Optometrics
A Dynasil Company

LASER COMPONENTS

LASER OPTICS & PRODUCTS

ML GRATINGS

ML gratings are original rulings or replicas that are normally used as end reflectors for tuning molecular lasers. Original gratings are ruled directly into an aluminum coating deposited on a kanigen coated copper substrate, resulting in an inherently higher damage threshold and are recommended for use with high powered molecular lasers.

The output wavelength of a molecular or dye laser can be tuned by rotating a Littrow mounted grating around an axis parallel to the grooves. The grating equation:

$$nl = d(\sin i \pm \sin i')$$

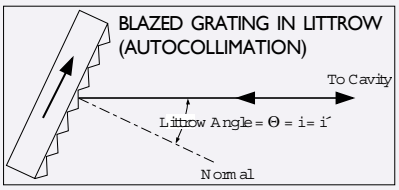
where n is the order of diffraction, l is the diffracted wavelength, d is the grating constant (the distance between successive grooves), i is the angle of incidence measured from the normal and i' is the angle of diffraction measured from the normal, reduces to nl = 2d sin i for the Littrow configuration.

The angle of incidence (i) is adjusted to select the output wavelength while creating a narrow gain profile.

BLAZE ANGLE AND ALIGNMENT

Because the ML series of gratings are designed for peak polarized efficiency, the groove angle is not equivalent to the Littrow blaze angle of the grating. As a result, when using a He-Ne laser for preliminary grating alignment, the brightest He-Ne order will not correspond to the blaze wavelength of the grating. The grating must be aligned using the calculated He-Ne order that corresponds to the wavelength of interest, regardless of its relative intensity.

The blaze arrow marked on the side or back of the grating should be oriented as shown below.

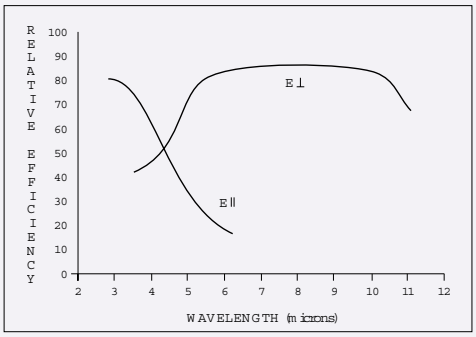


SUMMARY ML GRATING SPECIFICATIONS

MODEL NO.	GROOVES/ MM	MIN. ABS. POLARIZED EFFICIENCY	OPTIMUM RANGE (μ)	ANGULAR DISPERSION (nm/mr)
ML-301	75	≥ 88%	9.0 - 11.0	12.3
ML-302	100	≥ 88%	9.0 - 11.0	8.5
ML-303	150	≥ 88%	9.0 - 11.0	4.2
ML-304	135	≥ 88%	9.0 - 11.0	5.2
ML-401	150	≥ 88%	5.0 - 6.0	6.1
ML-402	300	≥ 82%	5.0 - 6.0	2.0
ML-501	300	≥ 80%	2.5 - 3.0	3.0
ML-502	450	≥ 85%	2.0 - 4.0	1.6
ML-601	300	≥ 80%	2.5 - 4.0	0.35
ML-701	90	≥ 88%	16.0 - 20.0	7.7

POLARIZATION

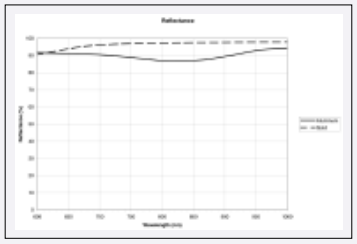
Typical efficiency curves illustrate that, in all cases, orienting the polarization of the E vector (P-Plane) perpendicular to the grooves (E⊥) increases the efficiency over a specific wavelength region. This should be considered when optimizing the figure of merit (Q) of a cavity, particularly when it is polarized by auxiliary components such as Brewster angle windows.



