SOI Nanophotonics

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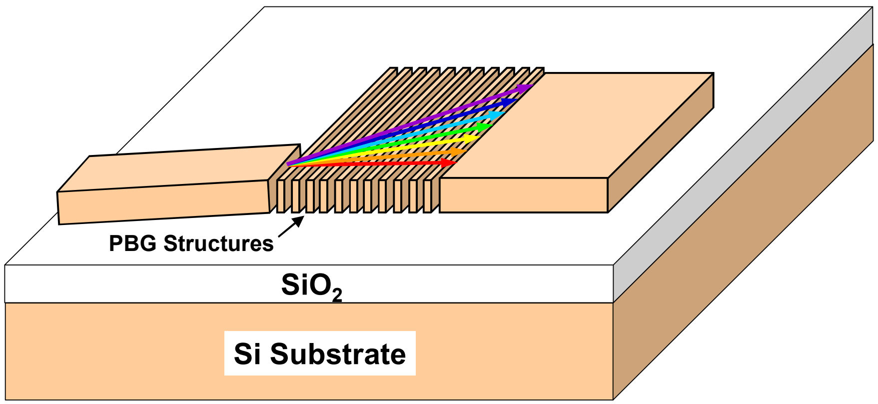


OBJECTIVE:

- Develop ultra-compact, low-cost microspectrometers for
  - bio/chemical sensing
  - spectroscopy
  - optical communications
  - RF signal processing

APPROACH:

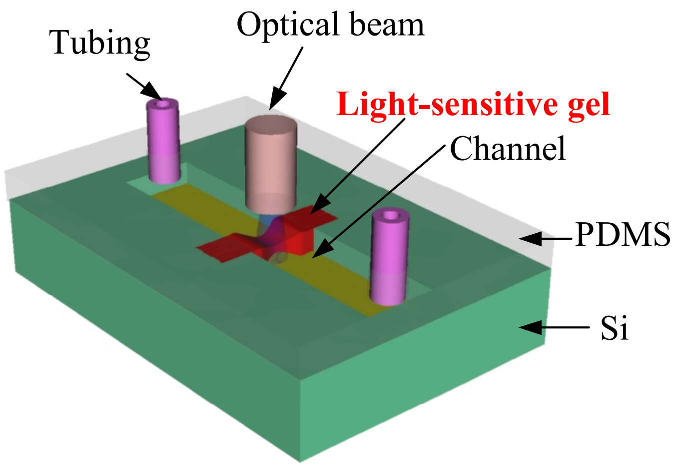
- PBG + NEMS + SOI
  - PBG: Photonic Band Gap
  - NEMS: Nanoscale MEMS
  - SOI: Silicon on Insulator
- Nanofabrication using DRIE (deep reactive ion etching)
- SiGe and SiGeC bandgap engineering and photodetectors
- Compatible with CMOS

MILESTONES AND SCHEDULE:

- Develop nanofabrication techniques on SOI (12 mo.)
- Demonstrate 1-D superprism (18 mo.)
- Demonstrate NEMS devices (24 mo.)
- Bandgap engineering (SiGeC) and detector integration (36 mo.)

Optically Actuated Microfluidic Chips

M. Wu, C.-M. Ho, B. Jalali



Light-Sensitive Gel Valve

OBJECTIVE:

- Develop optically actuated microfluidic devices
- Control microfluidic chips by optical beam steering
- Parallel detection with 2-D array of microspectrometers

APPROACH:

