Crosstalk is achieved despite the small size of the package and electronic functionality.

In future WDM-based systems, and that their availability

Acknowledgments: The authors wish to thank M. J. Robertson and H. J. Wickes for the laser arrays and J. V. Collins, A. P. McDona, K. Raffell and L. Johnston for laser bonding and hybrid assembly.

Fig. 3 Optical spectrum

Fig. 4 Eye diagram of modulated output at 2.5 Gbit/s

Areas. Thermal crosstalk, whereby the wavelength of one laser is affected by the current flowing in its neighbours, is dependent on the spacing between adjacent lasers and the effectiveness of the heatsinking under the laser array. We measured less than 0.1 nm of wavelength change when current in an adjacent laser was changed by 80 mA. Electrical crosstalk was minimised by careful design and layout, and was measured to be better than 20 dB at 2.5 Gbit/s.

Conclusion: We have demonstrated a high performance multiple wavelength laser transmitter which operates in the 1550 nm erbium fibre amplifier window at four wavelengths spaced by 4 nm. The compact 50 x 30 x 15 mm3 transmitter package includes an array of four DFB lasers, hybrid microoptics for efficient coupling into a singlemode output fibre, ECL-level compatible drive circuitry and a thermoelectric cooler for temperature stabilisation over a range of ambient temperatures.

The transmitter launches +5 dBm total (-1 dBm per laser) into a singlemode output fibre and provides independent 2.5 Gbit/s operation of each channel. Channel wavelengths are within ±0.3 nm of target, and very low thermal and electrical crosstalk is achieved despite the small size of the package and the close proximity of the lasers in the array.

We believe that this work has shown that it is feasible to consider the use of highly functional components of this type in future WDM-based systems, and that their availability could greatly improve the practicability of such systems.

Possible future developments include increasing the number of channels, incorporating multicontact lasers for even more precise wavelength control and the inclusion of additional electronic functionality.

Acknowledgments: The authors wish to thank M. J. Robertson and H. J. Wickes for the laser arrays and J. V. Collins, A. P.

Table 1 SUMMARY OF OPTICAL PERFORMANCE

<table>
<thead>
<tr>
<th>Optical performance</th>
<th>Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak output level (dBm)</td>
<td>1</td>
</tr>
<tr>
<td>Mean output level (dBm)</td>
<td>2</td>
</tr>
<tr>
<td>Wavelength (nm)</td>
<td>1548.8</td>
</tr>
<tr>
<td>Wavelength offset</td>
<td>0.2</td>
</tr>
</tbody>
</table>

References


CURRENT-MODE MULTIVALUED DYNAMIC MOS MEMORY WITH ERROR CORRECTION

E. K. F. Lee and P. G. Gulak

Introduction: A multivalued memory cell is a useful building block for multivalued logic applications and analogue computational networks, especially, for example, in neural networks

Recently developed voltage-mode multivalued memories appear suitable for these applications [7]. In addition, static current-mode multivalued memories have also been developed for multivalued logic applications [4]. In this Letter, a dynamic current-mode multivalued memory is proposed, which can support a larger number of storage levels than a static current-mode memory at the expense of longer refresh rate. Nevertheless, the soft error rate can be improved by a simple error correction technique. The storage element of a current-mode multivalued memory is a current copier [5], which can store discrete current values.

Analogous to the conventional binary DRAM, the stored values in a multivalued memory system have to be refreshed periodically and restored periodically and restored after the read operation. The refresh circuitry for multivalued memories consists of a quantiser that is replaced by an A/D convertor followed by a D/A convertor. When the current copier is selected for refresh, the current-mode A/D convertor will quantise the stored value and then load the quantised value back to the current copier through the D/A convertor. Different types of multivalued memory design can be developed using different types of quantisation technique. For storing large discrete levels, the single slope A/D technique is chosen to reduce the circuit complexity at the expense of long conversion time.
Because the number of stored levels for multivalued memories is inherently larger, it may have poor noise immunity and, hence, large soft error rate. The noise margin can be increased with a simple error correction technique [6], which requires storing and comparing the least significant bits (LSBs) from the A/D conversion of the stored level.

