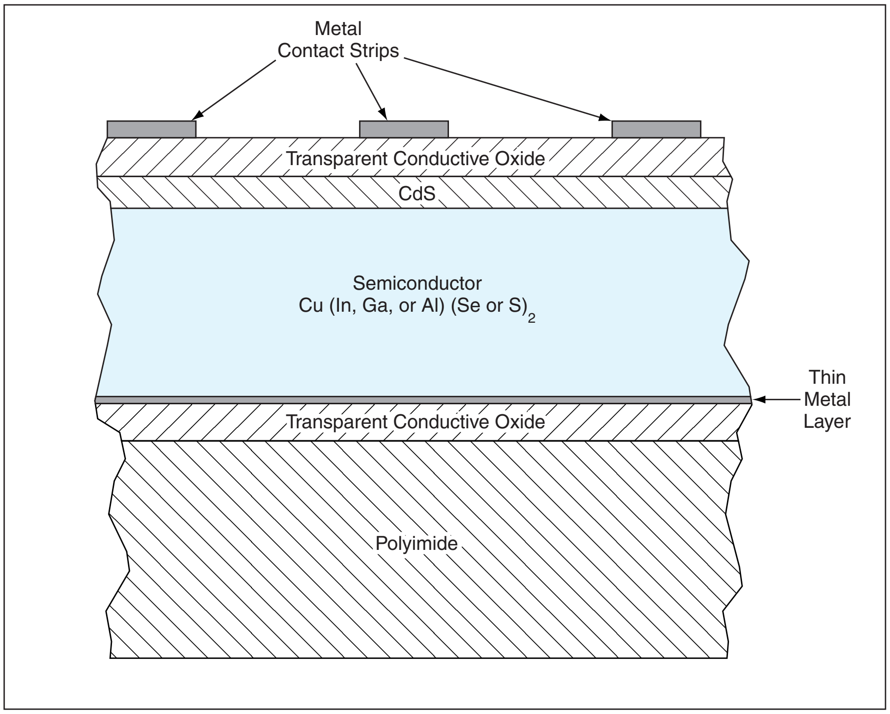

The **Semitransparent Back Contact** in this device consists of the two layers between the polyimide and solar-absorber layers.

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

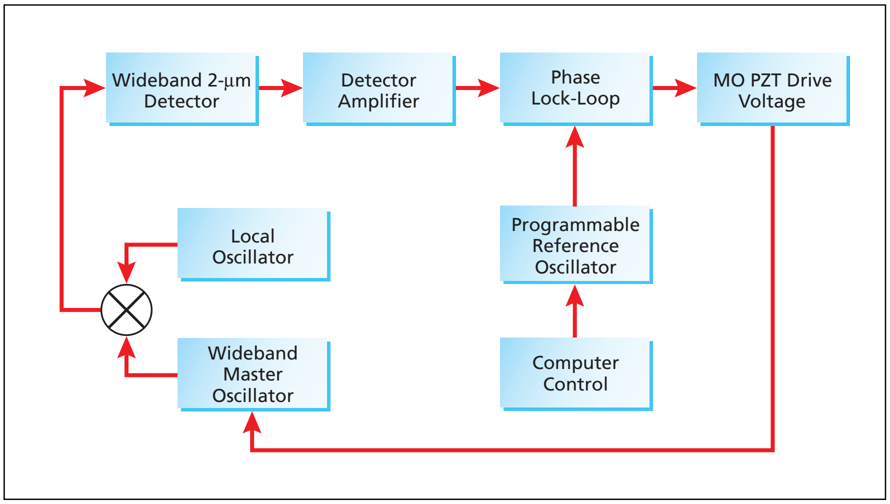

Figure 1. **Tm,Ho:YLF MO/LO Offset Locking System** incorporates the described improvements.

