



Figure 2. **Performance Characteristics:** (a) RF power emitted from solar powered radiating oscillator (the resolution bandwidth is 270 kHz) and (b) far field radiation pattern of solar powered radiating oscillator antenna.

tends between the drain and gate terminals of the transistor and includes a 1.2-pF capacitor that passes the oscillation signal while providing DC isolation between the drain and the gate.

A comparison between simulated and experimental performance data confirmed that the oscillation frequency is controlled mainly by the length of the feedback path. The RF signal radiated at the fundamental frequency from the solar powered antenna is shown in Figure 2(a). The magnetic field radiation pattern of the solar powered antenna is shown in Figure 2(b). The solar-powered oscillator antenna radiates a power of 1.8 mW at a frequency of about 11.2 GHz with a directivity of 5.25 relative to an isotropic radiation pattern. The power in the second harmonic at 22.4 GHz is 20 dB below the fundamental signal level. It has been found that a current of about 120 mA is needed to initiate oscillation, but thereafter the device

can continue to oscillate at a current <20 mA. One of the drawbacks of using commercial solar cells is its large size due to low efficiency. Ways to minimize solar-cell area could include: (1) powering the oscillator antenna from a rechargeable battery that would be recharged by a single, smaller solar cell, (2) the use of more-efficient solar cells, and/or (3) the use of a capacitor to supply the high current needed to start oscillation.

One notable advantage of using high-permittivity substrates is the inherent reduction in the sizes of resonant antenna elements. In addition to compactness, the designs of this oscillator antenna feature simple geometry, and the radiated power levels and radiation efficiency are comparable to those typical of oscillator antennas on lower-permittivity, thicker substrates.

Another motivation for the use of high-permittivity substrates is the prospect of developing solar oscillator array antenna

as fully integrated circuits. Some essential components of such a development have already been accomplished: High-mobility transistor structures are readily available on insulating substrates having dielectric properties similar to those of the microwave laminate material mentioned above. Dielectric substrate materials including gallium arsenide and sapphire that support high-frequency active electronic devices have relative permittivities between 10 and 14.

This work was done by Richard Q. Lee, Félix A. Miranda, Eric B. Clark, and David M. Wilt of Glenn Research Center and Carl H. Mueller, Carol L. Kory, and Kevin M. Lambert of Analex Corp. 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-18114-1.

Free-Space Optical Interconnect Employing VCSEL Diodes

These optical interconnects are applicable for large-capacity interconnection between information-processing equipment.

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Sensor signal processing is widely used on aircraft and spacecraft. The scheme employs multiple input/output nodes for data acquisition and CPU (central processing unit) nodes for data processing. To connect 110 nodes and CPU

nodes, scalable interconnections such as backplanes are desired because the number of nodes depends on requirements of each mission. An optical backplane consisting of vertical-cavity surface-emitting lasers (VCSELs), VCSEL

drivers, photodetectors, and transimpedance amplifiers is the preferred approach since it can handle several hundred megabits per second data throughput. Conventional electrical interconnects severely limit the perform-

ance of high-speed networks because of parasitic resistance and capacitance, which limit bandwidth and cause clock signals to skew. Moreover, they cause pin congestion and require large and bulky multi-pin connectors.

The next generation of satellite-borne systems will require transceivers and processors that can handle several Gb/s of data. These systems will significantly benefit from optical interconnect technology. This technique integrates laser diodes (LDs) and photodetectors (PDs) with RF/microwave electronic circuitry on a chip to form optical interconnects.

Optical interconnects have been praised for both their speed and functionality with hopes that light can relieve the electrical bottleneck predicted for the near future. High-speed, small-area metal-semiconductor-metal (MSM) photodetectors will allow dense photodetector arrays and provide added practicality to interconnects, without compromising overall performance. Optoelectronic intercon-

nects provide a factor of ten improvement over electrical interconnects.

Optical interconnect requires operation at high frequency with low RF/microwave losses at both the input and output end of the link while maintaining a large dynamic range. It is expected that VCSELs have higher reliability than edge-emitting laser diodes, as well as low power consumption, single-mode operation, and relative ease of fabrication while having very large bandwidths. In an interconnect circuit, laser diodes are directly intensity-modulated by the RF/microwave signals, and the photodetectors detect the received intensity-modulated signals.

For free-space optical interconnects, VCSEL diodes provide significant advantages over traditional edge-emitting laser diodes. Edge-emitting diodes must be cut and mounted after being fabricated, while VCSEL diodes can lase directly on the wafer. It is also possible to create arrays of VCSEL diodes directly on the

wafer, a virtual impossibility for the edge-emitting types. VCSEL diodes can be fabricated on the same wafer as the MSM photodetectors, increasing the functionality of an array of interconnects.

Optical interconnect technology has applications mainly in interchassis chip-to-chip interconnections. However, it can also find applications in intrachassis board-to-board for high-speed and EMI-free interconnections. Optical interconnects are also suited for large-capacity and high-density interconnection between information processing equipment.

This work was done by Rainee N. Simons, Gregory R. Savich, and Heidi Torres of 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-18444-1.