

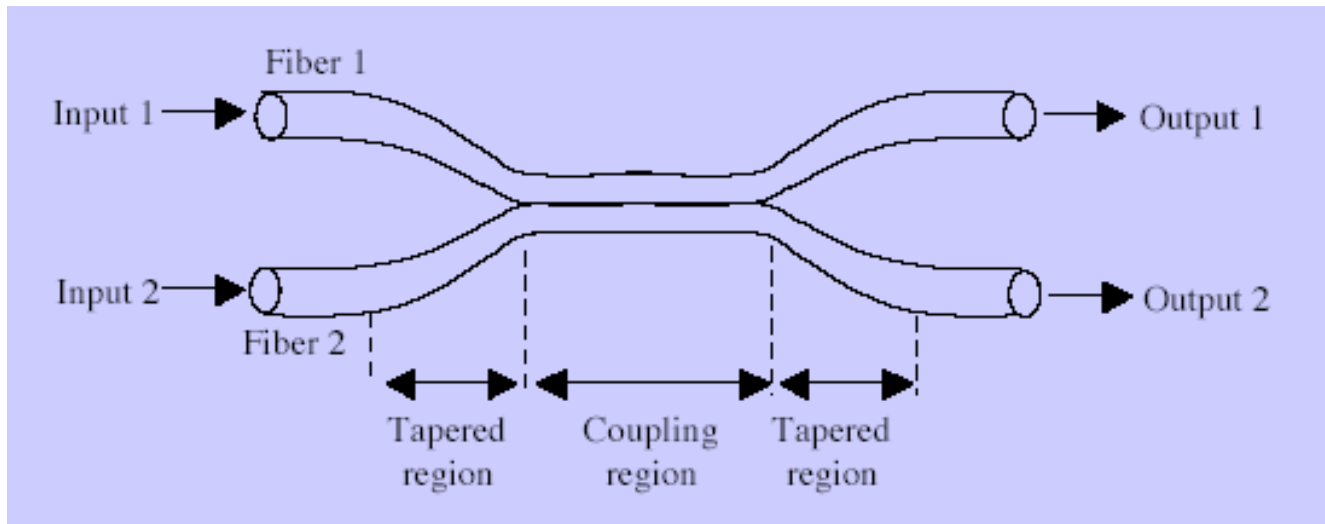


# OXC's

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# The 2x2 coupler

- The 2x2 coupler is a basic device in optical networks, and,
- It can be constructed in variety of different ways.
- A common construction is the *fused-fiber* coupler.

