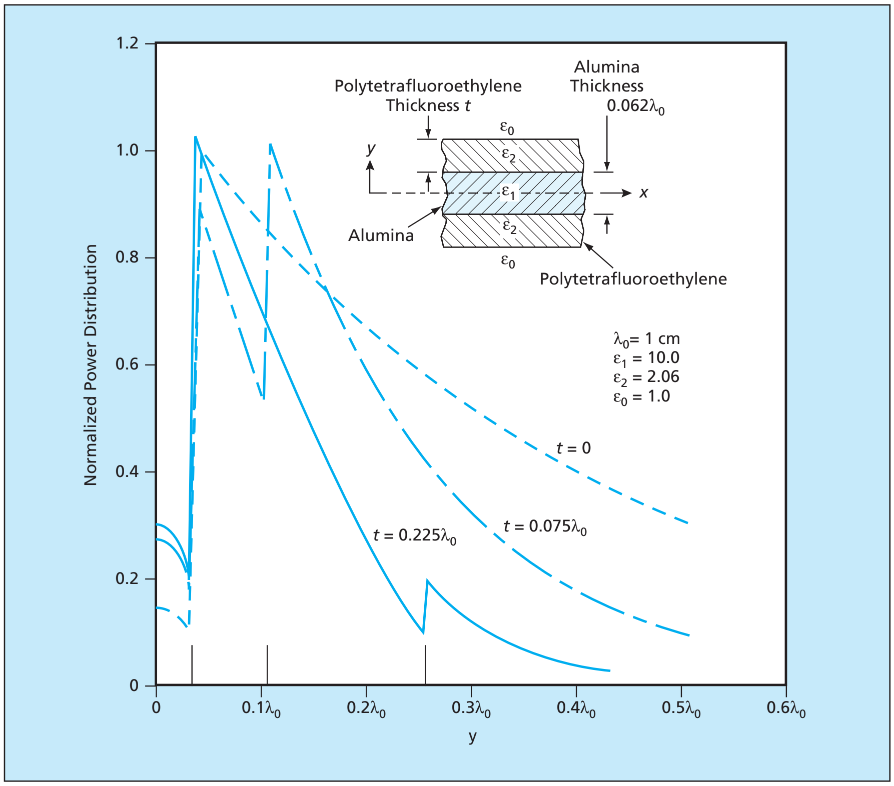

Normalized Power Densities were computed for a dominant $_eHE_{11}$ mode on a ribbon waveguide made of alumina (having assumed relative permittivity of 10), both uncoated and coated with various thicknesses polytetrafluoroethylene (having assumed relative permittivity of 2.06). The unit of thickness used in the computations was the free-space wavelength, λ_0.

and often lossy optical elements. Even chip-to-chip interconnections have been problematic in this frequency range. Metal wave-guiding structures (e.g., microstriplines and traditional waveguides) are not suitable for this frequency range because the skin depths of electromagnetic waves in this frequency range are so small as to give rise to high losses. Conventional rod-type dielectric waveguide structures are also not suitable for this frequency range because dielectric materials, including ones that exhibit ultralow losses at lower frequencies, exhibit significant losses in this frequency range.

Unlike microstripline structures or metallic waveguides, the proposed ribbon waveguides would be free of metal and would therefore not be subject to skin-depth losses. Moreover, although they would be made of materials that are moderately lossy in the frequency range of interest, the proposed ribbon waveguides would cause the propagating electromagnetic waves to configure themselves in a manner that minimizes losses.

The basic principle for minimizing losses was described in "Ceramic Ribbons as Waveguides at Millimeter Wavelengths" (NPO-21001), *NASA Tech Briefs*, Vol. 25, No. 4 (April 2001), page 49. To recapitulate: The cross-sectional geometry of a waveguide ribbon would be chosen in consideration of the permittivity of the ribbon material to support an electromagnetic mode in which most of the energy would propagate, parallel to the ribbon, through the adjacent free space and only a small fraction would propagate within the ribbon. As a result, the interaction of the propagating wave with the dielectric core (and thus the attenuation) would be minimal.

