enlarged with custom wafer probes (see figure) designed for the noted frequency band, which is that of WR-3 waveguides [waveguides having a standard rectangular cross section of 0.0340 by 0.0170 in. (0.8636 by 0.4318 mm)]. Among other things, the measurements showed a peak gain of 10 dB at a frequency of 235 GHz.

This work was done by Douglas Dawson, King Man Fung, Karen Lee, Lorene Samoska, Mary Wells, Todd Gaier, and Pekka Kangaslahti of Caltech; and Ronald Grandbacher, Richard Lai, Rohit Raja, and Po-Hsin Liu of NGST for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-42202

Mapping Nearby Terrain in 3D by Use of a Grid of Laser Spots

A relatively simple system would utilize triangulation.

NASA’s Jet Propulsion Laboratory, Pasadena, California

A proposed optoelectronic system, to be mounted aboard an exploratory robotic vehicle, would be used to generate a three-dimensional (3D) map of nearby terrain and obstacles for purposes of navigating the vehicle across the terrain and avoiding the obstacles. Like some other systems that have been, variously, developed and proposed to perform similar functions, this system would include (1) a light source that would project a known pattern of bright spots onto the terrain, (2) an electronic camera that would be laterally offset from the light source by a known baseline distance, (3) circuitry to digitize the output of the camera during imaging of the light spots, and (4) a computer that would calculate the 3D coordinates of the illuminated spots from their positions in the images by triangulation.

The difference between this system and the other systems would lie in the details of implementation. In this system, the illumination would be provided by a laser. The beam from the laser would pass through a two-dimensional diffraction grating, which would divide the beam into multiple beams propagating in different, fixed, known directions (see figure). These beams would form a grid of bright spots on the nearby terrain and obstacles. The centroid of each bright spot in the image would be computed. For each such spot, the combination of (1) the centroid, (2) the known direction of the light beam that produced the spot, and (3) the known baseline would constitute sufficient information for calculating the 3D position of the spot.

Concentrating the illumination into spots, instead of into lines as in some other systems, would afford signal-to-noise ratios greater than those of such other systems and would thereby also enable this system to image terrain and obstacles out to greater distances. The laser could be pulsed to obtain momentary illumination much brighter than ambient illumination, and the camera could be synchronized with the laser to discriminate against ambient light between laser pulses.

This work was done by Curtis Padgett, Carl Liebe, Johnny Chang, and Kenneth Brown of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-40611

Digital Beam Deflectors Based Partly on Liquid Crystals

Laser beams are switched to different directions, without using solid moving parts.

John H. Glenn Research Center, Cleveland, Ohio

A digital beam deflector based partly on liquid crystals has been demonstrated as a prototype of a class of optical beam-steering devices that contain no mechanical actuators or solid moving parts. Such beam-steering devices could be useful in a variety of applications, including free-space optical communications, switching in fiber-optic communications, general optical switching, and optical scanning. Liquid crystals are of special interest as active materials in nonmechanical beam steering and deflectors because of their structural flexibility, low operating voltages, and the relatively low costs of fabrication of devices that contain them. Recent advances in synthesis of liquid-crystal ma-
Narrow-Band WGM Optical Filters With Tunable FSRs

Microwave signals generated by optoelectronic oscillators can be tuned.

NASA’s Jet Propulsion Laboratory, Pasadena, California

Optical resonators of the whispering-galley-mode (WGM) type featuring DC-tunable free spectral ranges (FSRs) have been demonstrated. Previously, the FSRs of WGM optical resonators were determined solely by the resonator geometries and materials; hence, the FSR of such a resonator could be tailored by design, but once the resonator was constructed, its FSR was fixed. By making the tunable, one makes it possible to adjust, during operation, the frequency of a microwave signal generated by an opto-electronic oscillator in which an WGM optical resonator is utilized as a narrow-band filter.

Each tunable WGM resonator was made from a disk of lithium niobate, 2.6 mm in diameter and 120 μm thick. The edge of the disk was rounded by polishing to an approximately spherical surface. A ferroelectric-domain structure characterized by a set of rings concentric with the axis of the disk (see Figure 1) was created by means of a poling process in which a 1-µm-diameter electrode was dragged across the top surface of the disk in the concentric-ring pattern while applying a 2.5-kV bias between the electrode and a conductor in contact with the bottom surface of the disk. After the poling process, the top and bottom surfaces of the disk were placed in contact with metal electrodes that, in turn, were connected to a regulated DC power supply that was variable from 0 to 150 V. When a DC bias electric field is applied in such a structure, the indices of refraction in the positively poled concentric rings and in the unflipped, negatively poled concentric regions change by different amounts. The concentric-ring ferroelectric-domain structure of such a resonator can be engineered so that it overlaps with one or more radial resonator modes more than it does with other, adjacent modes. As a result, when the indices of refraction change in response to DC bias, some modes shift in frequency by amounts that differ from those of adjacent modes; the difference in frequency shift amounts to the desired change in the FSR between the affected adjacent modes.

A test was performed on each tunable resonator to observe the absorption spectrum of the resonator and the changes in frequencies of adjacent modes of interest as the applied DC bias voltage was varied.