Technical Note 8
HANDLING GRATINGS

A diffraction grating is a first surface optic, so its surface cannot be touched or otherwise come in contact with another object without damaging it and perhaps affecting its performance. Damage can take the form of contamination (as in the adherence of finger oils) or distortion of the microscopic groove profile in the region of contact. This Technical Note describes the reasons why a grating must be handled carefully and provides guidelines for doing so.

THE GRATING SURFACE

Commercially available diffraction gratings are replicated optics comprised of three layers: a substrate, an epoxy layer, and (usually) a reflective coating. Each layer meets a different purpose: (1) the metallic layer provides high reflectivity, (2) the epoxy layer holds the groove pattern and groove profile and (3) the substrate (usually glass) keeps the optical surface rigid.

Figure 1 – Composition of a replica diffraction grating. A section of a standard blazed grating with an aluminum coating is shown. Layer thicknesses are not shown to scale: generally the aluminum film thickness is about 1 micron, and the epoxy layer is between 30 and 50 microns; the substrate thickness is usually between 3 and 100 millimeters.
Since the groove profile is maintained by the epoxy layer, rather than the reflective (metallic) coating on top of it, protective coatings such as those that meet the military specification MIL-M-13508 (regarding first-surface aluminum mirrors) do not serve their intended purpose. Even if the aluminum coating itself were to be well-protected against contact damage, it is too thin to protect the softer epoxy layer underneath it. Even "fully cured" epoxy is not very hard, resembling molding clay in its resistance to contact damage. Consequently gratings are not provided with contact-protecting coatings.

**GRATING COSMETICS AND PERFORMANCE**

Warnings against touching the grating surface notwithstanding, damage to the surface occasionally occurs. Contact from handling, mounting or packaging can leave permanent visible marks on the grating surface. Moreover, some gratings have cosmetic defects that do not adversely impair the optical performance, or perhaps represent the best available quality for a grating with a particular set of specifications. For example, some gratings have 'worm tracks' due to mechanical ruling of the master grating from which the replicated grating was taken, others have coating defects like spit or spatter, and others have 'pinholes' (tiny voids in the reflective coating), &c. The many possible classifications of surface defects and the many opportunities to render the surface permanently damaged conspire to make the surfaces of many gratings look less than cosmetically perfect.

While this damage may be apparent upon looking that the grating, it is not straightforward to determine the effect this damage has on the performance of the grating. Often the area affected by damage or contamination is a small fraction of the total area of the grating. Therefore, only a small portion of the total number of grooves under illumination may be damaged, displaced or contaminated. A damaged or contaminated region on the surface of a grating may have little, if any, noticeable effect on the performance of the optical system because, a diffraction grating is usually used as an integrating optic (meaning that all light of a given wavelength diffracted from the grating surface is brought to focus in the spectral order of interest). In contrast, a lens or mirror that does not focus (say, an eyeglass lens or a bathroom mirror) will show a distortion in its image corresponding to the damaged region of the optic. This familiar experience – the annoying effect of a chip on an eyeglass lens or a smudge on a bathroom mirror – has led many to assume that a similar defect on the surface of a grating will lead to a similar deficiency in performance. The most appropriate performance test of a grating with surface damage or cosmetic defects is not visual inspection but instead to use the grating in its optical system and determine whether the entire system meets its specifications.

Damage to a region of grooves, or their displacement, will theoretically have some effect on the efficiency of the light diffracted from that region, as well as the total resolving power of the grating, but in practice such effects are generally not noticeable. Of more concern, since it may be measurable, is the effect surface damage may have on light scattered from the grating, which may decrease the signal-to-noise (SNR) of the optical system. Most forms of surface damage can be thought of as creating scattering centers where light that should be diffracted (according to the grating equation) is scattered into other directions instead.

**UNDOING DAMAGE TO THE GRATING SURFACE**

Damage to the microscopic groove profile is, unfortunately, irreversible; the epoxy layer, like molding clay, will retain a permanent imprint. Contamination of the grating surface with finger oils, moisture, vacuum pump oil, &c is also often permanent, particularly if the contaminated grating surface has been irradiated. If you have a damaged or contaminated grating, call the manufacturer to ask for advice, or to have us clean and inspect your grating.
Sometimes surface contamination can be removed partially, and once in a while completely, using a mild unscented dishwashing liquid. Care should be taken not to apply any pressure (even gentle scrubbing) to the grating surface. If contaminants remain, try using spectroscopic-grade solvents; the purity of such solvents should be ascertained before use, and only the purest form available used. The use of carbon dioxide (CO₂) snow, which reaches the grating surface in a sublimed state and evaporates, carrying with it the contaminants, has also been used with some success. The key to cleaning a grating surface is to provide no friction (e.g., scrubbing) that might damage the delicate groove structure.

GUIDELINES FOR HANDLING GRATINGS

- **Never touch the grooved surface of a diffraction grating.** Handle a grating by holding it by its edges. If possible, use powder free gloves while handling gratings.

- **Never allow any mount or cover to come in contact with the grooved surface of a diffraction grating.** A grating that will be shipped should have its surface protected with a specially-designed cover that does not touch the surface itself. Gratings that are not in use, either in the laboratory or on the manufacturing floor, should be kept in a closed box when not covered. Keep any oils that may be used to lubricate grating mount adjustments away from the front surface of the grating.

- **Do not talk or breathe over the grooved surface of a diffraction grating.** Wear a nose and face mask when it is required that you talk over the surface of a grating. Breath spray is particularly bad for reflection gratings, so one should not speak directly over the surface; instead, either turn away or cover the mouth (with the hand or a surgical mask).

FOR FURTHER INFORMATION

For additional information, please contact us.