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BROADBAND SILVER MIRRORS FOR THE VIS AND NIR

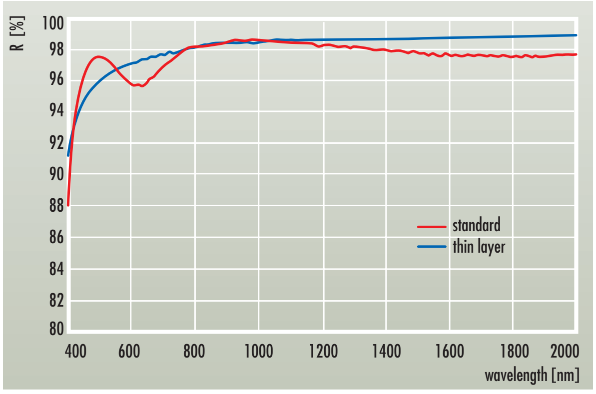

Figure 1: Reflectance spectra of silver mirrors with two types of protective coatings

Optical properties:

Standard:	R≥94% from 450nm to 600nm	
	R≥95.5% from 600nm to 1000nm	
	R≥97% for λ>1µm	
Thin layer:	R≥94% from 450nm to 600nm	
	R≥97% from 600nm to 1000nm	
	R≥98% for λ>1µm	

Special features:

- Highest reflectance of all metals in the VIS and NIR
- Sputtered silver mirrors show extremely low straylight losses (TS < 10^{-4} at 633nm)
- Silver must be protected because it is chemically unstable
- Sputtered protective layers guarantee very stable optical parameters and a lifetime of more than 4 years in normal atmosphere
- The thickness of the protective layer can be used to optimize the reflectance of the mirrors for different wavelength ranges (see example in figure 2).
- Optimized silver mirrors are ideal for use with femtosecond lasers (see pages 40–41)

Comparison of different types of protective layers

Property	Standard coating	Thin layer coating
Reflectance	Up to 2% lower than that of unprotected silver	Close to that of unprotected silver
Cleanability	o.k., tested according to MIL-M-13508C § 4.4.5	Cleaning is possible but the mechanical stability is worse than that of the standard coating

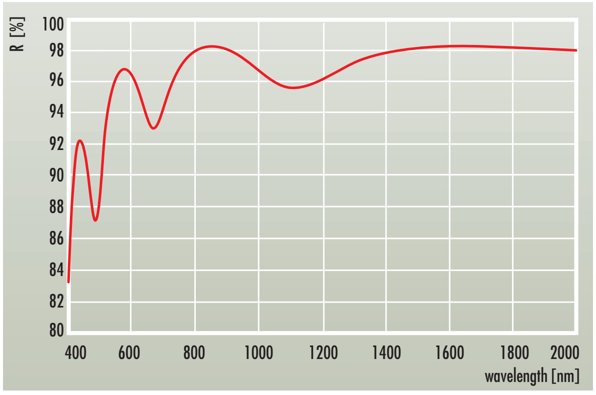

Figure 2: Reflectance spectrum of a silver mirror optimized for high reflectance between 1500 and 2000nm

SILVER MIRRORS WITH ENHANCED REFLECTIVITY

The reflectivity of silver mirrors can be enhanced for selected wavelengths or wavelengths regions by a dielectric overcoat. Figures 3 and 4 show examples for such silver mirrors with enhanced reflectivity. Such mirrors combine very high reflectances at the wavelengths of interest with a relatively high reflectance throughout the VIS which makes them ideal for use with a pilot laser.

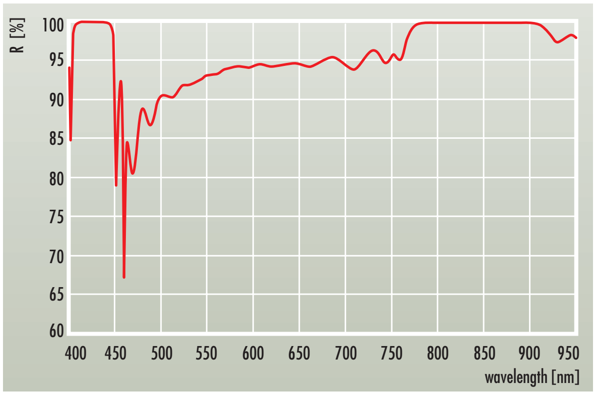

Figure 3: Silver mirror with enhanced reflectivity at 425 and 850nm (R>99.5%)

