

SiC Optically Modulated Field-Effect Transistor

Such transistors could be useful as ultraviolet detectors.

John H. Glenn Research Center, Cleveland, Ohio

An optically modulated field-effect transistor (OFET) based on a silicon carbide junction field-effect transistor (JFET) is under study as, potentially, a prototype of devices that could be useful for detecting ultraviolet light. The SiC OFET is an experimental device that is one of several devices, including commercial and experimental photodiodes, that were initially evaluated as detectors of ultraviolet light from combustion and that could be incorporated into SiC integrated circuits to be designed to function as combustion sensors. The ultraviolet-detection sensitivity of the photodiodes was found to be less than desired, such that it would be necessary to process their outputs using high-gain amplification circuitry. On the other hand, in principle, the function of the OFET could be characterized as a combination of detection and amplification. In effect, its sensitivity

could be considerably greater than that of a photodiode, such that the need for amplification external to the photodetector could be reduced or eliminated.

The experimental SiC OFET was made by processes similar to JFET-fabrication processes developed at Glenn Research Center. The gate of the OFET is very long, wide, and thin, relative to the gates of typical prior SiC JFETs. Unlike in prior SiC FETs, the gate is almost completely transparent to near-ultraviolet and visible light. More specifically:

- The OFET includes a p⁺ gate layer less than 1/4 μm thick, through which photons can be transported efficiently to the p⁺/p body interface.
- The gate is relatively long and wide (about 0.5 by 0.5 mm), such that holes generated at the body interface form a depletion layer that modulates the conductivity of the channel between the drain and the source.

The exact physical mechanism of modulation of conductivity is a subject of continuing research. It is known that injection of minority charge carriers (in this case, holes) at the interface exerts a strong effect on the channel, resulting in amplification of the photon-detection signal. A family of operating curves characterizing the OFET can be generated in a series of measurements performed at different intensities of incident ultraviolet light.

This work was done by Massood Tabib-Azar of Case Western Reserve University 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, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18349-1

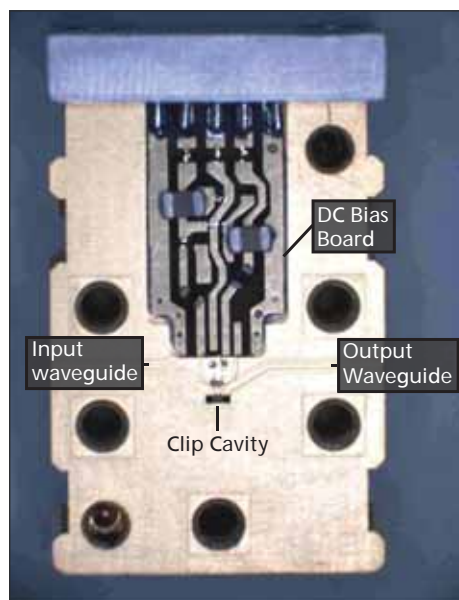
Submillimeter-Wave Amplifier Module With Integrated Waveguide Transitions

This technique can be used in submillimeter-wave imaging in homeland security, weapons detection, and commercial test equipment.

NASA's Jet Propulsion Laboratory, Pasadena, California

To increase the usefulness of monolithic millimeter-wave integrated circuit (MMIC) components at submillimeter-wave frequencies, a chip has been designed that incorporates two integrated, radial E-plane probes with an MMIC amplifier in between, thus creating a fully integrated waveguide module. The integrated amplifier chip has been fabricated in 35-nm gate length InP high-electron-mobility-transistor (HEMT) technology. The radial probes were mated to grounded coplanar waveguide input and output lines in the internal amplifier. The total length of the internal HEMT amplifier is 550 μm, while the total integrated chip length is 1,085 μm. The chip thickness is 50 μm with the chip width being 320 μm.

The internal MMIC amplifier is biased through wire-bond connections to the gates and drains of the chip. The chip has 3 stages, employing 35-nm gate length transistors in each



A photograph of the Split-Block Module, showing the input and output waveguide, chip cavity, and DC bias board.

stage. Wire bonds from the DC drain and gate pads are connected to off-chip shunt 51-pF capacitors, and additional off-chip capacitors and resistors are added to the gate and drain bias lines for low-frequency stability of the amplifier. Additionally, bond wires to the grounded coplanar waveguide pads at the RF input and output of the internal amplifier are added to ensure good ground connections to the waveguide package.

The S-parameters of the module, not corrected for input or output waveguide loss, are measured at the waveguide flange edges. The amplifier module has over 10 dB of gain from 290 to 330 GHz, with a peak gain of over 14 dB at 307 GHz. The WR2.2 waveguide cutoff is again observed at 268 GHz. The module is biased at a drain current of 27 mA, a drain voltage of 1.24 V, and a gate voltage of +0.21 V. Return loss of the module is very good between 5 to

25 dB. This result illustrates the usefulness of the integrated radial probe transition, and the wide (over 10-percent) bandwidth that one can expect for amplifier modules with integrated radial probes in the submillimeter-regime (>300 GHz).

