Technical Note

Choosing the correct mirror

Mirrors are ubiquitous components in optical systems. They can be used to steer and focus light, reject certain wavelengths, and combine wavelengths in imaging and other applications. When choosing a mirror, a number of factors need to be considered.

Materials

Metallic Mirrors exhibit a combination of reflectance and absorbance (and transmittance if thin enough). They can be used as wide wavelength-range reflectors, neutral density filters or neutral beamsplitters. Their spectral properties are defined by the type of metal used. The utility of these mirrors is largely independent of angle-of-incidence.

Dielectric Mirrors are composed of thin layers of non-absorbing materials (usually oxides and fluorides) which alternate in refractive index. The thickness and composition of the layers are designed to produce transmittance or reflectance in wavelength ranges defined by the customer or application. Little to no light is absorbed in these materials, so dielectric mirrors can often be used as dichroic mirrors (where light of some colors passes through, while light of other colors is reflected). Both the wavelength range and angle-of-incidence must be defined at the design stage.

Function

Imaging- Requires flatness of $\lambda/10$ or better to minimize distortion in the image. Non-imaging, beam-steering applications do not require such tight flatness specifications.

Wavelength combining- Dielectric dichroic mirrors can be used to combine laser beams onto a single axis. Flatness of $1/4\lambda$ per inch or better is required for this application.

Wavelength splitting- Dielectric dichroic mirrors can also be used to reflect desired wavelengths. Applications include hot-mirrors that reject NIR and IR light, reflecting excitation light and transmitting emission light and simultaneously detecting a number of different wavelength bands with multiple detectors. The transmitting and reflecting wavelengths need to be well-defined for this type of application. These are typically used at 45^o angle of incidence.

Wavelength rejection- In certain cases, a researcher may wish to reject certain wavelengths from the system. Examples include hot mirrors (which reflect IR/NIR), cold mirrors (which reflect shorter wavelengths and transmit longer wavelengths – often used in lamp assemblies) and order-sorting filters (unwanted wavelengths are reflected). Functionally, these are also dichroic mirrors applied in a different way, typically used at normal incidence or near-normal.

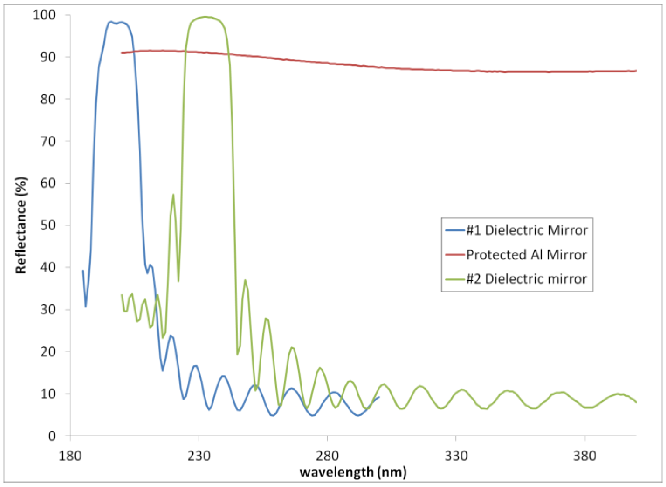
Angle of Incidence

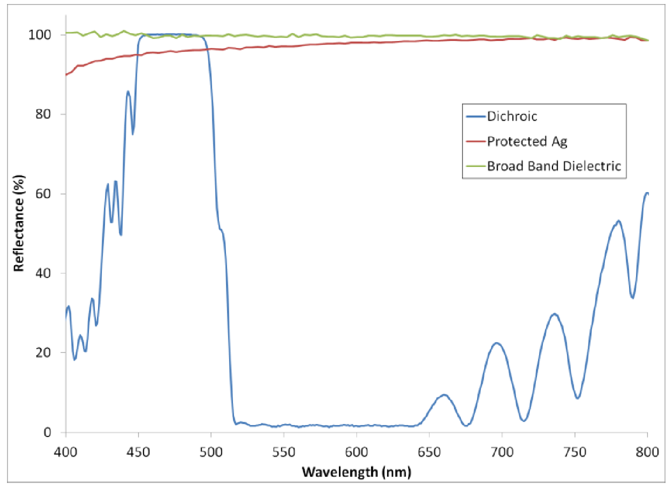
Mirrors are generally designed to be used at a specific angle of incidence. Hot mirrors are typically used at zero or near-zero degrees AOI, while dichroic mirrors are often used at 45^o. The optical design of the system dictates the AOI. Polarization differences must be considered when the AOI is greater than about 25^o. See our tech note about angles of incidence for more information.