POLARIZATION DEPENDENT EFFICIENCIES

COATING

ML gratings can be overcoated with gold, increasing the reflectivity at 10.6 microns by approximately 1%, but the damage threshold in high power applications may be reduced. No damage threshold minimums apply for overcoated gratings.



ALUMINUM VS. GOLD

SPECIFICATIONS

Clear Aperture 90%
Groove Parallelism to Edge ..... ± 0.5°
Dimensional Tolerances ..... ± 0.5 mm
Thickness:
  Originals ..... 10 mm ± 0.5 mm
  Replicas ..... 9.5 mm ± 0.5 mm
Damage Threshold:
  Original Gratings:
    CW Laser ..... 1 KW/cm²
    Pulsed Laser (100 nsec pulse) ..... 7 J/cm²
Replicated Gratings:
    CW Laser ..... 250 W/cm²
    Pulsed Laser (200 nsec pulse) ..... 3.5 J/cm²

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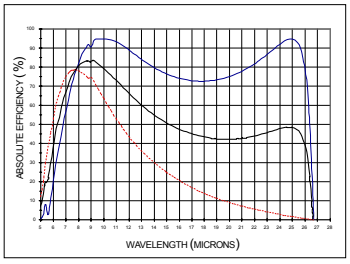
Larger graphs can be viewed from the Optometrics web site (www.optometrics.com). Go to the Support page and look under Laser Optics and Products for "Specific Grating Efficiency Curves".

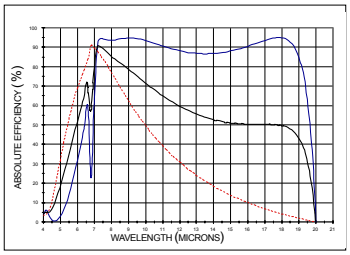
TYPICAL EFFICIENCY CURVES-ML GRATINGS

Perpendicular Polarization
Parallel Polarization
Average

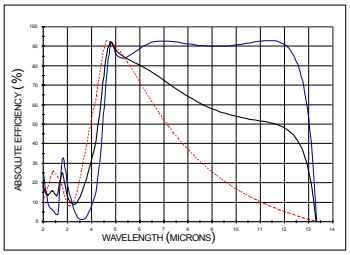
* All gratings are measured in the Littrow mounting configuration
* All gratings utilize an aluminum (Al) reflective coat



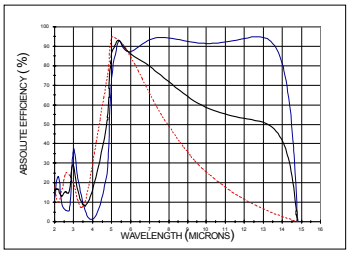
ML-301: 75 g/mm, Blazed at 10.6 µ(E⊥)
Angular Dispersion 12.3 nm/mr



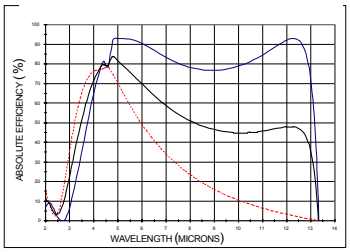
ML-302: 100 g/mm, Blazed at 10.6 µ (E⊥)
Angular Dispersion 8.5 nm/mr



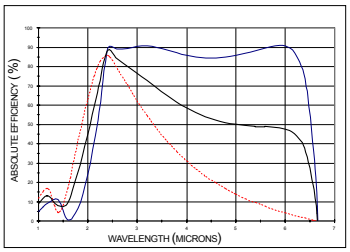
ML-303: 150 g/mm, Blazed at 10.6 µ (E⊥)
Angular Dispersion 2.0 nm/mr



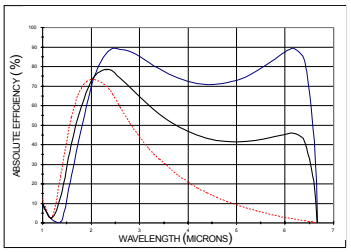
ML-304: 135 g/mm, Blazed at 10.6 µ (E⊥)
Angular Dispersion 3.0 nm/mr