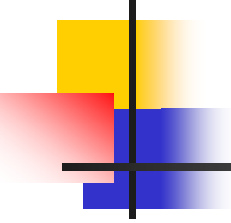




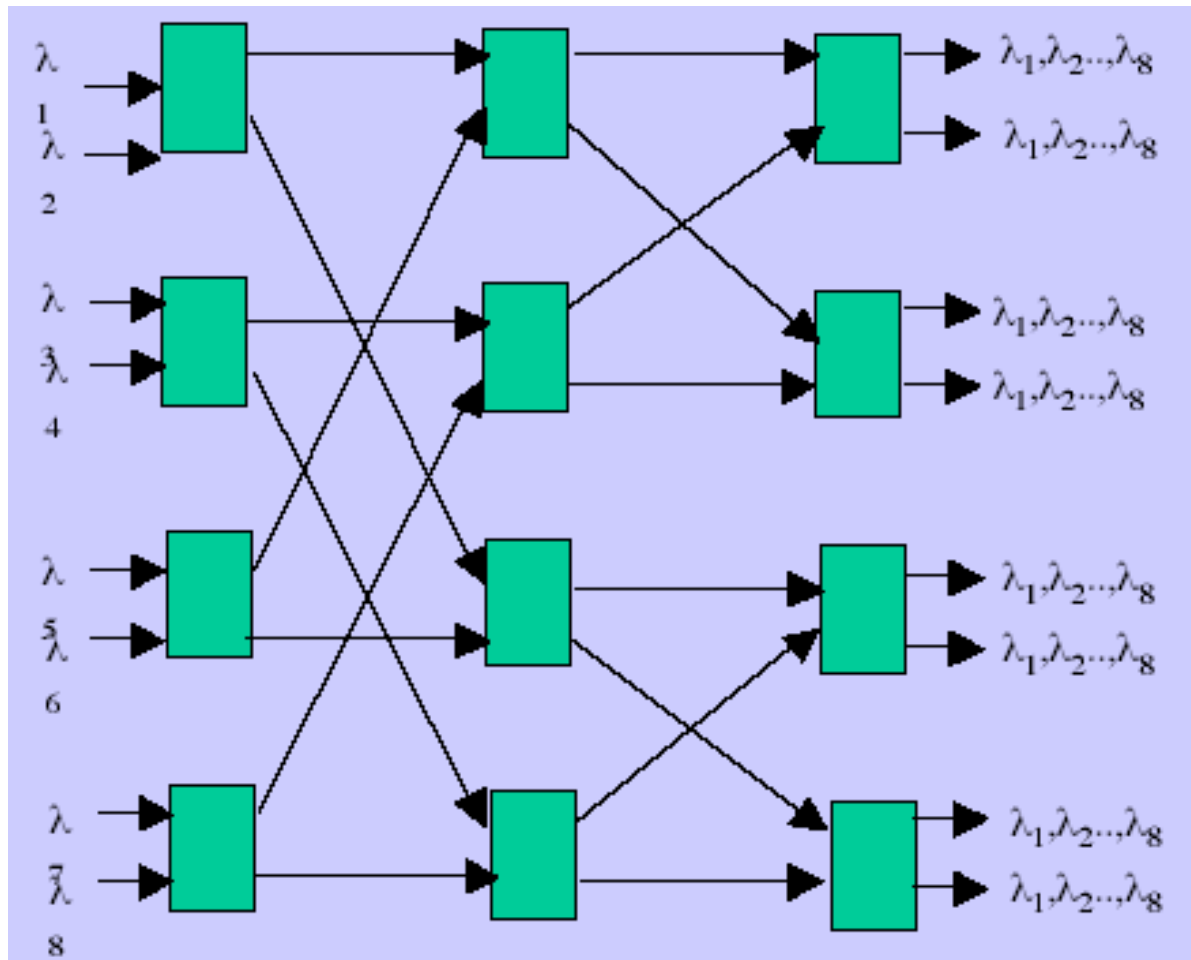
# 3-dB coupler

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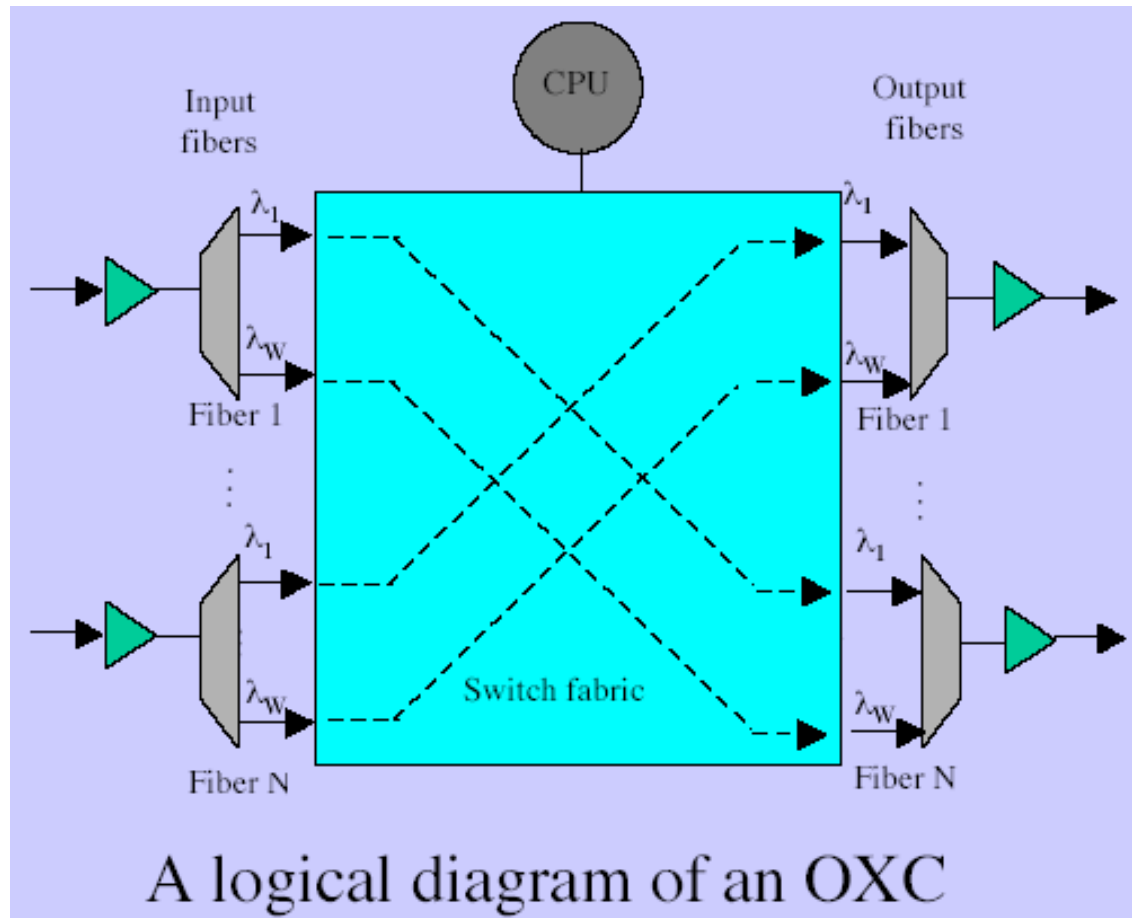
- A 2x2 coupler is called a *3-dB coupler* when the optical power of an input light applied to, say input 1 of fiber 1, is evenly divided between output 1 and output 2.
- If we only launch a light to the one of the two inputs of a 3-dB coupler, say input 1, then the coupler acts as a *splitter*.

