A 23785/AU

CONVENTION APPLICATION BY A COMPANY

FORM 8 – REGULATION 12 (2)

AUSTRALIA
PATENTS ACT 1952

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT

(a) Here insert (in full) Name of Company.

In support of the Convention Application made by
(a) BRITISH TELECOMMUNICATIONS public limited company

(b) Here insert Title of Invention.

(hereinafter referred to as "Applicant") for a patent for an invention entitled:
(b) POLARISATION SWITCHING IN ACTIVE DEVICES

(c) and (d) Here insert Full Name and Address of Company Official authorised to make declaration.

I, (c) FREDERICK JAMES BISCOE, a person authorised by
of (d) BRITISH TELECOMMUNICATIONS public limited company
81 NEWGATE STREET, LONDON, EC1A 7AJ, ENGLAND.

do solemnly and sincerely declare as follows:

1. I am authorised by Applicant to make this declaration on its behalf.

(e) Here insert Basic Country followed by date of Basic Application.

(f) Here insert Full Name(s) of Applicant(s) in Basic Country.

2. The basic Application(s) as defined by section 141 of the Act was / were made
in (e) GREAT BRITAIN on the 9 day of MARCH 19 88
by (f) BRITISH TELECOMMUNICATIONS public limited company
in .... on the .... day of 19
by ....
in .... on the .... day of 19
by ....
in .... on the .... day of 19
by ....

(g) Here insert (in full) Name and Address of actual Inventor or Inventors.

3. (g) IAN HUGH WHITE
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CAMBRIDGE
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VICARS CROSS
CHESTER, CHESHIRE
CH3 5HN
ENGLAND.

is/are the actual Inventor(s) of the invention and the facts upon which Applicant is entitled to make the Application are as follows:

See reverse side of this form for guidance in completing this part.

Applicant is the Assignee of the said inventor(s).

4. The basic Application(s) referred to in paragraph 2 of this Declaration was/were the first Application(s) made in a Convention country in respect of the invention, the subject of the Application.

DECLARED at London, England
this 1 day of September 19 89

(h) Personal Signature

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POLARISATION SWITCHING IN ACTIVE DEVICES

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(56) Prior Art Documents
US 4685108
US 4612645

(57) Claim

1. A bistable polarisation source comprising a semiconductor injection laser capable of providing optical gain in two distinguishable waveguiding paths, the waveguding paths extending substantially parallel to one another at a small enough separation to enable the fields of optical radiation in the two paths to overlap, the laser being switchable between first and second states in which the direct optical output of the laser is predominantly TE polarised and predominantly TM polarised respectively.

15. An optical clock arrangement for providing a regular stream of optical pulses comprising: laser means capable of providing optical gain in two distinguishable waveguiding paths, the waveguiding paths extending substantially parallel to one another at a small enough separation to enable the fields of

.../2

optical radiation in the two paths to overlap, the laser means being switchable between first and second states in which the direct optical output of the laser is predominantly TE polarized and predominantly TM polarized respectively; feedback means providing an optical path by means of which an optical output from the laser means may be fed back into the laser means; and polarization modifying means in said optical path providing a substantially orthogonal polarization shift in said fed back optical output.

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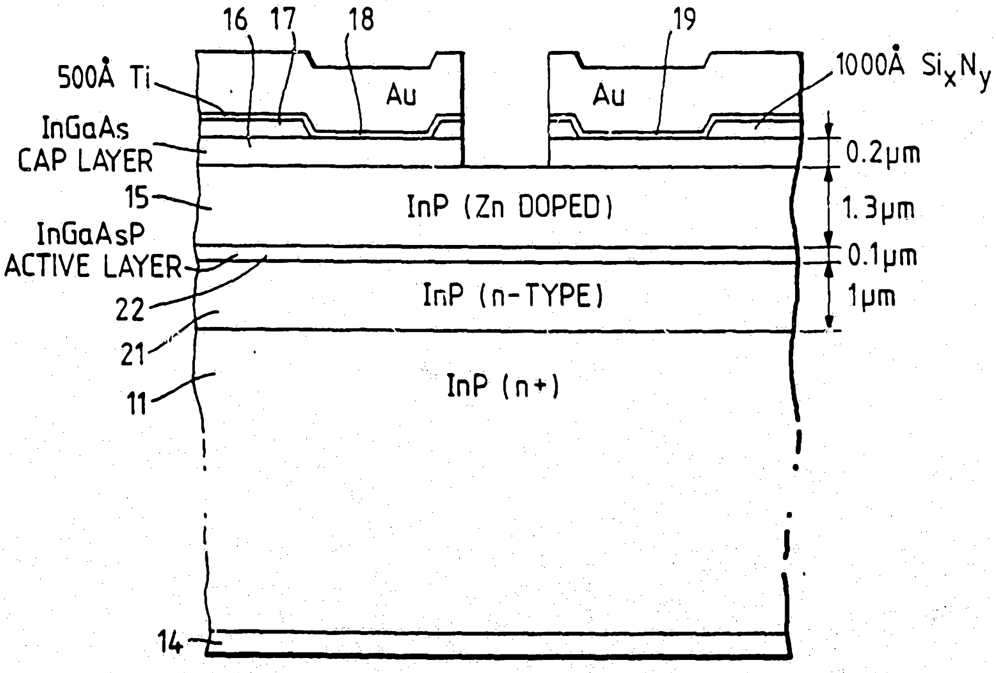


(57) Abstract

The output polarisation of a twin guide semiconductor laser is switched either by controlling the operating current of both guides or by injecting an optical signal. Twin-stripe and twin-ridge lasers of InGaAsP are described. True polarisation bistability is reported for a range of devices; the effect is temperature insensitive.