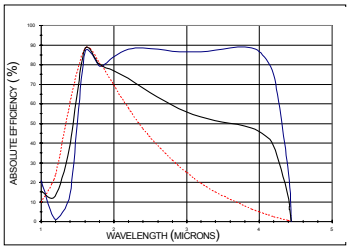
ML-401: 150 g/mm, Blazed at 5.4 µ (E⊥)
Angular Dispersion 6.1 nm/mr



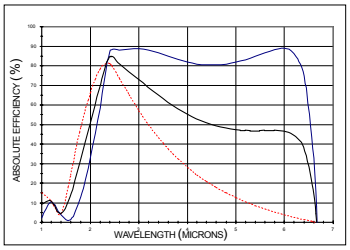
ML-402: 300 g/mm, Blazed at 5.4 µ (E⊥)
Angular Dispersion 2.0 nm/mr



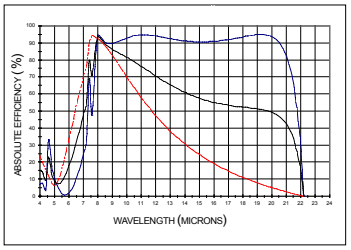
ML-501: 300 g/mm, Blazed at 2.8 µ (E⊥)
Angular Dispersion 3.0 nm/mr



ML-502: 450 g/mm, Blazed at 3.1 µ (E⊥)
Angular Dispersion 1.6 nm/mr



ML-601: 300 g/mm, Blazed at 3.5 µ (E⊥)
Angular Dispersion 0.35 nm/mr



ML-701: 90 g/mm, Blazed at 16.0 µ (E⊥)
Angular Dispersion 7.7 nm/mr

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ML SERIES GRATINGS - ORIGINAL AND REPLICATED

ML gratings are normally used as end reflectors for tuning molecular lasers. Original gratings are ruled directly into an aluminum coating deposited on a kanigen coated copper substrate, resulting in an inherently higher damage threshold than the replicas which are replicated onto a pyrex substrate.

SQUARES

SIZE	25 x 25 MM		30 x 30 MM		50 x 50 MM		58 x 58 MM	
MODEL NO.	ORIGINAL CAT. NO.	REPLICA CAT. NO.	ORIGINAL CAT. NO.	REPLICA CAT. NO.	ORIGINAL CAT. NO.	REPLICA CAT. NO.	ORIGINAL CAT. NO.	REPLICA CAT. NO.
ML-301	5-3012	5-3112	5-3019	5-3119	5-3015	5-3115	5-3016	5-3116
ML-302	5-3022	5-3122	5-3029	5-3129	5-3025	5-3125	5-3026	5-3126
ML-303	5-3032	5-3132	5-3039	5-3139	5-3035	5-3135	5-3036	5-3136
ML-304	5-3042	5-3142	5-3049	5-3149	5-3045	5-3145	5-3046	5-3146
ML-401	5-4012	5-4112	5-4019	5-4119	5-4015	5-4115	5-4016	5-4116
ML-402	5-4022	5-4122	5-4029	5-4129	5-4025	5-4125	5-4026	5-4126
ML-501	5-5012	5-5112	5-5019	5-5119	5-5015	5-5115	5-5016	5-5116
ML-502	5-5022	5-5122	5-5029	5-5129	5-5025	5-5125	5-5026	5-5126
ML-601	5-6012	5-6112	5-6019	5-6119	5-6015	5-6115	5-6016	5-6116
ML-701	5-7012	5-7112	5-7019	5-7119	5-7015	5-7115	5-7016	5-7116

