

# Optics | COATING TECHNOLOGIES

Optical Coatings	E-beam	IAD	APS	IBS
Laser Induced Damage Threshold*	20 J/cm <sup>2</sup>	>20 J/cm <sup>2</sup>	>25 J/cm <sup>2</sup>	20 J/cm <sup>2</sup>
Absorption (%)	<0.1	<0.02	<0.02	<0.02
Scatter (%)	<0.15	<0.15	<0.10	<0.10
Surface Roughness (Å RMS)	8	5	<4	1
Wet/Dry Shift (range) (%)	<0.8	<0.3	0	0

\*Laser Induced Damage Threshold (LIDT) depends on test wavelength, pulse width, repetition rate, and inspection method. Data from 1064 nm, 10 ns, 10 Hz. These values may be slightly higher or lower depending on deposition conditions and other process related parameters. Overall plasma processes have lower absorptions than conventional e-beam technologies.

CVI Melles Griot offers the most advanced coatings available on the market including:

- Antireflection coatings
- Metallic reflectors
- All-dielectric reflectors
- Hybrid reflectors
- Partial Reflectors (beamsplitters)
- Filters for monochromatic, dichroic, and broadband applications



# COATING TECHNOLOGIES | Optics

## Soft Films

Until the advent of electron bombardment vaporization, only materials that melted at moderate temperatures (2000°C) could be incorporated into thin-film coatings. Low-temperature materials produce softer, less durable coatings and consequently require specialized handling or protection.

## Electron Bombardment

Electron bombardment is capable of vaporizing even difficult-to-vaporize materials such as titanium oxide and zirconium oxide. A high-flux electron gun (1 A at 10 kV) is aimed at the film material contained in a large, water-cooled, copper crucible. Intense local heating melts and vaporizes some of the coating material in the center of the crucible without causing undue heating of the crucible itself.

Using large cooled crucibles precludes or eliminates the chance of reaction between the heated coating material and the metal of the boat or crucible. For particularly involatile materials, the electron gun can be focused to intensify its effects.

## Plasma Ion-Assisted Bombardment

Plasma ion-assisted deposition (PIAD) is a coating technique, often applied at low temperatures, which offers unique benefits including an increased durability to heat and humidity. Also, ion assisted bombardment during the coating process leads to a higher atomic or molecular packing density in the thin-film layers (increasing index of refraction), minimizes wavelength shift, and achieves the high adhesion and low absorption.

Finally, ion-assisted coating can also be used for cold or low-temperature processing. Eliminating the need to heat parts during coating allows cemented parts, such as cemented achromats, to be safely coated.

## Ion-beam Sputtering (IBS)

Ion-beam sputtering is a deposition method using a very high-kinetic energy ion beam. The target is external to the ion source which allows for independent or automated control of the ion energy and flux. The energy and flux of ions is composed of neutral atoms which allow either insulating or conducting targets to be sputtered directly onto the substrate, this allows for a wide range of coating options.

The high energy flux impacts the target source and ejects atoms directly towards the intended substrate. Direct sputtering provides a high level of accuracy and repeatability over numerous coating runs. IBS deposition produces dense coating layers with almost no scatter or absorption which minimizes or eliminates spectral shift due to moisture absorption.

## Magnetron Sputtering

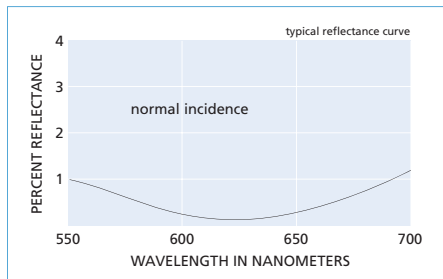
Magnetron sputtering is a thin film deposition process that utilizes a magnet behind a cathode to trap free electrons in a circuitous magnetic field close to the target surface. A metered gaseous plasma of ions or neutral particles is introduced and the accelerated electrons collide with the neutral gas atoms in their path. These interactions cause ionizing collisions and drive electrons off the gas atoms. The gas atom becomes unbalanced and will have more positively charged protons than negatively charged electrons.

