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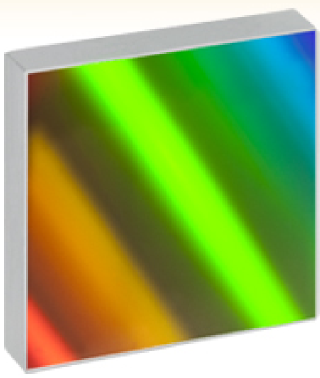
GL13-1850 - JUN 20, 2019

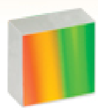
Item # GL13-1850 was discontinued on JUN 20, 2019. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

VISIBLE RULED REFLECTIVE DIFFRACTION GRATINGS

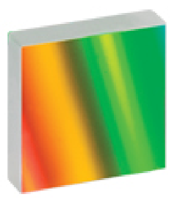
- **Gratings with 400 nm or 500 nm Blaze Wavelengths**
- **Higher Efficiencies than Holographic Gratings**



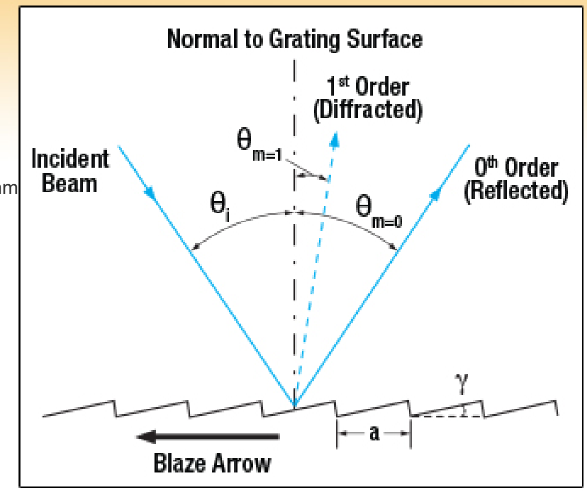
GR50-0605
50 mm x 50 mm
500 nm Blaze
Wavelength



GR13-1850
12.7 mm x 12.7 mm
500 nm Blaze
Wavelength



GR25-1204
25 mm x 25 mm
400 nm Blaze
Wavelength



See the *Gratings Tutorial* Tab Below for Definitions and Equations

OVERVIEW

Features

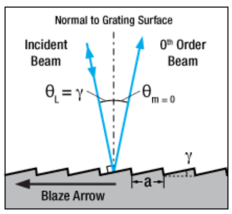
- Blaze Wavelengths of 400 or 500 nm
- High Grating Efficiency of 60 to 80% at Blaze Wavelength
- Low Ghosting, <0.5% of Parent Line
- Aluminum Reflective Coating
- Soda Lime Glass Substrate with 300 to 1800 Grooves/mm
- Produced from Ruled Original

Click to Enlarge
Diffraction Grating Mounted in Polaris Mirror Mount Using Diffraction Grating Adapter

Selection Guide	
Reflective Gratings	
Ruled	UV
	Visible
	Near IR
	Mid IR
Holographic	
Echelle	
Transmission Gratings	
UV	
Visible	
Near IR	

Thorlabs offers ruled diffraction gratings for use in the visible region. These gratings will have a relatively sharp efficiency peak about their blaze wavelength and are produced from ruled originals. They are offered with different blaze angles to suit a variety of applications in spectroscopy and analysis where high efficiency is of primary concern. For more information, please click on the *Gratings Tutorial* tab above. We also offer holographic gratings, which do not produce ghosting effects at the expense of efficiency. For information regarding the differences between grating types, please click on the *Gratings Guide* tab above.

Please note that these gratings are bare aluminum and do not contain an overcoat. However, custom MgF_2 or gold coatings are available to protect the aluminum surface of the gratings. The gold coating offers high performance in the IR, while the MgF_2 coating offers the best protection; contact Tech Support for further details.



Click to Enlarge
Ruled Diffraction Grating Used in Littrow Configuration ($\theta_i=\gamma$)
(Note: 1st Order Beam is Collinear and Antiparallel to Incident Beam)

Mounts and Adapters

Thorlabs offers a variety of mounts and adapters for precise and stable mounting and aligning square optics. All of Thorlabs' gratings can be mounted directly into the KM100C Right-Handed or KM100CL Left-Handed Kinematic Rectangular Optic Mount. Gratings can also be mounted in one of three Kinematic Grating Mount Adapters which can be used with any of Thorlabs' Ø1" Mirror Mounts, including the POLARIS-K1 Ultra-Stable Kinematic Mirror Mount.

