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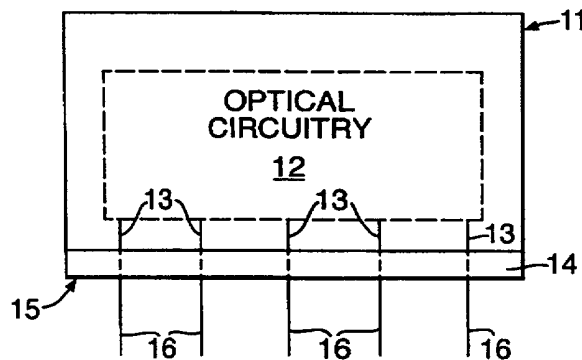
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(54) Abstract Title
Integrated chip optical device with polished edge to form junction with optical fibre

(57) An integrated chip optical device has a plurality of optical components 12 formed on a substrate including at least one waveguide 13 extending over a surface of the substrate to an edge 15 of the device, a protective layer being formed over at least part of said surface adjacent the edge region and the edge being polished to form a junction face for abutting said waveguide to an off-chip optical fibre 16. The polishing may be effected at an angle to the edge. The protective layer may be photoresist spun over the surface and parts of it not adjacent the edge may be selectively removed by photolithography. Plural waveguides may be attached to plural optical fibres by adhesive.

Fig. 1.



GB 2 355 314 A

Fig.1.

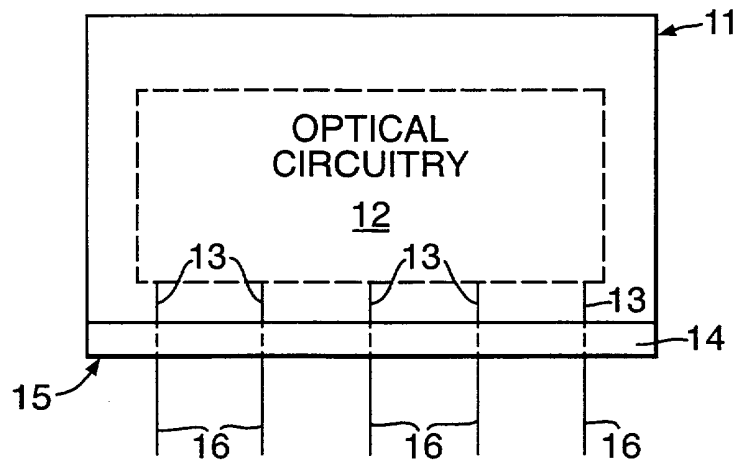
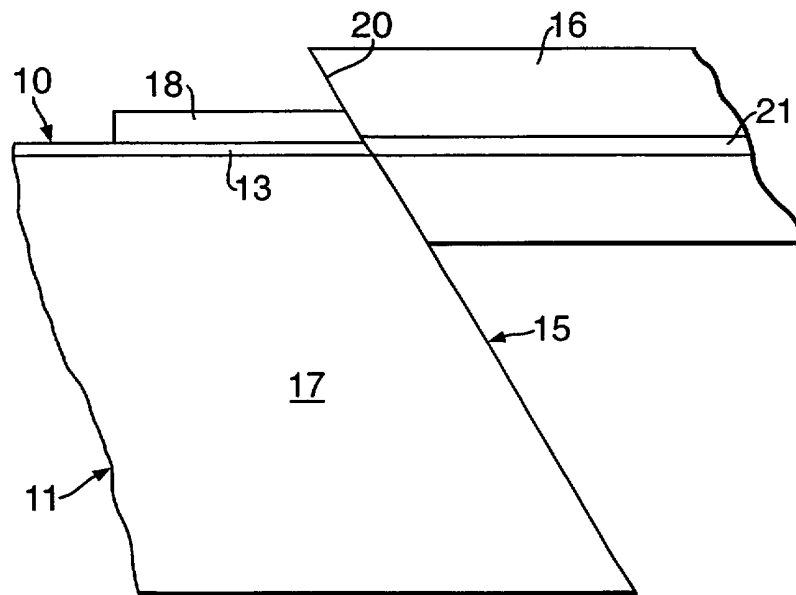


Fig.2.



IMPROVEMENTS IN OR RELATING TO INTEGRATED CHIP OPTICAL DEVICES

The invention relates to integrated chip optical devices and is particularly related to such devices where optical components including at least one waveguide are formed on a substrate.

In order to make external optical connections to such an integrated chip optical device, it may be required to join offchip optical fibres to waveguides onchip adjacent an edge of the chip. To achieve satisfactory optical function at such a junction it is desirable that the chip has high edge quality where any such junction is to be formed.

It is an object of the present invention to provide an improved method of forming an integrated chip optical device as well as an improved device, having high edge quality for such external optical junctions.