DIAMETERS

SIZE	25 MM DIA.		38 MM DIA.		50 MM DIA.	
MODEL NO.	ORIGINAL CAT. NO.	REPLICA CAT. NO.	ORIGINAL CAT. NO.	REPLICA CAT. NO.	ORIGINAL CAT. NO.	REPLICA CAT. NO.
ML-301	5-3011	5-3111	5-3017	5-3117	5-3014	5-3114
ML-302	5-3021	5-3121	5-3027	5-3127	5-3024	5-3124
ML-303	5-3031	5-3131	5-3037	5-3137	5-3034	5-3134
ML-304	5-3041	5-3141	5-3047	5-3147	5-3044	5-3144
ML-401	5-4011	5-4111	5-4017	5-4117	5-4014	5-4114
ML-402	5-4021	5-4121	5-4027	5-4127	5-4024	5-4124
ML-501	5-5011	5-5111	5-5017	5-5117	5-5014	5-5114
ML-502	5-5021	5-5121	5-5027	5-5127	5-5024	5-5124
ML-601	5-6011	5-6111	5-6017	5-6117	5-6014	5-6114
ML-701	5-7011	5-7111	5-7017	5-7117	5-7014	5-7114

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RECTANGLES

SIZE	12.5 x 25 MM		25 x 50 MM		1" x .825"	
MODEL NO.	ORIGINAL CAT. NO.	REPLICA CAT. NO.	ORIGINAL CAT. NO.	REPLICA CAT. NO.	ORIGINAL CAT. NO.	REPLICA CAT. NO.
ML-301	5-3610	5-3810	5-3013	5-3113	5-3018	5-3118
ML-302	5-3620	5-3820	5-3023	5-3123	5-3028	5-3128
ML-303	5-3630	5-3830	5-3033	5-3133	5-3038	5-3138
ML-304	5-3640	5-3840	5-3043	5-3143	5-3048	5-3148
ML-401	5-4610	5-4810	5-4013	5-4113	5-4018	5-4118
ML-402	5-4620	5-4820	5-4023	5-4123	5-4028	5-4128
ML-501	5-5610	5-5810	5-5013	5-5113	5-5018	5-5118
ML-502	5-5620	5-5820	5-5023	5-5123	5-5028	5-5128
ML-601	5-6610	5-6810	5-6013	5-6113	5-6018	5-6118
ML-701	5-7610	5-7810	5-7013	5-7113	5-7018	5-7118

COATINGS

Protective overcoatings that maintain or enhance reflectivity in the UV, Visible and IR regions are available for an additional charge.

AU-3 (Replica Grating Overcoat)	AU-4 (Original Grating Overcoat)

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LASER OPTICS & PRODUCTS

TF AND UTF SERIES GRATING END REFLECTORS FOR DYE LASERS

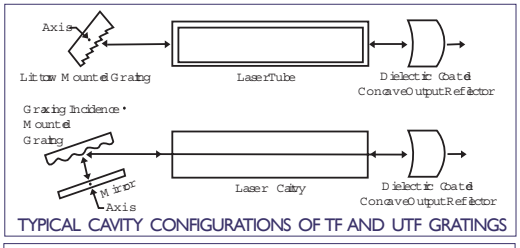
Optometrics LLC has developed a line of ultra high damage threshold replica diffraction gratings. These are made by a proprietary process and have withstood incident energies far in excess of those of normal replica gratings. Gratings are supplied on a Pyrex® substrate.

The output wavelength of the dye laser can be tuned by turning the Littrow-mounted diffraction grating end reflector about an axis parallel to the grooves. The equation relating wavelength to angle of incidence on the grating is $n\lambda = 2d \sin i$. Using this relationship, one can calibrate the mirror mount micrometer to i and, using a grating as one of the reflectors in a dye laser, causes the spectral line width of the output to be reduced to a narrow region around the Littrow wavelength. Maximum reduction is attained by increasing dispersion to the practical limit. As can be seen from the equation for angular dispersion, this limit is approached for the high blaze angle characteristic of echelles and finely spaced echellettes. Even greater selectivity can be attained by adding a Fabry-Perot etalon to the grating-mirror cavity. The efficiency of the spectral condensation in organic dye lasers is quite high, with figures of 70% being typical.