The positively charged ions are accelerated towards the negatively charged electrode and impact the target material. The energy transfer is greater than the binding energy of the target material, causing the release of free electrons, erosion of the target material, and ultimately the sputtering process. The ejected source material particles are neutrally charged and therefore unaffected by the negative magnetic field. The ejected atoms are transferred to a substrate into densely packed coating layers resulting in little or no spectral shift caused by moisture absorption. The release of free electrons feed the formation of ions and the propagation of the plasma. Due to close proximity the percentage of confined electrons that cause ionizing collisions dramatically increases. This allows for very high deposition rates at which the target material is eroded and subsequently deposited onto the substrate.

# Optics | ANTIREFLECTION COATINGS

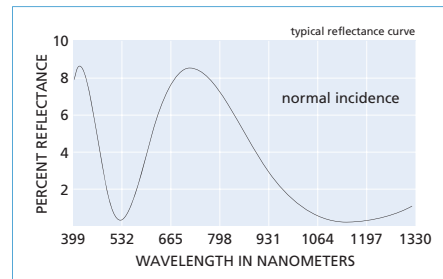
## Wavelength Specific Antireflection Coatings

Antireflection coatings intended for specific wavelengths offer the lowest reflection at the designed wavelength. There are two families of narrowband antireflection coatings from CVI Melles Griot.



### V-Coatings

V-type AR Coatings are the best choice for a single laser wavelength or multiple, closely-spaced wavelengths. Examples are the principle argon laser lines at 488 nm and 514 nm, the neodymium transitions in a variety of host materials at 1047-1064 nm, and the individual excimer laser lines. CVI Melles Griot will manufacture V-Type AR coatings for wavelengths from 193 nm to 10.6  $\mu\text{m}$ .

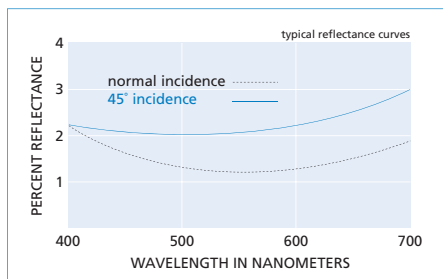


### Double-V and Triple-V Coatings

We offer Double-V and Triple-V multilayer antireflection coatings for use in Nd:YAG laser systems at normal incidence. Highly damage resistant, electron beam deposited dielectrics are used exclusively as coating materials.

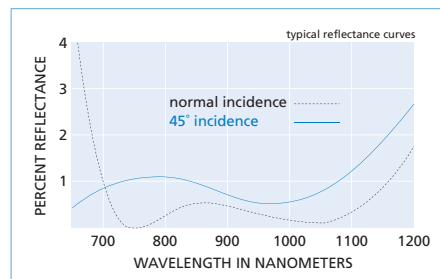
## Broadband Multilayer Antireflection Coatings

Broadband antireflection coatings provide a very low reflectance over a broad spectral bandwidth. These advanced multilayer films, are optimized to reduce overall reflectance to an extremely low level over a broad spectral range. There are three families of broadband antireflection coatings from CVI Melles Griot.



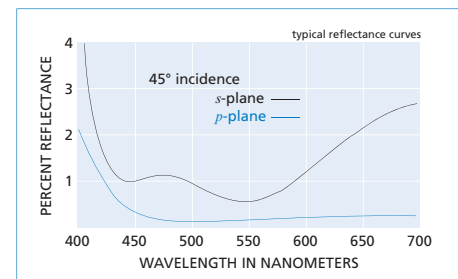
### Single-Layer $\text{MgF}_2$ Coatings

We offer two standard Single-Layer  $\text{MgF}_2$  coatings to cover 400 nm to 700 nm for visible applications or 520 nm to 820 nm for laser diode applications. Single-layer antireflection coatings are also ideal for use on very steeply curved or short-radius surfaces.



### HEBBAR™ Coatings

HEBBAR coatings exhibit a characteristic double-minimum reflectance curve covering a spectral range of some 250 nm or more. The reflectance does not exceed 1.0 percent, and is typically below 0.6 percent, over this entire range.