The invention provides a method of forming an integrated chip optical device comprising forming a plurality of optical components on a substrate including at least one waveguide extending over a surface of the substrate to an edge of the device, forming a protective layer over at least part of said surface including an edge region in which said edge is located, selectively removing the protective coating from certain regions of said surface while leaving the protective coating over said edge region, and polishing the edge of the device in said edge region to provide high edge quality enabling said waveguide to be abutted against and joined to an offchip optical fibre.

Preferably said protective coating comprises a hard setting photoresist.

Preferably said protective coating is spun over the surface of the chip.

Preferably the protective coating is selectively removed using

photolithography techniques.

Preferably a plurality of waveguides extend to said edge and each is secured to an offchip optical fibre.

Preferably each said waveguide is secured to an offchip fibre by adhesive with the fibre abutting the respective waveguide at said edge.

Preferably said edge is polished at an angle of inclination to the surface of the chip so as to reduce reflections at the edge passing along the waveguide or fibre.

In some embodiments said protective coating is removed from regions of the chip on which optical components are formed so as to leave said optical components uncovered by the protective layer.

The invention also provides an integrated chip optical device comprising a plurality of optical components on a substrate including at least one waveguide extending over a surface of the substrate to an edge of the device, a protective layer being formed selectively over part of the surface of the chip adjacent an edge region in which said edge is located, said edge being polished to provide a high edge quality thereby forming a junction face at the edge of the chip for abutting said waveguide to an offchip optical fibre.

Preferably said edge is polished at an angle of inclination to the surface of the chip so that the external face of the waveguide is not perpendicular to the length of the waveguide.

Preferably one or more offchip optical fibres abut a respective waveguide at said edge and are secured thereto by adhesive.

An embodiment of the present invention will now be described by way of example and with reference to the accompanying drawings in which:

Figure 1 is a schematic plan view of an integrated chip optical device in accordance with the present invention, and

Figure 2 shows on an enlarged scale a junction between one optical fibre and one waveguide in the device of Figure 1.

Figure 1 illustrates an integrated chip optical device such as a silicon chip waveguide device. Such a device may be formed on an integrated silicon substrate having a plurality of optical components formed integrally on the chip including a plurality of optical waveguides formed on the surface of the chip. In this example the chip is indicated at 11 and has a plurality of optical circuit devices 12 of known type. These optical devices may be connected by optical waveguides 13 to an edge region 14 extending along one edge 15 of the chip 11. The construction of the optical circuitry 12 and the waveguides 13 is of known type.

In order to make external connections for the chip. The waveguides 13 have an exposed end face adjacent the edge 15 and they abut respective optical fibres 16 at the edge 15.

In order to provide good optical operation it is required that the edge 15 has a high edge quality where the ends of the waveguides 13 abut end faces of the fibres 16.

To provide the high edge quality, the chip 11 has a spun-on coating of a hard setting photoresist after the optical circuitry 12 and waveguides 13 have been formed on the chip. The protective coating is patterned by photolithography so as to remove the protective coating from unwanted areas of the chip while leaving the protective coating along the edge region 14 up to the edge 15. In this way the protective coating only covers the edge region and the waveguide ends adjacent the edge 15. The optical circuitry 12 is now uncovered so that the optical

circuitry is not effected by any unwanted stresses that may be caused by leaving a protective coating over the optical components formed in the circuitry 12. After selective removal of the protective coating the edge 15 together with the protective coating in the edge region 14 is polished to give a high edge quality with high quality optical properties. This is illustrated in more detail in the enlarged view of Figure 2. In this Figure the chip 11 has a substrate 17 which may be silicon, with a waveguide 13 extending to the edge 15. The waveguide is covered by the protective coating 18 extending as a strip along the edge region 14. The edge 15 including the end of the waveguide 13 and the edge of the protective coating 18 are polished at an inclined angle relative to the surface and plane of the chip 11 so as to avoid the end face 15 being perpendicular to the plane of the chip. The optical fibre 16 has a similar inclined end face 20 and as illustrated in Figure 2, the core 21 of the optical fibre 16 is aligned in abutting contact with the end face of the waveguide 13. By use of an inclined face, there is reduction of any reflection at the junction being passed along the waveguide 13 or optical fibre 16.

Although Figure 2 illustrates only one optical fibre, it will be understood that optical fibres will be abutted against each of the waveguide outlets from the device shown in Figure 1 and each fibre will be secured by adhesive in abutting contact with the highly polished end face 15 in alignment with the respective waveguide 13.

The use of the protective coating 18 over the edge region 14 allows a high quality edge to be formed on the chip by polishing without damaging the structure of the waveguide where their ends reach the edge 15 of the chip.

The above example may be a silicon on insulator rib waveguide device.

The invention is not limited to the details of the foregoing example.