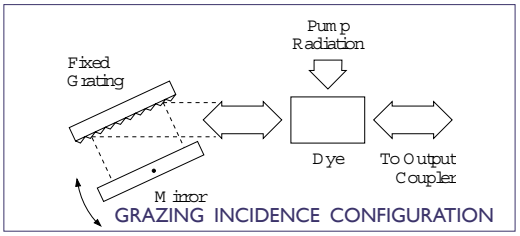
Gratings are normally used in one of two configurations: Littrow (see page 1) or grazing incidence (see figure below).

DAMAGE THRESHOLDS

1. TF Replicated Grating:
   Pulsed ..... 350 milli-joules/cm² @ 200 n sec.
   CW ..... 40 watts/cm²
2. UTF-P Replicated Grating:
   (pulsed type)
   Pulsed ..... 3.5 joules/cm² @ 200 n sec.
   CW ..... 80 watts/cm²
3. UTF-CW Replicated Grating:
   (For continuous high power applications)
   Pulsed ..... 3.5 joules/cm² @ 200 n sec.
   CW ..... 250 watts/cm²



TYPICAL CAVITY CONFIGURATIONS OF TF AND UTF GRATINGS



GRAZING INCIDENCE CONFIGURATION

GROOVES PER MM	BLAZE λ (nm)	BLAZE ANGLE	DISPERSION (nm/mr) {Echelles @ 500 NM}
RULED			
1200	300	10° 22'	0.82
1200	500	17° 26'	0.79
1200	750	26° 45'	0.74
1200	1000	36° 52'	0.67
1800	500	26° 45'	0.50
ECHELLES			
31.6	Echelle	63°	14.37
316	Echelle	63°	1.44
79	Echelle	75°	3.28
79	Echelle	63°	5.75

HIGH RESOLUTION ECHELLES

Special low period gratings designed for use in the high orders. Generally used with a second grating or prism to separate overlapping diffracted orders. Supplied on precision glass substrates, Echelles have a resolution of 80-90% of theoretical (See Echelles in summary table above.)

GRAZING INCIDENCE GRATINGS

Grazing incidence is a simple and inexpensive optical configuration that can tune and increase the resolution of a dye laser. A holographic grating, functioning as an end reflector in a dye laser cavity, is positioned so that laser radiation strikes the grating almost perpendicular to the grating normal. As the angle of incidence approaches 89 degrees, a relatively large area of the grating is illuminated by the laser beam, increasing angular dispersion and resolving power significantly. The sizes of the grating and mirror (12.7 x 50.8 mm) are optimized for grazing incidence. The grating is fixed and tuning is achieved by rotation of the mirror. The laser beam is diffracted twice in grating incidence, resulting in a two fold increase in resolution. Low grating efficiency is characteristic of the grazing incidence configuration but is compensated for by the high gain of the dyes used.

Grooves per mm ..... 1200, 1800, 2400 or 3600
Thickness ..... 9.5 mm ±0.5 mm
Resolution ..... 50% to 90% of theoretical
Dimensional Tolerances ..... ±0.5 mm
Clear Aperture ..... 10.0 x 46.0 mm

Efficiency at Grazing Incidence:
- Single Pass ..... Approx. 24%
- Double Pass ..... Approx. 4%

Mirror:
- Coating ..... AlSiO
- Thickness ..... 9.5 mm ±0.5 mm

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TF AND UTF SERIES GRATINGS
All dimensions in millimeters.