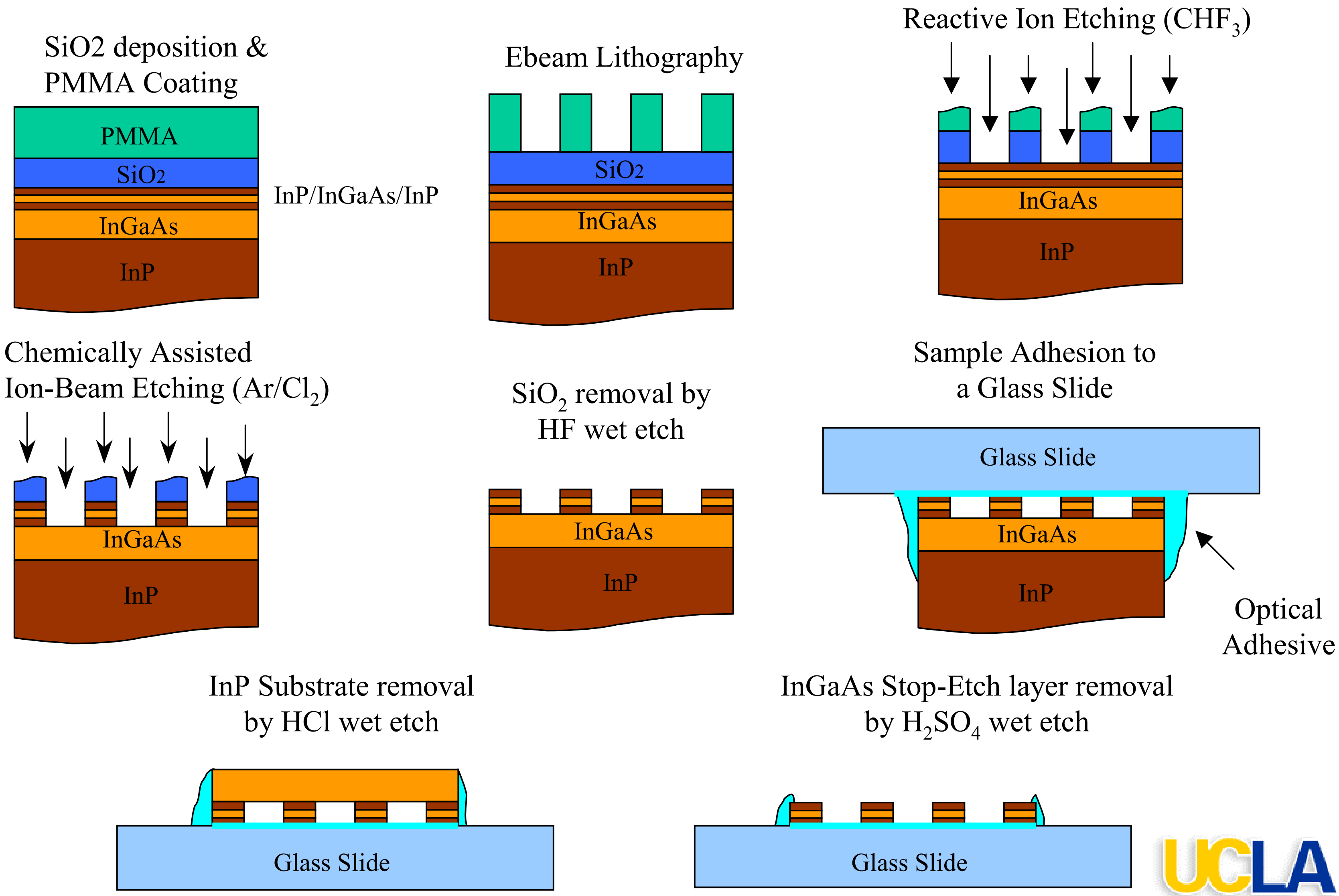
- Optical actuation based on light-sensitive gels
- Optically actuated pumps, valves, mixers
- Microbeam control of optical actuators
- 2D array of Fourier-transform microspectrometers

SCHEDULE AND MILESTONES:

- Demonstrate optical actuation principle (12 mo.)
- Demonstrate microspectrometer concepts (12 mo.)
- Demonstrate working devices (24 mo.)
- Perfecting devices and integrate into systems (36 mo.)

