Richardson Gratings™
A Newport Company

705 St. Paul Street
Rochester, New York 14605
Telephone: (585) 248-4100
Fax: (585) 248-4111
E-mail: gratings@newport.com
Web Site: http://www.gratinglab.com

Technical Notes

Technical Note 2
PULSE COMPRESSION AND STRETCHING WITH DIFFRACTION GRATINGS

Diffraction gratings, used in conjunction with chirped pulses, are the key to compressing or stretching a laser pulse (*i.e.*, increasing or decreasing their peak power with little loss in energy).

PULSE COMPRESSION

When a spectrally broad laser pulse is incident on a diffraction grating, the various wavelengths that make up the pulse will diffract from the grating at angles that depend on wavelength. If this pulse has its wavelength "chirped" so that the frequency increases during the length of the pulse, then diffraction will spread out the light in proportion, with the first part of the pulse (longer wavelengths) diffracting at a larger angle. The trailing portion of the pulse (shorter wavelengths) will diffract at a smaller angle and is directed to the leading edge of the second grating (see Figure 1). When the light diffracts from the second grating, which is oriented parallel to the first grating, the different parts of the pulse (with their correspondingly different wavelengths) will diffract at angles which yield a pulse whose parts are nearly in time synchronism. Peak power greatly increases, while total energy remains nearly the same.

PULSE STRETCHING

A pulse is sometimes stretched instead, in order to extract the maximum stored energy as well as reduce possible damage to optical components from excessive powers. This can be accomplished by using a pair of gratings in an "antiparallel" arrangement (see Figure 2). This works exactly opposite to the compression scheme in that the chirped pulse is spread out more by the gratings so that the resulting laser beam is longer in duration.

DISPERSION

The grating equation,

$$m\lambda = d\,(\sin\alpha + \sin\beta), \qquad (1)$$

can be differentiated to give the angular spread (dispersion) of the spectrum:

$$\frac{d\beta}{d\lambda} = \frac{\sin\alpha + \sin\beta}{\lambda\cos\beta} \qquad (2)$$

Here α and β are the angles of incidence and diffraction, m is the diffraction order, λ is the wavelength and d is the groove spacing.

Figure 1 – Pulse compression using two gratings with the same groove frequency and efficiencies peaked for the polarization and wavelength of the laser. The damage threshold is about 200 to 300 mJ/cm^2 for pulses of duration under 1 nsec.

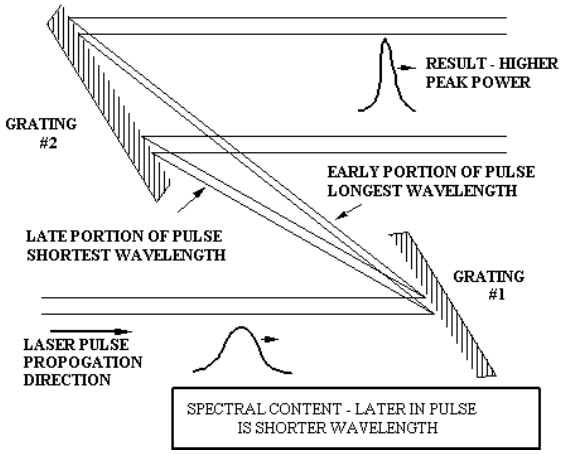
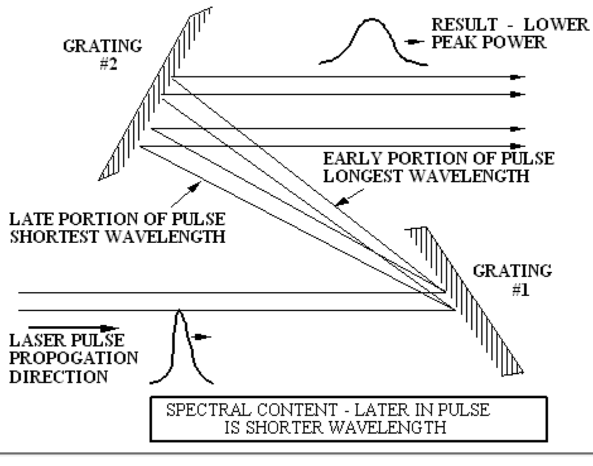


Figure 2 – Pulse stretching. This arrangement of two identical gratings allows for lower peak power to be transmitted through the laser system, thereby increasing the amount of stored energy which can be extracted.



EFFICIENCY BEHAVIOR

The efficiency behavior of several typical gratings used for pulse compression and stretching are shown in the figures below.

