

4:30pm - 4:45pm  
SCL11.4

Room A1

HIGH POWER EDGE-EMITTING LIGHT EMITTING DIODES AT 1.5  $\mu\text{m}$  WITH  
EXTREMELY LOW BACK FACET FEEDBACK

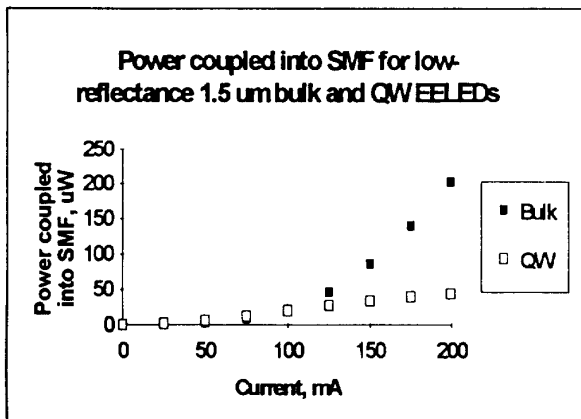
J.E. Fouquet, G.R. Trott, W.V. Sorin and M.J. Ludowise  
Hewlett-Packard Laboratories  
3500 Deer Creek Rd., Palo Alto, CA 94304

D.M. Braun and D.J. Derickson  
Microwave Technology Division, Hewlett-Packard Company  
1412 Fountaingrove Parkway, Santa Rosa, CA 95403

This paper describes novel semiconductor sources for optical low coherence reflectometry (OLCR), a measurement technique for characterizing device and fiber reflections with high sensitivity and high spatial resolution.<sup>1</sup> Lasers and conventional superluminescent LEDs are not suitable for OLCR because strong reflections from the back facets mask weak reflection signals from the device or fiber under test. Even standard EELEDs show significant reflections, which have limited the dynamic range of previous measurements. Low source output powers have also limited sensitivity. In order to obtain high power while minimizing internal reflections, a high single pass gain device is required. The record combination of high power and low internal reflections of the EELEDs reported here significantly expands the dynamic range and sensitivity of LED-based reflectometry at 1.5  $\mu\text{m}$ . This work also compares the characteristics of quantum well and bulk EELEDs.

InGaAsP EELEDs were fabricated using a semi-insulating planar buried heterostructure process<sup>2</sup> with a single regrowth. Both full 1.5  $\mu\text{m}$ -emitting quantum well separate confinement heterostructures and bulk device structures were grown by metalorganic chemical vapor deposition. Mesas were etched down to the  $n$  InP lower cladding layer. Semi-insulating InP:Fe was regrown to provide current and optical confinement. Separate contacts over the continuous waveguide allow independent biasing of a gain region near the output facet and a back absorber. To achieve high single-pass gain, a long (800  $\mu\text{m}$ ) gain contact was used.

The EELEDs were mounted on heatsinks and the front facets were anti-reflection coated. Reverse biasing the back absorber contacts reduced the effective bandgap through the quantum confined Stark effect in the quantum well devices and the Franz-Keldysh effect in the bulk devices. We have previously used a similar approach to reduce back facet reflections to 85 dB below the device output level in a quantum well EELED at 1.3  $\mu\text{m}$ .<sup>3</sup>

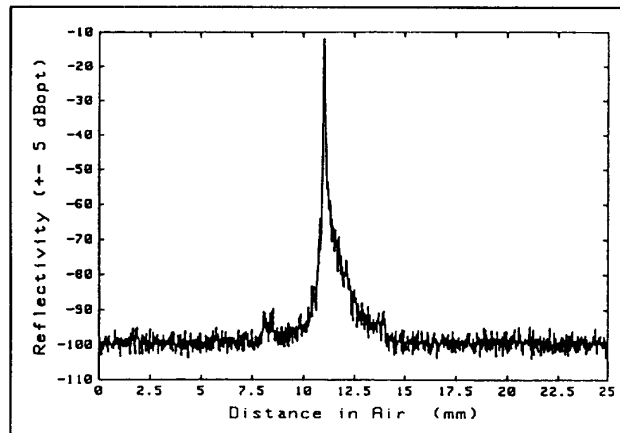


Power coupled into a single mode fiber (SMF) was measured as a function of gain contact current for the quantum well and bulk devices. The quantum well EELED had higher output power at currents below 70 mA; the bulk EELED achieved over 200  $\mu\text{W}$  at 200 mA current, compared to 44  $\mu\text{W}$  for the quantum well device during room temperature operation. At a heatsink temperature of 0  $^{\circ}\text{C}$ ,

0.95 mW of power with a smooth spectrum was coupled into single mode fiber from the same bulk device at 200 mA.

Reflections were measured using the EELED (nominally at room temperature) as an OLCR source and a mirror in the position of the device under test. At 200 mA, all internal reflection sidelobes from the quantum well device are more than 80 dB below the reference signal (coherence spike of EELED in reflectometer using mirror as device under test), as shown in the figure. Measurements can now be made with a dynamic range of 80 dB, more than 30 dB greater than in previous measurements.

At 200 mA the bulk device exhibits backscatter sidelobes 50-55 dB below the reference signal. These sidelobes originate in the active region and are amplified by the high gain. They can be reduced to 80 dB below the reference signal at lower gain (lower current), but at the cost of reducing the output power to a level comparable to the quantum well device. Still, the power-reflection performance of both devices in OLCR far exceeds that of any other semiconductor LEDs we have observed.



1. R.C. Youngquist, S. Carr and D.E.N. Davies, *Opt. Lett.*, **12**, p. 158, 1987.
2. B.I. Miller, U. Koren and R.J. Capik, *Elec. Lett.*, **22**, p. 947, 1986.
3. J.E. Fouquet, W.V. Sorin, G.R. Trott, M.J. Ludowise and D.M. Braun, *Phot. Tech. Lett.*, **5**, p. 509, 1993.