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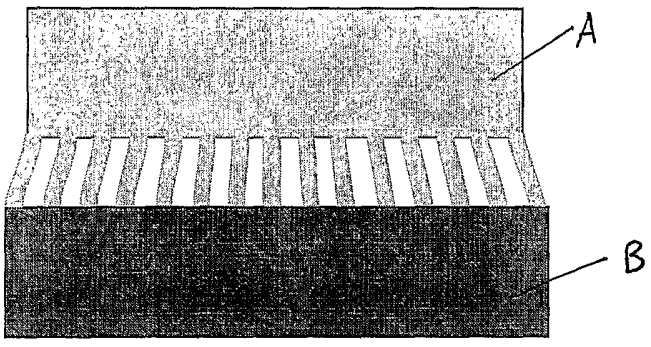
(54) Title: SUPPORT FOR AN OPTICAL OR ELECTRICAL CHIP



(57) Abstract: A combination of an optic and/or electronic chip and a support on which it is mounted, the support including at least a first component formed of a first material, wherein at least a portion of said first component at an interface with said chip or at an interface with an optional second component of the support is orderly interspersed with a second material of lower modulus.

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OPTIC/ELECTRONIC CHIP SUPPORT

The present application relates to a support for an optic and/or electronic chip, and in particular to a support by which the stress resulting from the intimate attachment of two dissimilar materials can be reduced.

Problems with stress are fundamental in many areas of mechanical engineering and arise when different materials are bonded together. This is a particularly concerning problem for many semiconductor devices which are of necessity bonded onto a substrate of a different material with different expansion coefficients, different thermal conductivity and different elastic moduli. It is widely known that sufficient stress applied to semiconductor devices can alter the electronic characteristics, electro-optic characteristics and is a significant source of reliability problems.

Figure 1 shows the result of bonding between two materials A &B where material A has a lower expansion coefficient than B. Heating the couple produces well known bending to minimise the total stress energy produced. There will be a shear stress at the interface.

One solution to the general problem of minimising stress for planar interfaces is to choose materials that are closely matched in expansion or have a bonding interface that contains a material which can plastically deform between the two materials. Lead-tin solder is such a material and is widely employed not only because it will wet to plated surfaces and provide good electrical contact, but its low melting point, low modulus and low elastic yield point allow it to absorb bonding stresses over a wide range of temperatures. If the interface bond is achieved by soldering for example, the shear stress may be sufficient to initiate creep in the solder. In this case the stress energy will be absorbed by producing irreversible structural changes in the solder. Another solution to this problem is to use a polymer or epoxy bonding fillet between the two bonded surfaces. A consequence of all of these is that some part of the bond material or structure undergoes plastic deformation in order to absorb the stress. As the temperature of the assembly changes, the material is cycled through continued plastic deformation. For most metals such as solders this means that in the plastic

regime the microstructure of the material changes. This is well known and the changes that arise are generally generation and movement of dislocations, growth and movement of grain boundaries and generation and movement of vacancies and interstitials. Generation of these entities leads to impaired mechanical and electrical properties and eventually to mechanical failure such as fracture. In addition, plastic deformation will also give rise to irrecoverable microscopic movement between the relevant materials. This is a major problem for some application such as micro-optical components where the above constraints are required and in addition the positions of the bonded components are extremely critical in order to satisfy the coupling of optical beams from one to another. For this situation, any plastic deformation will produce misplacement and misalignment of components such as semiconductor lasers or other electro-optic components and eventual loss or impairment of the electro-optical performance.

It is an aim of the present invention to provide a technique by which the above-discussed problems can be at least partially solved.

The present invention provides a support for an optic and/or electronic chip as defined in any of claims 1, 2, 15, 20, 24 and a method of controlling the movement of an optic and/or electronic chip according to claim 19. Embodiments of the invention are defined in the dependent claims.

Embodiments of the invention are described in detail hereunder, by way of example only, with reference to the accompanying drawings.

