PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G01N 21/86, H01J 40/14 — A1

(11) International Publication Number: WO 97/24607

(43) International Publication Date: 10 July 1997 (10.07.97)

(21) International Application Number: PCT/US96/20380

(22) International Filing Date: 24 December 1996 (24.12.96)

(30) Priority Data:
08/582,432 2 January 1996 (02.01.96) US

(71) Applicant: MITSUBISHI MATERIALS CORPORATION [US/US]; 535 Oakmead Parkway, Sunnyvale, CA 94086 (US).

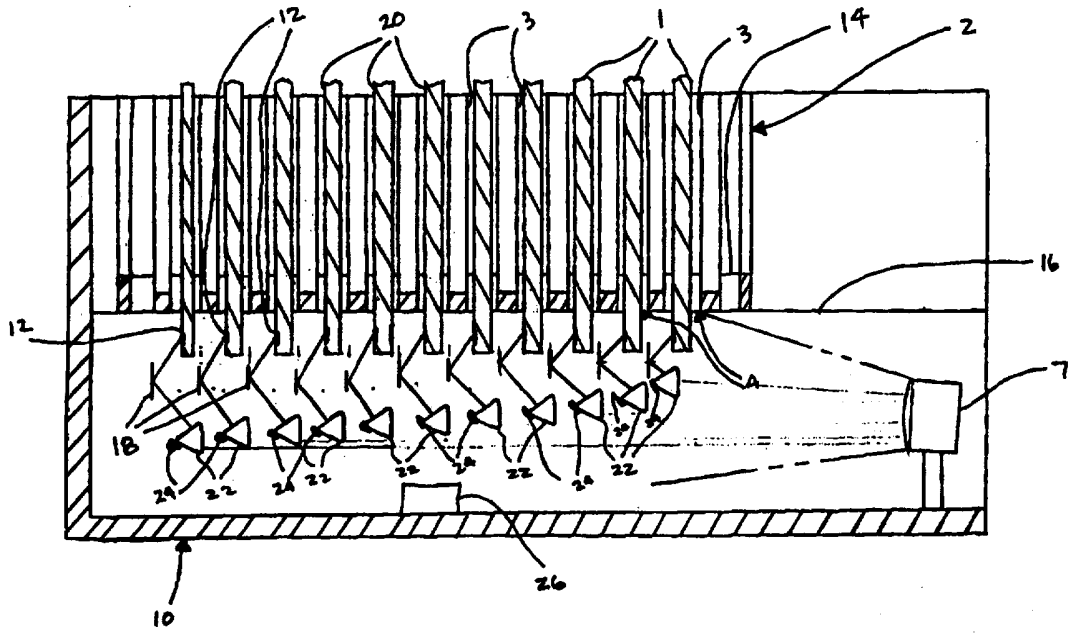
(72) Inventors: LEONOV, Mark; 1778 Audiea Place, Santa Clara, CA 95051 (US). KERBA, Emile; 481 Border Hill Drive, Los Altos, CA 94024 (US).

(74) Agents: DILLAHUNTY, T., Gene et al.; Burns, Doane, Swecker & Mathis, L.L.P., P.O. Box 1404, Alexandria, VA 22313-1404 (US).

(81) Designated States: JP, KR, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: SUBSTRATE READING DEVICE AND METHOD



(57) Abstract

A substrate reading apparatus (10) is arranged to sequentially read the identification marks (12) on each of a plurality of substrates (1). The substrates can be those used for the production of computer chips, memory disks, or liquid crystal displays. The identification marks are on the principle surface (20) of each of the substrates, which are accommodated in a conventional carrier or cassette (2). The substrates (1) are carried in slots (3) of the cassette. An optical system, comprising reader (7), mirrors (18), and optical elements (22), is mounted below the cassette in a fixed stationary relationship to the cassette such that the identification marks of each of the plurality of substrates can be read by the optical system without contacting the substrates and with minimal movement of the optical system relative to the cassette.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	**GB**	United Kingdom	**MW**	Malawi
AT	Austria	**GE**	Georgia	**MX**	Mexico
AU	Australia	**GN**	Guinea	**NE**	Niger
BB	Barbados	**GR**	Greece	**NL**	Netherlands
BE	Belgium	**HU**	Hungary	**NO**	Norway
BF	Burkina Faso	**IE**	Ireland	**NZ**	New Zealand
BG	Bulgaria	**IT**	Italy	**PL**	Poland
BJ	Benin	**JP**	Japan	**PT**	Portugal
BR	Brazil	**KE**	Kenya	**RO**	Romania
BY	Belarus	**KG**	Kyrgystan	**RU**	Russian Federation
CA	Canada	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CF	Central African Republic			**SE**	Sweden
CG	Congo	**KR**	Republic of Korea	**SG**	Singapore
CH	Switzerland	**KZ**	Kazakhstan	**SI**	Slovenia
CI	Côte d'Ivoire	**LI**	Liechtenstein	**SK**	Slovakia
CM	Cameroon	**LK**	Sri Lanka	**SN**	Senegal
CN	China	**LR**	Liberia	**SZ**	Swaziland
CS	Czechoslovakia	**LT**	Lithuania	**TD**	Chad
CZ	Czech Republic	**LU**	Luxembourg	**TG**	Togo
DE	Germany	**LV**	Latvia	**TJ**	Tajikistan
DK	Denmark	**MC**	Monaco	**TT**	Trinidad and Tobago
EE	Estonia	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**UG**	Uganda
FI	Finland	**ML**	Mali	**US**	United States of America
FR	France	**MN**	Mongolia	**UZ**	Uzbekistan
GA	Gabon	**MR**	Mauritania	**VN**	Viet Nam

