Optical Components

Optical Materials

- Generally specified according their ranges of transparency.
  - Glass (BK7, …)
  - Quartz (Fused Silica)
  - CaF_2, MgF_2
  - Ge, Si, Sapphire, LaF

Mirrors

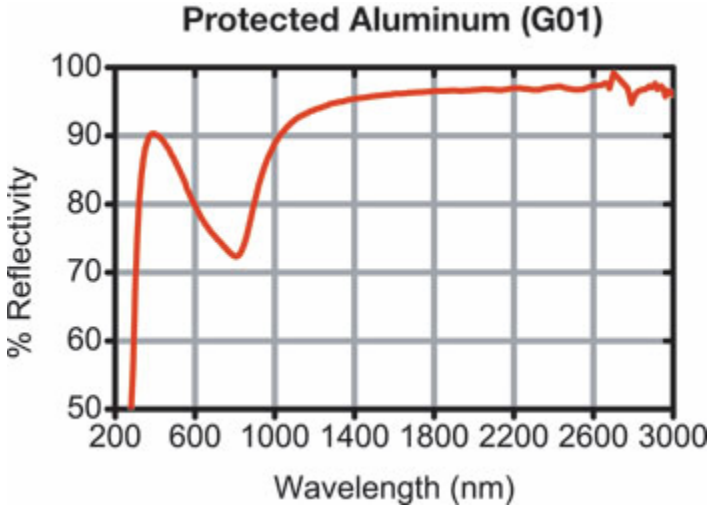
- They are specified by;
  - Coating
  - Reflection range
  - Flatness
  - Surface quality
  - Substrate material
  - Size
  - Radius of curvature

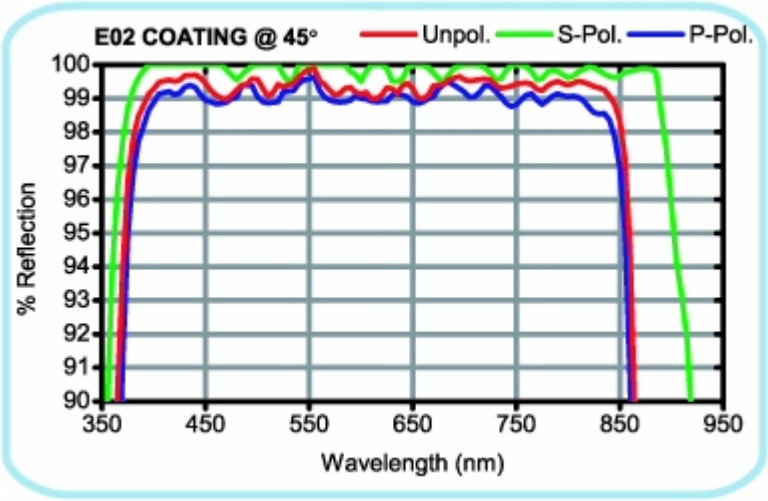
Material	Fused Silica	
Flatness	λ/10	
Surface Quality	10-5 Scratch Dig	
Back Surface	Fine Ground	
Clear Aperture	>90% of Diameter	
Thickness	Ø1/2" Optics	6 mm (0.236")
	Ø1" Optics	6 mm (0.236")
	Ø2" Optics	12 mm (0.472")
Thickness Tolerance	±0.2 mm	
Laser Damage Threshold	2 kW/cm^2 (CW) 100 mJ/cm^2 (10 ns Pulse)	
Diameter Tolerance	+0.00 mm / -0.10 mm	

A typical spec sheet for a broadband dielectric mirror

Coatings

- **Metallic** coatings mainly are Aluminum, Silver and Gold.
  - They utilize the high reflection coefficient (70% - 95%) of metals.
  - There is some absorption into the metal. Therefore they are not very suitable for high intensity lasers.
  - They are pretty broadband.
- **Dielectric** coatings are multiple thin layers of insulators.
  - They utilize thin film constructive interference.
  - The reflection coefficient can be made very high (>99%) with little absorption.
  - The reflection coefficient spectrum can be tailored to one's needs (broadband, narrowband, multi-band).
  - They are sensitive to angle of incidence, polarization.





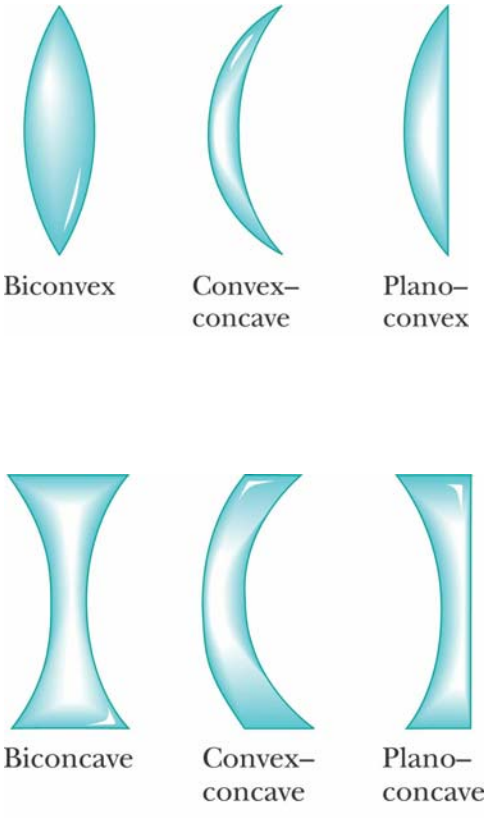
Lenses

- They are specified by;
  - Surface curvature
  - Material
  - Anti-reflection coating
  - Focal length (f)
  - Diameter (D)
  - f-number (D/f)
  - Surface quality

Lens Shape	Plano/Convex
Material	BK7 - Grade A
Design Wavelength	633 nm
Index of Refraction	1.515 at Design Wavelength
Centration	<= 3 arcmin
Clear Aperture	>90% of Diameter
Focal Length Tolerance	+/- 1%
Surface Quality	40/20 Scratch Dig
Diameter Tolerance	+0.00 mm / -0.10 mm
Wavelength Range	650-1050 nm -B Coating

Lens Shapes

- Plano-convex
  - Suitable for focusing a collimated beam
- Bi-convex
  - Suitable for point-to-point focusing
- Plano- and bi-concave
  - Defocusing and collimation
- Cylindrical
  - Focusing in one dimension
- Achromats
  - Two lenses glued together for lesser chromatic aberration.