The refresh circuit with 1 LSB error correction consists of five basic building blocks: current comparator, quantised-level generator (QLG), 1 bit counter, phase detector and exclusive-or gate for comparing the LSBs. The schematic diagram of the memory cell and the refresh circuit is shown in Fig. 1. The current comparator consists of three current mirrors as described in Reference 4. The QLG is required for the single slope A/D technique and is realised as follows. When φ1 is on, the reference current Iref is loaded into current copier 2 while Y is on. The current copiers are capable of sinking or sourcing the resulting current Iref to the loads during φ1 or R, where Iref = Iref(n - 1) in current copier 2 are added and loaded into current copier 1. The resulting current Iref is loaded into current copier 2 while Y is on. The current copiers are capable of sinking or sourcing the resulting current Iref to the loads during φ1 or R, where Iref = Iref(n - 1) in current copier 2 are added and loaded into current copier 1. The QLG is reset when H is low. The 1 bit coupler is used to generate the LSB.

When a value is written (as controlled by W) to the memory cell, the LSB bit is also loaded to the latch of the memory cell. The refresh circuit is controlled by a set of four clock signals, X, Y, φ1 and φ2. The signal H defines the time for each A/D conversion and the number of storage levels. When H and φ1 go high (refer to Fig. 2), Iref and the current stored in current copier 2 are added and loaded into current copier 1. The resulting current Iref is compared with the current output Iref from the memory cell during φ2. At the same time, the value of the 1 bit counter representing the LSB of the quantised value will be compared with the value of the 1 bit latch using an exclusive-or gate, which determines the value of X (either equal to φ2 or φ2). When Iref is larger than Iref, the comparator output at C will go high and trigger the phase detector by pulling up input D. If the value of the latch is the same as the value of the counter (no error), Iref will be loaded into current copier 2 at φ2 and the phase detector will generate the refresh signal R at φ2. The memory cell will be refreshed with Iref. If the value of the latch is not equal to the value of the counter (an error), the phase detector will generate the refresh signal R at φ2 and the current stored (equal to Iref(n - 1)) in current copier 2 will be written into the memory cell. The noise margin of the stored current values, therefore, increases to two quantised levels. The stored value of the current copier is measured using a current mirror and the desired storage value is 17.6 μA as defined by the amplitude of the second pulse from the QLG. The dashed line represents the stored value with a value lower than the desired value. The values of the counter and the latch are the same (no error) during quantisation. The solid line represents the stored value, which is larger than the desired value. Therefore, the value of the counter and the latch will be different (an error). The stored values for both cases of error and no error will be refreshed to a value that is slightly different from the desired value (by 1.9 μA, which is less than the quantisation interval) owing to charge injection of the switches.

Conclusion: A current-mode dynamic multivalued memory is presented that is based on current copier and single slope A/D techniques. An error correction technique is used to increase the noise immunity of the stored value by storing and comparing the LSBs of the stored value. With this error correction technique, the period between refresh can be increased allowing a system designer to multiplex many memory cells (current copiers) to one refresh circuit. In addition, the number of storage levels can be increased for a given noise margin.
RELIABLE HIGH-POWER (40mW) OPERATION OF TRANSVERSE-MODE STABILISED InGaAlP LASER DIODES WITH STRAINED ACTIVE LAYER

K. Nitta, M. Okajima, Y. Nishikawa, K. Itaya and G. Hatakoshi

Indexed terms: Lasers, Semiconductor lasers

Reliable high-power operation of transverse-mode stabilised InGaAlP laser diodes has been achieved by using a selectively-buried-ridge waveguide structure with a very thin (150Å) active layer. A strained In$_{0.47}$Ga$_{0.53}$P active layer and a 800µm cavity length were employed to reduce the operation current density at high-power and high-temperature operation. A highly reliable operation for over 2000h has been achieved with a 40mW output at 40°C. The lifetime of the lasers was limited by the operation current density.