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- If we launch a light to input 1 and a light to input 2 of a 3-dB coupler, then the two lights will be coupled together and the resulting light will be evenly divided between outputs 1 and 2.
  - In the above case, if we ignore output 2, the 3-dB coupler acts as a *combiner*.

# A banyan network of 3-dB couplers



# Optical cross connects (OXC)





# OXC functionality

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- It switches optically all the incoming wavelengths of the input fibers to the outgoing wavelengths of the output fibers.
- For instance, it can switch the optical signal on incoming wavelength  $\lambda_i$  of input fiber  $k$  to the outgoing wavelength  $\lambda_i$  of output fiber  $m$ .



# Converters

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- If it is equipped with converters, it can switch the optical signal of the incoming wavelength  $\lambda_i$  of input fiber  $k$  to another outgoing wavelength  $\lambda_j$  of the output fiber  $m$ .
- This happens when the wavelength  $\lambda_i$  of the output fiber  $m$  is in use.
- Converters typically have a limited range within they can convert a wavelength.





# Optical add/drop multiplexer (OADM)

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- An OXC can also be used as an OADM.
- That is, it can terminate the optical signal of a number of incoming wavelengths and insert new optical signals on the same wavelengths in an output port.
- The remaining incoming wavelengths are switched through as described above.



# Transparent and Opaque Switches

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## *Transparent switch:*

- The incoming wavelengths are switched to the output fibers optically, without having to convert them to the electrical domain.

## *Opaque switch:*

- The input optical signals are converted to electrical signals, from where the packets are extracted. Packets are switched using a packet switch, and then they are transmitted out of the switch in the optical domain.