Physical Environment

The physical environment that the mirror is exposed to should dictate the durability requirements. For space applications, temperature cycling can be important. For outdoor applications, humidity and temperature cycling, salt fog, abrasion resistance and condensation may be issues. Radiative flux (when the filter is placed in an intense or highly energetic beam) may result in performance degradation over time. In a protected laboratory instrument or air-conditioned lab space there are few environmental requirements.

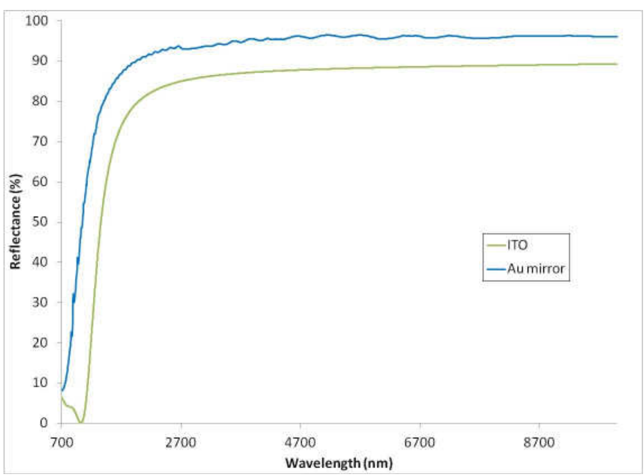
Wavelength Range

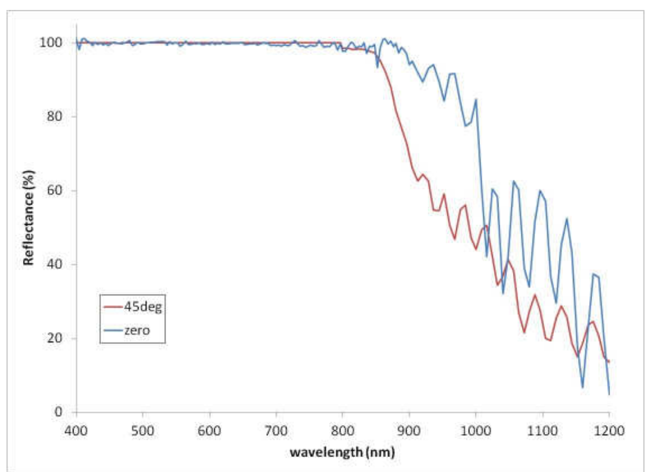




UV (180-400 nm) While traditional metal mirrors work over a large wavelength range, different metals may work best over certain wavelength ranges. Below 430 nm, first-surface Aluminum mirrors protected with Magnesium Fluoride are typically recommended. Omega has also developed dielectric mirrors optimized for this range that are composed of thin layers of transition metal oxides and Silicon Dioxide or Magnesium Fluoride and Lanthanide Fluorides for the lowest wavelengths.

Visible (400-700 nm) Historically, visible mirrors are composed of Silver on the top side (first-surface) or back side of a piece of glass. They are often protected with an additional layer of Silicon dioxide (for first-surface) or a plastic material that is non-transmissive (for back-surface). Dielectric mirrors made of alternating layers of non-absorbing materials are designed to maximize reflectance at specific angles and wavelengths while transmitting others. Enhanced metal mirrors combine metal and dielectric layers to increase reflectivity.





NIR – IR (700 nm - 10 micron) In the NIR and IR, gold mirrors are often used which absorb light in some visible wavelengths, but have high reflectance (>95% above 1500 nm). Another option is a transparent conductive oxide mirror (like ITO) which provides high reflectivity at longer wavelengths with transparency at shorter (visible) wavelengths.

Broadband Sometimes an application requires high reflectivity over a wavelength range that spans several of those mentioned above. Such applications include hyperspectral imaging, astronomy and solar photothermal or photovoltaics. For the highest and flattest reflectivity response, dielectric mirrors can be designed (similar to our Ultra Broadband Dielectric Mirror)