SUBSTRATE READING DEVICE AND METHOD

Field of the Invention

This invention relates to methods and apparatus for reading identification marks on substrates including but not limited to semiconductor wafers, memory disks, flat panels, etc.

Background of the Invention

In a general process for manufacturing a semiconductor device, a predetermined number of substrates are accommodated in a vessel called a cassette or carrier. The substrates are moved between the various processing steps in the cassette.

It is important to identify the substrates throughout the different manufacturing steps which they undergo. For this purpose, it is conventional for each substrate to carry an identification mark (alpha-numeric or bar code) at a standard location on one or both of its surfaces, usually at a specified angle or distance from an identifiable discontinuity formed on the periphery of the substrate so that the orientation of the substrate can be easily determined, and the location of the identification is then calculated.

Many of the steps undergone by the substrate after it has been marked involve the deposition of metals or chemicals over the identification mark. The identification mark is typically etched into the smooth surface of the substrate (e.g. by means of a laser or a diamond stylus) so that the mark will show through such deposited layers. The marks are very small in size, such that magnification is a practical requirement for reading them, and even though the marks are etched into the substrate, they become more and more difficult to read as the substrate is processed. As a result, the industry has not been able to develop a fully reliable method for machine reading identification marks on substrates. Such a method is highly desirable in order to achieve the objectives of reducing the misidentification of substrates, increasing reading rates, increasing automation, and minimize handling of the substrates.

Summary of the Invention

As further described in detail below, we have discovered a number of novel ways for improving the ease and reliability with which identification marks on substrates can be read. The method and apparatus of the present invention provide a practical means for machine reading the identification marks on substrates while the substrates are stacked in the cassettes or carriers which are conventionally used to store and transport the substrates between processing steps. With the present inventions, the substrates can remain in the cassette with minimum moving parts to reduce the creation of dust particles that can contaminate the substrates.

In one aspect, this invention provides an apparatus for reading an identification mark on a principal surface of each of a plurality of substrates, the plurality of substrates being in a cassette or carrier having a plurality of parallel slots for the substrates, the apparatus comprises a support for supporting the cassette, and an optics system for reading and recording each identification mark on each substrate located below the cassette, and fixed in stationary relationship to the cassette, such that the identification mark of each of the plurality of substrates can be read by the optics system without contacting the substrates and with minimal movement of the optics system relative to the cassette.

In another aspect, this invention provides a method for reading an identification mark on a principal surface of each of a plurality of substrates, the plurality of substrates being in a cassette having a plurality of parallel slots for the substrates, the method comprises supporting the cassette, and reading the identification mark of each of the plurality of substrates with an optics system located below the cassette without contacting each of the plurality of substrates and with minimal movement of the optic's system relative to the cassette.

Brief Description of the Drawing

Figure 1 is a diagrammatic, sectional view of one embodiment of the present invention.

Figure 2 is an end view of the embodiment of Figure 1 with a part of the end of the cassette removed for clarity.

Figure 3 is a diagrammatic view of an alternate embodiment of the present invention.

Detailed Description of the Invention

The present invention will now be described with reference to the accompanying drawings. It is to be understood, however, that although this description will refer to individual features of the apparatus or methods of using the apparatus in the context of the apparatus as a whole, the present disclosure includes the use of such individual features in combinations other than those explicitly disclosed, either with each other, or with features previously referred to (whether as part of the present invention or as part of the prior art), or with features known to (or suggested by this specification to) those skilled in the technologies of semiconductor substrates, mechanical engineering, optical viewing systems (including displays) and optical character recognition (including automatic processing techniques associated therewith).