Warning

Optical gratings can be easily damaged by moisture, fingerprints, aerosols, or the slightest contact with any abrasive material. Gratings should only be handled when necessary and always held by the sides. Latex gloves or a similar protective covering should be worn to prevent oil from fingers from reaching the grating surface. No attempt should be made to clean a grating other than blowing off dust with clean, dry air or nitrogen. Solvents will likely damage the grating's surface.

Thorlabs uses a clean room facility for assembly of gratings into mechanical setups. If your application requires integrating the grating into a sub-assembly or a setup please contact Tech Support to learn more about our assembly capabilities.

GRATINGS TUTORIAL

Diffraction Gratings Tutorial

Diffraction gratings, either transmissive or reflective, can separate different wavelengths of light using a repetitive structure embedded within the grating. The structure affects the amplitude and/or phase of the incident wave, causing interference in the output wave. In the transmissive case, the repetitive structure can be thought of as many tightly spaced, thin slits. Solving for the irradiance as a function wavelength and position of this multi-slit situation, we get a general expression that can be applied to all diffractive gratings when θ_i = 0°,

$$a \sin(\theta_m) = m\lambda \qquad (1)$$

known as the *grating equation*. The equation states that a diffraction grating with spacing a will deflect light at discrete angles (θ_m), dependent upon the value $m\lambda$, where m is the order of principal maxima. The diffracted angle, θ_m, is the output angle as measured from the surface normal of the diffraction grating. It is easily observed from Eq. 1 that for a given order m, different wavelengths of light will exit the grating at different angles. For white light sources, this corresponds to a continuous, angle-dependent spectrum.

Transmission Gratings

One popular style of grating is the transmission grating. This type of diffraction grating is created by scratching or etching a transparent substrate with a repetitive, parallel structure. This structure creates areas where light can scatter. A sample transmission grating is shown in Figure 1.

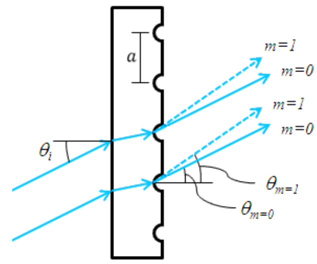


Figure 1. Transmission Grating

The transmission grating, shown in Figure 1, is comprised of a repetitive series of narrow-width grooves separated by distance a. The incident light impinges on the grating at an angle θ_i, as measured from the surface normal. The light of order m exiting the grating leaves at an angle of θ_m, relative to the surface normal. Utilizing some geometric conversions and the general grating expression (Eq. 1) an expression for the transmissive diffraction grating can be found:

$$a\,[\sin(\theta_m) - \sin(\theta_i)] = m\lambda \qquad (2)$$

where both θ_i and θ_m are positive if the incident and diffracted beams are on opposite sides of the grating surface normal, as illustrated in the example in Figure 1. If they are on the same side of the grating normal, θ_m must then be considered negative.

Reflective Gratings

Another very common diffractive optic is the reflective grating. A reflective grating is traditionally made by depositing a metallic coating on an optic and ruling parallel grooves in the surface. Reflective gratings can also be made of epoxy and/or plastic imprints from a master copy. In all cases, light is reflected off of the ruled surface at different angles corresponding to different orders and wavelengths. An example of a reflective grating is shown in Figure 2. Using a similar geometric setup as above, the grating equation for reflective gratings can be found:

$$a\,[\sin(\theta_m) + \sin(\theta_i)] = m\lambda \qquad (3)$$

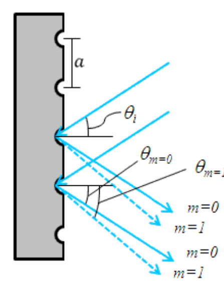


Figure 2. Reflective Grating

where θ_i is positive and θ_m is negative if the incident and diffracted beams are on opposite sides of the grating surface normal, as illustrated in the example in Figure 2. If the beams are on the same side of the grating normal, then both angles are considered positive.