Embodiments of the invention solve the problem of limiting any distortion of material to the elastic regime and to spread the shear over a distance much larger than the conventional bonding interface. Figure 2 shows how this may be achieved by designing an interface in the form of a comb of two or more materials such that the properties of the comb structure are in some way combined to give a set of properties which can be engineered to meet several requirements. These would include; limits on the net strain without entering the plastic regime of the materials, limits on the stress which is transmitted to the sensitive component of the structure, limits on the resulting

electrical and/or thermal properties, and limits on the mechanical properties such as shear strength. The options for solving this problem by design are:-

1. The materials of the comb can be either one or other or both of the two materials (A, B) being bonded, or could be one of the materials (A or B) and air gaps, or could be one of the materials (A or B) and a filler of another material (C, or D) or could be two materials which are different from the two materials being joined, (C and D). (Figure 3)

2. The ratio of the widths of the alternating comb materials can be constant through the structure (Fig 3). The widths of the two materials comprising the comb can also be different; material C may have smaller finger width than material D (air) to give more compliance.

3. The separation between comb fingers and the width of the fingers through the structure may change. (Figure 4) This is a natural variation that would allow for greater strain between the two materials at the periphery of the bond compared to the centre region.

4. The length of the fingers may vary from centre to periphery to allow the nett compliance to be modified over the bond. This allows some freedom to make the stress evenly distributed across the structure. (Figure 5)

5. The fingers comprising the comb structure are shown aligned in one direction. This results in stress minimisation and modification in one direction perpendicular to the comb section. This may be sufficient for structures which have length considerably larger than the width. For structures where the dimensions of the interface are comparable in the two perpendicular directions, it may be advantageous to design a two dimensional comb structure such as an array of pins to give isotropic stress compensation. The arrangement of the pins may be subject to the considerations raised above for the one-dimensional cases. (Figure 6)

A practical example of this solution is in the attachment of lithium niobate optical waveguide devices to a substrate whereby the waveguide (located at the top of the

chip 1) is optically coupled to a semiconductor laser by means of micro-lenses. (Figure 7) The positional tolerance of the combined structure is less than one micron. The lithium niobate and laser devices are stress sensitive and have to operate over a range of temperatures. Since the lithium niobate device is several centimetres long, significant strain occurs between the lithium niobate and the mounting material which leads to continuous and unpredictable movement between the laser and lithium niobate over time and over temperature. Figure 8 shows the mechanical solution involving a combed structure which allows greater compliance at the end of the device to give low stress and mechanical positional stability for purposes of optical alignment to the laser.

Fabrication of a combed (interleaved) structure can be achieved by several means. The method chosen depends on the materials comprising the materials A & B and the comb materials C & D. In addition the dimension of the structure may be some tens of microns for example for bonding small chips or may be some millimeters or centimeters for larger mechanical structures. For these, precision mechanical milling, photolithographic metal etching, chemical etching, moulding, are all possible.

Due to the complexity of the problem of minimising stress for different geometrical and material structures it may be required to find the best solution by a design study using for example finite element analysis to determine the distortion, strain and stress values that result from specific designs and to verify that each material is operating within its elastic limits.

CLAIMS

1. A combination of an optic and/or electronic chip and a support on which it is mounted, the support including at least a first component formed of a first material, wherein at least a portion of said first component at an interface with said chip or at an interface with an optional second component of the support is orderly interspersed with a second material of lower modulus.

2. A combination according to claim 1, wherein said portion of the first component defines recesses filled with said second material.

3. A combination according to claim 1 or claim 2, wherein the second material is a shearable material.

4. A combination according to claim 1 or claim 2, wherein the second material is a gas or gas mixture.

5. A combination according to any preceding claim, wherein the support includes said first and second components, and the average thermal expansivity of the first component in at least a first direction parallel to the plane of the chip is between those of the chip and the second component, such that the thermal expansivity of the chip in said first direction is closer to that of the combination of the first and second components than that of the second component alone.

6. A combination according to any preceding claim, wherein the interspersion of said second material is configured such that the stiffness of the first component varies from the centre outwards in a first direction parallel to the plane of the chip.

7. A combination according to any preceding claim, wherein the proportion of the second material increases from the centre outwards in said first direction.

8. A combination according to claim 2, wherein the depth of the recesses increases from the centre outwards in said first direction.

9. A combination according to claim 2, wherein the diameter of the recesses increases outwards in said first direction.

10. A combination according to any of claims 1 to 5, wherein the interspersion of said second material is configured such that the stiffness of the first component varies from the centre outwards in orthogonal first and second directions parallel to the plane of the chip.

11. A combination according to any of claims 1 to 5, wherein the proportion of the second material increases from the centre outwards in both said first and second directions.