POLARISATION SWITCHING IN ACTIVE DEVICES

The present invention relates to the controlled switching of polarisation states in the optical output of a semiconductor optical device.

The radiation used in optical communications is not necessarily in the visible part of the electromagnetic spectrum and the words "optical" and "light" when used in this specification are not to be interpreted as implying any such limitation. For example, longer wavelengths are preferred for transmission through silica optical fibres because the loss minima occur in such fibres in the infra-red region, at 1.3μm and 1.55μm approximately.

Electronically controlled polarisation modulators or switches are important components for high-speed optical communications and data transmission systems. Currently bulk and waveguide polarisation switches based on the use of the electro-optic effect are the most commonly used passive devices.

Polarisation bistability in semiconductor lasers shows promise for use in all-optical signal processing systems, in routing systems and in optical computing and has aroused much interest. Polarisation bistability arises from the ability of certain types of diode laser to emit light with either its transverse electric field polarised parallel to the junction plane (TE) or with its transverse magnetic field polarised parallel to the junction plane (TM), depending on relative mode losses determined by the device structure. In most semiconductor diode lasers, the TE mode sees a higher reflectivity at the facets than the TM mode, resulting in predominantly TE polarised light output. However, polarisation switching has been achieved by varying the relative TE-TM mode cavity losses, for example by generating stress inside the active region through the application of external pressure. Y C Chen and J M Liu have reported (Applied Physics Letters, Volume 45, Number 6, 15 September 1984, Pages 604 to 606) polarisation switching in InGaAsP/InP buried heterostructure lasers operating near their polarisation transition temperature of -68^{o}C. Chen and Liu report that polarisation switching of the laser output is achieved by a relative change in the net gain of the TM and TE modes through a small perturbation (of the order of 1^{o}C) of the junction temperature induced by the injection current. Although Chen and Liu suggest that with sufficient internal strain in the device's active layer the polarisation transition occurs at room temperature, and indicate that for InGaAsP/InP lasers the strain can be created easily by introducing a small amount (of the order of 10^{-4}) of lattice mismatch between the InGaAsP active layer and the InP cladding layers and InP substrate, neither they nor anyone else appear to have been able to achieve such current driven polarisation switching at room temperature.

Polarisation switching has also been induced by the injection of TM polarised light from a master laser into a TE-emitting slave laser causing the latter to switch to a TM-emitting state, but switch-back and locking of the TE mode have not been observed (A Sapia, P Spano. and B Daino, Applied Physics Letters, Vol 50, No 2, 12 January 1987, Pages 57 - 59).

Mori, Shibtat and Kajiwara of Matsushita have reported (extended abstracts of 18th, 1986, International conference on solid state devices and materials, Tokyo, pp 723 - 724) what appears to be polarisation bistability controlled by applied current in an InGaAsP buried heterostructure laser simultaneously injected with a 0.7mW TM wave from a similar laser.

To date, despite their tremendous commercial importance neither optically triggered bistable switching nor room temperature direct polarisation switching have been reported.

According to a first aspect the present invention provides a bistable polarisation source comprising a semiconductor injection laser capable of providing optical gain in two distinguishable waveguiding paths, the waveguding paths extending substantially parallel to one another at a small enough separation to enable the fields of optical radiation in the two paths to overlap, the laser being switchable between first and second states in which the direct optical output of the laser is predominantly TE polarised and predominantly TM polarised respectively.

According to a second aspect the present invention provides an optical logic element comprising a semiconductor injection laser capable of providing optical gain in two distinguishable waveguiding paths, the waveguiding paths extending substantially parallel to one another at a small enough separation to enable the fields of optical radiation in the two paths to overlap, the laser being switchable between first and second states in which the direct optical output of the laser is predominantly TE polarised and predominantly TM polarised respectively.

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

Figure 1 shows a schematic plan view of a polarisation switching element and optical triggering element produced on a single chip;

Figure 2 shows a schematic cross section through a semiconductor injection laser for use in the present invention;

Figure 3 shows a plot of light output against drive current for each of Guides 1 and 2 driven simultaneously;

Figure 4 shows plots of the relationship between the triggering pulses applied to contacts 3 and 4 respectively and the output of TE and TM polarised light from the other pair of guides;

Figure 5 shows the inverting operation of a device according to the invention operated in a switching mode in which it is not bistable; and

Figure 6 shows schematically how a device according to the invention can be operated in an optical clock configuration.

Although terms such as "above" and "uppermost" are used in this specification, they are used for convenience of description only and should not be taken to imply any necessary associated orientation unless the context indicates otherwise.

Referring to Figure 1, a twin stripe laser is facet etched to produce two twin stripe lasers 1 and 2 on a single chip. The 'parent' laser is a 1.3 um InGaAsP double heterostructure laser grown on an InP substrate 11 using conventional liquid phase epitaxy.

The structure of the lasers is best described with reference to Figures 1 and 2. The InP substrate 11 is 100 - 150 um thick and is metallised on its lowermost face 14. Onto the substrate 11 are grown, by conventional epitaxial growth techniques, four layers: a 1 um layer 21 of n-doped InP; a 0.1 um active layer 22 of InGaAsP lattice matched to InP; a 1.3 um layer 15 of Zn doped InP; and a 0.2 um capping layer 16 of InGaAs. Each of the doped layers is doped to a conventional level for use in semiconductor laser technology. The active layer 22 lies between two layers 21, 15 of higher band gap and lower refractive index material to give both optical and carrier confinement in a direction normal to the layers.