For straight runs, the ribbon waveguides would be uncoated. However, since most of the guided power would be carried in the nearly lossless air just outside the ribbon, a significant portion of the guided power could be expected to be radiated (and thus lost) where the guiding ribbon was sharply curved (for example, to bend it around a corner). In such a case, the short length of the ribbon containing the curve could be coated with a layer of a polymer having a suitable permittivity intermediate between that of air and that of the ribbon, so that most of the power would not be radiated but would remain confined within the polymer layer (see figure) while propagating around the corner.

This work was done by Cavour Yeh, Daniel Rascoe, Fred Shimabukuro, Michael Tope, and Peter Siegel of Caltech 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:

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Refer to NPO-30339, volume and number of this NASA Tech Briefs *issue, and the page number.*

HEMT Frequency Doubler With Output at 300 GHz

This is the highest-frequency HEMT doubler reported to date.

NASA's Jet Propulsion Laboratory, Pasadena, California

An active frequency doubler in the form of an InP-based monolithic microwave integrated circuit (MMIC) containing a high-electron-mobility transistor (HEMT) has been demonstrated in operation at output frequencies in the vicinity of 300 GHz. This is the highest-frequency HEMT doubler reported to date, the next-highest-frequency active HEMT doubler having been previously reported to operate at 180 GHz. While the output power of this frequency doubler is less than that of a typical Schottky diode, this frequency doubler is considered an intermediate product of a continuing effort to realize the potential of active HEMT frequency doublers to operate with conversion efficiencies greater than those of passive diode frequency doublers. An additional incentive for developing active HEMT frequency dou-

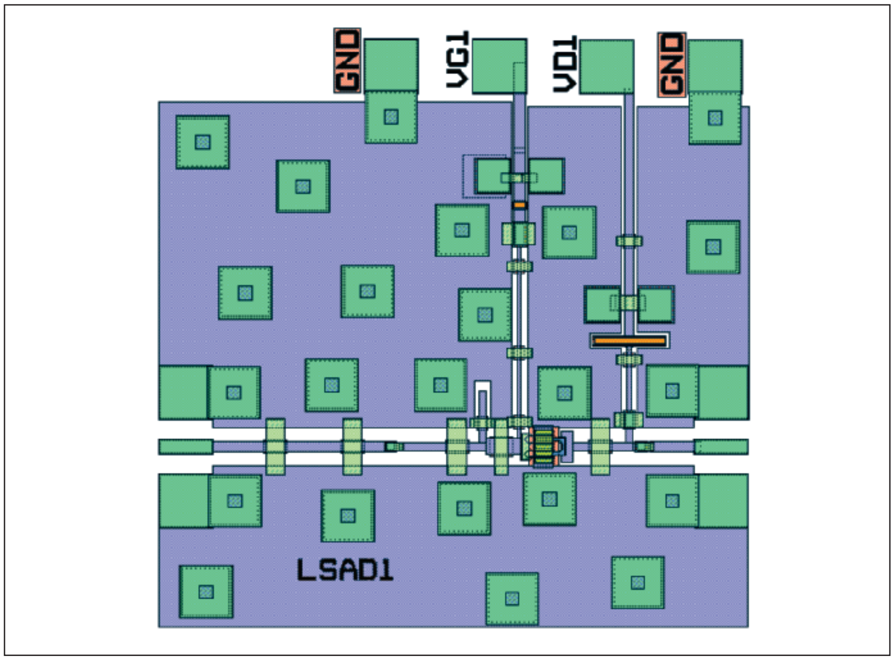

Figure 1. This **MMIC** embodies an active frequency doubler rated for a nominal output frequency of about 300 GHz.

