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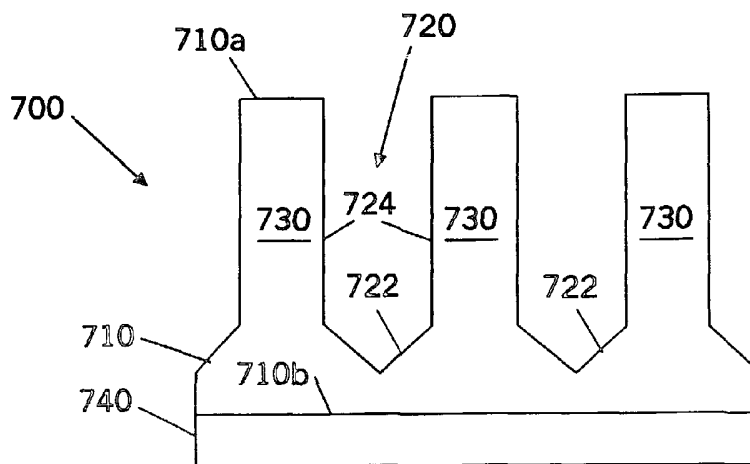
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[Continued on next page]

(54) Title: LIGHT EMITTING DIODES INCLUDING MODIFICATIONS FOR LIGHT EXTRACTION AND MANUFACTURING METHODS THEREFOR



(57) Abstract: Light emitting diodes include a substrate having first and second opposing faces and that is transparent to optical radiation in a predetermined wavelength range and that is patterned to define, in cross-section, a plurality of pedestals that extend into the substrate from the first face towards the second face. A diode region on the second face is configured to emit light in the predetermined wavelength range, into the substrate upon application of voltage across the diode region. A mounting support on the diode region, opposite the substrate is configured to support the diode region, such that the light that is emitted from the diode region into the substrate, is emitted from the first face upon application of voltage across the diode region. The first face of the substrate may include therein a plurality of grooves that define the plurality of triangular pedestals in the substrate. The grooves may include tapered sidewalls and/or a beveled floor. The first face of the substrate also may include therein an array of via holes. The via holes may include tapered sidewalls and/or a floor.



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European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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*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/US 02/02849

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 H01L33/00

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)  
IPC 7 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, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 779 924 A (KISH JR FRED A ET AL) 14 July 1998 (1998-07-14)  figures 8,13,14	1-5,7,8, 14-33, 103-120, 123-128, 135-148
X	PATENT ABSTRACTS OF JAPAN vol. 010, no. 293 (E-443), 4 October 1986 (1986-10-04) -& JP 61 110476 A (NEC CORP), 28 May 1986 (1986-05-28) abstract	1
X	US 6 015 719 A (KISH JR FRED A ET AL) 18 January 2000 (2000-01-18) figure 3	1
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Further documents are listed in the continuation of box C.

Patent family members are listed in 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
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- \*O\* document referring to an oral disclosure, use, exhibition or other means
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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

19 November 2002

Date of mailing of the international search report

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International Application No

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 00 33365 A (LINTHICUM KEVIN J ;RAJAGOPAL PRADEEP (US); UNIV NORTH CAROLINA (US) 8 June 2000 (2000-06-08) cited in the application abstract ---	33
A	US 5 585 648 A (TISCHLER MICHAEL A) 17 December 1996 (1996-12-17) abstract ---	33
Y	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 12, 29 October 1999 (1999-10-29) -& JP 11 191641 A (MATSUSHITA ELECTRON CORP), 13 July 1999 (1999-07-13) abstract ---	6,9-13, 43-88, 94-101, 129-134
Y	LEE C H ET AL: "BONDING OF INP LASER DIODES BY AU-SN SOLDER AND TUNGSTEN-BASED BARRIER METALLIZATION SCHEMES" SEMICONDUCTOR SCIENCE AND TECHNOLOGY, INSTITUTE OF PHYSICS. LONDON, GB, vol. 9, no. 4, 1 April 1994 (1994-04-01), pages 379-386, XP000443385 ISSN: 0268-1242 the whole document ---	6,9-13, 43-88, 94-101, 129-134
A	HONMA S ET AL: "Evaluation of barrier metals of solder bumps for flip-chip interconnection" ELECTRONIC MANUFACTURING TECHNOLOGY SYMPOSIUM, 1995, PROCEEDINGS OF 1995 JAPAN INTERNATIONAL, 18TH IEEE/CPMT INTERNATIONAL OMIYA, JAPAN 4-6 DEC. 1995, NEW YORK, NY, USA, IEEE, US, 4 December 1995 (1995-12-04), pages 113-116, XP010195562 ISBN: 0-7803-3622-4 the whole document ---	10
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## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 02/02849

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 767 581 A (BANDO KANJI ET AL) 16 June 1998 (1998-06-16) cited in the application the whole document -----	9

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 02/02849

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 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 II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional 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.:  
  
1-33, 43-88, 94-101, 103-120, 123-148
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/US 02 02849

## FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-5, 7, 8, 14-33, 103-120, 123-128, 135-148

LED comprising a substrate with a plurality of pedestals and its manufacturing method.

2. Claims: 34-42

LED with a substrate having two surfaces with different area.

3. Claims: 6, 9-13, 43-88, 94-101, 129-134

LED with a specific contact structure and its manufacturing method.

4. Claims: 89-93, 102

LED comprising a SiC substrate with a GaN based diode region.

5. Claims: 121, 122

LED with means for extracting from the substrate light that is emitted into the substrate by a diode region.

Claims 6,9-13, referring back to claims 1 and 4, lack unity a posteriori since the subject matter of claim 1 to which these claim indirectly refer is not new over US-A-5779924 (cf. e.g. Figs. 8, 13,14); the additional features of claim 4 is obvious.

Claims 103-120, referring back to claim 89 lack unity a posteriori since the subject matter of claim 89 is not new over US-A-5585648 disclosing a GaN/SiC LED.

Claims 43-45, referring back to claims 39-42, lack unity a posteriori since the subject matter of claims 39-42 does not involve an inventive step over US-A-5779924 or JP-A-61110476 both disclosing LEDs with substrates having different surface areas.

Claims 94-101, referring back to claim 92,90,89, lack untiy a posteriori since the subject matter of claim 89 is not new over US-A-5585648 disclosing a GaN/SiC LED, the additional features of claims 90, 92 being obvious.

The subject matter of claims 129-134, referring back to

INTERNATIONAL SEARCH REPORT

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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

claims 127, 125, 124, lack unity a posteriori since the subject matter of claim 124 is not new over US-A-5779924 (cf. e.g. Figs. 8, 13,14), the additional features of claims 125, 127 being obvious.



## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 02/02849

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