Onto the capping layer 16 is deposited a 1000A layer 17 of Six Ny. Two stripe windows 18, 19 are etched through the Six Ny down to the level of the capping layer 16. A double metal layer of 3 um of Au on 500 Angstroms of Ti is deposited on the dielectric layer 17 and into the stripe windows 18, 19 then etched to form the four contacts 12, 12^1, 13, 13^1 by forming the transverse and longitudinal gaps H and W. Although both the Ti and Au layers are etched to form the transverse gap H, only the Au layer is etched to form the longitudinal gap. Where the transverse gap H is formed the Au:Ti contact layer is removed by ion beam milling, the silicon nitride by dry etching with CF_4, and the semiconductor layers removed by reactive ion etching. Finally, the two current stripes are electrically isolated by etching, using a reactive ion beam, down to the bottom of the InGaAs cap layer 16. As the reactive ion etch is not selective, the etch step is stopped after a predetermined time calculated with a knowledge of the etch rate. A slight over etch, which removes part of the Zn doped layer, is acceptable.

The overall length (the distance between the end facets) of the device shown in Figure 1 is 325 um, with a 15 um wide facet etch displaced from the centre producing asymmetrical devices with two pairs of waveguides 170 and 140 um long. The overall width of the device is 200 um. The stripe windows are 6 um wide, the inside edges of the stripes being separated by 10 um.

The resistance measured between each pair of contacts in a direction across the width of the device is about 40 Ω while that measured in a direction along the device, traversing the transverse gap H, is greater than 200 KΩ. Operated one at a time, the four lasers exhibit similar performance. With the dimensions and construction given above, and with drive current pulses of 300 ns width, the individual lasers typically have threshold currents of around 140 mA above which TE polarised light was generated. If the drive current is further increased, the lasers begin to generate significant levels of TM light. The increase in TM mode intensity is accompanied by a rapid increase in the quantum efficiency of the lasing TE mode, and a subsequent decrease in the intensity of the TE mode.

When a pair of guides at one end of the device, for example guides 1 and 2, are driven together with currents above the threshold value of each individual laser guide, the other pair of guides not being energised, there is observed an abrupt, discontinuous decrease in the TE intensity and sudden appearance of the TM mode in both lasers. With equal drive levels of 170 mA to each of Guides 1 and 2, strong polarisation switching is found as shown in Figure 3. Here, a large and sharp decrease in the intensity of one mode coincides with a similar increase in the orthogonal mode. This switching occurs simultaneously in both guide outputs, in the same direction. It is possible, by adjusting each current, to achieve a virtual switch-off of the higher intensity (lasing) mode with rejection ratios of the order of 20:1. The switch can also be triggered in both directions by superimposing brief, low amplitude current pulses onto one of the drive currents. With the 300 ns drive currents used reliable switching could be achieved by superimposing alternating positive and negative 10 ns, 5 mA current pulses onto one of the drive currents. The operation was independent of the adjacent device.

With the configuration shown in Figures 1 and 2 it is also possible to switch the output of guides 1 and 2 optically by utilising the pair of guides 3 and 4, at the opposite end of the device. With the Guides 1 and 2 energised with individual drive currents of 170 mA, a short, 40 ns, threshold current pulse applied to one of guides 3 and 4 switched the output of guides 1 and 2 in one direction. 100 ns later a second similar current pulse applied to the other guide (4 or 3) switched the outputs of Lasers 1 and 2 back to the original state, as shown in Figure 4.

The difference in level of the two triggering pulses, shown in Figure 4, is due to the difference in threshold values of the two guides 3 and 4 in the sample on which Figure 4 is based. With switching induced optically in this way rejection ratios of more than 15:1 have been obtained with a measured switching time of 100 ps, limited by the rise time of the avalanche photodiodes of the detection system. Such rapid switching makes the device attractive for use in fast optical switches. The combination of one of the devices and an optical polariser would enable very rapid on/off switching of laser light, at a rate much faster than it is conventionally possible to switch a semiconductor laser.

By using a device of the general type shown in Figure 2, in combination with an appropriate polariser, rapid on/off switching of a laser beam is effected using only very small control currents at low voltage. It is clearly an advantage of the present invention that switching can be achieved without the necessity to use the high voltages required by electro-optic modulators and pockel's cells.

Clearly, as those skilled in the art will understand, there is no necessity for the source of the optical triggering pulses (the triggering source) to be located on the same chip as the laser whose output polarisation is switched (the switching element). The optical triggering pulses could be carried to the switching element by an optical fibre or other optical waveguide. It is of course also not essential that the triggering source comprises lasers which are essentially identical to those of the switching element. Hence, although the wavelength of the triggering pulses should be within the gain spectrum of the switching element (which typically would be a few tens of nanometers), it is possible for the triggering source to comprise a laser of a configuration other than twin-stripe or twin-ridge and of materials other than InGaAsP alloys. The triggering source could also consist of a single laser, rather than what is effectively two, by providing some means to switch its output between the two guides of the switching element. When using optical triggering pulses, the polarisation of the triggering pulse is that to which the appropriate waveguide output is to be switched.

When the device is used in the current-controlled switching mode, the triggering source which is not activated, appears to make no contribution to the operation of the device. Consequently it appears that one half of the device shown in Figure 2, that is either guides 1 and 2 or guides 3 and 4, could be produced separately and used as a current controlled polarisation switch. Such a device has the advantage that it is very small and provides controlled polarisation switching without the need for extra components such as gratings.