High-power transverse-mode stabilised InGaAlP laser diodes [1-3] are key components in applications relating to optical information processing systems, such as optical disc file equipment and high-speed laser beam printers. High-power operation of transverse-mode stabilised InGaAlP laser diodes has been realised using a selectively-buried-ridge waveguide (SBR) structure [1] and a heterobarrier blocking (HBB) structure [3] with a thin active layer lattice matched to the GaAs substrate. However, such a thin active layer leads to carrier overflow from the active layer into the p-cladding layer, resulting in the deterioration of the temperature characteristics.

Recently, high-power InGaAlP SBR lasers operating at high temperature have been realised by using a strained thin active layer and a highly doped p-cladding layer [4, 5]. The use of a composition-shifted In$_{0.47}$Ga$_{0.53}$P (Δn/m = +1%) active layer with a smaller bandgap energy than that of a lattice-matched In$_{0.47}$Ga$_{0.53}$P has remarkably improved the temperature characteristics owing to the large bandgap difference between the active and cladding layers. A highly doped p-cladding layer also increases the conduction-band heterobarrier height at the interface of the active layer and the p-cladding layer [6], because the Fermi level of the p-type cladding layer lies a short distance down from the top of the valence band, and also because the bandgap itself becomes large by the atomic disordering formation effect [7]. A strained active layer and a highly doped p-cladding layer thus have a great effect in reducing the carrier overflow from the active layer to the p-cladding layer. The authors have introduced a longer cavity to reduce the threshold current density and thermal resistance. High-power operation at a high temperature has been realised by these methods.

This Letter reports highly reliable operation exceeding 2000h for a 40mW output at 40°C for transverse-mode stabilised InGaAlP laser diodes with a thin (150Å) In$_{0.47}$Ga$_{0.53}$P active layer and a 800µm cavity length.

The laser structure was grown by low-pressure metalorganic chemical vapour deposition (MOCVD). The double heterostructure consisted of an Si-doped n-In$_{0.47}$Ga$_{0.53}$As$_{0.5}$P$_{0.5}$ cladding layer (n = 3 × 10$^{17}$ cm$^{-3}$), a 150Å strained (Δn/a = +1%) In$_{0.47}$Ga$_{0.53}$P active layer, and a Zn-doped p-In$_{0.47}$Ga$_{0.53}$As$_{0.5}$P$_{0.5}$ cladding layer (p = 7 × 10$^{17}$ cm$^{-3}$). The stripe width was 5µm. The SBR laser structure diode lasers were fabricated in the same way as described before [7]. An antireflection (10%) coating of Al$_2$O$_3$ and a high-reflection (90%) coating made of Al$_2$O$_3$/Si multilayers were formed on the front and rear facets, respectively, by RF sputtering. The use of the antireflection coating on the front facet is effective in reducing the optical power density. However, this facet reflectivity reduction causes a threshold current increase. This asymmetric coating was made so as not to change the threshold current between uncoated and asymmetrically coated lasers [8]. Laser chips were mounted on Cu heatsinks in a p-side-down configuration. The resulting lasers operated with a continuous wave (CW) at 698 nm with a threshold current of 60mA and a slope efficiency of 0.9 W/A. The characteristic temperature of the laser diodes was 30-50°C. The maximum output power of 126mW was limited by catastrophic optical damage (COD).

Fig. 1 shows the aging characteristics of the strained SBR laser with a 800µm cavity length. The lasers had been operating stably for over 4000h. The output power was 30mW and the ambient temperatures were 30-50°C. As shown in this Figure, no marked increase in the operation current was observed. The operation current increase after 4000h operation was less than 6mA, which is equivalent to a 1-Ω/kh degradation rate. This result indicates that 30mW output power class InGaAlP visible-light laser diodes will become practically usable devices.

Fig. 2 shows the aging characteristics for the strained SBR lasers with 800µm cavity under 40mW output power at 30-40°C. The lasers exhibited stable operation over 2000h. This high reliability is considered to be the effect of the high maximum output power of more than 100mW and that of the good temperature characteristics due to the use of a thin (150Å) active layer and of a long (800µm) cavity.