GROOVES PER MM	BLAZE ANGLE	BLAZE λ (nm)	DISPERSION (nm/mr) @ 500 nm	12.5 x 25 x 6	25 x 25 x 9.5	30 x 30 x 9.5	50 x 50 x 9.5
TF SERIES							
1200	10° 22'	300	0.82	3-4131	3-2131	3-3131	3-5131
1200	17° 26'	500	0.79	3-4151	3-2151	3-3151	3-5151
1200	26° 45'	750	0.74	3-4171	3-2171	3-3171	3-5171
1200	36° 52'	1000	0.67	3-4111	3-2111	3-3111	3-5111
1800	26° 45'	500	0.50	3-4851	3-2851	3-3851	3-5851
UTF-P SERIES (Pulsed)							
1200	10° 22'	300	0.82	3-4133	3-2133	3-3133	3-5133
1200	17° 26'	500	0.79	3-4153	3-2153	3-3153	3-5153
1200	26° 45'	750	0.74	3-4173	3-2173	3-3173	3-5173
1200	36° 52'	1000	0.67	3-4113	3-2113	3-3113	3-5113
1800	26° 45'	500	0.50	3-4853	3-2853	3-3853	3-5853
UTF-CW SERIES (Continuous)							
1200	10° 22'	300	0.82	3-4134	3-2134	3-3134	3-5134
1200	17° 26'	500	0.79	3-4154	3-2154	3-3154	3-5154
1200	26° 45'	750	0.74	3-4174	3-2174	3-3174	3-5174
1200	36° 52'	1000	0.67	3-4114	3-2114	3-3114	3-5114
1800	26° 45'	500	0.50	3-4854	3-2854	3-3854	3-5854

TF AND UTF SERIES GRATINGS - ECHELLES
All dimensions in millimeters.

GROOVES PER MM	BLAZE ANGLE	BLAZE λ (nm)	DISPERSION (nm/mr) @ 500 nm	12.5 x 25 x 6	12.5 x 25 x 9.5	12.5 x 50 x 9.5	25 x 50 x 9.5
TF SERIES							
31.6	63°	Echelle	14.37	3-6311	3-1311	3-9311	3-7311
316	63°	Echelle	1.44	3-6362	3-1362	3-9362	3-7362
79	75°	Echelle	3.28	3-6771	3-1771	3-9771	3-7771
79	63°	Echelle	5.75	3-6731	3-1731	3-9731	3-7731
UTF-P SERIES (Pulsed)							
31.6	63°	Echelle	14.37	3-6313	3-1313	3-9313	3-7313
316	63°	Echelle	1.44	3-6363	3-1363	3-9363	3-7363
79	75°	Echelle	3.28	3-6773	3-1773	3-9773	3-7773
79	63°	Echelle	5.75	3-6733	3-1733	3-9733	3-7733
UTF-CW SERIES (Continuous)							
31.6	63°	Echelle	14.37	3-6314	3-1314	3-9314	3-7314
316	63°	Echelle	1.44	3-6364	3-1364	3-9364	3-7364
79	75°	Echelle	3.28	3-6774	3-1774	3-9774	3-7774
79	63°	Echelle	5.75	3-6734	3-1734	3-9734	3-7734

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HIGH RESOLUTION ECHELLE GRATINGS
All dimensions in millimeters.

GROOVES /MM	BLAZE ANGLE	BLAZE λ	12.5 x 25 x 6	12.5 x 25 x 9.5	12.5 x 50 x 9.5	25 x 50 x 9.5
31.6	63°	UV - 57µ	3-6368	3-1368	3-9368	3-7368
79	63°	UV - 23µ	3-6768	3-1768	3-9768	3-7768
79	75°	UV - 25µ	3-6778	3-1778	3-9778	3-7778
316	63°	UV - 5.7µ	3-6668	3-1668	3-9668	3-7668

GRAZING INCIDENCE GRATINGS AND MIRROR
All dimensions in millimeters.

REPLICATED HOLOGRAPHIC GRATING (12.7 x 50.8 mm)				
GROOVES/MM	1200	1800	2400	3600
BLAZE λ (nm)	Vis	Vis	Vis	UV
	CATALOG NO.	CATALOG NO.	CATALOG NO.	CATALOG NO.
NORMAL (TF)	5-2401	5-2402	5-2403	5-2404
UTF-P (Pulsed)	5-2406	5-2407	5-2408	5-2409
UTF-CW (Continuous)	5-2410	5-2411	5-2412	5-2413

MIRROR: Used in conjunction with grazing incidence gratings (above) for double pass high resolution tuning of dye lasers.	
12.7 x 50.8 mm	5-2405

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