12. A combination according to any preceding claim, wherein the chip has optical and/or electronic properties that are stress sensitive.

13. A combination according to any of claims 1 to 11, wherein the chip is in optical communication with an independently mounted optical device.

14. A combination according to claim 13, wherein the optical communication between the chip and the optical device is sensitive to relative movements of the chip and the optical device of less than a micron.

15. A support for mounting an optic and/or electronic chip, including at least first and second components, wherein at least one of the first and second components is formed of a first material and includes a portion at an interface with the other that is orderly interspersed with a second material of lower modulus.

16. A use of a support according to claim 15 for mounting a device that has optical and/or electronic properties that are stress sensitive.

17. A use of a support according to claim 15 for mounting an optic chip for optical communication with an independently mounted optical device.

18. Use according to claim 17, wherein the optical communication between the chip and the optical device is sensitive to relative movements of the chip and the optical device of less than a micron.

19. A method of controlling the movement in response to a change in temperature of an optic and/or electronic chip mounted on a support comprising at least a first component including a portion at an interface with said chip or at an interface with an optional second component of the support; the method comprising the steps of: designing the structure of said portion taking into consideration the effect on the modulus and thermal expansivity of the support in at least a first direction parallel to the plane of the chip, and then producing the first component according to such design.

20. A combination of an optic and/or electronic chip and a support on which it is mounted, the support including at least a first component including at least a portion at an interface with said chip or at an interface with a second component also forming part of the support that is structurally modified so as to reduce the effective thermal expansivity and effective modulus of the support in at least a first direction parallel to the plane of the chip.

21. A combination according to claim 20, wherein said portion is structured such that the stiffness thereof varies from the centre outwards in said first direction.

22. A combination according to claim 21, wherein said portion is structurally modified so as to reduce the effective thermal expansivity and effective modulus of the support in orthogonal first and second directions parallel to the plane of the chip.

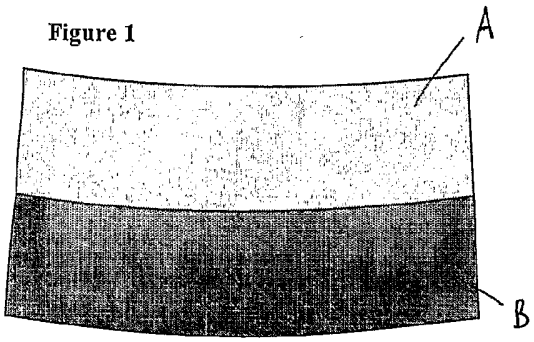
23. A combination according to claim 22, wherein said portion is structured such that the stiffness thereof varies from the centre outwards in said first and second directions.

24. A support for an optic and/or electronic chip including at least first and second components, wherein at least one of the first and second components has a portion at at an interface with the other that is structurally modified so as to reduce the effective

thermal expansivity and effective modulus of the support in at least a first direction parallel to the plane of the chip.

25. A support for an optic and/or electronic chip including at least first and second components, wherein at least one of the first and second components has a portion at at an interface with the other that is structurally modified so as to reduce the effective thermal expansivity and effective modulus of the support in orthogonal first and second directions parallel to the plane of the chip.

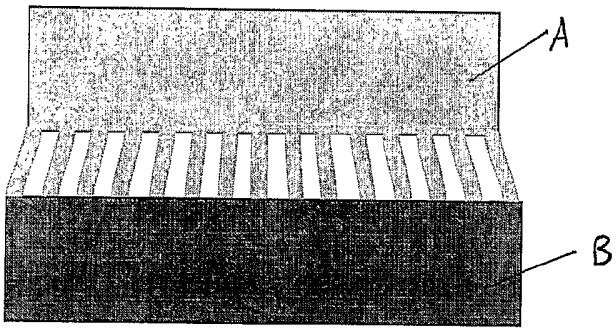
Figure 1



Material A - low expansion Coefficient
Material B - high expansion Coefficient
Raising temperature produces tensile stress in A and curvature as shown in Figure 1.

Figure 2 shows basic action of comb - to absorb strain between two dissimilar materials leaving bulk of material A with lower stress and lower curvature.