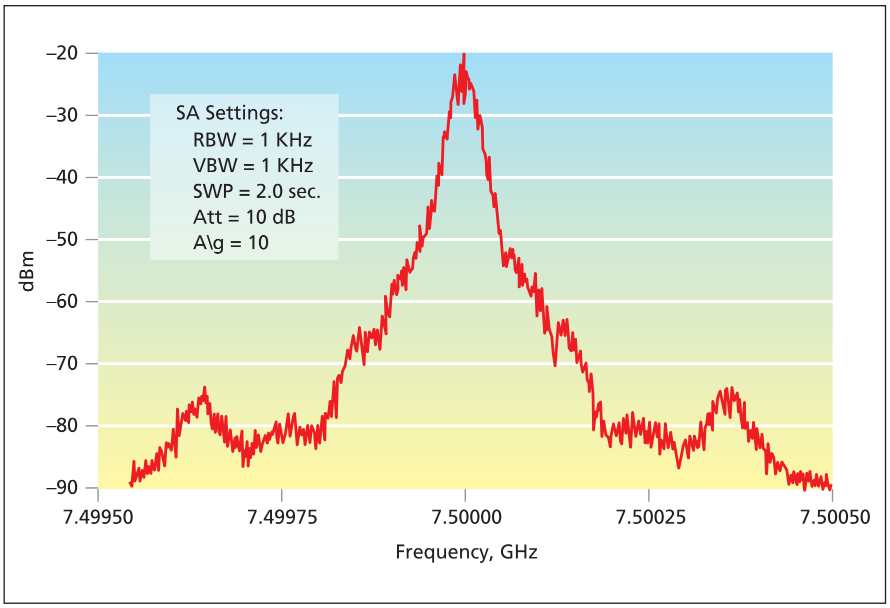

Figure 2. **Heterodyne Beat Note Stability** is depicted when Tm,Ho:YLF MO and LO lasers are actively offset-locked 7.5 GHz apart. Locking stability is ≈30 kHz over many seconds. [SA = signal analyzer; RBW = resolution bandwidth; VBW = video bandwidth; SWP = duration of frequency sweep; Att = attenuation; A\g = antenna gain.]

very high target velocities with respect to a static or moving lidar platform.

Efforts to date have focused on development of Tm,Ho:YLF lasers operating near 2.05 µm, which have much potential for both efficient space-based wind lidar systems and CO_2 DIAL measurements. The locking techniques are readily applicable to any number of other wavelengths and laser formats.

Recent work on MO/LO offset locking has focused on increasing the offset locking range, improving the graded-InGaAs photoreceiver performance, and advancing the maturity of the offset locking electronics. Figure 1 provides a schematic diagram of the offset-locking system. Improvements to the design of the tunable MO laser resonator resulted in continuous, fast, SLM piezo-tuning range of 25 GHz—more than double the range of the initial prototype. Major progress was also made in the performance of very wideband, 2-µm-sensitive heterodyne photoreceivers. The fiber-coupled, hybridized-preamplifier photoreceivers developed most recently exhibited heterodyne detection bandwidth of 4 GHz to the 3 dB point, and adequate bandwidth to demonstrate robust offset-locking to 10 GHz. This advanced component is now offered as a standard product. Remarkably, these very small (30-µm active area diameter), thin, fast PIN (positive/intrinsic/negative) devices exhibit ≈70 percent quantum efficiency to 4 GHz, adequate for direct use as a heterodyne receiver in many applications. With some degradation in locking robustness, MO/LO offsets of as much as 13.2 GHz were obtained. Settling times were typically 15 ms for 1 GHz steps, and locking stability was measured at 30 kHz over 20-s intervals. The system incorporated a LabVIEW-based GUI and robust auto-locking servo, greatly enhancing its usefulness in offset locking experiments and use as a wideband photoreceiver calibration instrument. Figure 2 shows a typical locking stability result.

This work was done by Sammy W. Henderson, Charley P. Hale, and David M. E'Epagnier of Coherent Technologies, Inc. for **Marshall Space Flight Center**. *For further information, contact Kent Blanchard at ctilidar.com or (303) 379-3264.*
MFS-31434

Optical Profilometers Using Adaptive Signal Processing

Sizes would be reduced, leading to development of hand-held profilometers.

John F. Kennedy Space Center, Florida

A method of adaptive signal processing has been proposed as the basis of a new generation of interferometric optical profilometers for measuring surfaces. Many current optical surface-measuring profilometers utilize white-light-interferometry and, because of optical and mechanical components essential to their operation, are comparable in size to desktop computers. In contrast, the proposed profilometers would be portable, hand-held units. Sizes could be thus reduced because the adaptive-signal-processing method would make it possible to substitute lower-power coherent light sources (e.g., laser diodes)