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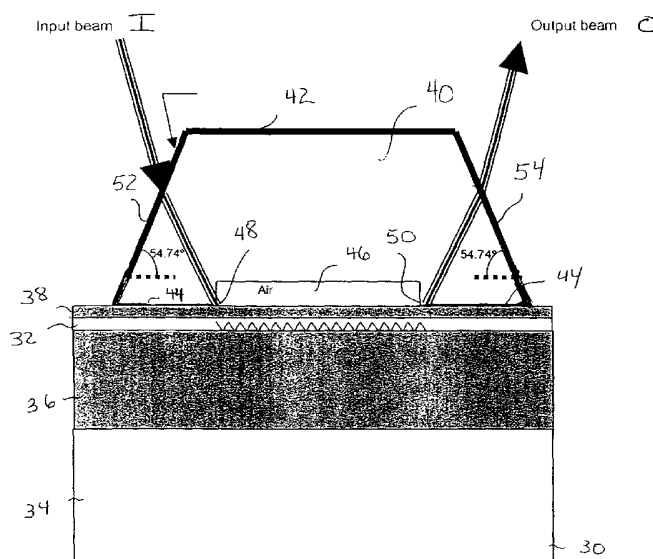
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[Continued on next page]

(54) Title: PERMANENT LIGHT COUPLING ARRANGEMENT AND METHOD FOR USE WITH THIN SILICON OPTICAL WAVEGUIDES



(57) Abstract: A trapezoidal shaped single-crystal silicon prism (40) is formed and permanently attached to an SOI wafer (30), or any structure including a silicon optical waveguide (32). In order to provide efficient optical coupling, the dopant species and concentration within the silicon waveguide (32) is chosen such that the refractive index of the silicon waveguide is slightly less than that of the prism coupler (refractive index of silicon = 3.5). An intermediate evanescent coupling layer (38), disposed between the waveguide and the prism coupler, comprises a refractive index less than both the prism and the waveguide. In one embodiment, the evanescent coupling layer (38) comprises a constant thickness. In an alternative embodiment, the evanescent coupling layer may be tapered to improve coupling efficiency between the prism and the waveguide. Methods of making the coupling arrangement are also disclosed.

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TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

— as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations

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**Declarations under Rule 4.17:**

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for all designations

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/09656

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G02B 6/34

US CL : 385/36

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)

U.S. : 385/36, 30, 31, 39, 48, 51, 129-131

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 practicable, search terms used)  
USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/0039430 A1 (DELIWALA) 27 February 2003 (27.02.2003), see entire document.	1-19, 24
Y		20-23
Y	US 6,021,239 A (MINAMI et al) 01 February 2000 (01.02.2000), see entire document.	20-23
A	US 4,877,301 A (YOKOMORI et al) 31 October 1989 (31.10.1989), see entire document.	1-48
A	US 5,235,589 A (YOKOMORI et al) 10 August 1993 (10.08.1993), see entire document.	1-48
A	US 3,883,221 A (RIGROD) 13 May 1975 (13.05.1975), see entire document.	1-48
A	US 4,979,788 A (BRAZAS, JR) 25 December 1990 (25.12.1990), see entire document.	1-48

☐ Further documents are listed in the continuation of Box C.

☐ 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 application or patent 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

"T"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/09656

### Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:  
Please See Continuation Sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐  
☐

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/09656

### BOX III. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-24, drawn to an optical coupling arrangement.

Group II, claim(s) 25-48, drawn to a method of making an optical coupling arrangement.

The inventions listed as Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I is the claimed structure of the optical coupling arrangement, whereas the special technical feature of the Group II is a particular method of making an optical coupling arrangement. Since the special technical feature of Group II is not present or required in the Group I claims, the unity of invention is lacking.