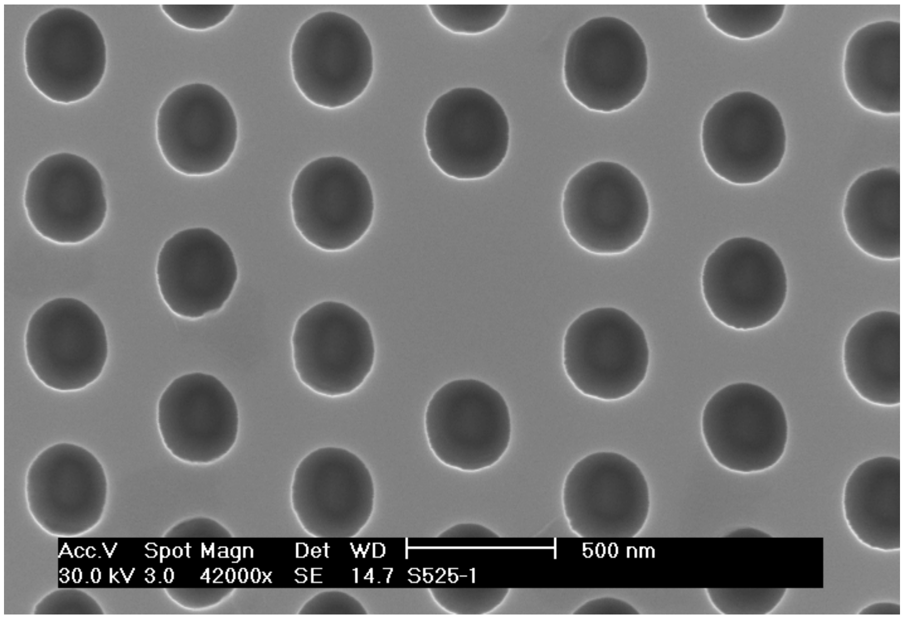
2D Photonic Crystal Defect Cavities

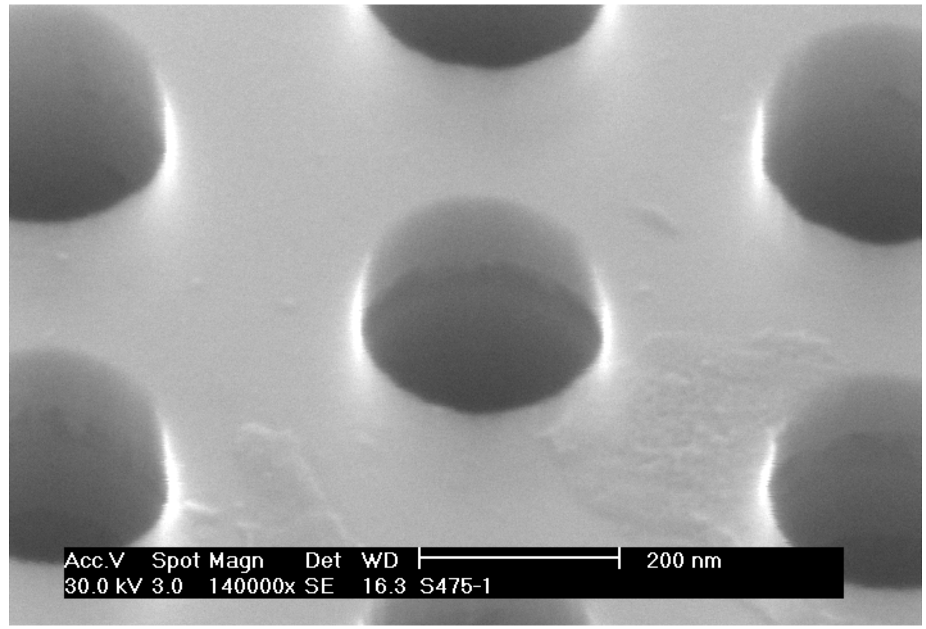
Fabrication Process



2D Photonic Crystal Defect Cavities

Fabricated Devices

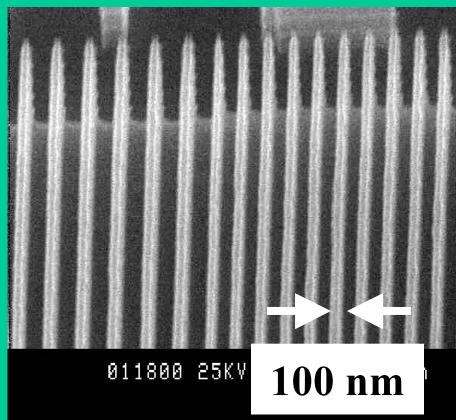




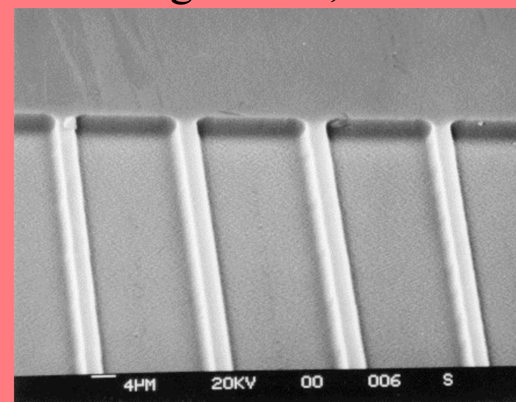
Device fabricated on InP/$In_{0.53}Ga_{0.47}As$/InP Double Heterostructure.
Resonance frequency in the 1.49–1.6 µm range, tunable by adjusting lattice parameter.

