April 1974

# NASA TECH BRIEF

*Goddard Space Flight Center*



## Fabrication of Optical Reflecting Diffraction Gratings by Light-Interference Phenomenon

### The problem:

Optical reflecting diffraction gratings used in spectroscopic instruments are fabricated with a great degree of precision. Typically, diffraction gratings are ruled with a diamond ruling engine which operates in a vibration-free and highly-stable thermal environment. The diamond ruling engine method is limited to fabricating plane and spherical concave gratings. As a result of the diamond fabrication process, these gratings are characterized by ghosts (false spectral lines), stray or scattered radiation, and astigmatism for concave gratings. The grating size is limited by the ruling engine and diamond life. Further, depending upon grating size and groove frequency, the time to fabricate an original grating is 1 to 5 weeks of ruling 24 hours a day.

### The solution:

Optical reflecting diffraction gratings can be fabricated using a combination of photoresist material and light-interference phenomenon.

### How it's done:

In the new process, suitable substrates are fabricated to optical tolerances (less than 1/4 wavelength) and then are coated with a thin photosensitive plastic (photoresist) layer, 20 to 200-nm thick, which remains chemically stable after processing. Two divergent or collimated blue (457.9-nm) laser beams are directed to intersect, producing narrow interference fringes at the intersection. The number of fringes per mm (groove frequency) is determined by the angle between the laser beams at the intersection.

To record the interference pattern, the photoresist-covered substrate is positioned at the intersection of the laser beams. After the desired exposure, the recording is developed in a chemical solution and washed. The developer dissolves away the exposed parts of the photoresist and leaves grooves at the sites of interference maxima. The results are groove profiles intermediate between sinusoidal and square wave patterns in the photoresist. After drying, the grating is covered with an aluminum coating or any other highly reflecting material to improve the grating performance.

This new technique features the following:

1. A major reduction in the cost of fabricating original high-quality optical reflecting diffraction gratings.
2. The gratings exhibit very low stray or scattered radiation, improve the signal noise ratio, and eliminate false spectral lines (ghosts).
3. Gratings can be fabricated free of optical aberrations, such as astigmatism, coma, and spherical aberration at selected wavelengths. Also, optical aberrations are reduced at all other wavelengths.
4. Gratings may be fabricated with high groove frequencies (up to 6000 grooves/mm) and may be larger than 30 by 30 cm.
5. Gratings can be fabricated on practically any surface geometry.
6. Fabrication time has been reduced to from 20 to 90 minutes, as compared to from 1 to 5 weeks required by the diamond ruled method.
7. Initial equipment cost has been reduced tenfold.

### Note:

Requests for further information may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Code 207.1
Greenbelt, Maryland 20771
Reference: TSP73-10516

### Patent status:

NASA has decided not to apply for a patent.

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Category 03