A large number of devices of various different dimensions and combinations of dimensions have been fabricated and assessed and have been found to give the desired rapid controlled switching of polarisation states.

This polarisation switching characteristic makes devices according to the invention useful in optical logic applications. Firstly, the devices can provide an inverting function by showing a low output when addressed by an external optical signal. This operation is shown in Figure 5, where a TE polarised optical input pulse 20 from a source 21 produces a corresponding dip 22 in the TM output, Figure 5a, of device 23. Simultaneously, the TE output, Figure 5b, of device 23 shows the opposite reaction, a positive pulse corresponding to the TM "negative pulse". Overall, the total light output, Figure 5c, of device 23 stays substantially constant in accordance with the profile of the current pulse I_2 applied to the relevant electrode of device 23. The current supplied to the two electrodes of the switching element is such, in this example, for the device to operate in a switchable mode rather than in a bistable mode. It is for this reason that the optical output switches back to TM after removal of the TE input pulse.

For this mode of operation, the current applied to the electrode should be somewhere in the range where, were both electrodes to be driven, there is a rapid decrease in TE output, and a simultaneous increase in TM output, with increasing current (as previously described with reference to Figure 3). In general, the requisite current for this type of operation will be somewhere within the range of 1.1 to 1-4 times threshold current, the actual operable range of any device generally being narrower than the just quoted range. For the device used to generate Figure 3, a current of slightly less than 170mA would be appropriate (1.2 x I_t). It is, however, an easy matter to determine the appropriate electrode current, since the TE/TM transition is readily observed. Of course, if the switching element were initially to have a TE output, the input pulse would need to be TM polarised if the switching element's output polarisation were to be switched. This type of action could be used to provide an optical "NOT" gate.

Secondly, this inverting function can be used in an optical logic clock, as shown schematically in Figure 6. Here the device 25 without the triggering source is placed in an external cavity 26 which incorporates a quarter wave plate 27 which enables light emitted with TE polarisation to be reinjected as TM and vice versa. The result is switching of the laser output between the orthogonal polarisations at the round trip period of the cavity. The external cavity 26 comprises a mirror 28 and a facet 29 of the device 25. Alternatively, a second distinct mirror 30 may effectively take the place of the facet as the cavity's second reflector. In either configuration, the near facet 31 of device 25 is preferably anti-reflection coated but this is not essential. In the first configuration the distant facet 29 (in this embodiment a cleaved facet) is not anti-reflection coated, and hence functions as a mirror, while in the second configuration it too is preferably anti-reflection coated. When mirror 28 is planar, an objective lens 32 is used between the near facet 31 and the mirror 28. As shown in Figure 6 the objective lens is positioned between the quarter-wave plate 27 and the laser 25. With an external cavity length of about 30cm we have achieved stable operation of a clock of this type over several hundred cycles. The device was operated in the bistable mode with both electrodes receiving similar currents.

In order to achieve the desirable effects that we have observed a sufficient level of coupling between the waveguides is required. Those skilled in the art will appreciate that the amount of coupling between two waveguides which are adjacent and substantial parallel one with the other is dependant on the product of the length of the waveguides and the coupling coefficient. As those skilled in the art will also be aware, the coupling coefficient is dependant of the width and separation of the waveguides, and on the index difference between each guide and its surroundings. While we believe that it may be possible to provide too much coupling, we have not yet managed to produce a structure which, as the result of too much coupling, fails to achieve the desirable effects we are seeking. The following ranges of dimensions, taken together with the other information contained within this specification should enable those skilled in the art to produce devices according to the invention but using different materials, (eg GaAlAs - GaAs), dimensions and configurations.

We have found that the length of the switching device is important, as is the separation of the waveguides in that device. Stripe separation has been varied over a range from 5μm to more than 20μm. Above 20μm separation, with the configuration and waveguide lengths that we are using, there tends to be insufficient coupling between the waveguides for sharp triggering to be achieved. If the length of the switching device waveguides is less than about 170μm, rapid bistable switching between polarisation states is no longer achieved although the output polarisation state is still in fact switchable optically or by controlling the drive current. Switching is achieved within about 3 ns, this being limited by the carrier recombination time. Preferably the switching device has a cavity length of more than 170μm, more preferably more than 190μm.

Stripe width was varied in the range 5 to 6μm but within this range was found to have no effect on the polarisation switching characteristic.

Devices of the type shown in Figure 2 were also made with a range of different gap widths between the triggering element and the switching element. Gap widths ranged from 15 to 20μm and within this range this variable was found to have no effect on the polarisation switching.

Given that the switching element is essentially based on the presence of a pair of suitably coupled waveguides it is worth looking at what other structures could be used to provide such an optical configuration.

Although the laser devices described above use standard stripe geometries, both gain and index guiding is involved in the device operation. Consequently it is not essential that simple stripe device structures be used. Suitable alternative waveguide structures include ridge or buried heterostructures as these can allow ready TE/TM operation. Clearly the tighter optical confinement provided in index guided structures means that in general the two guides, if there is to be sufficient coupling between them, will have to be closer together than the corresponding guides in gain guided structures such as those described above. Depending on the length of the cavities, and other factors, the waveguides should preferably be no more that about 15μm apart, and more preferably no more than about 10μm apart. The minimum cavity length needed to achieve sufficient interaction and coupling is generally likely to be appreciably more than 150μm and may be more than 200μm.

