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

Efforts to date have focused on devel-
oping Tm,Ho:YLF lasers operating
near 2.05 µm, which have much poten-
tial for both efficient space-based wind
lidar systems and CO\textsubscript{2} DIAL measure-
ments. The locking techniques are read-
illy applicable to any number of other
wavelengths and laser formats.

Recent work on MO/LO offset lock-
ing has focused on increasing the off-
set locking range, improving the
graded-InGaAs photoreceiver per-
formance, and advancing the maturity
of the offset locking electronics. Fig-
ure 1 provides a schematic diagram of
the offset-locking system. Improv-
ements 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 hetero-
dyne photoreceivers. The fiber-cou-
pled, hybridized-preamplifier photo-
receivers developed most recently
exhibited heterodyne detection band-
width 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 diame-
ter), thin, fast PIN (positive/intrin-
sic/negative) devices exhibit
≈70 per-
cent quantum efficiency to 4 GHz,
adequate for direct use as a hetero-
dyne receiver in many applications.

With some degradation in locking ro-
busness, 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 meas-
ured at 30 kHz over 20-s intervals. The
system incorporated a LabVIEW-based
GUI and robust auto-locking servo,
greatly enhancing its usefulness in off-
set locking experiments and use as a
wideband photoreceiver calibration in-
strument. Figure 2 shows a typical
locking stability result.

This work was done by Sammy W. Hender-
son, Charley P. Hale, and David M. E’Epag-
nier of Coherent Technologies, Inc. for
Mar-
shall Space Flight Center. For further
information, contact Kent Blanchard at
cilidar.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 pro-
filometers for measuring surfaces. Many
current optical surface-measuring pro-
filometers utilize white-light-interferome-
try and, because of optical and mechanical
components essential to their operation,
are comparable in size to desktop comput-
ers. In contrast, the proposed profilome-
ters 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)
Improved Photon-Emission-Microscope System

An advanced photon-emission microscope is combined with the latest image-processing software.

NASA’s Jet Propulsion Laboratory, Pasadena, California

An improved photon-emission-microscope (PEM) instrumentation system has been developed for use in diagnosing failure conditions in semiconductor devices, including complex integrated circuits. This system is designed primarily to image areas that emit photons, at wavelengths from 400 to 1,100 nm, associated with device failures caused by leakage of electric current through SiO₂ and other dielectric materials used in multilayer semiconductor structures. In addition, the system is sensitive enough to image areas that emit photons during normal operation. This system supplements a prior PEM system based on a photon-intensified, gated, charge-coupled-device (CCD) camera.

This system includes an optical microscope fitted with a low-light-level imaging subsystem based on a state-of-the-art high-resolution (1,024 × 1,024 pixel), cooled, back-illumination CCD camera in a light-proof enclosure. Another major subsystem is a computer running the latest in Windows-based image-processing software, which can facilitate generation of test reports and research papers by putting out image files in popular formats, including tagged image file (TIF), bit map (BMP), and Joint Photographic Experts Group (JPEG) formats.

A device under test (DUT) is placed on a translation stage under the microscope. This stage enables movement of the DUT along both axes perpendicular to the optical axis, as well as along the optical axis for focusing. Any of several microscope objective lenses affording different magnifications (5x, 20x, 50x, and 100x with extra long working distance) can be selected. The exposure time is programmable between 5 milliseconds and 2 hours. Provisions for setups of external equipment, including the power supply for the DUT and digital multimeters, can be incorporated into custom software.

In operation, the system integrates the photons emitted from the DUT, and the resulting bright spots (showing the locations of substantial emission of photons) are displayed superimposed on an image of the DUT that was acquired previously under visible light. Failure-analysis engineers can use the information in this display to locate failure sites on the DUT.

This work was done by Duc Vu of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-42121

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A Simple Michelson Interferometer could constitute the optical subsystem of a profilometer, provided that the adjustable mirror were scanned and the output of the photodetector processed as described in the text.

for white light sources and would eliminate the need for most of the optical components of current white-light profilometers. Furthermore, whereas the height scanning ranges of current surface-measuring profilometers are of the order of millimeters, the adaptive-signal-processing method would make it possible to attain scanning ranges of the order of decimeters in the proposed profilometers.

The figure depicts the optical layout of a simple Michelson interferometer configured for use as a profilometer, according to the proposal, for measuring the deviation from flatness of a nominally flat surface that contains a pit. The pit can be characterized as comprising multiple facets at different depth, each producing a coherence function having signal intensity proportional to its size. As a result, the output of the photodetector in this interferometer would include a multitude of overlapping coherence functions that cannot be easily discriminated.

A complete overlapping-coherence-function profile of the surface area within the interrogating light beam would be collected by recording and processing the photodetector output as a function of height while scanning the adjustable mirror through the interrogation depth. The adjustable mirror could be mounted on a piezoelectric actuator for rapid scanning in height. Optionally, a digitally controlled micromirror device could also be used to scan the light beam laterally (horizontally in the figure) across the surface. Modern digital signal-processing hardware would be used to rapidly acquire and process the photodetector output and the overlapping coherence signals contained therein according to the adaptive method described below.

In this method, a Fourier transform of a synthetic intensity-versus-depth signal generated from a mathematical model of the surface to be measured would be subtracted from the Fourier transform of the intensity-versus-depth signal obtained by the interferometer scan of the surface to be measured. The result of the subtraction would be an error signal. The coefficients of the model, representing the sizes and depths of facets in the pit, would be adjusted to minimize the error signal. To obtain the coherence function needed for the model, it would be necessary to perform a calibration measurement, prior to operation, in which a reference mirror known to be optically smooth and flat would be substituted for the surface to be measured.

This work was done by Gregory A. Hall, Robert Youngquist, and Wasfy Mikhael of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-12647

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