All Optical Synchronisation with Frequency Division using a Self Pulsating Laser Diode

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Acknowledgments: We gratefully acknowledge stimulating discussions with G. L. Walker, A. E. White, M. A. Pollack, J. Stone, P. D. Magill and T. L. Koch.

15th May 1992

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References


10. OKAMURA, K., IWATYUKI, K., and OKAMURA, T.: 'An all-optical clock distribution with all-optical frequency division and multiplication of the distributed clock. To achieve this a master optical clock is distributed to two slave lasers. One slave laser divides the frequency of the optical clock by a fixed value of two and the other slave laser is used to multiply the optical clock frequency by two. In addition we demonstrate that by DC control of the absorber of the slave laser the division/multiplication ratio can be varied.

Experimental setup: Fig. 1 shows the experimental setup for optical clock distribution. In this experiment a master optical clock is distributed to two slave lasers. The source of optical clock signals is a tunable grating external cavity laser which is modelocked by an RF signal from a frequency synthesizer. The grating laser is operated at a bias current of 21.4 mA modulated at 541.7 MHz at +22 dBm. The pulse width measured on a 20 GHz photodiode was less than 120 ps.

This master clock is distributed to the two slave lasers using single-mode fibre and two outputs of a four output fibre splitter. Each of the slave lasers A and B shown in Fig. 1 is a twin section InGaAsP BH device with a length of 500 μm and a 4:1 gain to absorber section length ratio. The slave lasers are operated within their selfpulsation regime, described previously [6]. The outputs of the slave lasers are monitored on an avalanche photodiode with a bandwidth greater than 1 GHz. All of the lasers in the system setup were temperature controlled to within ±0.1°C.

Operation: The master laser operates at 541.7 MHz with an average output power of 172 μW at a wavelength of approximately 1612.8 nm. This master signal is shown in Fig. 2a, where the pulse duration shown is limited by the bandwidth of the avalanche photodiode used. With the master optical clock blocked the selfpulsation frequency of slave laser A is set to just below 270 MHz using an absorber voltage of 0.250 V. The frequency of slave laser B is set to just below 1083 MHz using an absorber voltage of 0.366 V. The gain section current of both slave lasers is set to 90 mA.

The master optical clock is then used to injection lock both slave lasers. Synchronisation also occurs and in the case of slave laser A the selfpulsation frequency changes to exactly 270.85 MHz providing frequency division by two. For slave laser B the frequency changes to exactly 1083.4 MHz when synchronisation occurs providing frequency multiplication by two. The outputs of slave lasers A and B are shown in Fig. 2b and c, respectively. In both cases the oscilloscope is triggered by a signal from the frequency synthesizer, demonstrating that synchronisation takes place in time. The degree of synchronisation can also be checked using a spectrum analyser.
reported previously [4]. The noise floor relative to the peak level of the synchronised fundamental component of the self-pulsating laser output is greater than 38dB for both slave lasers.

It is also possible under DC absorber control to vary the multiplication and division ratio of the synchronised slave clock. This is achieved by changing only the DC absorber voltage. The results for slave laser B are shown in the Table 1. As the absorber voltage is increased, synchronisation occurs between different harmonics of the master signal and the self-pulsation signal. This changes the multiplication-division ratio. In Table 1, the third entry corresponding to an output frequency of 812.55 MHz represents multiplication by a rational fraction, in this case 3/2.

The average injection power into the slave lasers required for synchronisation is approximately 3 μW in each case. Given this low power level a fanout in excess of 50 is possible for an average mode locked laser power of 172 pW. Furthermore the self-pulsating laser also provides a net optical power gain which will make subsequent electronic processing easier. For example when slave laser B is synchronised the average output power is 240 μW, a net gain of 19 dB.

Conclusion: We have demonstrated for the first time all-optical clock distribution with all-optical frequency division and multiplication using selfpulsating twin section laser diodes with a high fanout value. It is also possible to vary the multiplication-division ratio using DC control only. The self-pulsating lasers also provide optical gain. This technique will be useful in systems where a single master clock must be distributed to a number of slave systems, but where each system requires a synchronous clock of a different frequency.

Acknowledgment: The authors would like to thank M. J. Robertson of British Telecom Laboratories for providing the lasers used in this work and T. Murphy of Aster Ireland for providing the unitary coupler.


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References


InAIAs/InGaAs HETEROJUNCTION BIPOLAR TRANSISTORS WITH AlAs ETCH-STOP LAYER


Indexing terms: Bipolar device, Transistors, Semiconductor devices and materials

A seven monolayer AlAs layer was used as an etch stop at the emitter-base heterojunction of an NPN In0.53Al0.47As/In0.53Ga0.47As HBT. The etch-stop HBTs displayed higher DC gain and similar microwave performance when compared to devices without the AlAs layer.

Introduction: Heterojunction bipolar transistors (HBTs), lattice matched to InP, continue to show promise as highperformance devices for analogue, digital, and optoelectronic applications [1]. Thin InGaAs base layers are exploited to reduce transit times and increase operating frequencies [2, 3]. However, exposing a thin InGaAs base beneath an InAlAs emitter is a processing challenge because selective wet chemical etchants, permitting the removal of InAlAs without penetration into the underlying InGaAs, are not available. Recently, Broekaert and Forstät [4] used a succinic acid, hydrogen peroxide, and ammonium hydroxide (SA) solution for selective etching of both InGaAs and InAlAs over thin (3–10 monolayer) AlAs layers. In this work, we report the application of the AlAs etch stop to InAlAs/InGaAs HBTs. A seven monolayer AlAs layer was placed between an InAlAs

Fig. 2 Oscillograph showing frequency division and multiplication of master clock

Fig. 2 Oscillograph showing frequency division and multiplication of master clock

a Grating external cavity LD output: master clock signal
b Slave LD A output: master clock frequency divided by 2
c Slave LD B output: master clock frequency multiplied by 2

Table 1 ABSORBER DC VOLTAGE CONTROL OF MULTIPLICATION-DIVISION RATIO

<table>
<thead>
<tr>
<th>Absorber voltage</th>
<th>Synchronised selfpulsation frequency</th>
<th>Multiplication-division ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>MHz</td>
<td>1:2</td>
</tr>
<tr>
<td>0.292</td>
<td>270.85</td>
<td></td>
</tr>
<tr>
<td>0.317</td>
<td>541.70</td>
<td>1:1</td>
</tr>
<tr>
<td>0.340</td>
<td>812.55</td>
<td>3:2</td>
</tr>
<tr>
<td>0.366</td>
<td>1083.40</td>
<td>2:1</td>
</tr>
</tbody>
</table>

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ELECTRONICS LETTERS 16th July 1992 Vol. 28 No. 15