Figure 3 – Efficiency curve: 1800 g/mm. [5138]. Red dashed curve: P-plane; solid black curve: S-plane.

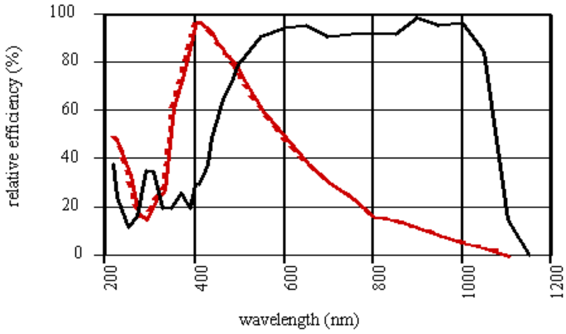


Figure 4 – Efficiency curve: 1200 g/mm. [2917]. Red dashed curve: P-plane; solid black curve: S-plane.

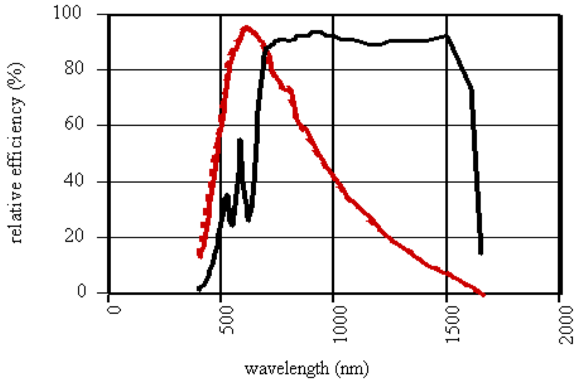


Figure 5 – Efficiency curve: 600 g/mm. [MR131]. Red dashed curve: P-plane; solid black curve: S-plane.

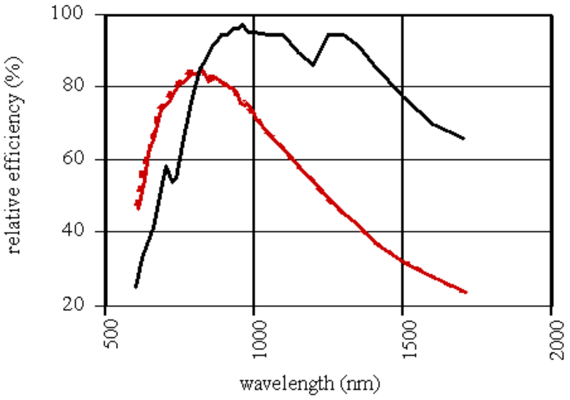
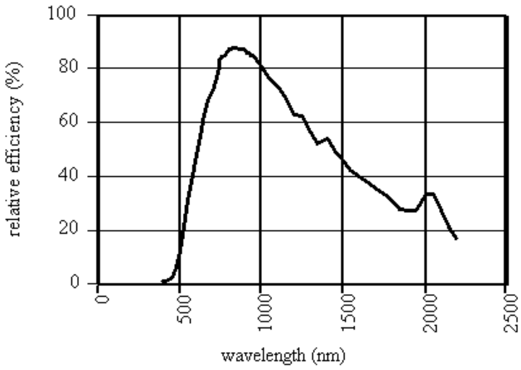


Figure 6 – Efficiency curve: 316 g/mm. [1503]. Solid: 45° polarization.



ORDERING INFORMATION

Popular transmission grating sizes and prices are listed in the *Diffraction Grating Catalog* and *Price Guide*. Different specifications can be accommodated: please contact us for price quotations. Prices are subject to change without notice.

FOR FURTHER INFORMATION

For additional information, please contact us.

SOME TECHNICAL REFERENCES

- A. Sullivan *et al.*, "Multiterawatt 100-fs laser", *Optics Letters* **16**, 1406-1408 (1991).
- F. G. Patterson, R. Gonzales & M. D. Perry, "Compact 10-TW, 800-fs Nd:glass laser", *Optics Letters* **16**, 107-1109 (1991).
- D. Strickland & G. Mourou, *Opt. Commun.* **56**, 219 (1985).
- K. Yamakawa, C. Barty *et al.*, "Generation of a High-Energy Picosecond Laser Pulse with a High-Contrast Ratio by CPA", *IEEE JQE* **27**, (1991).

back to top

Richardson Gratings
705 St. Paul Street, Rochester, New York 14605 USA
Telephone: (585) 248-4100, Fax: (585) 248-4111
E-mail: gratings@newport.com,
Web Site: http://www.gratinglab.com