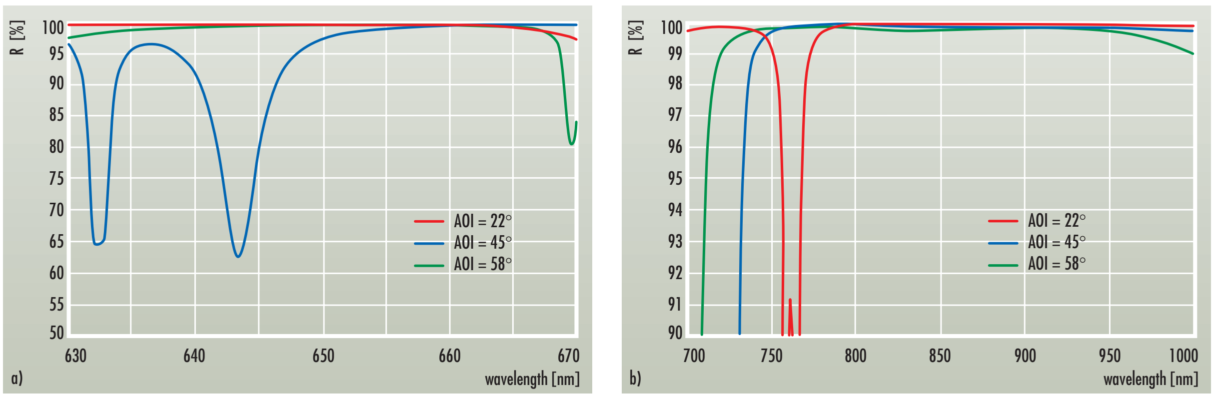

Figure 4: Reflectance spectra of a silver based scanning mirror for laser diodes in the NIR: HR (22°–58°,805–940nm) >99.3% combined with R>50% between 630 and 670nm

For more information on dielectrically enhanced silver mirrors see pages 12–15 and 41.

BROADBAND MIRROR FOR THE UV, VIS AND NIR

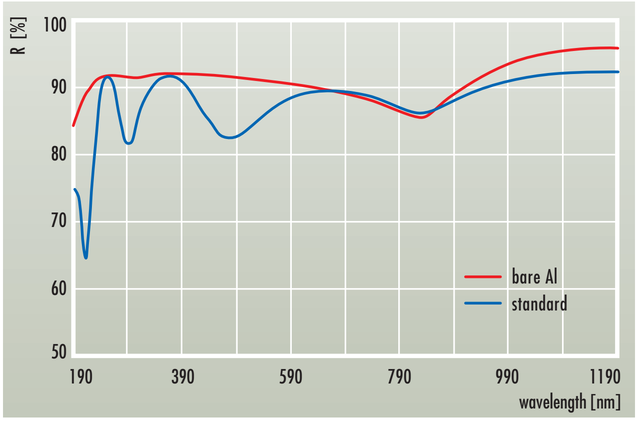

Figure 1: Reflectance spectra of bare aluminum and of a standard protected aluminum mirror

Optical properties:

Bare aluminum: R > 80% at 193 nm
R = 92% at 248 nm
R > 85% from 200 nm to 950 nm (R > 90% from 230 nm to 600 nm)
R > 90% for λ > 1 µm

Standard mirror: R = 82 … 92% from 240 nm to 550 nm
R = 85 … 92% from 550 nm to 950 nm
R > 92% for λ > 1 µm

The position of the minima and maxima of the reflectance depends on the design of the protective layer system and on the angle of incidence (AOI). Please specify AOI and the wavelenghts of interest to optimize the reflectance as far as possible. The figure 2 shows the reflectance spectra of a mirror which was optimized for high reflectivity at 266 nm, 400 nm and 800 nm at AOI = 45°.

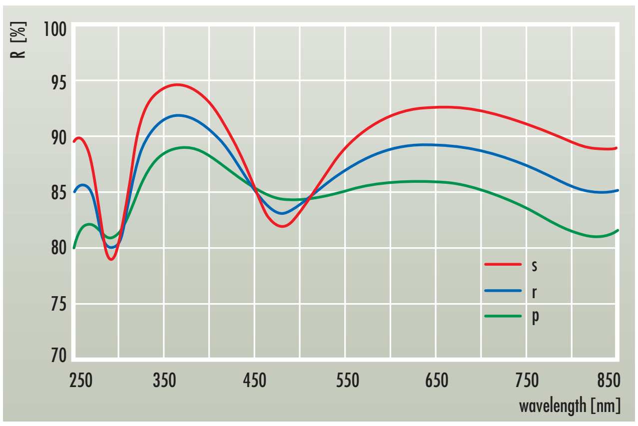

Figure 2: Reflectance spectra of an aluminum mirror optimized for R > 85% at 266 nm, 400 nm and 800 nm (AOI = 45°, unpolarized light)