We have found that with devices as described above the desirable effects are obtained without the need for any control of device temperature. Not only is this a tremendous advantage, but it is also very unexpected, since others unsuccessfully looking to achieve controlled polarisation bistability have assumed that precise temperature control would be necessary.

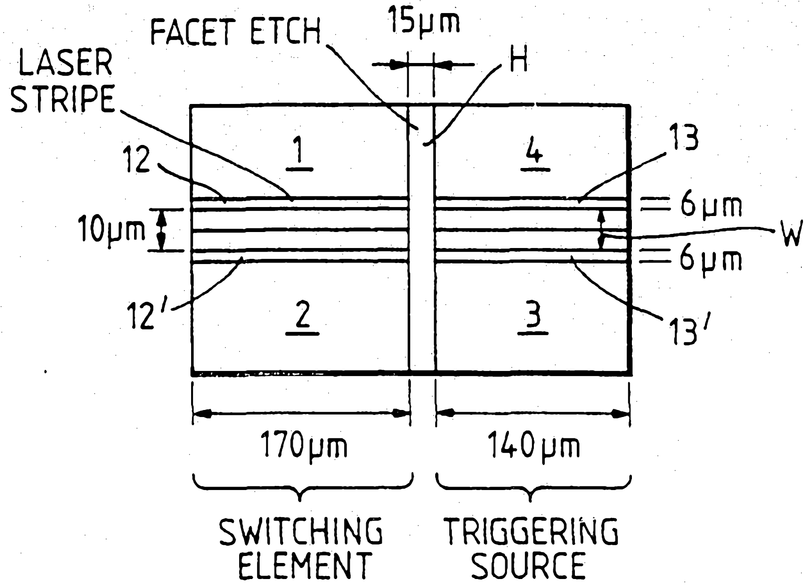
CLAIMS

1. A bistable polarisation source comprising a semiconductor injection laser capable of providing optical gain in two distinguishable waveguiding paths, the waveguding paths extending substantially parallel to one another at a small enough separation to enable the fields of optical radiation in the two paths to overlap, the laser being switchable between first and second states in which the direct optical output of the laser is predominantly TE polarised and predominantly TM polarised respectively.
2. A polarisation source as claimed in Claim 1 wherein in both said first and second states the ratio of the dominant polarisation type to the subordinate polarisation type is greater than 10 to 1.
3. A polarisation source as claimed in Claim 1 wherein the ratio is greater than 15 to 1.
4. A polarisation source as claimed in Claim 3 wherein the ratio is greater than 20 to 1.
5. A polarisation source as claimed in any of the preceding claims wherein switching between said states is effected by adjusting the operating current of the laser.
6. A polarisation source as claimed in any one of Claims 1 to 4 wherein switching between said states is effected by injecting optical control signals.

7. A polarisation source as claimed in any one of the preceding Claims wherein said laser comprises a twin stripe laser.
8. A polarisation source as claimed in Claim 7 wherein said laser has an active layer which is 150 μm or more in length.
9. A polarisation source as claimed in Claim 8 wherein said active layer is 170μm or more in length.
10. A polarisation source as claimed in any one of claims 7 to 9 wherein the twin stripes are separated by a distance of between 5 and 20μm.
11. A polarisation source as claimed in any one of Claims 1 to 6 wherein the said laser comprises a twin ridge waveguide laser.
12. A polarisation source as claimed in Claim 11 wherein the ridge waveguides are separated by no more than 10μm.
13. A polarisation source as claimed in Claim 11 or Claim 12 wherein said laser has an active layer which is 170μm or more in length.
14. An optical logic element comprising a semiconductor injection laser capable of providing optical gain in two distinguishable waveguiding paths, the waveguiding paths extending substantially parallel to one another at a small enough separation to enable the fields of optical radiation in the two paths to overlap, the laser being switchable between first and second states in which the direct optical output of the laser is predominantly TE polarised and predominantly TM polarised respectively.

15. An optical clock arrangement for providing a regular stream of optical pulses comprising: laser means capable of providing optical gain in two distinguishable waveguiding paths, the waveguiding paths extending substantially parallel to one another at a small enough separation to enable the fields of optical radiation in the two paths to overlap, the laser means being switchable between first and second states in which the direct optical output of the laser is predominantly TE polarized and predominantly TM polarized respectively; feedback means providing an optical path by means of which an optical output from the laser means may be fed back into the laser means; and polarization modifying means in said optical path providing a substantially orthogonal polarization shift in said fed back optical output.
16. An optical clock arrangement as claimed in claim 15 wherein said feedback means consists essentially of a single mirror.
17. An optical clock arrangement as claimed in claim 15 wherein said feedback means comprises a ring resonator.
18. An optical clock arrangement as claimed in claim 17 wherein the ring resonator comprises a plurality of reflectors.