UCLA's Previous Work on SOI

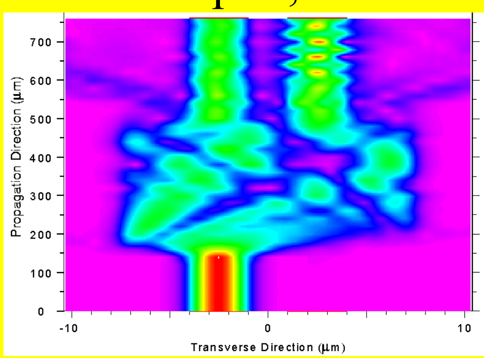
SOI Photonic Bandgap Devices, 1998



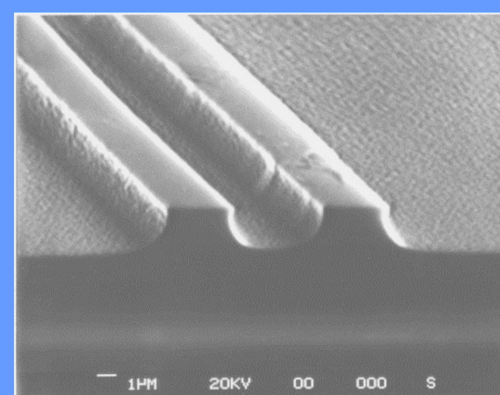
SOI Arrayed Waveguide Grating WDM, 1997



Multimode Interference Coupler, 1996

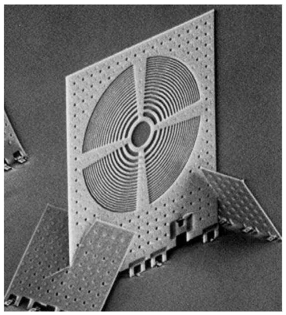


Directional Coupler, 1996

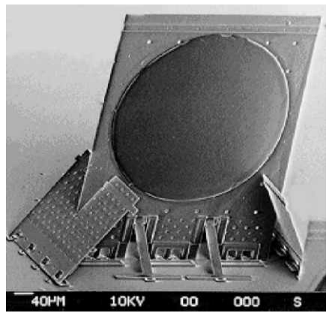


Optical MEMS at UCLA

Integrable Micro-Optics

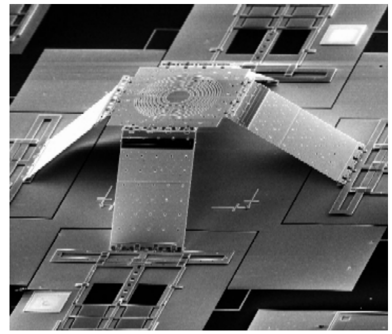