Both the reflective and transmission gratings suffer from the fact that the zeroth order mode contains no diffraction pattern and appears as a surface reflection or transmission, respectively. Solving Eq. 2 for this condition, $\theta_i = \theta_m$, we find the only solution to be m=0, independent of wavelength or diffraction grating spacing. At this condition, no wavelength-dependent information can be obtained, and all the light is lost to surface reflection or transmission.

This issue can be resolved by creating a repeating surface pattern, which produces a different surface reflection geometry. Diffraction gratings of this type are commonly referred to as blazed (or ruled) gratings. An example of this repeating surface structure is shown in Figure 3.

Blazed (Ruled) Gratings

The blazed grating, also known as the echelette grating, is a specific form of reflective or transmission diffraction grating designed to produce the maximum grating efficiency in a specific diffraction order. This means that the majority of the optical power will be in the designed diffraction order while minimizing power lost to other orders (particularly the zeroth). Due to this design, a blazed grating operates at a specific wavelength, known as the blaze wavelength.

The blaze wavelength is one of the three main characteristics of the blazed grating. The other two, shown in Figure 3, are a, the groove or facet spacing, and γ, the blaze angle. The blaze angle γ is the angle between the surface structure and the surface parallel. It is also the angle between the surface normal and the facet normal.

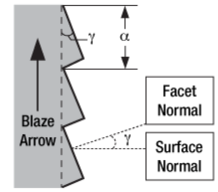


Figure 3. Blazed Grating Geometry

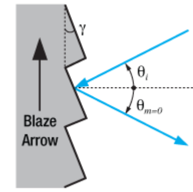


Figure 4. Blazed Grating, 0th Order Reflection

The blazed grating features geometries similar to the transmission and reflection gratings discussed thus far; the incident angle (θ_i) and m^{th} order reflection angles (θ_m) are determined from the surface normal of the grating. However, the significant difference is the specular reflection geometry is dependent on the blaze angle, γ, and NOT the grating surface normal. This results in the ability to change the diffraction efficiency by only changing the blaze angle of the diffraction grating.

The 0th order reflection from a blazed grating is shown in Figure 4. The incident light at angle θ_i is reflected at θ_m for m = 0. From Eq. 3, the only solution is θ_i = $-\theta_m$. This is analogous to specular reflection from a flat surface.

The specular reflection from the blazed grating is different from the flat surface due to the surface structure, as shown in Figure 5. The specular reflection, θ_r, from a blazed grating occurs at the blaze angle geometry. This angle is defined as being negative if it is on the same side of the grating surface normal as θ_i. Performing some simple geometric conversions, one finds that

$$\theta_i - \theta_r = 2\gamma \qquad (4)$$

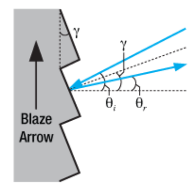


Figure 5. Blazed Grating, Specular Reflection from Facet

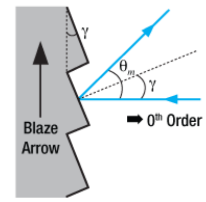


Figure 6. Blazed Grating, Incident Light Normal to Grating Surface

Figure 6 illustrates the specific case where θ_i = 0°, hence the incident light beam is perpendicular to the grating surface. In this case, the 0th order reflection also lies at 0°. Utilizing Eqs. 3 and 4, we can find the grating equation at twice the blaze angle:

$$a\sin(-2\gamma) = m\lambda \qquad (5)$$

Littrow Configuration

The Littrow configuration refers to a specific geometry for blazed gratings and plays an important role in monochromators and spectrometers. It is the angle θ_i at which the grating efficiency is the highest. In this configuration, the angle of incidence of the incoming and diffracted light are the same, θ_i = θ_m, and m > 0 so

$$2a\sin(\theta_L) = m\lambda_D \qquad (6)$$

The Littrow configuration angle, θ_L, is dependent on the most intense order (m = 1), the design wavelength, λ_D, and the grating spacing a. It is easily shown that the Littrow configuration angle, θ_L, is equal to the blaze angle, γ, at the design wavelength. The Littrow / blaze angles for all Thorlabs' Blazed Gratings can be found in the grating specs tables.