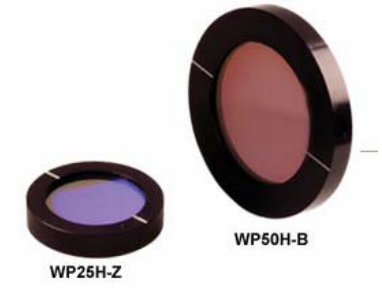


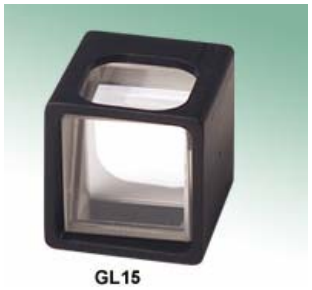
Beam Splitters and Windows

- Beam Splitters - Optical surfaces coated for partial reflection of a wavelength range
  - Metallic, dielectric, polka-dot coatings
  - Can be wavelength, polarization and angle of incidence specific
- Windows - Optical surfaces for insulation, optical access, viewports, etc.
  - Surface flatness and quality is important.
  - Can be Brewster angled, wedged, flat.

Polarizers

- Types
  - Plate
  - Cube
  - Wire-grid
- Specs
  - Bandwidth
  - Extinction ratio (T_{max} / T_{min})
  - Damage threshold

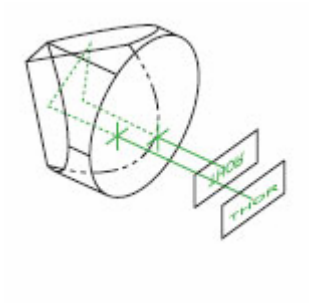




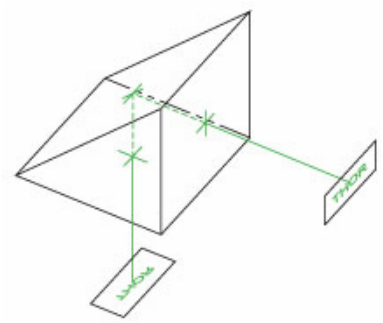
Wave Plates

- Remember double refraction - one polarization of light sees a different index of refraction than the other.
- Since the index determines the speed of light inside the material, light at different polarizations travels at different speeds.
- Any polarization can be represented by the sum of two orthogonal polarizations.
- The polarization axis aligning with the lower index is the fast axis, the one aligning with the higher index is the slow axis.
- Let's say initially, the incident light has a polarization that makes an angle of θ with the fast axis.
- If the relative delay introduced by the material between the two polarizations is equal to half a period, then the overall polarization of the light beam will have rotated a total of 2θ degrees. This is called a **half-wave** plate.
- If the relative delay is equal to a quarter of a period then both polarizations are equally excited and linearly polarized light is turned in to circularly polarized light. This is a **quarter-wave** plate.

Prisms

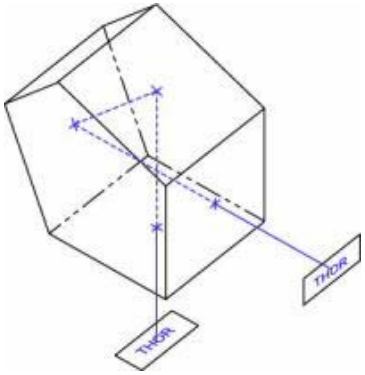


Retroreflectors

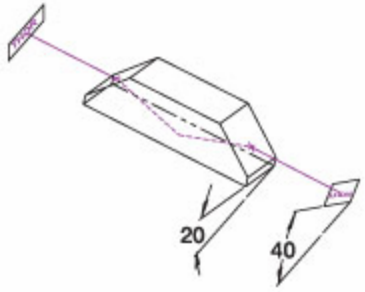


Right angle prisms

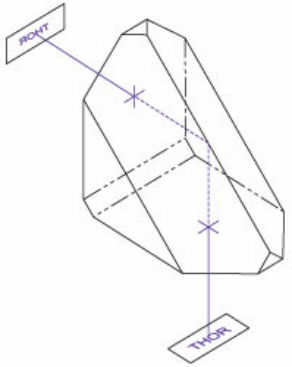
Dispersion prisms



Penta prisms



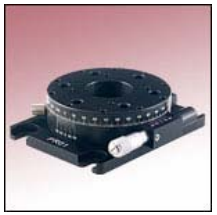
Dove prisms



Roof prisms

Opto-Mechanical Components

- Mirror Mounts
  - Kinematic
  - Gimbal
- Lens Mounts
  - Fixed
  - Centering
- Posts, Post Holders
- Bases
  - Fixed
  - Universal
  - Magnetic
- Translation Stages
  - Motorized (piezo, stepper motor)
  - Manual (dovetail, crossed roller bearing)
  - Rotational



Vibration Isolation

- Mechanical vibrations in the 1-100 Hz range can be detrimental to optical measurements.
- Both active and passive damping techniques are used.