Application Note: Monolithic Silicon Grating Arrays

LightSmyth Technologies is proud to introduce monolithic, single-substrate, silicon grating arrays that uniquely provide instantaneous high-resolution access to optical bandwidths substantially exceeding that of a single grating. No moving parts are required. LightSmyth monolithic grating arrays are consistent with single shot data acquisition for many broadband applications, e.g. laser-induced breakdown spectroscopy and can help reduce system component numbers dramatically. This application note details device design and operation.

Detailed Device Description

Primary Array Gratings

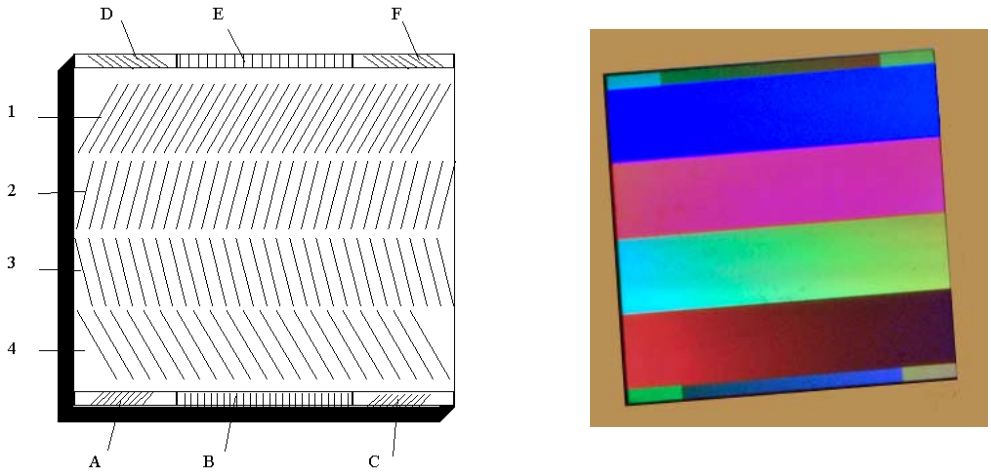

Figure 1. Schematic representation of LightSmyth Grating Array and photograph

A schematic of LightSmyth grating array SAG-1212A-Al is shown in Figure 1. As can be seen, the array consists of four primary gratings (1 through 4), occupying most of the substrate, and six additional smaller reference gratings (A through E) that are located at top and bottom of the substrate. An immediately noticeable feature of the primary gratings is that their grating lines exhibit a non-zero tilt with respect to the substrate vertical that is different for each grating. Tilting the grating lines provides critical function since the tilt rotates the grating's dispersion plane so that gratings of different tilt produce dispersed outputs that are angularly and thus vertically displaced from each other. At the right of Figure 1 is a photograph of the grating array product. Tilting of the lines is not obvious in the photograph.

The effect of the primary grating tilts is illustrated in Figure 2 which schematically shows the dispersion lines of the primary gratings in the far field as solid black lines. The scale in Figure 2 measures the approximate output angle with respect to the grating normal. Positive angles indicate output directions on