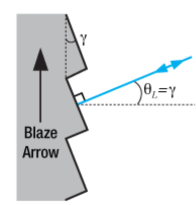


Figure 7. Littrow Configuration

$$\theta_L = \gamma \qquad (7)$$

It is easily observed that the wavelength dependent angular separation increases as the diffracted order increases for light of normal incidence (for θ_i = 0°, θ_m increases as m increases). There are two main drawbacks for using a higher order diffraction pattern over a low order one: (1) a decrease in efficiency at higher orders and (2) a decrease in the free spectral range, $(\Delta\lambda)_{FSR}$, defined as:

$$(\Delta\lambda)_{FSR} = \frac{\lambda}{m} \qquad (8)$$

where λ is the central wavelength, and m is the order.

The first issue with using higher order diffraction patterns is solved by using an Echelle grating, which is a special type of ruled diffraction grating with an extremely high blaze angle and relatively low groove density. The high blaze angle is well suited for concentrating the energy in the higher order diffraction modes. The second issue is solved by using another optical element: grating, dispersive prism, or other dispersive optic, to sort the wavelengths/orders after the Echelle grating.

Holographic Surface Gratings

While blazed gratings offer extremely high efficiencies at the design wavelength, they suffer from periodic errors, such as ghosting, and relatively high amounts of scattered light, which could negatively affect sensitive measurements. Holographic gratings are designed specially to reduce or eliminate these errors. The drawback of holographic gratings compared to blazed gratings is reduced efficiency.

Holographic gratings are made from master gratings by similar processes to the ruled grating. The master holographic gratings are typically made by exposing photosensitive material to two interfering laser beams. The interference pattern is exposed in a periodic pattern on the surface, which can then be physically or chemically treated to expose a sinusoidal surface pattern. An example of a holographic grating is shown in Figure 8.

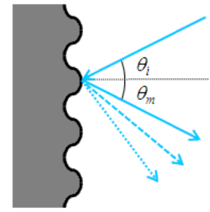


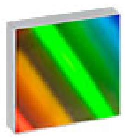
Figure 8. Holographic Grating

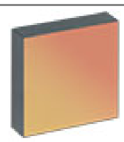
Please note that dispersion is based solely on the number of grooves per mm and not the shape of the grooves. Hence, the same grating equation can be used to calculate angles for holographic as well as ruled blazed gratings.

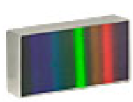
GRATINGS GUIDE

Reflective Gratings

Reflective grating master copies are made by depositing a metallic coating on an optic and ruling parallel grooves in the surface. Thorlabs' reflective gratings are made of epoxy and/or plastic imprints from a master copy, in a process call replication. In all cases, light is reflected off of the ruled surface at different angles corresponding to different orders and wavelengths. All of Thorlabs' ruled reflective diffraction gratings exhibit a sawtooth profile, also known as blazed, while our reflective holographic diffraction gratings exhibit a sinusoidal profile. For more information, please refer to the *Gratings Tutorial* tab.

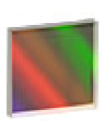
Ruled Diffraction Gratings			
	Ruled	UV Visible Near IR Mid IR	Ruled gratings can achieve higher efficiencies than holographic gratings due to their blaze angles. They are ideal for applications centered near the blaze wavelength. Thorlabs offers replicated ruled diffraction gratings in a variety of sizes and blaze angles.
UV Ruled Reflective Blazed Diffraction Gratings			More [+]
Visible Ruled Reflective Blazed Diffraction Gratings			More [+]
Near-IR Ruled Reflective Blazed Diffraction Gratings			More [+]
Mid-IR Ruled Reflective Blazed Diffraction Gratings			More [+]

Holographic Diffraction Gratings		
	Holographic	Holographic gratings have a low occurrence of periodic errors, which results in limited ghosting, unlike ruled gratings. The low stray light of these gratings makes them ideal for applications where the signal-to-noise ratio is critical, such as Raman Spectroscopy.
Reflective Holographic Sinusoidal Diffraction Gratings		More [+]

Echelle Diffraction Gratings		
	Echelle	Echelle gratings are low period gratings designed for use in high diffraction orders. They are generally used with a second grating or prism to separate overlapping diffracted orders. They are ideal for applications such as high-resolution spectroscopy.
Echelle Ruled Blazed Diffraction Gratings		More [+]

Transmission Gratings

Transmission gratings are created by scratching or etching a transparent substrate with a repetitive, parallel structure. This structure creates areas where light can scatter. Thorlabs' transmission gratings are manufactured using the ruled method, which creates a sawtooth diffraction profile. Transmission gratings can also be made of epoxy and/or plastic imprints from a master copy, in a process call replication. For more information, please refer to the *Gratings Tutorial* tab.

