

Fabricating Blazed Diffraction Gratings by X-Ray Lithography

Grooves having arbitrarily shaped cross sections can be formed on curved substrates.

NASA's Jet Propulsion Laboratory, Pasadena, California

Gray-scale x-ray lithography is undergoing development as a technique for fabricating blazed diffraction gratings. As such, gray-scale x-ray lithography now complements such other grating-fabrication techniques as mechanical ruling, holography, ion etching, laser ablation, laser writing, and electron-beam lithography. Each of these techniques offers advantages and disadvantages for implementing specific grating designs; no single one of these techniques can satisfy the design requirements for all applications.

Gray-scale x-ray lithography is expected to be advantageous for making gratings on steeper substrates than those that can be made by electron-beam lithography. This technique is not limited to sawtooth groove profiles and flat substrates: various groove profiles can be generated on arbitrarily shaped (including highly curved) substrates with the same ease as sawtooth profiles can be generated on flat substrates. Moreover, the gratings fabricated by this technique can be made free of ghosts (spurious diffraction components attributable to small spurious periodicities in the locations of grooves).

The first step in gray-scale lithog-

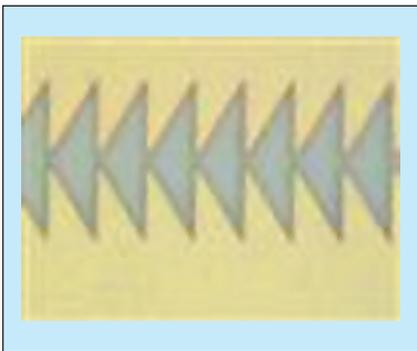


Figure 1. Sample X-Ray Mask is shown with a period of 9 μm and gold thickness of 5 μm .

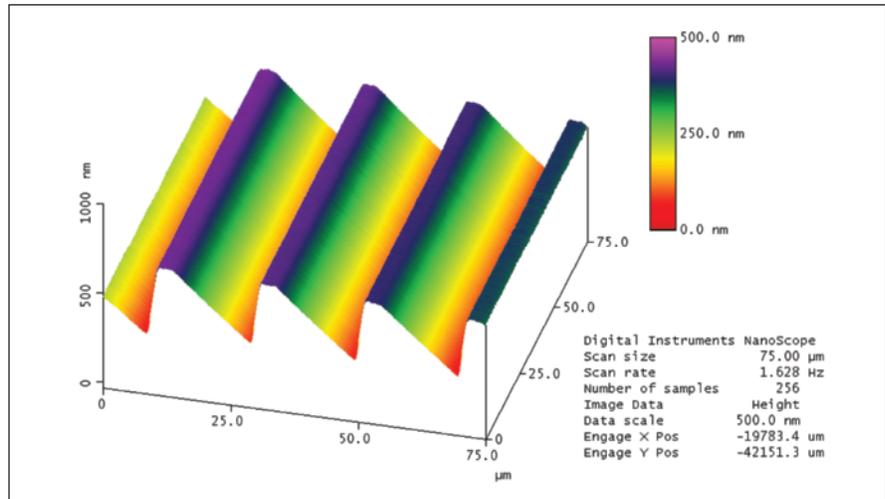


Figure 2: Atomic Force Microscope Scan of grooves is generated through this technique. The period is 20 μm . The peak efficiency was measured to be 82 percent.

raphy is to conformally coat a substrate with a suitable photoresist. An x-ray mask (see Figure 1) is generated, placed between the substrate and a source of collimated x-rays, and scanned over the substrate so as to create a spatial modulation in the exposure of the photoresist. Development of the exposed photoresist results in a surface corrugation that corresponds to the spatial modulation and that defines the grating surface.

The grating pattern is generated by scanning an appropriately shaped x-ray area mask along the substrate. The mask example of Figure 1 would generate a blazed grating profile when scanned in the perpendicular direction at constant speed, assuming the photoresist responds linearly to incident radiation. If the resist response is nonlinear, then the mask shape can be modified to account for the nonlinearity and produce a desired groove profile. An example of grating grooves generated by

this technique is shown in Figure 2. A maximum relative efficiency of 88 percent has been demonstrated.

This work was done by Pantazis Mouroulis, Frank Hartley, and Daniel Wilson of Caltech and Martin Feldman of Louisiana State University for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1)

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Innovative Technology Assets Management

JPL

Mail Stop 202-233

4800 Oak Grove Drive

Pasadena, CA 91109-8099

(818) 354-2240

E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-30915, volume and number of this NASA Tech Briefs issue, and the page number.