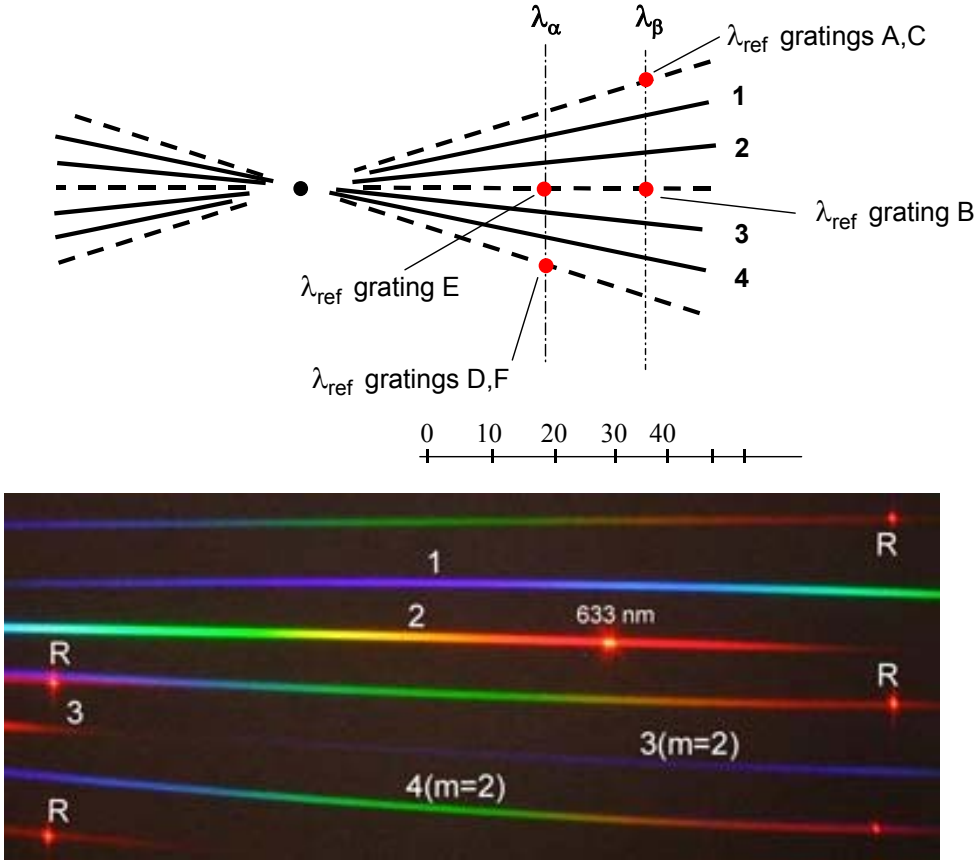

Figure 2. Far-field output from grating array and photograph (below) with HeNe and white light input

the same side as the input to the grating. The input light is incident at 20 degrees relative to the grating normal.

Solid lines to the left and right of the grating normal (at 0°) are opposite signs of first order and the solid dot at the extrapolated intersection point of all the lines is the specular reflection (zeroth order) output common to all gratings. In addition to having different tilt angle the four primary gratings have different line spacings that are chosen so that the four gratings produce contiguous spectral coverage over approximately a factor of three in wavelength in the four separate output stripes within a predetermined output angular range.

The six small gratings at the top and bottom of the substrate provide calibration markers in the output field designed to allow fully electronic, single-reference wavelength, calibration of a two-dimensional detector. For a given reference wavelength, the six calibration gratings provide alignment marks that indicate beginning and end points of the spectral coverage provided by the primary gratings. In Figure 2, the dashed lines represent dispersed output light from the calibration gratings A-F. The solid dots on the dashed lines at right represent outputs of the calibration gratings when a reference wavelength is

input (632.8 nm assumed in the Figure). The calibration grating signals provide multiple markers that allow one to determine the wavelength as a function of position along each of the primary gratings dispersion lines. The scale at the bottom of the schematic in Figure 2 indicates that angle, relative to the grating normal, that light along the central dispersion line diffracts from the grating. Note that the wavelength range denoted by the calibration spots is insensitive to the input angle at which the grating is used.

At the bottom of Figure 2, a photograph of the far field grating array output is shown. The region photographed is bracketed by the calibration grating markers shown both in the photograph and in the output schematic.

Detailed Monolithic Grating Array Properties

The actual properties of the LightSmyth grating array SAG-1212A are given in Table I. The wavelength ranges of the four gratings when a HeNe reference is used is given in Table II. These values change with reference wavelength, but as noted are insensitive to input angle.

Table I: Grating Array Properties

Grating	Contour Tilt relative to Vertical (degrees)	Contour Spacing (nm)
1	3	559.1
2	1.5	745.6
3	-1.5	1001.9
4	-3	1362.5
A	4.5	678.2
B	0	678.2
C	4.5	678.2
D	-4.5	927.8
E	0	927.8
F	-4.5	927.8

Table 2: Primary Grating Wavelength Ranges between Calibration Markers for 632.8 nm Reference Wavelength

Primary Grating	Shorter Wavelength (nm) λ_α	Longer Wavelength (nm) λ_β
1	381	522
2	509	696
3	683	935
4	929	1271

Note: Specifications may change without notice. Not responsible for typographical errors.

April 10, 2007