INVESTIGATION OF SPECTRAL PROPERTIES OF ULTRAVIOLET GRATINGS

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INTRODUCTION

This report summarizes research activities during the six month period from September 1, 1966, to February 28, 1967, the first six months of the project. The purpose of the research is to study the properties of UV gratings, original and replica, before and after exposure to simulated space environments.

RESEARCH ACTIVITIES

I. Method of Studying Gratings

It is felt that replica gratings exposed to a simulated space environment would show the most dramatic (before and after exposure) change in the efficiency and the amount of scattered light. It was decided, therefore, to devote the major portion of our effort at the College of William and Mary to measuring the efficiency and scattered light of plane gratings before and after exposure to electron bombardment in vacuum.

The measurements on plane gratings are scheduled using a Hinteregger-type lamp with a One Meter Normal Incidence McPhearson Monochromator providing the source of monochromatic ultraviolet radiation, and a 0.3 Meter McPhearson monochromator serving as a grating test chamber. The efficiency measurements will be effected by first measuring the power transmitted through the test chamber as a function of wave length with the grating under test in place, then performing the same measurement with a plane mirror replacing the grating. In this manner we shall be able to measure the ratio of the power reflected by the grating under test relative to the plane mirror. This ratio $R(\lambda)$ would be the actual efficiency of the grating if the reflection coefficient $r(\lambda)$ of the plane mirror was equal to unity. In practice $r(\lambda) < 1$ and the grating efficiency $E(\lambda)$ is given by,

$$E(\lambda) = \frac{R(\lambda)}{r(\lambda)}$$

We shall most likely only know the general form of $r(\lambda)$ for our mirror, however, if $r(\lambda)$ remains constant with time we shall be able to measure the ratio of the efficiency after exposure $E_a(\lambda)$ to the efficiency before exposure $E_b(\lambda)$. This ratio is given by,

$$\frac{E_a(\lambda)}{E_b(\lambda)} = \frac{R_a(\lambda)}{R_b(\lambda)} ,$$

and is independent of $r(\lambda)$.

The measurement of scattered light is easily effected by scanning the grating under test with the monochromator positioned on a strong emission line of the lamp. This will be carried out before and after exposure using the strong source emission lines.

There is not expected to be any great difficulty in completing these measurements above 1050Å. Aluminum mirrors overcoated with MgF_2 are very stable and have reflectivities of the order of 80% from 1200Å to 2000Å. Window materials for the lamp are available above 1050Å (LiF cutoff). Below 1050Å the measurements on plane gratings become very difficult due to the poor reflectivities of all metals in this region (Pt. is probably the best reflector in this region, however, at 700Å the reflectivity is only about 15%), and the absence of windows transmitting below 1050Å forcing one to employ differential pumping techniques.

The work below 1050Å would probably be best carried out studying concave as opposed to plane gratings, thus eliminating the need for the two additional mirror reflections required for studying plane gratings. A study of concave grating efficiencies could, in principle, be effected as outlined above for plane gratings.

DESCRIPTION OF PRESENT AND FUTURE RESEARCH BY PHASES

II. Phase 1

A. UV Source Stability

The stability and reproducibility performance of the Hinteregger discharge lamp has been investigated in the range from 1050Å to 3000Å. The monitor system consists of a 0.3 meter spectrometer equipped with a sodium salicylate coated photomultiplier detecting system, the lower wave length limit being determined by the MgF_2 coated optics. The discharge lamp has been studied both in A.C. arc as well as spark operational modes using both He and A as the working lamp gas. Our measurements have indicated the need for "high purity" gas in order to insure reproducibility of the intensities of the various spectral intensities and these have now been obtained.

The stability of the spectra under both arc and spark modes of lamp operation thus far indicate that satisfactory requirements are met by this system, with intensities above 1050Å being adequate for the intended study. The MgF_2 cutoff at approximately 1050Å has precluded an appraisal of the intensities of spectral lines below that wave length

B. Vacuum System

Much effort has been spent on developing a vacuum system to eliminate oil contaminations within the monochromator chamber— thereby, eliminating contamination of the gratings under test. The present vacuum system is capable of maintaining approximately 0.1 microns with the lamp gas turned off and a ratio of chamber to lamp pressure of better than 100 to 1 under operating conditions. It is believed that adequate vacuum pump oil filtering has been obtained by the use of molecular sieve filters.

C. Grating Adaptor

A precision ($\pm$ 0.0001 in.) adaptor has been fabricated to mount the test (plane) gratings with its surface on axis of the precision monochromator grating mount bearing. Tests of this adaptation have indicated satisfactory instrumentation.

D. Grating Protection

Adequate protection of the gratings to be studied has been effected through the perfection of a controlled dry nitrogen atmosphere "dry box" to enable transfers to dessicators for transport to and from the space environment simulation irradiation facilities while providing protection from moisture for the gratings while in storage.

Phase 2

A. One Meter Monochromator

This phase of the study is to be centered about adapting the one meter normal incidence monochromator as a wave length selector for input into the 0.3 meter monochromator serving as a test chamber for the gratings under study. The procedures for efficiency and scattered light measurements are to be perfected during this phase and are anticipated to be conducted above 1050Å due to the MgF_2 cutoff as previously mentioned.

The results of this study are expected to indicate the feasibility of studying plane gratings below 1050Å and if such seem appropriate, will indicate the requirements necessary in addition to the Platinum coated optics.

B. Preliminary Tests

Preliminary tests of plane gratings for efficiency and scattered radiation are anticipated during this phase of the study. Results of these tests should indicate the feasibility of proceeding with plane gratings below 1050Å. However, it is expected that only tests of concave gratings in this range will be feasible.

Phase 3

A. Grating Studies

It is expected that with the preliminary results obtained during phases one and two, we will be able to proceed with the plane grating studies as outlined in the previous section.

PERSONNEL

The personnel working on this problem are listed below.

Faculty

Howard R. Gordon

James D. Lawrence

John L. McKnight

George S. Ofelt

Melvin A. Pittman

Graduate Student

Hayden Gordon
NSF Trainee