Figure 2



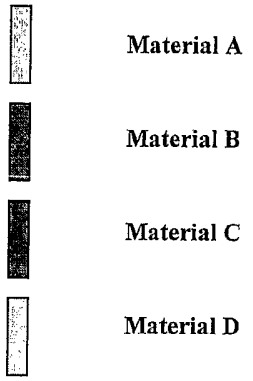


Figure 3

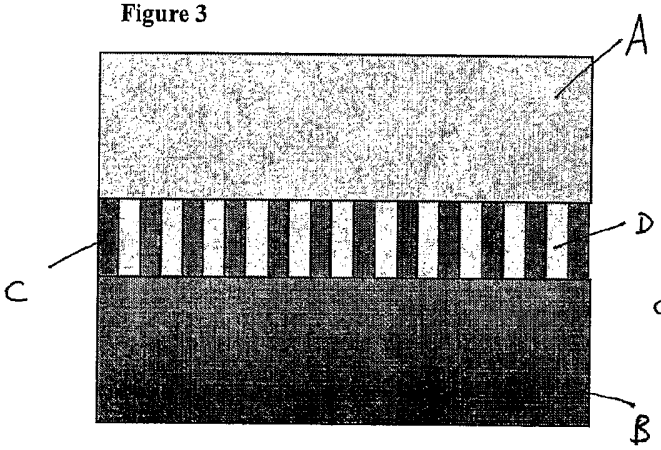


Figure 4

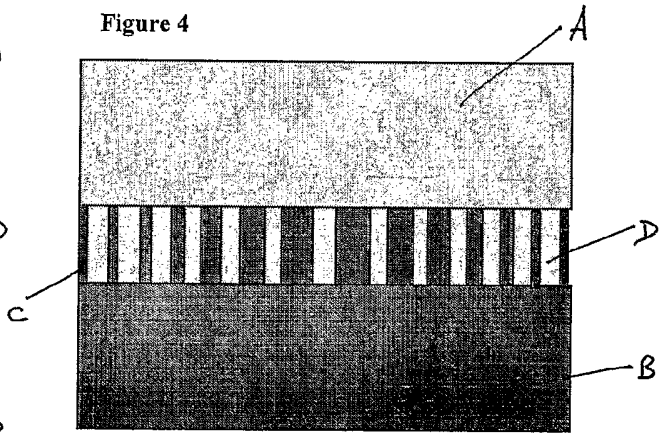


Figure 5

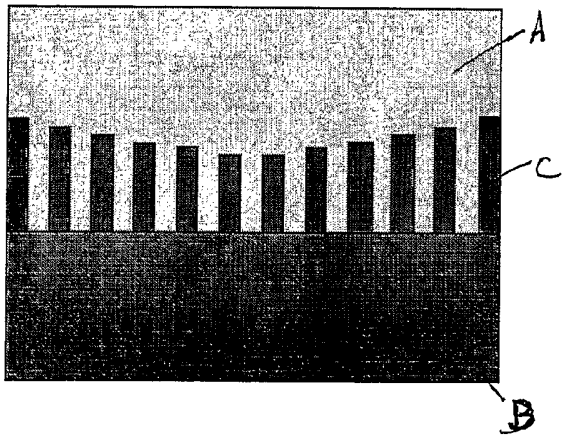


Figure 6

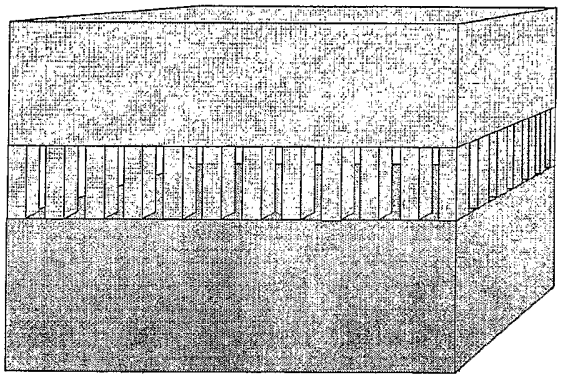


Figure 7 Section showing optical coupling between laser (1) and Lithium Niobate waveguide chip (2)