Diffractive Lens



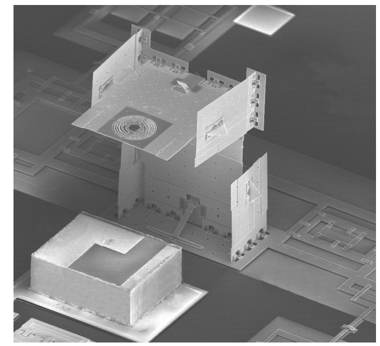
Refractive Lens

MEMS Actuators

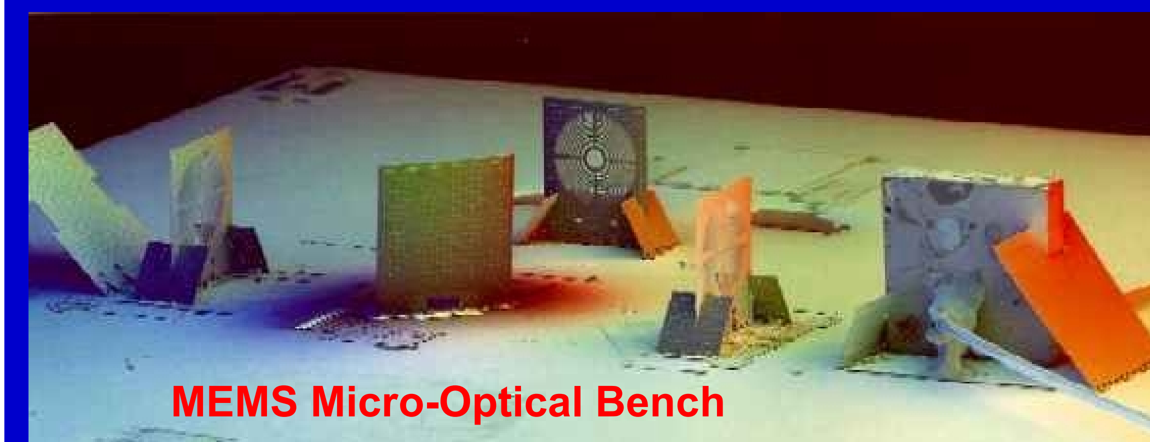


Micro XYZ Stage

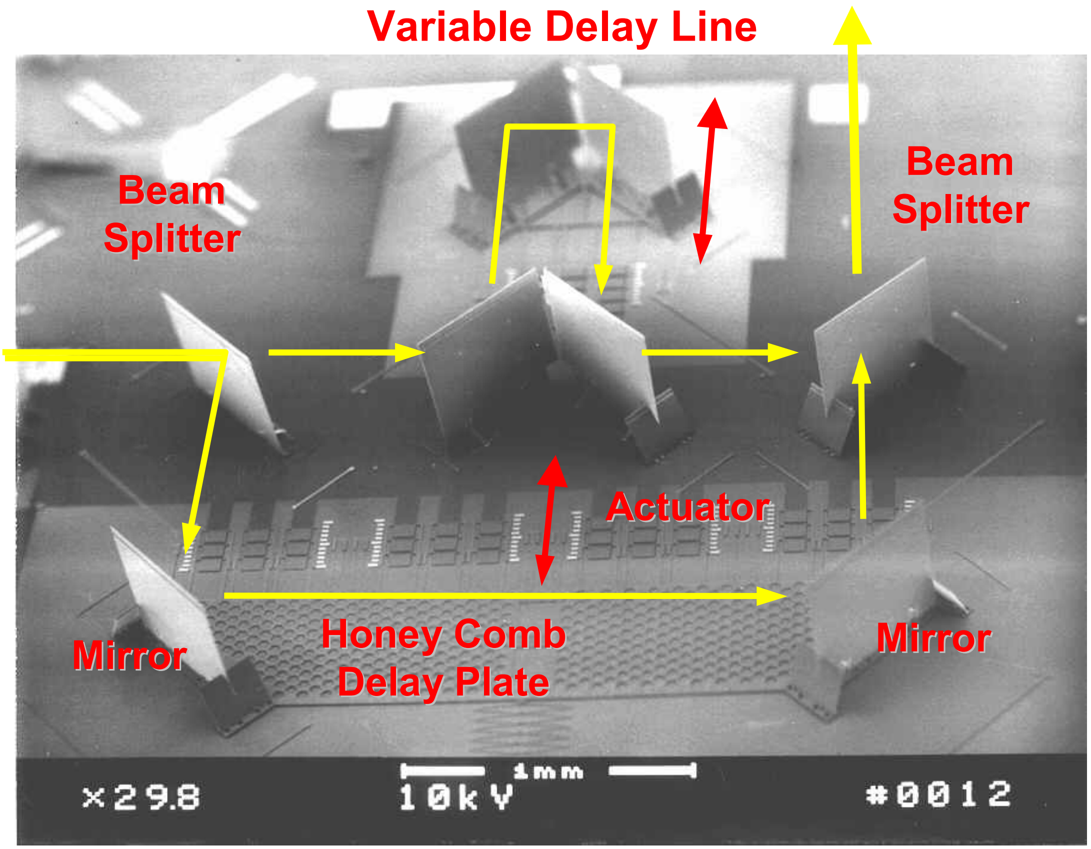
Opto MEMS



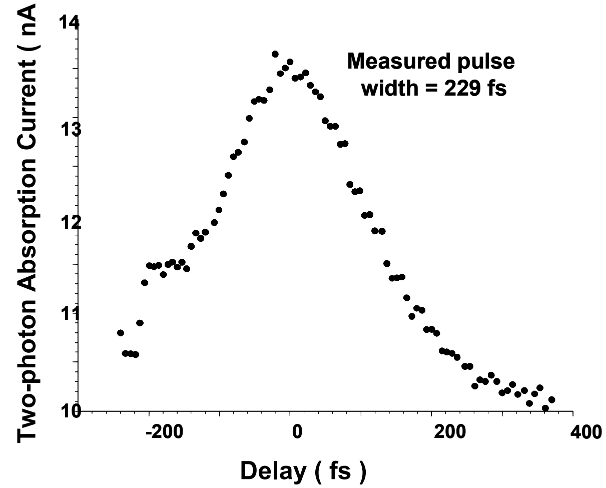
VCSEL + μlens



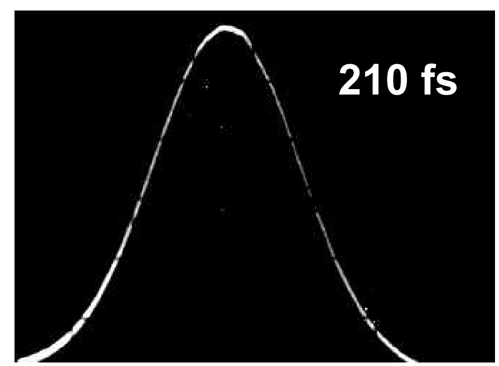
Single-Chip Interferometer



MEMS Autocorrelator

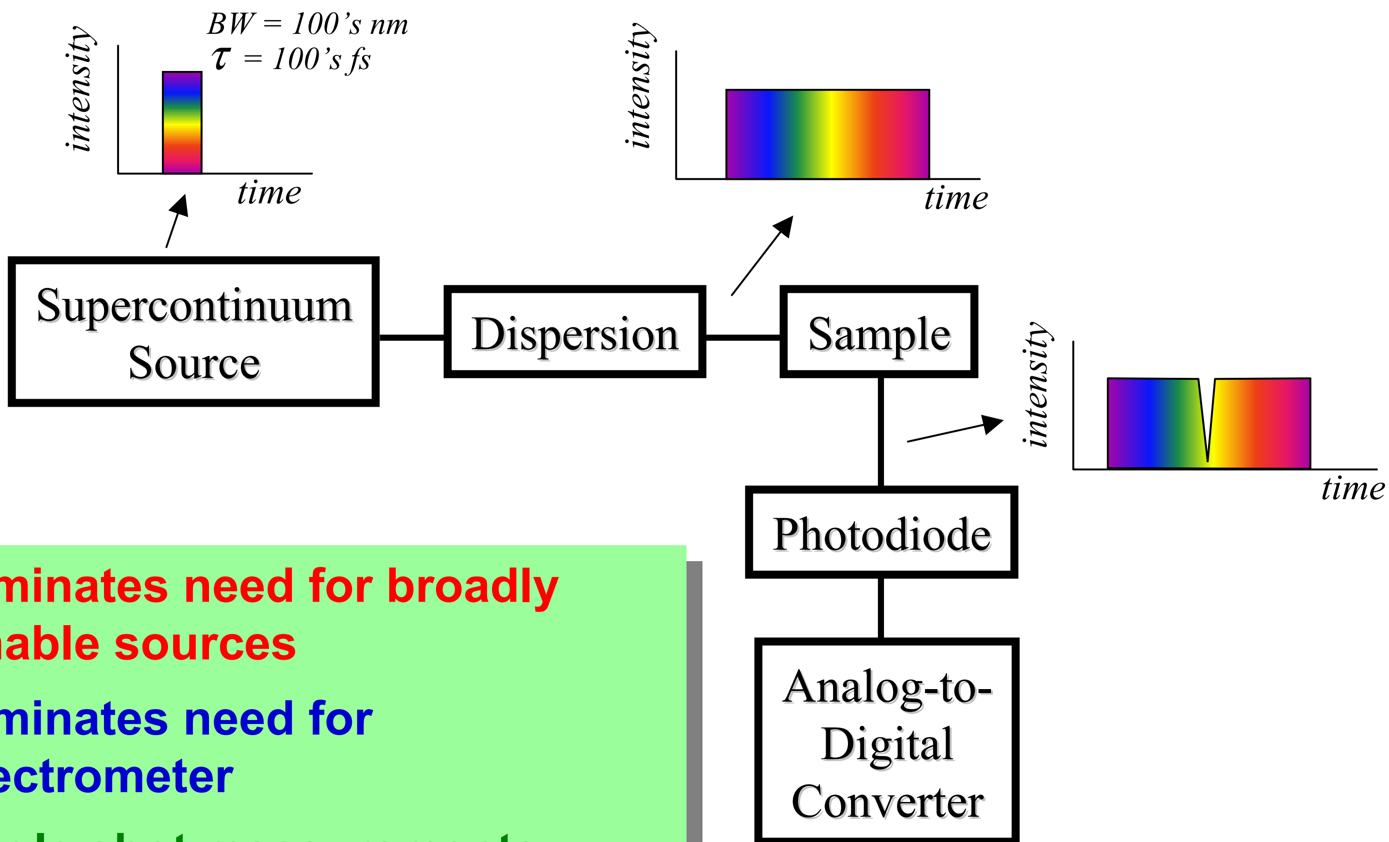