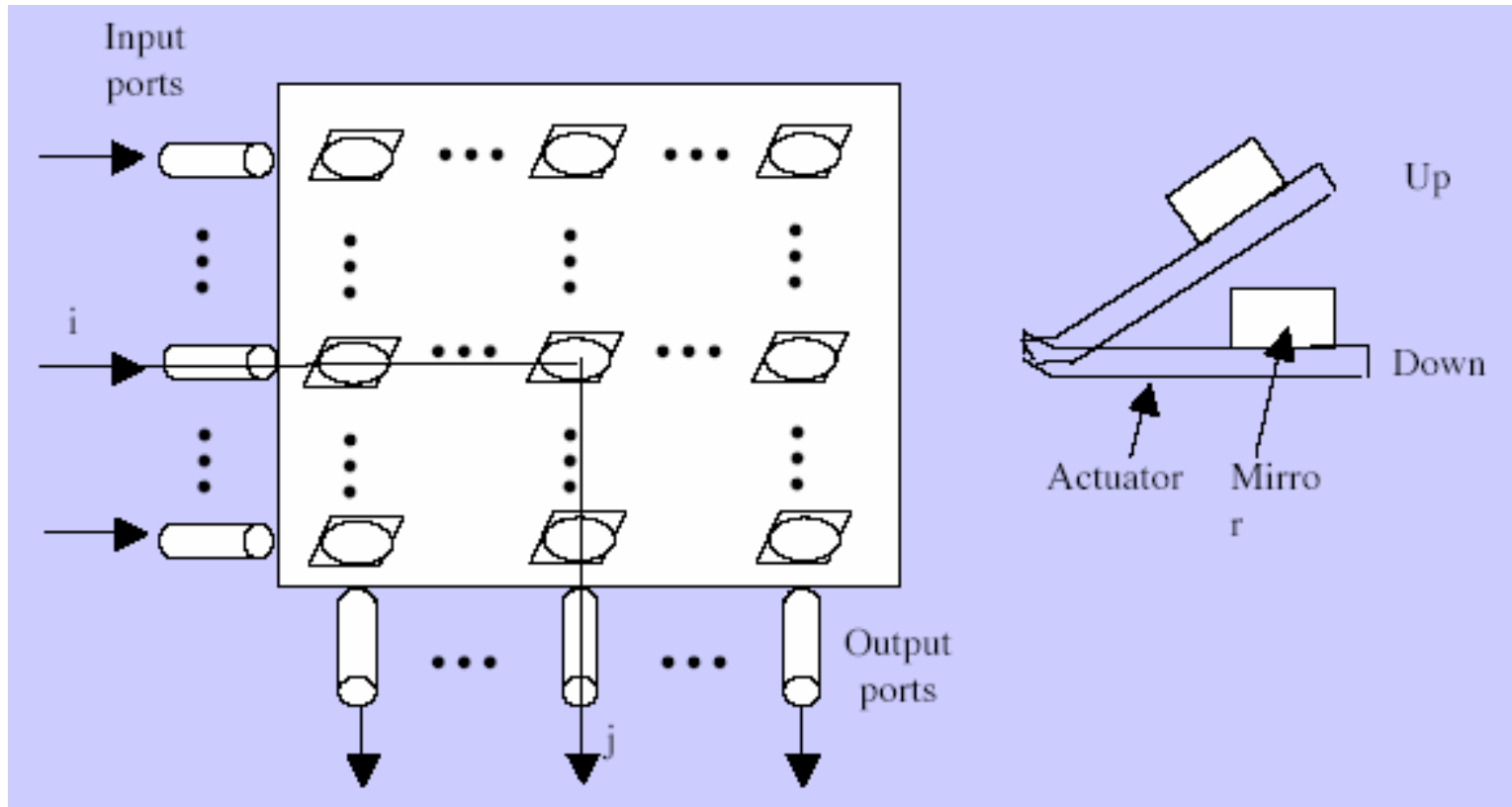


# Switch technologies

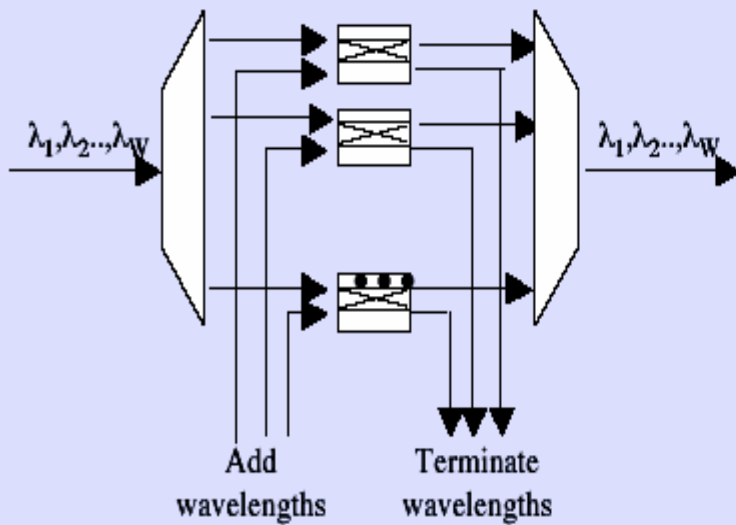
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- Several different technologies exist:
  - *micro electronic mechanical systems (MEMS)*
  - *semiconductor optical amplifiers (SOA)*
  - *micro-bubbles*
  - *holograms*
  - Also, 2x2 directional coupler , such as the *electro-optic switch*, the *thermo-optic switch*, and the *Mach-Zehnder interferometer*, can be used to construct large OXC switch fabrics