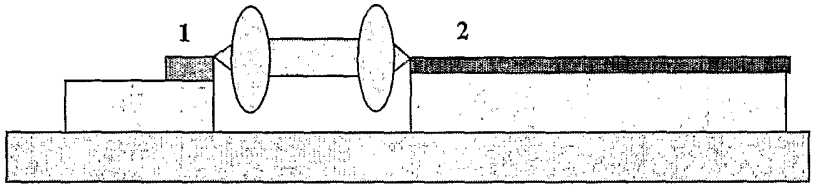
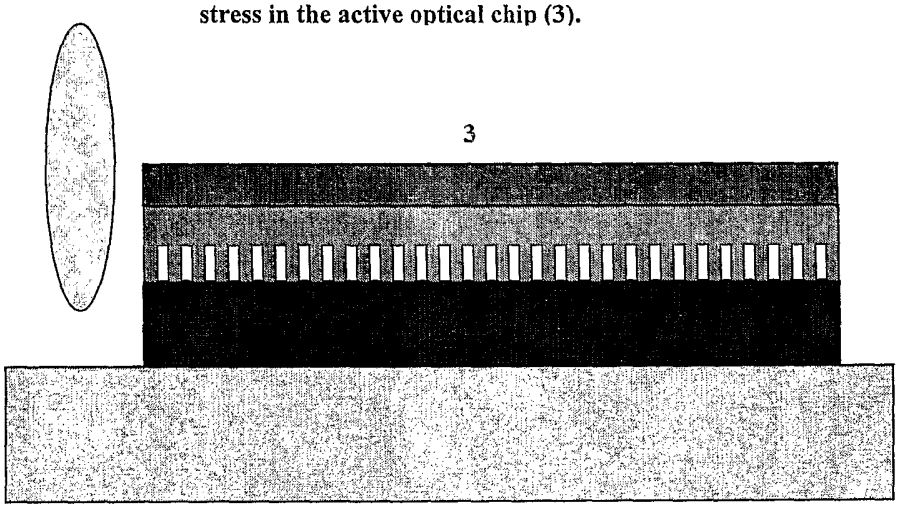


Figure 8 Section showing structured carrier on which Lithium Niobate waveguide chip (3) is bonded. The comb structure described previously serves to minimise stress in the active optical chip (3).



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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
306453WO/MNE		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB2006/000854	10/03/2006	16/03/2005
Applicant		
BOOKHAM TECHNOLOGY PLC		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the international Bureau.

This international search report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      [X] the international application in the language in which it was filed
      [ ] a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. [ ] **Certain claims were found unsearchable** (See Box No. II)

3. [ ] **Unity of invention is lacking** (see Box No III)

4. With regard to the **title,**
   [ ] the text is approved as submitted by the applicant
   [X] the text has been established by this Authority to read as follows:

   SUPPORT FOR AN OPTICAL OR ELECTRICAL CHIP

5. With regard to the **abstract,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings,**
   a. the figure of the **drawings** to be published with the abstract is Figure No. 2
      [ ] as suggested by the applicant
      [ ] as selected by this Authority, because the applicant failed to suggest a figure
      [X] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2006/000854

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L23/492 G02B6/42 H01S5/022

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02B H01S H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 324 987 A (IACOVANGELO ET AL) 28 June 1994 (1994-06-28) column 2, line 12 - column 4, line 8; figures 1-3	1-3,5,6, 10,12, 15,16, 19-25
Y	the whole document	7-9,11
X	US 2001/048705 A1 (KITAOKA YASUO ET AL) 6 December 2001 (2001-12-06) paragraph [0160] - paragraph [0184]; figure 16	1-3, 13-18, 20,24,25

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 May 2006	06/06/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Blau, G

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2006/000854

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 536 509 B1 (KOIDL PETER ET AL) 25 March 2003 (2003-03-25) column 4, line 1 - line 34; figures 2,4,6 column 5, line 4 - line 29 column 5, line 57 - column 6, line 21	1-4,15, 16,20, 24,25
Y	the whole document	7-9,11
X	EP 0 403 080 A (PLESSEY RES CASWELL; PLESSEY RESEARCH CASWELL LIMITED) 19 December 1990 (1990-12-19) the whole document	1-3,5, 12-20, 24,25
X	EP 0 355 913 A (N.V. PHILIPS' GLOEILAMPENFABRIEKEN) 28 February 1990 (1990-02-28) column 3, line 31 - column 4, line 14; figure 1a column 4, line 42 - line 51 column 4, line 57 - column 5, line 6 column 8, line 1 - line 6	1-3,12, 15,16,19

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2006/000854

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