In Figs. 1 and 2, the substrate reading apparatus 10 is arranged to sequentially read the identification marks 12 on each of a plurality of substrates 1. The substrates can be those used for the production of computer chips, memory disks or those used to produce liquid crystal displays. The identification marks are on principal surface 20 of each of the substrates. The substrates 1 are accommodated in a conventional cassette or carrier 2. Cassette 2 has a plurality of parallel slots 3 at predetermined intervals in which the large number of substrates 1 are inserted for transportation between processing steps. Supports 14 are formed in the side walls of the carrier 2 for supporting the substrates along their sides. The cassette 2 has an open portion 4 in each slot 3 in the lower portion of the carrier 2 to allow the lower portion of each substrate and thus the identification marks 12 to extend below the carrier. Each substrate generally having its flat, notch or other peripheral discontinuity at the bottom end. Cassette 2 is inserted into the top of apparatus 10 and rests on support members 16 on each side of the apparatus.

Mounted in the apparatus 10 below the lower surface of the cassette is a reader 7. Reader 7 can be a CCD camera, infrared camera, bar code reader, Optical Character Reader (OCR), etc. Also mounted in apparatus 10 is a plurality of mirrors 18 corresponding with each substrate. An optical member (such as a prism, lens, combination of prisms or lenses, etc.) 22 and illumination source 24 are positioned between each mirror 18 and the reader 7. Preferably, the entire optics system is stationary to prevent the production of unwanted dust particles. However, it may be necessary to have minimal movement of the optical member and/or mirror to compensate for the tolerances in the position of the substrates. Minimal movement is movement just sufficient to compensate for tolerances in the positioning of substrates and/or components such that the identification marks will be properly focused or positioned in the field of view of the reader. Preferably, the movement will be limited to ± .08 inches laterally and/or ± 2 degrees rotationally or less. The optical members 22 redirect illumination (in the form of a reflection from the identification mark created by the illumination source) received from the mirror to the reader 7 for recognition and storage. Illumination sources 24 can be light emitting diodes, laser light, infrared radiation, etc. Illumination of any wavelength can be used. With the configuration of Fig. 1, the mirrors are located in front of the principal surface 20 of each substrate to reflect illumination from the illumination source 24 onto the identification marks 12 and to reflect the image received from the illumination mark to the optical member 22. A sequencer 26 can be provided that is electrically connected or in remote communication with each illumination source 24. The sequencer illuminates and extinguishes each illumination source individually in sequence such that only one image is visible to the reader 7 at a time so that it can be accurately determined as to which substrate is being read.

Any optical system can be used to provide the desired image to the reader 7 as will be recognized by one of ordinary skill in the art of optical viewing systems and optical character recognition.

When the first light source is turned on, light from the first light source strikes the first mirror and is reflected from the first mirror onto the target area (e.g., identification marks) of the first substrate. If the light strikes a part of the target area which is coplanar with the principal plane of the substrate, the reflection strikes the first mirror and is reflected into the first optical member. The first optical member redirects the reflection to the field of view of the reader 7. The reader then reads and records the identification mark on the first substrate. Then, the first light source is turned off and the second light source is turned on. Light from the second light source strikes the second mirror and is reflected from the second mirror onto the target area of the second substrate. If the light strikes a part of the target area which is coplanar with the principal plane of the substrate, the reflection strikes the second mirror and is reflected into the second optical member, The second optical member redirects the reflection to the field of view of the reader 7. The reader then reads and records the identification marks of the second substrate. This sequence continues for the number of substrates present. At least the interior surfaces of the apparatus are preferably treated, (e.g. painted matte black) so as to minimize stray reflections.

The cassette of substrates can be in any orientation, providing that measures are taken to ensure that the spacing between substrates is maintained. Preferably the cassette is orientated so that this is achieved by the force of gravity alone. It is also preferred that when a substrate is in the viewing position, it should contact a known surface of the cassette, so that its position is precisely known. Accordingly, it is preferred that the cassette support is such that, when a cassette of substrates is supported by the cassette support, the principal planes of the substrates are inclined to the vertical at an angle of 0° to 45°. Of course, the optical system will be arranged accordingly.

The mirrors in the first embodiment are necessarily very small in order that each mirror can fit into the confined space between the substrates. The precise relationship between each mirror and the substrate is, therefore, very important. The location and angle of each mirror, and the location of each

optical member are preferably such that light which reflects off the mirror into the optical reader is at an angle of between 0 to 180 degrees relative to the plane of the mirror. Likewise, the location and viewing direction of the reader are preferably such that the light which enters the reader leaves the optical member at an angle of between 0 to 180 degrees relative to an imaginary horizontal plane.

Figure 3 is a diagrammatic illustration of another embodiment of the present invention in which the optical system comprises a reader 7' and an illumination source 24 for each substrate 1 present in a cassette (not shown). Sequencer 26 illuminates and extinguishes each illumination source sequentially as described previously. Or in the alternative, activates and deactivates each reader sequentially.

