Electronics/Computers

Waveguide Power-Amplifier Module for 80 to 150 GHz

The amplifier can now be connected to other equipment more easily.

NASA's Jet Propulsion Laboratory, Pasadena, California

A waveguide power-amplifier module capable of operating over the frequency range from 80 to 150 GHz has been constructed. The module comprises a previously reported power amplifier packaged in a waveguide housing that is compatible with WR-8 waveguides. (WR-8 is a standard waveguide size for the nominal frequency range from 90 to 140 GHz.) Because the amplifier in its unpackaged form was a single, fragile InP chip, it was necessary to use special probes to make electrical connections between the amplifier and test equipment in order to measure the power gain and other aspects of amplifier performance. In contrast, the waveguide power-amplifier module is robust and can be bolted to test equipment and to other electronic circuits with which the amplifier must be connected for normal operation.

The amplifier in its unpackaged form was reported in "Power Amplifier With 9 to 13 dB of Gain from 65 to 146 GHz" (NPO-20880), *NASA Tech Briefs*, Vol. 25, No. 1 (January 2001), page 44. To recapitulate: the amplifier provides three stages of amplification, implemented by means of four InP high-electron-mobility transistors in a grounded coplanar waveguide circuit with lumped-element interstage and shunt capacitors. The circuit also features a unique coplanar waveguide power-combining structure in the output stage. The output radio-frequency power was measured to be 25 to 40 mW from 106 to 140 GHz.

The figure shows selected aspects of the amplifier in its present packaged form. In addition to packaging in a waveguide housing, the amplifier was modified to suppress low-frequency oscillations, to which the amplifier was previously susceptible because it had high gain at DC. The modifications consisted mostly of special placement of bypass capacitors and radio-frequency chokes within the package. The packaged amplifier was found to operate stably, and to produce a gain of at least 7 dB while producing output power of at least 10 mW at frequencies from 80 to 150 GHz.

This work was done by Lorene Samoska, Sander Weinreb, and Alejandro Peralta of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
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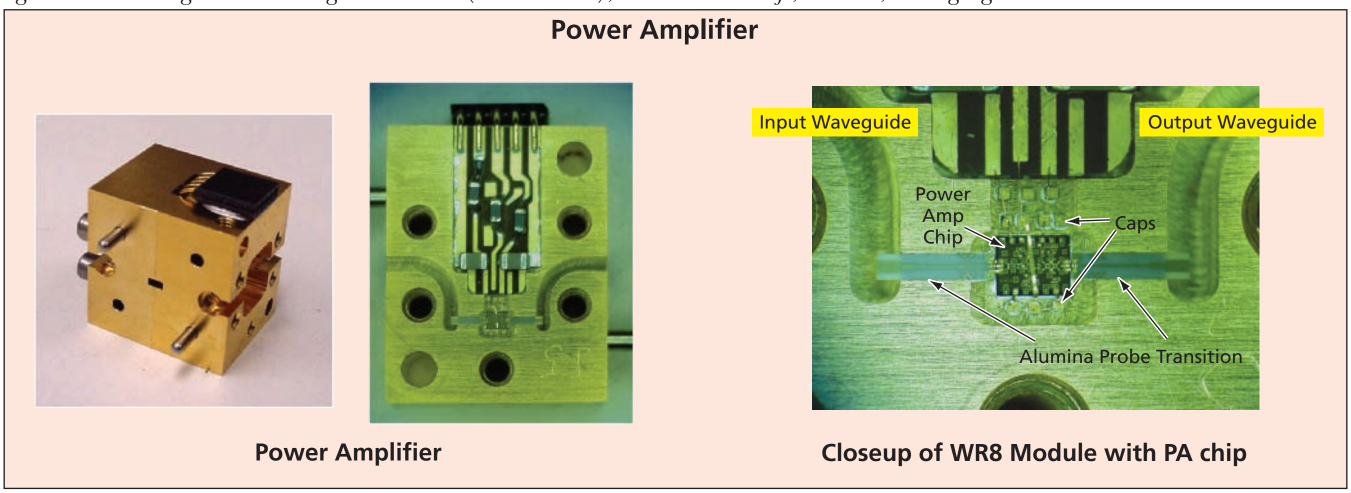