Fig.2.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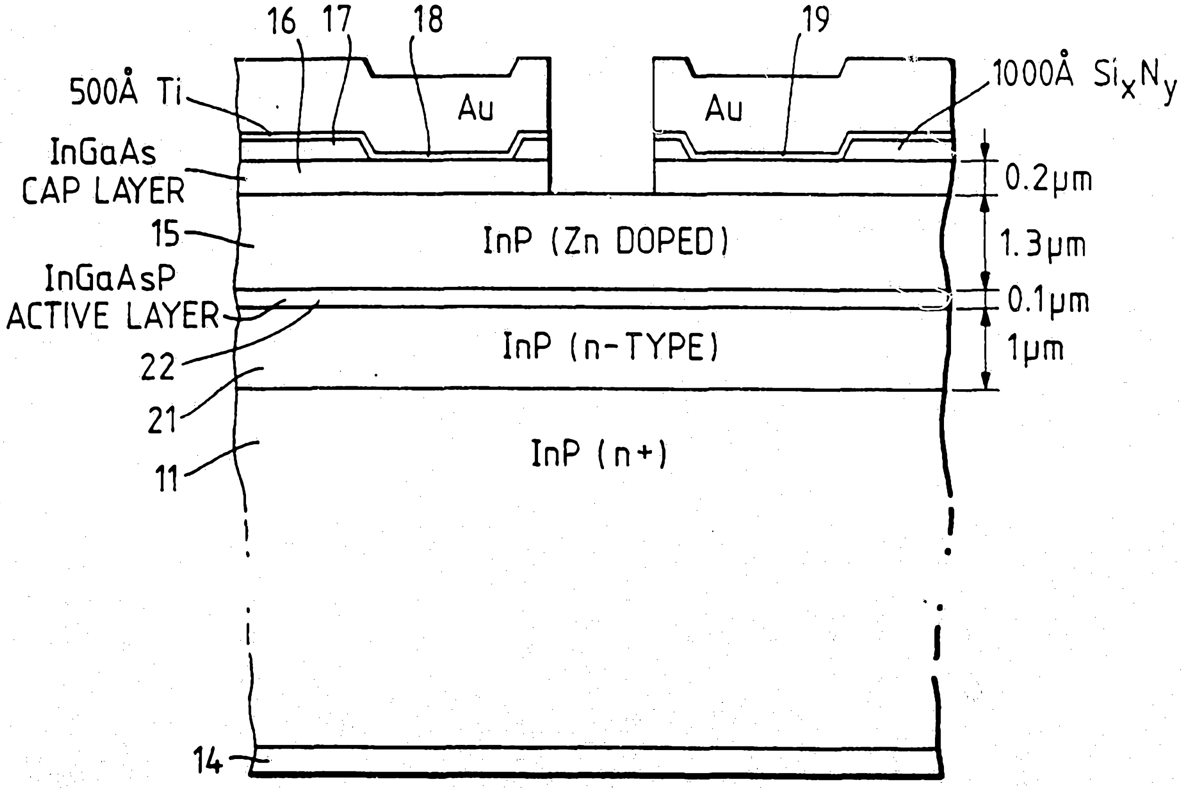
15μm
H
LASER STRIPE
1
4
13
12
=6μm
10μm
W
=6μm
12'
2
3
13'
170μm
140μm
SWITCHING ELEMENT
TRIGGERING SOURCE

Fig.1.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17
18
19
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Au
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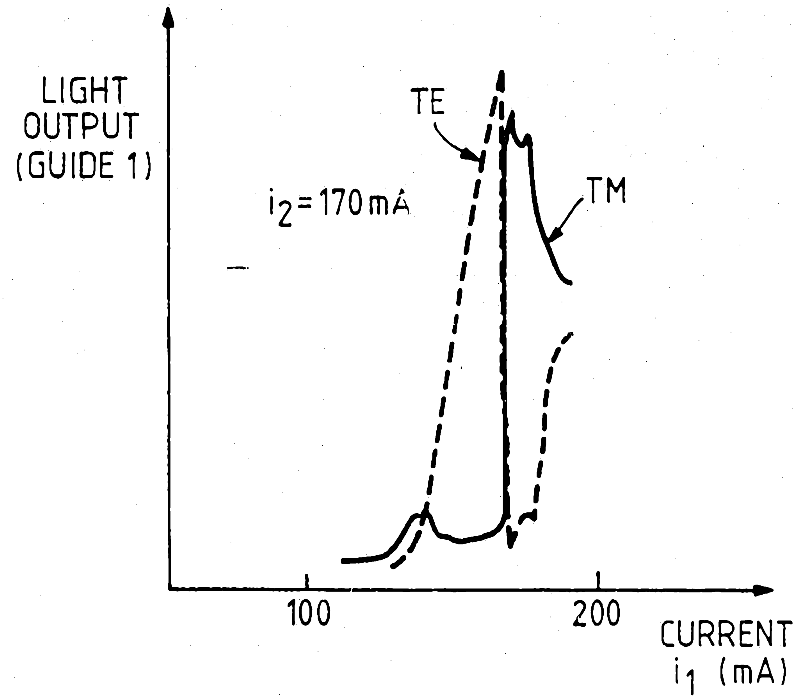
InP (n-TYPE)
1μm
22
21
InP (n+)
11
14

Fig. 3.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OUTPUT
(GUIDE 1)
TE
TM
i2=170mA
100
200
CURRENT
i1 (mA)

Fig. 6.