OPTIMIZED ALUMINUM MIRRORS FOR THE DUV AND VUV

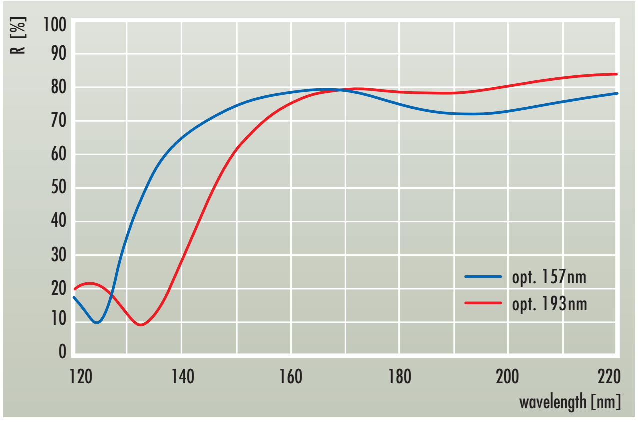

Figure 3: **UV optimized Al:** reflectance spectra of Al mirrors optimized for 157nm and 193nm (0°)

Optical properties: Special coating design depending on the wavelengths of interest
Optimized for 157 nm: R = 74 … 78% for 157 nm (R > 70% from 150–200 nm)
Optimized for 193 nm: R = 75 … 80% for 193 nm
Optimized for 248 nm: R > 90% for 248 nm

Special features:
- High reflectivity in the wavelength range specified
- Extremely low straylight losses ($TS < 10^{-4}$ at 633 nm, $TS < 10^{-3}$ at 248 nm, $TS \approx 5 \times 10^{-3}$ at 193 nm)
- Standard mirrors can be cleaned using ethanol or acetone and are resistant to moderate abrasion (tested according to MIL-M-48497A § 4.5.4.2 and § 4.5.3.3)
- VUV optimized mirrors should be treated with extreme care
- All mirrors are resistant to humidity (tested according to MIL-M-13508C § 4.4.7)
- Highly stable optical parameters because of sputtered SiO_2 protective layer

ENHANCED ALUMINUM MIRRORS FOR 157nm

- Reflectance at 157 nm can be further improved be dielectric overcoatings (up to R > 94%).
- Reflectance in the VIS: R = 60 … 80%. This can be used for a pilot laser.
- Especially mirrors with R = 85 …90% can be used at a wider range of AOI than all dielectric mirrors of this reflectivity.

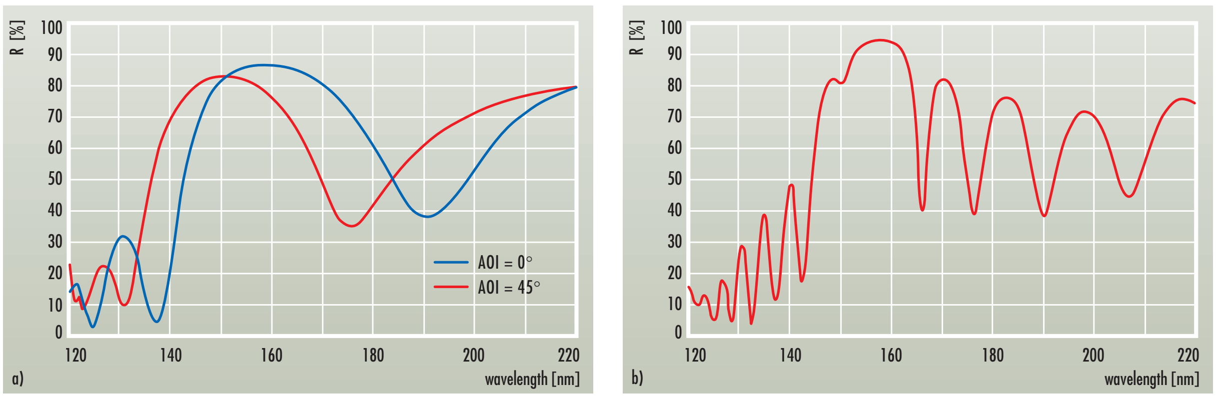

Figure 4: Reflectance spectra of two types of enhanced Al mirrors for 157nm: a) R>80% for AOI = 0° … 45°, b) R>94%