CLAIMS:

1. A method of forming an integrated chip optical device comprising forming a plurality of optical components on a substrate including at least one waveguide extending over a surface of the substrate to an edge of the device, forming a protective layer over at least part of said surface including an edge region in which said edge is located, selectively removing the protective coating from certain regions of said surface while leaving the protective coating over said edge region, and polishing the edge of the device in said edge region to provide high edge quality enabling said waveguide to be abutted against and joined to an offchip optical fibre.
2. A method according to claim 1 in which said protective coating comprises a hard setting photoresist.
3. A method according to claim 1 or claim 2 in which said protective coating is spun over the surface of the chip.
4. A method according to any one of the preceding claims in which the protective coating is selectively removed using photolithography techniques.
5. A method according to any one of the preceding claims in which a plurality of waveguides extend to said edge and each waveguide is secured to an offchip optical fibre.
6. A method according to claim 5 in which each said waveguide is secured to an offchip fibre by adhesive with the fibre abutting the respective waveguide at said edge.
7. A method according to any one of the preceding claims in which said edge is polished at an angle of inclination to the surface of the chip so as to reduce reflections at the edge passing along the waveguide or fibre.

8. A method according to any one of the preceding claims in which said protective coating is removed from regions of the chip on which certain optical components are formed so as to leave said certain optical components uncovered by the protective layer.

9. An integrated chip optical device comprising a plurality of optical components on a substrate including at least one waveguide extending over a surface of the substrate to an edge of the device, a protective layer being formed selectively over part of the surface of the chip adjacent an edge region in which said edge is located, said edge being polished to provide a high edge quality thereby forming a junction face at the edge of the chip for abutting said waveguide to an offchip optical fibre.

10. An integrated chip optical device as claimed in claim 9 in which said edge is polished at an angle of inclination to the surface of the chip so that the external face of the waveguide is not perpendicular to the length of the waveguide.

11. An integrated chip optical device according to either of claims 9 or 10 in which one or more offchip optical fibres abut a respective waveguide at said edge and are secured thereto by adhesive.

12. An integrated chip optical device according to any one of claims 9 to 11 comprising a silicon on insulator rib waveguide device.

7.

CLAIMS:

1. A method of forming an integrated chip optical device comprising forming a plurality of optical components on a substrate including at least one waveguide extending over a surface of the substrate to an edge of the device, forming a protective layer over at least part of said surface including a surface region adjacent said edge, selectively removing the protective coating from certain areas of said surface while leaving the protective coating over said surface region adjacent said edge, and polishing the edge of the device adjacent the coating to provide high edge quality enabling said waveguide to be abutted against and joined to an offchip optical fibre.
2. A method according to claim 1 in which said protective coating comprises a hard setting photoresist.
3. A method according to claim 1 or claim 2 in which said protective coating is spun over the surface of the chip.
4. A method according to any one of the preceding claims in which the protective coating is selectively removed using photolithography techniques.
5. A method according to any one of the preceding claims in which a plurality of waveguides extend to said edge and each waveguide is secured to an offchip optical fibre.
6. A method according to claim 5 in which each said waveguide is secured to an offchip fibre by adhesive with the fibre abutting the respective waveguide at said edge.
7. A method according to any one of the preceding claims in which said edge is polished at an angle of inclination to the surface of the chip so as to reduce reflections at the edge passing along the waveguide or fibre.

8. A method according to any one of the preceding claims in which said protective coating is removed from regions of the chip on which certain optical components are formed so as to leave said certain optical components uncovered by the protective layer.

9. An integrated chip optical device comprising a plurality of optical components on a substrate including at least one waveguide extending over a surface of the substrate to an edge of the device, a protective layer being formed selectively over part of the said surface of the chip adjacent an edge region in which said edge is located, said edge being polished to provide a high edge quality adjacent said protective layer thereby forming a junction face at the edge of the chip for abutting said waveguide to an offchip optical fibre.

10. An integrated chip optical device as claimed in claim 9 in which said edge is polished at an angle of inclination to the surface of the chip so that the external face of the waveguide is not perpendicular to the length of the waveguide.

11. An integrated chip optical device according to either of claims 9 or 10 in which one or more offchip optical fibres abut a respective waveguide at said edge and are secured thereto by adhesive.

12. An integrated chip optical device according to any one of claims 9 to 11 comprising a silicon on insulator rib waveguide device.

13. An integrated chip optical device substantially as hereinbefore described with reference to Figures 1 and 2 of the accompanying drawings.



Application No: GB 9924511.0
Claims searched: 1-12

Examiner: Meredith Reynolds
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**Patents Act 1977
Search Report under Section 17**

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.R): G2J (JGDBF)
Int Cl (Ed.7): G02B 6/30
Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2268813A (IOC)(Fig 1, pp 8-9)	9,11
X	EP 0170457A (BT)(Figs 1-2, pp 8-10)	9,11
X	US 5444805 (Bosch)(Figs 1-4)	9,11-12
X	US 5073002 (Hockaday)(Figs, Col 3)	1,4,6,9

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.