (1, 2, 4), Hermann Haus and Harry Tuller (3)

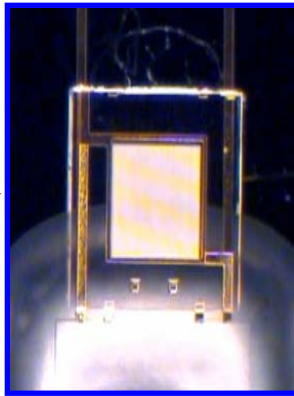


# Nanostructured Origami™

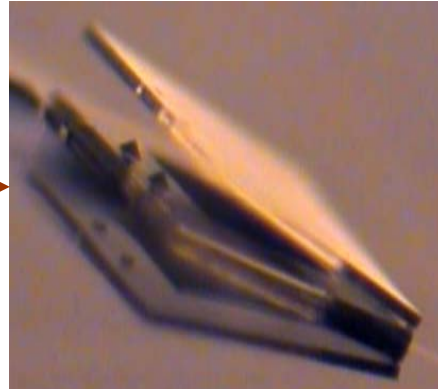
## 3D fabrication and assembly method



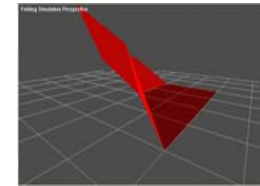
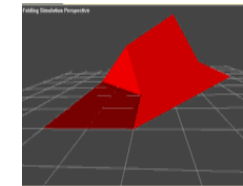
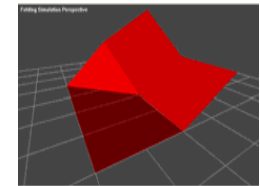
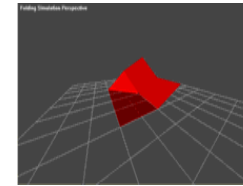
Folding  
Pattern optical elements



Folded  
Membranes are folded on the wafer



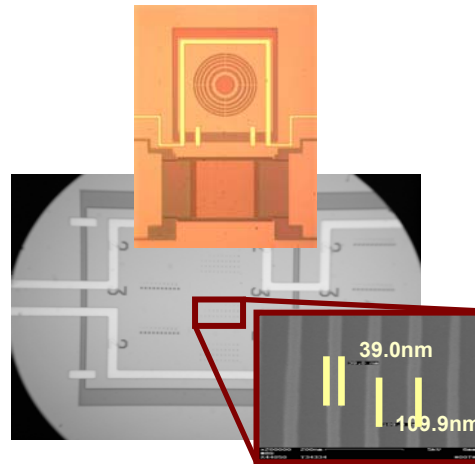
Aligned  
Novel hinge pins ensure < 2 μm alignment



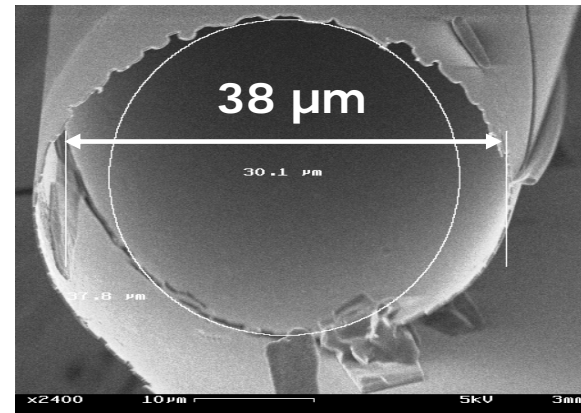
Design and simulation software tool using **screw calculus** for kinematics; future: **wrench calculus** for dynamics, charge models for unfolding



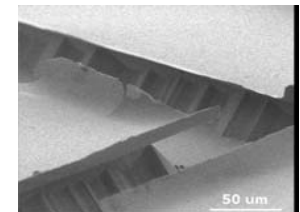
Fabrication processes:  
**SU-8, silicon**



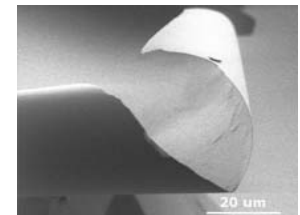
Patterning:  
**Optical, e-beam litho**



Controlling curvature through stress and etch timing



10 min      20 min



Collaborators: Hank Smith, Erik Demaine, MIT  
**Massachusetts Institute of Technology**

George Barbastathis  
Mechanical Engineering Department