Conventional Autocorrelator



- **Chip area ~ 4 mm x 4.5 mm**
- **Delay resolution achieved: 22 nm (~ 0.15 fs)**
- **Potentially useful for Fourier Transform Spectroscopy (FTS)**

Time Domain Spectroscopy



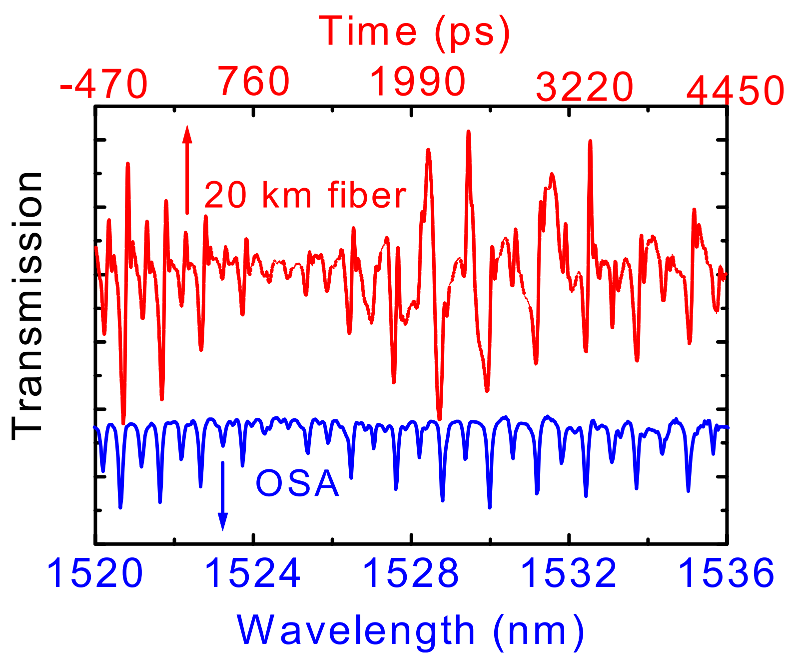
- Eliminates need for broadly tunable sources
- Eliminates need for spectrometer
- Single shot measurements possible while maintaining low peak power