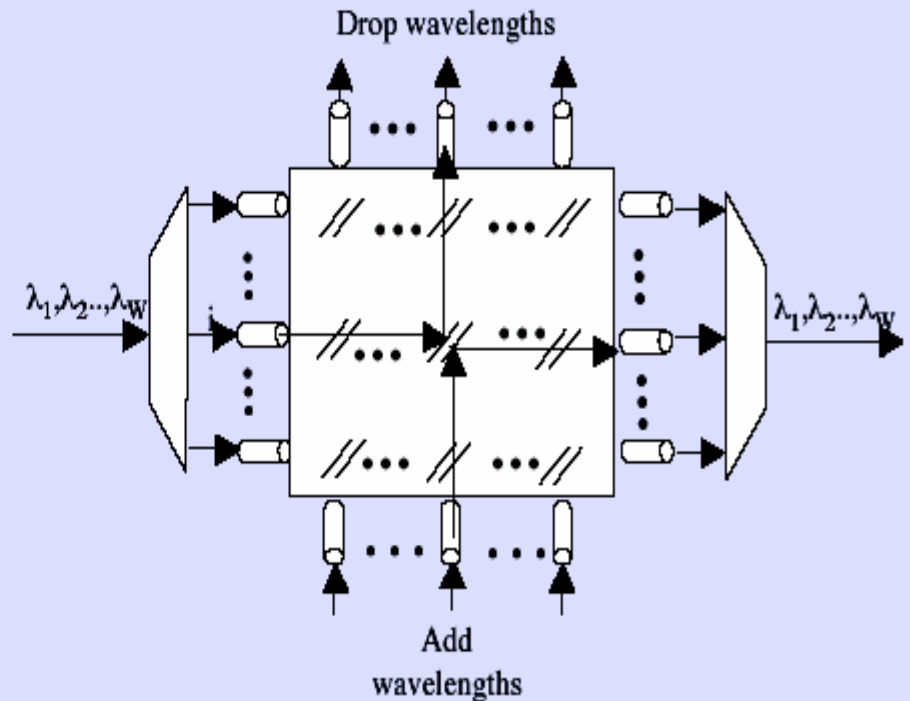
# 2D MEMS switching fabric



# A 2D MEMS OADM

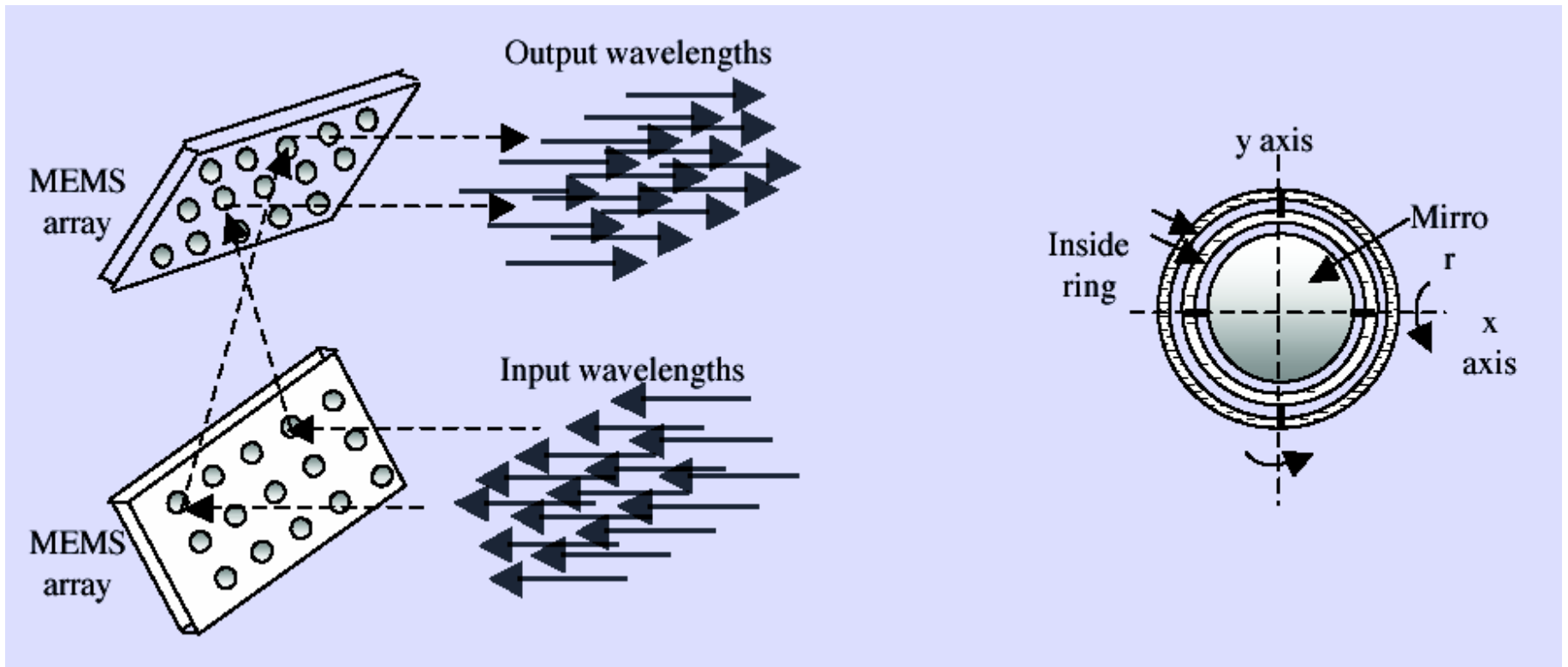


Logical design



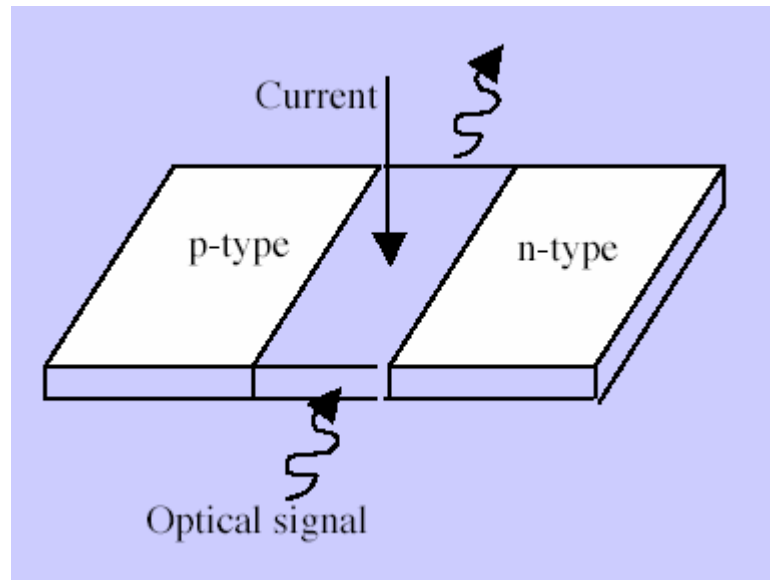
2D MEMS implementation

# 3D MEMS switching fabric



# Semiconductor optical amplifier (SOA)

- A SOA is a *pn-junction* that acts as an amplifier and also as an on-off switch



# A 2x2 SOA switch

- Wavelength  $\lambda_1$  is split into two optical signals, and each signal is directed to a different SOA. One SOA amplifies the optical signal and permits it to go through, and the other one stops it. As a result  $\lambda_1$  may leave from either the upper or the lower output port.
- Switching time is currently about 100 psec.