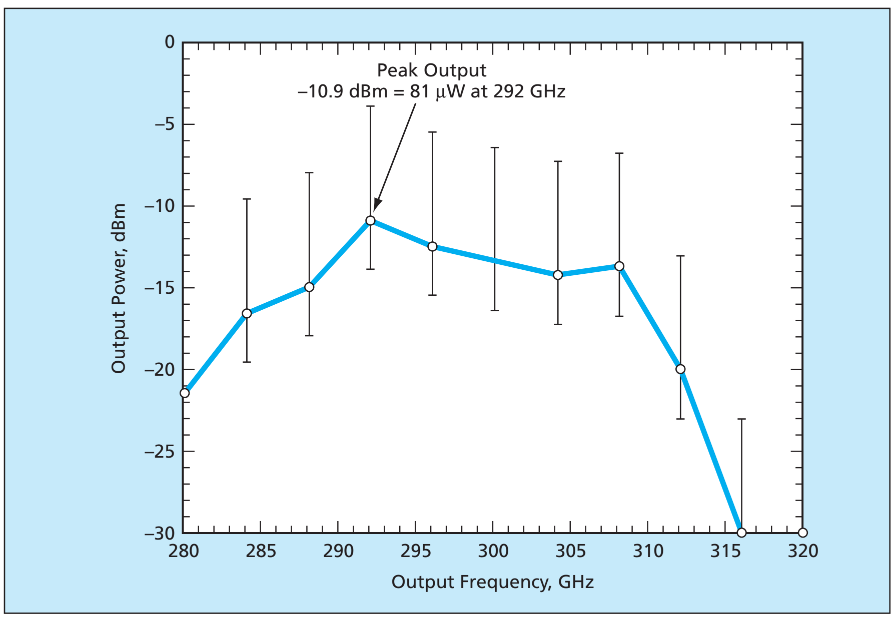

Figure 2. The **Output Power** of the MMIC of Figure 1 was measured at several output frequencies from 280 to 316 GHz.

blers lies in the fact that they can be integrated with amplifiers, oscillators, and other circuitry on MMIC chips.

The circuitry of the doubler MMIC (see Figure 1) features grounded coplanar waveguides. Air bridges and vias are used to make contact with the ground plane. The HEMT is biased for Class-A operation (in which current is conducted throughout each cycle of oscillation), which would ordinarily be better suited to linear amplification than to frequency doubling. Ordinarily, class-B operation (in which current is conducted during about half of each cycle of oscillation) would be more suitable for frequency doubling because of the essential nonlinearity of partial-cycle conduction. The reason for the unusual choice of class A was that computational simulations had shown that in this case, the efficiency in class B would be less than in class A.

The input matching circuit of this doubler includes transmission lines that afford a good impedance match at the fundamental frequency, plus an open stub to prevent leakage of the second harmonic through the input terminals. The output circuit was designed to suppress the fundamental while providing a good match for the second harmonic.

In a test, this doubler was driven by an input signal at frequencies from 140 to 158 GHz and its output at the corresponding second-harmonic frequencies of 280 to 316 GHz was measured by means of a power meter connected to the MMIC via waveguide wafer probes and a high-pass (fundamental-suppressing) waveguide. The results of this test are summarized in Figure 2.

This work was done by Lorene Samoska and Jean Bruston of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30581

Single-Chip FPGA Azimuth Pre-Filter for SAR

Range resolution is reduced by a selectable factor to reduce the volume of data.

NASA's Jet Propulsion Laboratory, Pasadena, California

A field-programmable gate array (FPGA) on a single lightweight, low-power integrated-circuit chip has been developed to implement an azimuth pre-filter (AzPF) for a synthetic-aperture radar (SAR) system. The AzPF is needed to enable more efficient use of data-transmission and data-processing resources: In broad terms, the AzPF reduces the volume of SAR data by effectively reducing the azimuth resolution, without loss of range resolution, during times when end users are willing to accept lower azimuth resolution as the price of rapid access to SAR imagery. The data-reduction factor is selectable at a decimation factor, *M*, of 2, 4, 8, 16, or 32 so that users can trade