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GOLD MIRRORS FOR THE NIR

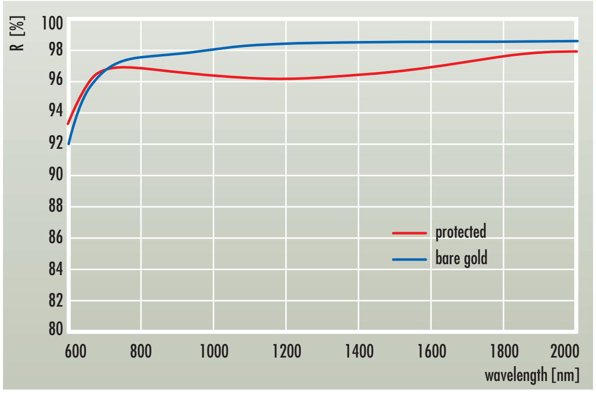

Figure 1: Reflectance spectra of protected and unprotected gold mirrors

Optical properties: bare gold: R > 97 % from 700 nm to 1 µm
R > 98 % for λ > 1 µm

Protected: R > 96 % from 700 nm to 2 µm
R > 98 % for λ > 2 µm

Special features:

- High reflectance in the NIR
- Extremely low straylight losses (TS < 10^{-4} at 633 nm)
- Gold mirrors are chemically stable and can thus be used without protective layer
- Unprotected gold is soft and is easily scratched if it is touched
- Protected mirrors can be cleaned (tested according to MIL-M-13508C § 4.4.5)

BROADBAND NEUTRAL DENSITY FILTERS FOR THE NIR / IR

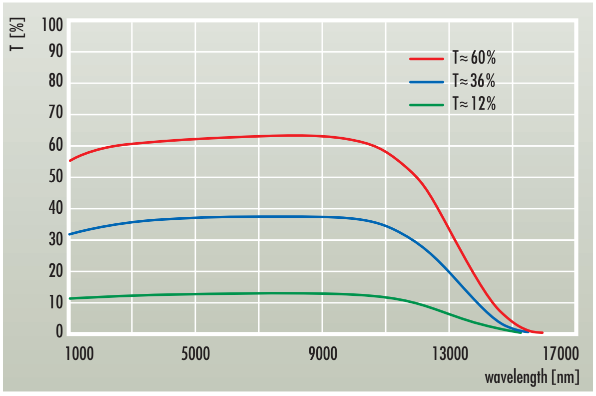

Figure 2: Transmittance spectra of broadband neutral density filters with different transmittance values

- Broad wavelength range of nearly constant transmission (~1 µm to 10 µm)
- Substrate: BaF_2
- Other transmittance values on request

OTHER METALLIC COATINGS

· Chromium with extremely low pinhole density
  – Coatings on mask blanks and silicon wafers
· Zirkonium for use as filter for EUV radiation
· Molybdenum, platinum, copper, nickel and nickel/chromium according to customer specification

METALLIC COATINGS – AN OVERVIEW

Reflectance of metallic coatings

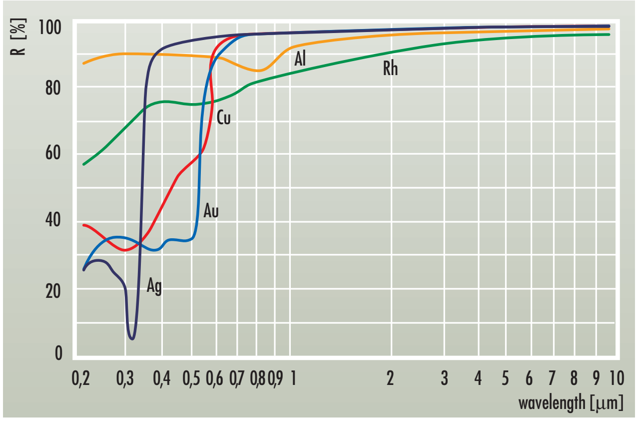

Figure 3: Reflectance of several metals versus wavelength (taken from A. McLeod "Thin film optical filters", A. Hilger, London, 1985)

· Silver: highest reflectance in the VIS and NIR, chemically unstable, soft, can only be used with protective layers, see separate data sheets on pages 40 – 41 and 60 – 61
· Gold: similar reflectance as silver in the NIR, chemically stable, soft, cannot be cleaned without protective layers
· Aluminum: relatively high and constant reflectance in the VIS and NIR, highest reflectance in the UV; surface oxide layer absorbs in the deep UV, soft, see separate data sheet on pages 62 – 63
· Chromium, platinum and rhodium can be used without protective layer

Protective layers:
· Ensure cleanability and chemical stability
· Influence on the reflectance of the metal
· Very thin sputtered layers can be used for chemical protection of the metal because of high atomic density of the layers. Such layers show minimal influence on the VIS and NIR reflectivity of the metal.
· Even silver can be protected efficiently (lifetime more than 4 years for front surface mirrors).
· Mechanical protection and cleanability can only be reached by relatively thick protective layer systems.
· Optimization of the protective layer system for the wavelength of interest is particularly necessary in the UV.

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