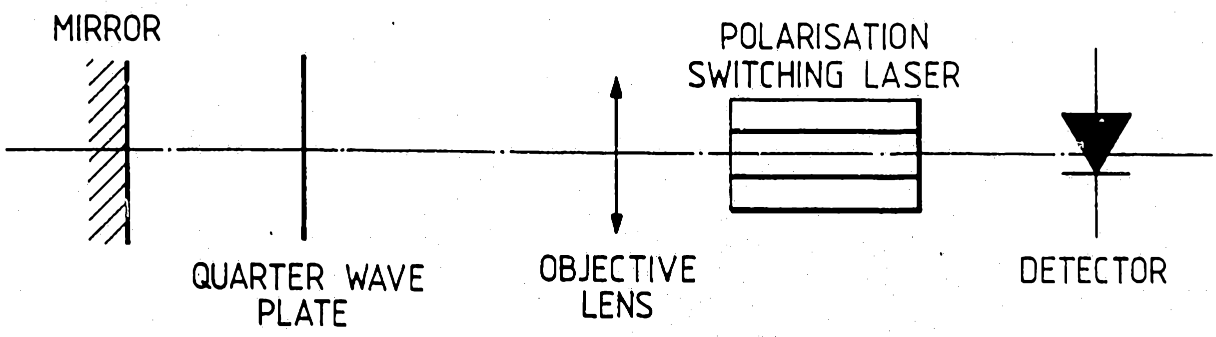
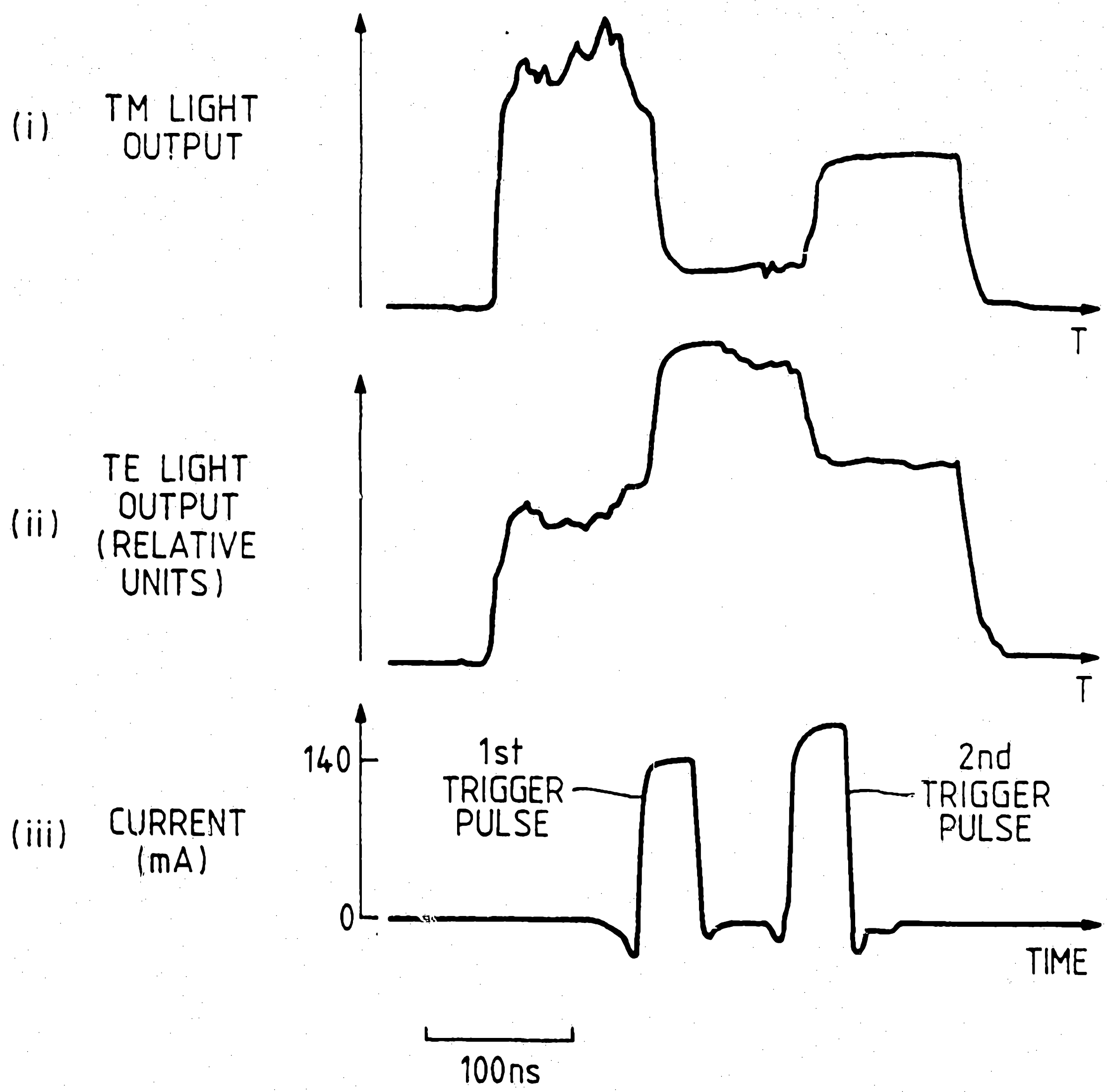

MIRROR
POLARISATION
SWITCHING LASER
QUARTER WAVE
PLATE
OBJECTIVE
LENS
DETECTOR

Fig. 4.