This technology was developed for a submillimeter-wave imaging system under the DARPA SWIFT program, in collaboration with Northrop Grumman Corporation. Submillimeter-wave imaging has many applications to

homeland security, hidden weapons detection, airport security, detection of bio-weapons, as well as potential applications in commercial test equipment. This technology is partially a semiconductor chip product and partially a waveguide module. The semiconductor is not fixed in its final form, but the module is essentially fixed in its final form.

This work was done by Lorene Samoska, Goutam Chattopadhyay, David Pukala, Todd Gaier, Mary Soria, and King Man

Fung of Caltech and William Deal, Gerry Mei, Vesna Radisic, and Richard Lai of Northrop Grumman Corporation for NASA's Jet Propulsion Laboratory. The contributors would like to acknowledge the support of Dr. Mark Rosker and the Army Research Laboratory. This work was supported by the DARPA SWIFT Program and Army Research Laboratory under the DARPA MIPR no. 06-U037 and ARL Contract no. W911QX-06-C-0050. Further information is contained in a TSP (see page 1). NPO-45088

Metrology System for a Large, Somewhat Flexible Telescope

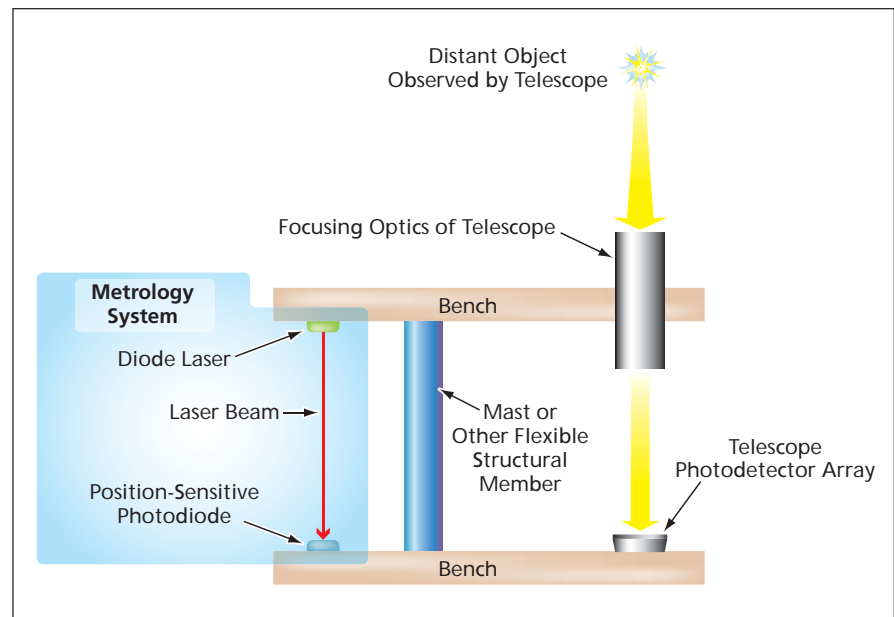
This system would measure focal-plane position errors caused by structural deformations.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed metrology system would be incorporated into a proposed telescope that would include focusing optics on a rigid bench connected via a deployable mast to another rigid bench holding a focal-plane array of photon counting photodetectors. Deformations of the deployable mast would give rise to optical misalignments that would alter the directions (and, hence, locations) of incidence of photons on the focal plane. The metrology system would measure the relative displacement of the focusing-optics bench and the focal-plane array bench. The measurement data would be used in post-processing of the digitized photodetector outputs to compensate for the mast-deformation-induced changes in the locations of incidence of photons on the focal plane, thereby making it possible to determine the original directions of incidence of photons with greater accuracy.

The proposed metrology system is designed specifically for the Nuclear Spectroscopic Telescope Array (NuSTAR) a proposed spaceborne x-ray telescope. The basic principles of design and operation are also applicable to other large, somewhat flexible telescopes, both terrestrial and spaceborne. In the NuSTAR, the structural member connecting the optical bench and the photodetector array would be a 10-m-long deployable mast, and there is a requirement to keep errors in measured directions of incidence of photons below 10 arc seconds (3 sigma).

The proposed system would include three diode lasers that would be mounted on the focusing-optics bench. For clarity, only one laser is



This Deformation of the Mast would change the position of incidence of the laser beam on the position-sensitive photodiode.

shown in the figure, which is a greatly simplified schematic diagram of the system. Each laser would be aimed at a position-sensitive photodiode that would be mounted on the detector bench alongside the aforementioned telescope photodetector array. The diode lasers would operate at a wavelength of 830 nm, each at a power of 200 mW. Each laser beam would be focused to a spot of ≈ 1 -mm diameter on the corresponding position-sensitive photodiode. To reduce the effect of sunlight on the measurements, a one-stage light baffle and an 830-nm transmission filter of 10-nm bandwidth would be placed in front of the posi-

sion-sensitive photodiode. For each metrology reading, the output of the position-sensitive detector would be sampled and digitized twice: once with the lasers turned on, then once with the lasers turned off. The data from these two sets of samples would be subtracted from each other to further reduce the effects of sun glints or other background light sources.

This work was done by Carl Christian Liebe, Randall Bartman, and Walter Cook of Caltech and William Craig of Lawrence Livermore National Laboratory for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-44119