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 → 420 nm → shortest wavelength
   b. MOEMS components
      i. Flat mirrors and mirror segments:
         → Horizontal mirrors → highly polished Si coated with highly reflective coatings
         → Vertical mirrors → i. precise vertical fabrication E childish (110) not et al.3
         ii. fabricate horizontally & stand up

   
   \[ \text{mirror} \]
   \[ \text{substrate} \] \[ \Rightarrow \] \[ \text{mirror structure is stood up} \]
   \[ \text{vertically and locked in place} \]

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. LEDs
   ii. Laser diodes
   iii. VCSELs → Vertical-Cavity Surface-Emitting Laser (diode based)
   iv. VECSELs → Vertical-External -Cavity Surface-Emitting Laser (11 11)
   v. 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

   \[
   \begin{align*}
   \text{collimated light} & \quad \text{focal point} \\
   \text{lens focal length} & \quad \text{a "positive" or "converging" lens}
   \end{align*}
   \]

   \[
   \begin{align*}
   \text{focal point} & \quad \text{focal length} \\
   \text{a "negative" or "diverging" lens}
   \end{align*}
   \]

   → fabricated by special etching techniques such as grayscale lithography
ii. **Diffractive Micro lenses** → based on optical diffraction

- Diffraction → bending of light around an obstacle

\[
a = \text{slit opening} \ \& \ \text{shown for} \ a = 2^3
\]

\[
\text{incident light wavefront}
\]

\[
\text{light out here}
\]

\[
\text{light in}
\]

\[
\text{light out here}
\]

\[
\text{a =} \lambda \ \text{is possible with MEMS technology}
\]

→ 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

   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 → pixelated
   
   ii. Continuous membrane micromirror for wavefront adjustment

   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**