1. Optical MEMS → "MOEMS" → Micro- Opto - Electromechanical Systems
→ utilize MEMS technology to realize devices that interact with light

a. Visible light spectrum

approximately 400nm to 700nm

Red → 700nm → longest wavelength

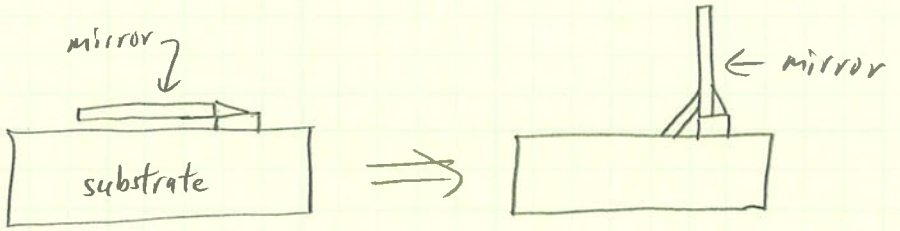
Violet → 420nm → shortest wavelength

b. MOEMS Components

① flat mirrors and mirror segments:

→ Horizontal mirrors → highly polished Si coated with highly reflective coatings

→ Vertical mirrors → i. precise vertical fabrication {anisotropic (110) wet etch}
ii. fabricate horizontally + stand up



as fabricated

mirror structure is stood up vertically and locked in place

② optical wave guides

→ embed fiber optic cable in the substrate

→ realize low-loss optical waveguide structures in the substrate by using appropriate materials, design and microfabrication

③ light sources

i. LED's

ii. laser diodes

iii. VCSELs → Vertical-Cavity Surface-Emitting Laser (diode based)

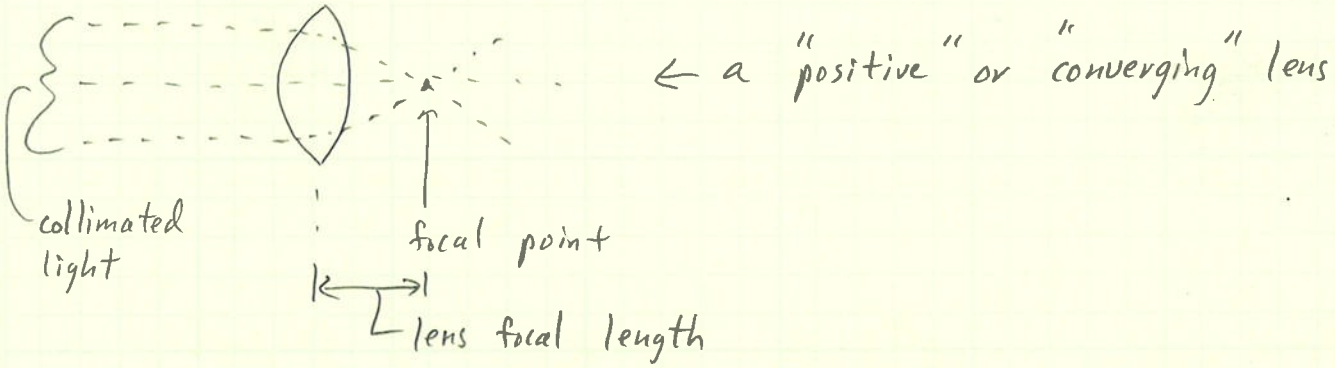
iiii'. VECSELs → Vertical-External-Cavity Surface-Emitting Laser (" ")