Transmission Diffraction Gratings		
	UV Visible Near IR	Thorlabs' transmission gratings disperse incident light on the opposite side of the grating at a fixed angle. They are ruled and blazed for optimum efficiency in their respective wavelength range, are relatively polarization insensitive, and have an efficiency comparable to that of a reflection grating optimized for the same wavelength. They are ideal for applications that require fixed gratings such as spectrographs.
UV Transmission Blazed Diffraction Gratings		More [+]
Visible Transmission Blazed Diffraction Gratings		More [+]
NIR Transmission Blazed Diffraction Gratings		More [+]

Selecting a grating requires consideration of a number of factors, some of which are listed below:

Efficiency:
Ruled gratings generally have a higher efficiency than holographic gratings. Holographic grating tend to have a lower efficiency but a broader effective wavelength range. The efficiency of ruled gratings may be desirable in applications such as fluorescence excitation and other radiation-induced reactions.

Blaze Wavelength:
Ruled gratings have a sawtooth groove profile created by sequentially etching the surface of the grating substrate. As a result, they have a sharp peak efficiency around their blaze wavelength. Holographic gratings are harder to blaze, and tend to have a sinusoidal groove profile resulting in a less intense peak around the design wavelength. Applications centered around a narrow wavelength range could benefit from a ruled grating blazed at that wavelength.

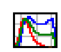
Stray Light:
Due to a difference in how the grooves are made, holographic gratings have less stray light than ruled gratings. The grooves on a ruled grating are machined one at a time which results in a higher frequency of errors. Holographic gratings are made through a lithographic process, which generally creates smoother grating masters free of tool marks. Replicants made from these masters exhibit less stray light. Applications such as Raman spectroscopy, where signal-to-noise is critical, can benefit from the limited stray light of the holographic grating.

Resolving Power:
The resolving power of a grating is a measure of its ability to spatially separate two wavelengths. It is determined by applying the Rayleigh criteria to the diffraction maxima; two wavelengths are resolvable when the maxima of one wavelength coincides with the minima of the second wavelength. The chromatic resolving power (R) is defined by $R = \lambda/\Delta\lambda = n*N$, where $\Delta\lambda$ is the resolvable wavelength difference, n is the diffraction order, and N is the number of grooves illuminated. Due to their low groove density, Echelle gratings provide high resolving power.

For further information about gratings and selecting the grating right for your application, please visit our Gratings Tutorial.

Caution:
The surface of a diffraction grating can be easily damaged by fingerprints, aerosols, moisture or the slightest contact with any abrasive material. Gratings should only be handled when necessary and always held by the sides. Latex gloves or a similar protective covering should be worn to prevent oil from fingers from reaching the grating surface. Solvents will likely damage the grating's surface. No attempt should be made to clean a grating other than blowing off dust with clean, dry air or nitrogen. Scratches or other minor cosmetic imperfections on the surface of a grating do not usually affect performance and are not considered defects.

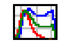
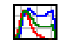
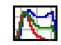
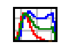
400 nm Blaze Wavelength Reflective Diffraction Gratings

Item #	Dimensions (W x H x D)	Blaze Wavelength	Grooves/mm	Blaze Angle	Dispersion	Efficiency Curves[a,b]
GR25-1204	25 mm x 25 mm x 6 mm	400 nm	1200	13° 53'	0.81 nm/mrad	
GR50-1204	50 mm x 50 mm x 9.5 mm					

- All gratings utilize an aluminum reflective coating. The efficiency data is measured in the Littrow mounting configuration and provided for reference only. Actual grating efficiency is 60 to 80% at the blaze wavelength.
- For diffraction gratings, parallel and perpendicular polarization are defined with respect to the lines of the grating.