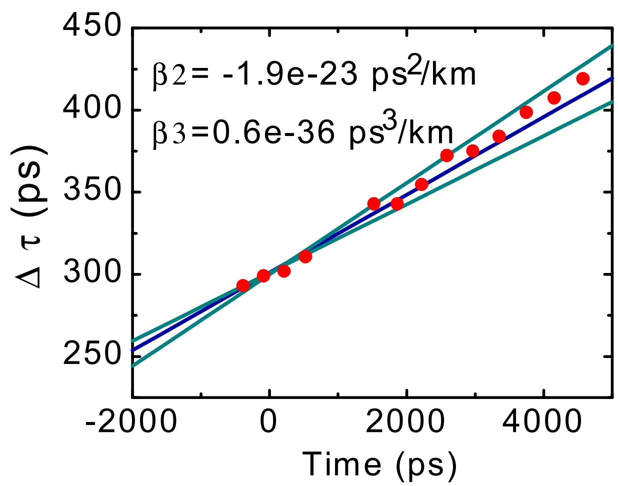
Time Domain Spectroscopy

- Phase difference (ϕ) due to dispersion is given by

$$\phi = \frac{1}{2}\beta_2 L(\Delta\omega)^2 + \frac{1}{6}\beta_3 L(\Delta\omega)^3 + \ldots$$

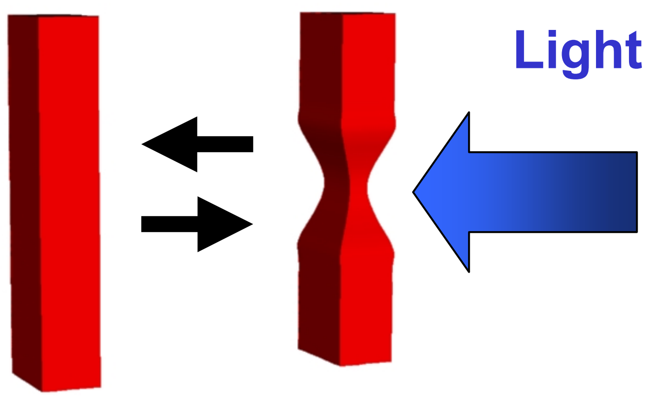
- β_3 causes non-linear time-to-wavelength mapping
- Self phase modulation can be ignored



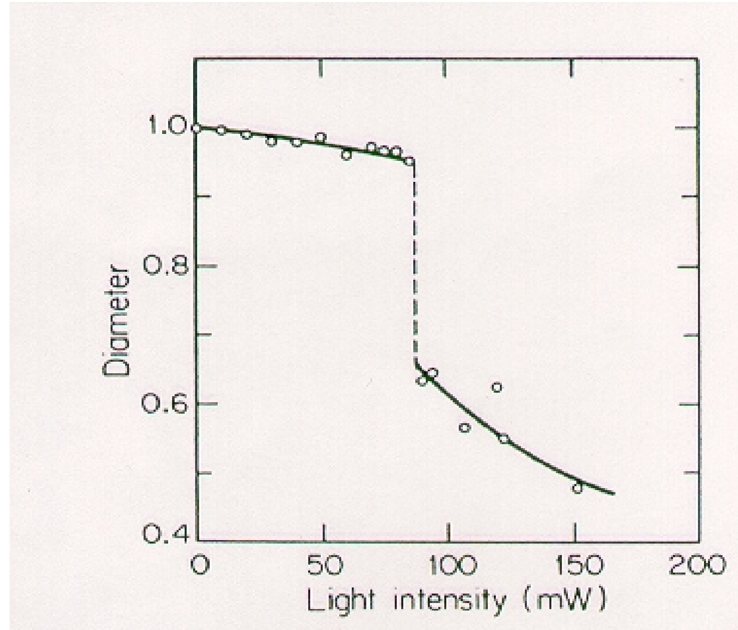


Resolution is comparable to the highest resolution, 0.08 nm, available for HP optical spectrum analyser (OSA).