iv. External light source

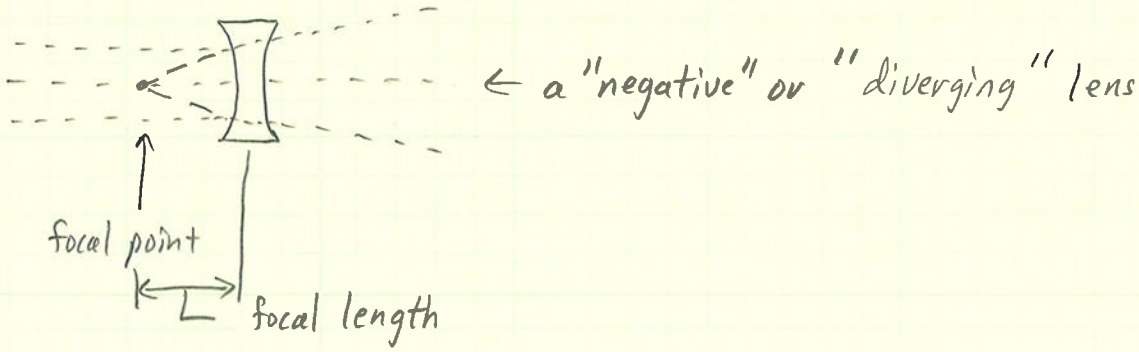
④ Micro lenses

i. Refractive micro lenses → based on optical refraction

→ optically transparent materials are micromachined to realize miniature concave or convex lenses



← a "positive" or "converging" lens

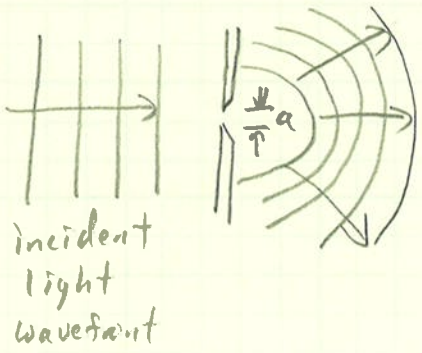


← a "negative" or "diverging" lens

→ fabricated by special etching techniques such a grayscale lithography

ii Diffractive Microlenses → based on optical diffraction

Diffraction → bending of light around an obstacle



a = slit opening {shown for $a = \lambda$}

$a = \lambda$ is possible with MEMS technology

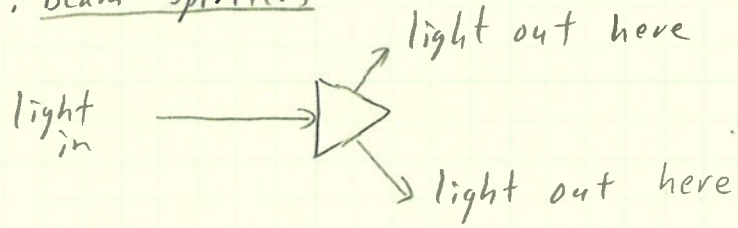
→ Diffractive Gratings can be micromachined to realize various types of lenses

⑤ Other micro-optical components:

i. Optical Diffusers

ii. Retro-Reflectors → light reflects out to same location as it entered
↳ Corner Cube is one type

iii. Beam-Splitters



c. Static MOEMS Systems

① Micro-optic arrays

one application → disposable binocular glasses for sporting events

② Optical instrument on a chip

→ Interferometer → measures displacement or velocity

→ spectrometer → chemical detection

→ optical correlator {performs an FFT of a signal optically}

d. Dynamic MOEMS Systems

→ combines MEMS actuators with micro-optics

① Fiber Optic Switches

② Deformable Mirrors → "spacial light modulators"

i. arrays of micro mirrors that spacially change the optical wavefront → pixilated

ii. continuous membrane micromirror for wavefront adjustement

iii. Adaptive Optics

→ detects distorted optical wavefront {non-flat} using an optical wavefront sensor and corrects the wavefront using a deformable mirror

→ complex MOEMS system

③ TI DLP {Digital Light Processor}

→ An array of flat micromirrors on electrostatic actuators on an SRAM chip

→ each mirror element is either pointed in the "On" or the "off" direction

④ Tilt mirror chips

→ analog range of motion

→ 1-D or 2-D

⑤ Holographic TV → future