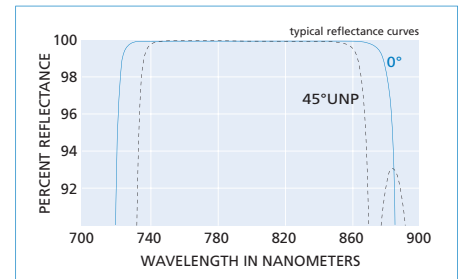
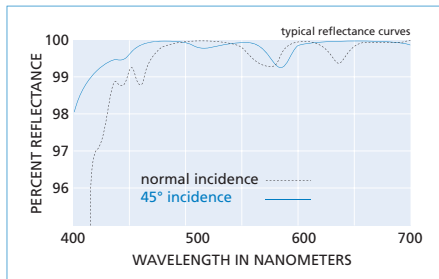
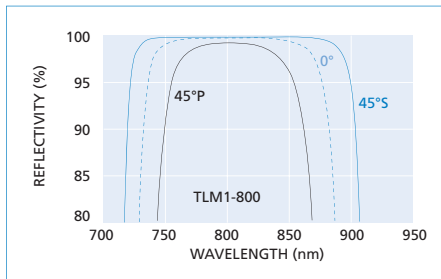
### BBAR-Series Coatings

We offer six overlapping broad band antireflection (BBAR) coating designs covering the entire range from 193 nm to 1600 nm. The BBAR coatings are unique in the photonics industry by providing both a low average reflection of  $\leq 0.5\%$  over a very broad range and also providing the highest damage threshold for pulsed and continuous wave laser sources (10J/cm<sup>2</sup>, 20ns, 20Hz at 1064 nm and 1MW/cm<sup>2</sup> CW at 1064 nm respectively).

# HIGH-REFLECTION COATINGS | Optics

## Dielectric High-Reflection Coatings

CVI Melles Griot offers a wide range of dielectric coatings to maximize reflection. These coatings are developed for specific purposes such as reflecting a narrow bandwidth, a broad range of wavelengths or for special purposes such as minimizing dispersion. Below are examples for those types of coatings.



### Laser-Line High-Reflection Coatings

Laser-line coatings are designed to offer the highest possible reflection and damage threshold at the designed wavelengths and can be optimized for angles of incidence at 0 degrees or 45 degrees. Standard coatings are available from 193 to 1550 nm

### MAXBRite™ Coatings (MAXB)

MAXBRite™ (multilayer all-dielectric xerophilous broadband reflecting interference) coatings are the best broadband mirror coatings commercially available. The MAXBRite™ coatings are available for four broad regions. 245-390 nm, 420-700 nm, 480-700 nm, and 630-850 nm. They all reflect over 98 percent of incident laser radiation within their respective wavelength ranges.

### Ultrafast Coating (TLMB)

We have developed a new coating for ultrafast laser systems operating in the near-infrared spectral region. This all-dielectric coating, centered at 800 nm, minimizes pulse broadening for ultrafast applications. The coating also offers exceptionally high reflectance for both s- and p-polarizations in the 750 nm to 870 nm spectral region. The ultrafast coating is ideal for high-power Ti:sapphire laser applications. This coating is superior to protected and enhanced metallic coatings because of its ability to handle higher powers.

## Metallic High-Reflection Coatings

CVI Melles Griot offers eight standard metallic high-reflection coatings formed by vacuum deposition. These coatings can be used at any angle of incidence and can be applied to most optical components.

Metallic reflective coatings are delicate and require care during cleaning. Dielectric overcoats substantially improve abrasion resistance, but they are not impervious to abrasive cleaning techniques.

Coating Type	Wavelength Range (nm)	Average Reflectance (%)	Damage Threshold *		Former Coating Suffix	PRODUCT CODE
			Pulsed (J/cm <sup>2</sup> )	cw (MW/cm <sup>2</sup> )		
Vacuum UV Aluminum	157	> 80	not tested	not tested	-	VUVA
Deep UV Aluminum	193	> 90	not tested	not tested	-	DUVA
UV Enhanced Aluminum	250-600	85	0.3	22.0	/028	PAUV
Protected Aluminum	400-10,000	90	0.5	22	/011	PAV
Enhanced Aluminum	450-650	92	0.3	12.0	/023	EAV
Protected Silver	400-20,000	95	1.6	73.0	/038	PS
Protected Gold	650-10,000	95.0	0.4	17.0	/055	PG
Bare Gold	700-20,000	99	1.1	48.0	/045	PG-BARE

\*PAUV coating: 10-nsec pulse at 355 nm; all others: 20-nsec pulse at 1064 nm typical