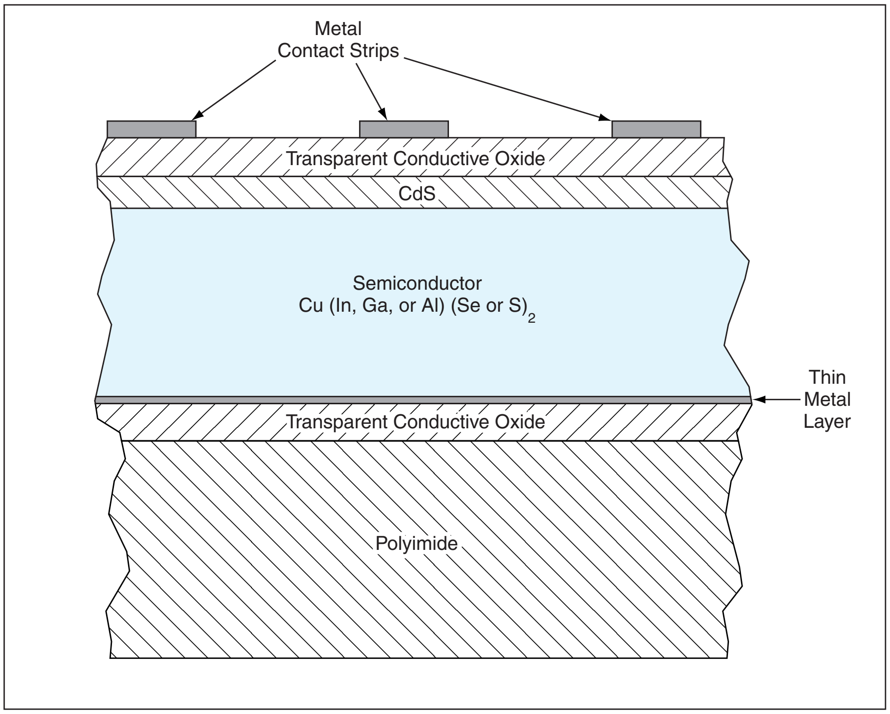
The **Amplifier Module** features a housing that is compatible with WR-8 waveguides. (Note: The largest dimension of the waveguide block is smaller than the size of a quarter.)

Better Back Contacts for Solar Cells on Flexible Substrates

Advantages are greater efficiency and tighter adhesion.

John H. Glenn Research Center, Cleveland, Ohio

Improved low-resistance, semitransparent back contacts, and a method of fabricating them, have been developed for solar photovoltaic cells that are made from thin films of I-III-VI_2 semiconductor materials on flexible, high-temperature-resistant polyimide substrates or superstrates. [The term "I-III-VI_2" is an abbreviated indication that the semiconductor materials are compounds of elements in periods IB, IIIA, and VIA of the periodic table in the stoichiometric ratio of 1:1:2.



The **Semitransparent Back Contact** in this device consists of the two layers between the polyimide and solar-absorber layers.

More specifically, these are compounds of general empirical formula Cu(In, Ga, or Al) (Se or S)$_2$.] The innovative aspect of the present development lies in the extension, to polyimide substrates or superstrates, of a similar prior development of improved low-resistance, semitransparent back contacts for I-III-VI$_2$ solar cells on glass substrates or superstrates. A cell incorporating this innovation can be used either as a stand-alone photovoltaic device or as part of a monolithic stack containing another photovoltaic device that utilizes light of longer wavelengths.

The figure depicts a generic device incorporating these innovations in the substrate configuration. The semitransparent back contact that is the main focus of this article consists of two layers: The first layer deposited on the substrate is a transparent, electrically conductive oxide (for example, ZnO, $InSnO_2$, or SnO_2). This layer acts mainly as a current collector. The second layer performs as contact interface layer capable of making good electrical contact with the solar-absorber material; this layer is deposited over the conducive oxide to a thickness of <40 Å.

A solar-absorber layer — a p-doped I-III-VI$_2$ semiconductor layer, possibly having an n-doped surface sublayer — is grown over the thin metal layer by co-evaporation or another suitable thin-film deposition technique. Next, a layer of CdS that serves as a window and/or a heterojunction partner with the I-III-VI$_2$ semiconductor is deposited on the semiconductor surface by a chemical-bath or other suitable technique that does not damage the semiconductor surface. Finally, another transparent, electrically conductive oxide layer (typically of $InSnO_2$) that is mostly transparent to the solar spectrum is deposited over the CdS.

The semitransparency of the back contact enables the cell to function whether illuminated from the front or the back surface. Also relative to the opaque back contacts of prior such cells, the semitransparent back contact enables this cell to operate at a lower temperature, and, consequently, with greater energy-conversion efficiency. During the course of development, it was discovered that the innovative semitransparent back contact increases the adhesion between the polyimide and the solar-absorber (I-III-VI$_2$ semiconductor) layer — an important advantage, inasmuch as adhesion between polyimide substrates and traditional opaque molybdenum back contacts had been found to be problematic.

This work was done by Lawrence M. Woods and Rosine M. Ribelin of ITN Energy Systems, Inc., for **Glenn Research Center**. *Further information is contained in a TSP (see page 1).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17376.

Tunable, Highly Stable Lasers for Coherent Lidar

Designs have been refined to satisfy competing requirements for stability and tenability.

Marshall Space Flight Center, Alabama

Practical space-based coherent laser radar systems envisioned for global winds measurement must be very efficient and must contend with unique problems associated with the large platform velocities that the instruments experience in orbit. To compensate for these large platform-induced Doppler shifts in space-based applications, agile-frequency offset-locking of two single-frequency Doppler reference lasers was thoroughly investigated. Such techniques involve actively locking a frequency-agile master oscillator (MO) source to a comparatively static local oscillator (LO) laser, and effectively producing an offset between MO (the lidar slave oscillator seed source, typically) and heterodyne signal receiver LO that lowers the bandwidth of the receiver data-collection system and permits use of very high-quantum-efficiency, reasonably-low-bandwidth heterodyne photoreceiver detectors and circuits. Similar techniques are being applied in atmospheric CO_2 differential-absorption lidar work, where MO sources need to be actively offset-locked to CO_2 reference cells for continuous absolute-calibration purposes. Active MO/LO offset-locking is also highly applicable to lidar problems involving