(i) TM LIGHT OUTPUT
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(ii) TE LIGHT OUTPUT (RELATIVE UNITS)
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(iii) CURRENT (mA)
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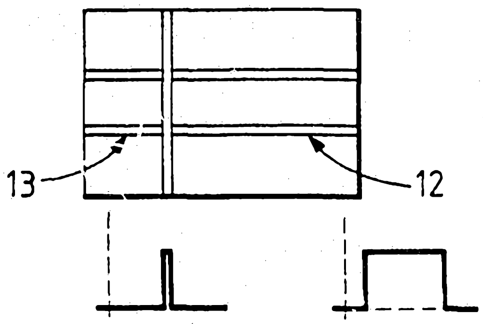
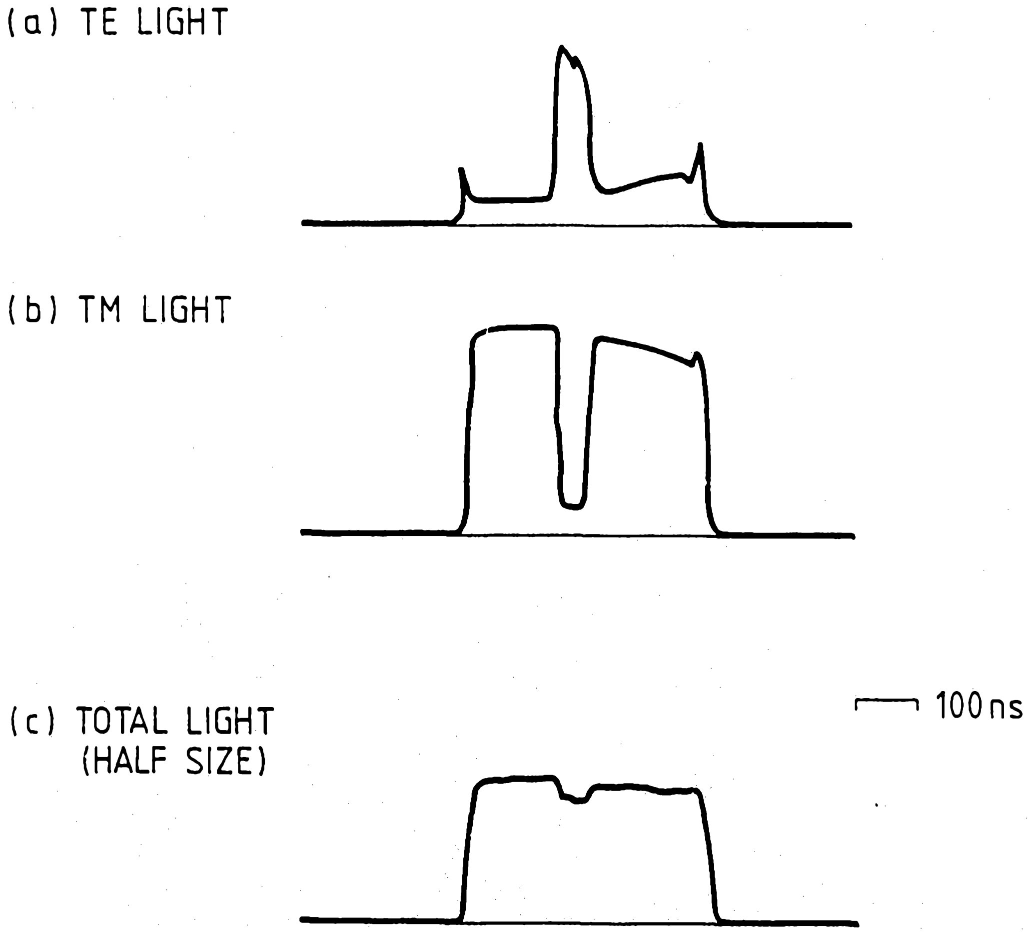
1st TRIGGER PULSE
2nd TRIGGER PULSE
TIME
100ns

Fig.5.





INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 89/00236

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^4: H 01 S 3/103; G 02 F 3/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC^4	H 01 S; G 02 F; G 02 B; H 04 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	IEEE Journal of Quantum Electronics, vol. QE-21, no. 4, April 1985, IEEE (New York, US), J.-M. Liu et al.: "Digital optical signal processing with polarization-bistable semiconductor lasers", pages 298-306, see chapters I,II,VI; figure 1 --	1,5,6,14
A	US, A, 4612645 (J.-M. LIU et al.) 16 September 1986, see column 1, lines 1-53; column 8, lines 4-14; claims 1,3 --	1,5
A	IEE Proceedings, vol. 131, no. 5, part H, October 1984 (Old Woking, Surrey, GB), I.H. White et al.: "Optical bistability in twin-stripe lasers", pages 309-321, see pages 309-311; pages 316-317, chapter 6; figures 1,4,6,14 -- ./.	1,5-9,14

° Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
14th June 1989	07. 07. 89
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN

Form PCT/ISA/210 (second sheet) (January 1985)

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	Applied Physics Letters, vol. 51, no. 24, 14 December 1987, American Institute of Physics (New York, US), Y. Mori et al.: "Optical polarization bistability with high switching speed in a TM wave injected buried hetero-structure laser", pages 1971-1973, see the whole article --	1,6
A	Applied Physics Letters, vol. 50, no. 8, 23 February 1987, American Institute of Physics (New York, US), M. Watanabe et al.: "Optical tristability using a twin-stripe laser diode", pages 427-429, see page 427; figures 1,3,4 --	1,5,7,11
A	Applied Physics Letters, vol. 50, no. 16, 20 April 1987, American Institute of Physics (New York, US), M.-C. Amann: "Polarization control in ridge-waveguide-laser diodes", pages 1038-1040, see pages 1038,1040; figures 1,2 --	1,11,13
A	US, A, 4685108 (R.J. SEYMOUR et al.) 4 August 1987, see column 1, line 19 - column 2, line 27; figures 1-3 --	1,15
P,X	Electronics Letters, vol. 24, no. 19, 15 September 1988 (Stevenage, Herts, GB), R.S. Linton et al.: "Optically triggered polarisation bistability in GaInAsP twin stripe injection lasers using integrated devices", pages 1232-1234, see the whole document	1-3,5-8, 10,11
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 8900236

SA 27646

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 27/06/89
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4612645	16-09-86	US-A- 4689793	25-08-87
US-A- 4685108	04-08-87	None	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82