Optical Phase Transition in Hydrogels



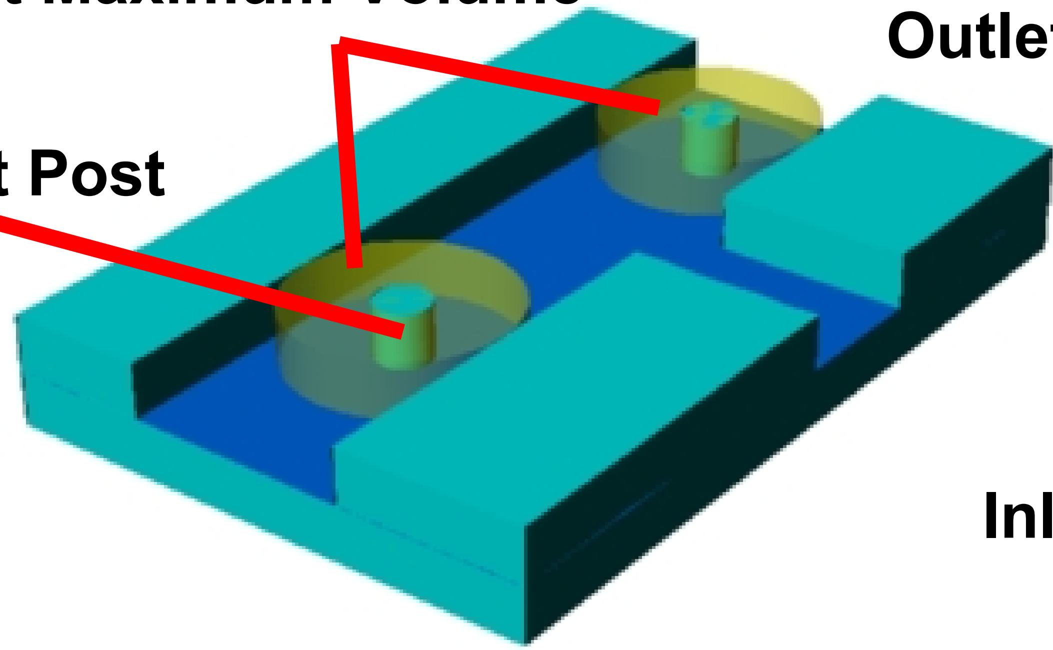
Light Sensitive Gel



- Phase transition in hydrogels by visible light (Tanaka, 1990)
- Gel volume strongly dependent on temperature, light intensity due to heating of network polymers
- Discontinuous volume change greater than 60%
- Estimated response time for micro components ~5ms

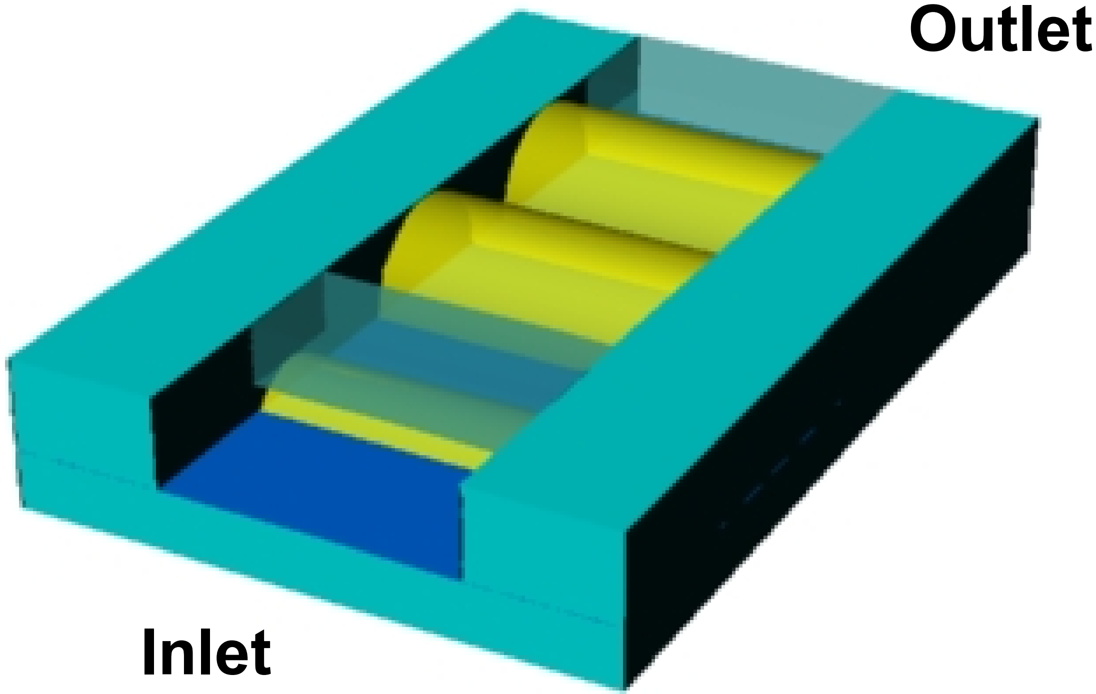
Light-responsive hydrogel is basis for actuation schemes

Optically Driven Valve

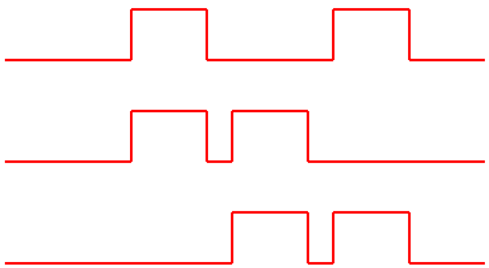


Hydrogel patterning easily incorporated in photolithography process

Optically Driven Pump



Peristaltic pump driven by 3 light sources in 3-phase sequence:



Converts light energy into mechanical pumping

Summary

- Highly integrated Bio-chemical photonic sensors
- SOI and IIIV-on-glass material
- Nano-photonics spectrometers
- Optically actuated microfluidics
- Time domain spectroscopy