Part Number	Description	Price	Availability
GR25-1204	**Ruled Reflective Diffraction Grating, 1200/mm, 400 nm Blaze, 25 x 25 x 6 mm**	**$113.46**	**Today**
GR50-1204	**Ruled Reflective Diffraction Grating, 1200/mm, 400 nm Blaze, 50 x 50 x 9.5 mm**	**$223.56**	**Today**

500 nm Blaze Wavelength Reflective Diffraction Gratings

Item #	Dimensions (W x H x D)	Blaze Wavelength	Grooves/mm	Blaze Angle	Dispersion	Efficiency Curves[a,b]
GR13-0305	12.7 mm x 12.7 mm x 6 mm	500 nm	300	4° 18'	3.32 nm/mrad	
GR25-0305	25 mm x 25 mm x 6 mm					
GR50-0305	50 mm x 50 mm x 9.5 mm					
GR13-0605	12.7 mm x 12.7 mm x 6 mm		600	8° 37'	1.65 nm/mrad	
GR25-0605	25 mm x 25 mm x 6 mm					
GR50-0605	50 mm x 50 mm x 9.5 mm					
GR13-1205	12.7 mm x 12.7 mm x 6 mm		1200	17° 27'	0.80 nm/mrad	
GR25-1205	25 mm x 25 mm x 6 mm					
GR50-1205	50 mm x 50 mm x 9.5 mm					
GR13-1850	12.7 mm x 12.7 mm x 6 mm		1800	26° 44'	0.50 nm/mrad	
GR25-1850	25 mm x 25 mm x 6 mm					
GR50-1850	50 mm x 50 mm x 9.5 mm					

- All gratings utilize an aluminum reflective coating. The efficiency data is measured in the Littrow mounting configuration and provided for reference only. Actual grating efficiency is 60 to 80% at the blaze wavelength.
- For diffraction gratings, parallel and perpendicular polarization are defined with respect to the lines of the grating.

Part Number	Description	Price	Availability
GR13-0305	**Ruled Reflective Diffraction Grating, 300/mm, 500 nm Blaze, 12.7 x 12.7 x 6 mm**	**$69.08**	**Today**
GR25-0305	**Ruled Reflective Diffraction Grating, 300/mm, 500 nm Blaze, 25 x 25 x 6 mm**	**$113.46**	**Today**
GR50-0305	**Ruled Reflective Diffraction Grating, 300/mm, 500 nm Blaze, 50 x 50 x 9.5 mm**	**$223.56**	**Today**
GR13-0605	**Ruled Reflective Diffraction Grating, 600/mm, 500 nm Blaze, 12.7 x 12.7 x 6 mm**	**$69.08**	**Today**
GR25-0605	**Ruled Reflective Diffraction Grating, 600/mm, 500 nm Blaze, 25 x 25 x 6 mm**	**$113.46**	**Today**
GR50-0605	**Ruled Reflective Diffraction Grating, 600/mm, 500 nm Blaze, 50 x 50 x 9.5 mm**	**$223.56**	**Today**
GR13-1205	**Ruled Reflective Diffraction Grating, 1200/mm, 500 nm Blaze, 12.7 x 12.7 x 6 mm**	**$69.08**	**Today**
GR25-1205	**Ruled Reflective Diffraction Grating, 1200/mm, 500 nm Blaze, 25 x 25 x 6 mm**	**$113.46**	**Today**
GR50-1205	**Ruled Reflective Diffraction Grating, 1200/mm, 500 nm Blaze, 50 x 50 x 9.5 mm**	**$223.56**	**Today**
GR13-1850	**Ruled Reflective Diffraction Grating, 1800/mm, 500 nm Blaze, 12.7 x 12.7 x 6 mm**	**$69.08**	**Lead Time**
GR25-1850	**Ruled Reflective Diffraction Grating, 1800/mm, 500 nm Blaze, 25 x 25 x 6 mm**	**$113.46**	**Lead Time**
GR50-1850	**Ruled Reflective Diffraction Grating, 1800/mm, 500 nm Blaze, 50 x 50 x 9.5 mm**	**$223.56**	**Lead Time**

Visit the *Visible Ruled Reflective Diffraction Gratings* page for pricing and availability information:
https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=8626