With the optics system of the present invention, the substrates in a conventional cassette can be read sequentially without having a translating reader, having to move any components except to rotate and/or translate them minimally for alignment purposes in some instances, or having to move any of the substrates thus reducing or eliminating the production of dust particles that may contaminate the substrates.

As indicated above, the apparatus is particularly useful when the identification marks and associated peripheral discontinuities of the substrates are at the bottom ends of the slot. If they are not, then the apparatus must include means for rotating the substrates so as to bring the identification marks into the target area (as described for example in U.S. Pat. No. 4,892,455 the disclosure of which is incorporated herein by reference in its entirety).

The foregoing has described the principles, preferred embodiments and modes of operation of the present invention. However, the invention should not be construed as being limited to the particular embodiments discussed. Thus, the above-described embodiments should be regarded as illustrative rather than restrictive, and it should be appreciated that variations may be made in those embodiments by workers skilled in the art without departing from the scope of the present invention as defined by the following claims.

THE INVENTION CLAIMED IS:

1. An apparatus for reading an identification mark on a principal surface of each of a plurality of substrates, the plurality of substrates being in a cassette having a plurality of parallel slots for the substrates, the apparatus comprising:

a support for supporting the cassette;

an optics system for reading and recording each identification mark on each substrate located below the cassette and fixed in stationary relationship to the cassette such that the identification mark of each of the plurality of substrates can be read by the optics system without contacting the substrates and with minimal movement of the optics system relative to the cassette.

2. The apparatus of Claim 1 wherein the optics system comprises:

a reader corresponding to each of the plurality of substrates for reading the identification mark on each of the plurality of substrates; and

an illumination source corresponding to the reader for providing direct illumination of the identification mark.

3. The apparatus of Claim 2 wherein the reader is a camera and the illumination source is a light emitting diode.

4. The apparatus of Claim 2 wherein the reader is a camera and the illumination source is a laser.

5. The apparatus of Claim 2 further comprising:

a sequencer coupled to the illumination source for sequentially illuminating and extinguishing the illumination source so that the reader can read the identification mark on a single substrate.

6. The apparatus of Claim 1 wherein the optics system comprises:

an illumination source mounted so as to correspond to each of the plurality of substrates;

a mirror corresponding to each of the plurality of substrates for facilitating indirect illumination of the identification mark by the illumination source, the mirror being mounted in front of the principal surface of each of the substrates; and

a reader located on an opposite side of each of the plurality of substrates from the principal surface for reading the identification mark on each of the plurality of substrates reflected in the mirror.

7. The apparatus of Claim 6 further comprising:

an optical member corresponding to each of the plurality of substrates, the optical member being located between the reader and the mirror so as to deviate illumination incident on the optical member from the mirror to the reader.

8. The apparatus of Claim 6 wherein the reader is a camera and the illumination source is a light emitting diode.

9. The apparatus of Claim 6 wherein the reader is a camera and the illumination source is a laser.

10. The apparatus of Claim 6 further comprising:

a sequencer coupled to the illumination source for sequentially illuminating and extinguishing the illumination source so that the reader can read the identification mark on a single substrate.

11. The apparatus of Claim 1 wherein each of the plurality of substrates can be read by the optics system with no movement of the optics system relative to the cassette.

12. A method for reading an identification mark on a principal surface of each of a plurality of substrates, the plurality of substrates being in a cassette having a plurality of parallel slots for the substrates, the method comprising:

supporting the cassette; and

reading the identification mark of each of the plurality of substrates with an optics system located below the cassette without contacting each of the plurality of substrates and with minimal movement of the optics system relative to the cassette.

13. The method of Claim 12 wherein the reading step comprises:

providing a reader corresponding to each of the plurality of substrates for reading the identification mark on each of the plurality of substrates; and

illuminating the identification mark with an illumination source corresponding to the reader,

14. The method of Claim 13 further comprising:

sequentially illuminating and extinguishing the illumination source so that the reader can read the identification mark on a single substrate.

15. The method of Claim 11 wherein the reading step comprises:

providing an illumination source for each of the plurality of substrates;

providing a mirror in front of the principal surface of each of the substrates;

indirectly illuminating the identification mark on each of the plurality of substrates with each illumination source and mirror; and

reading the reflection of each identification mark on the plurality of substrates with a reader located on an opposite side of each of the plurality of substrates from the principal surface.

16. The method of Claim 15 further comprising:

deviating illumination incident on an optical member from the mirror to the reader.

17. The method of Claim 15 further comprising:

sequentially illuminating and extinguishing each illumination source so that the reader can read the identification mark on a single substrate.

18. The method of Claim 12 wherein the reading step is conducted with no movement of the optics system relative to the cassette.

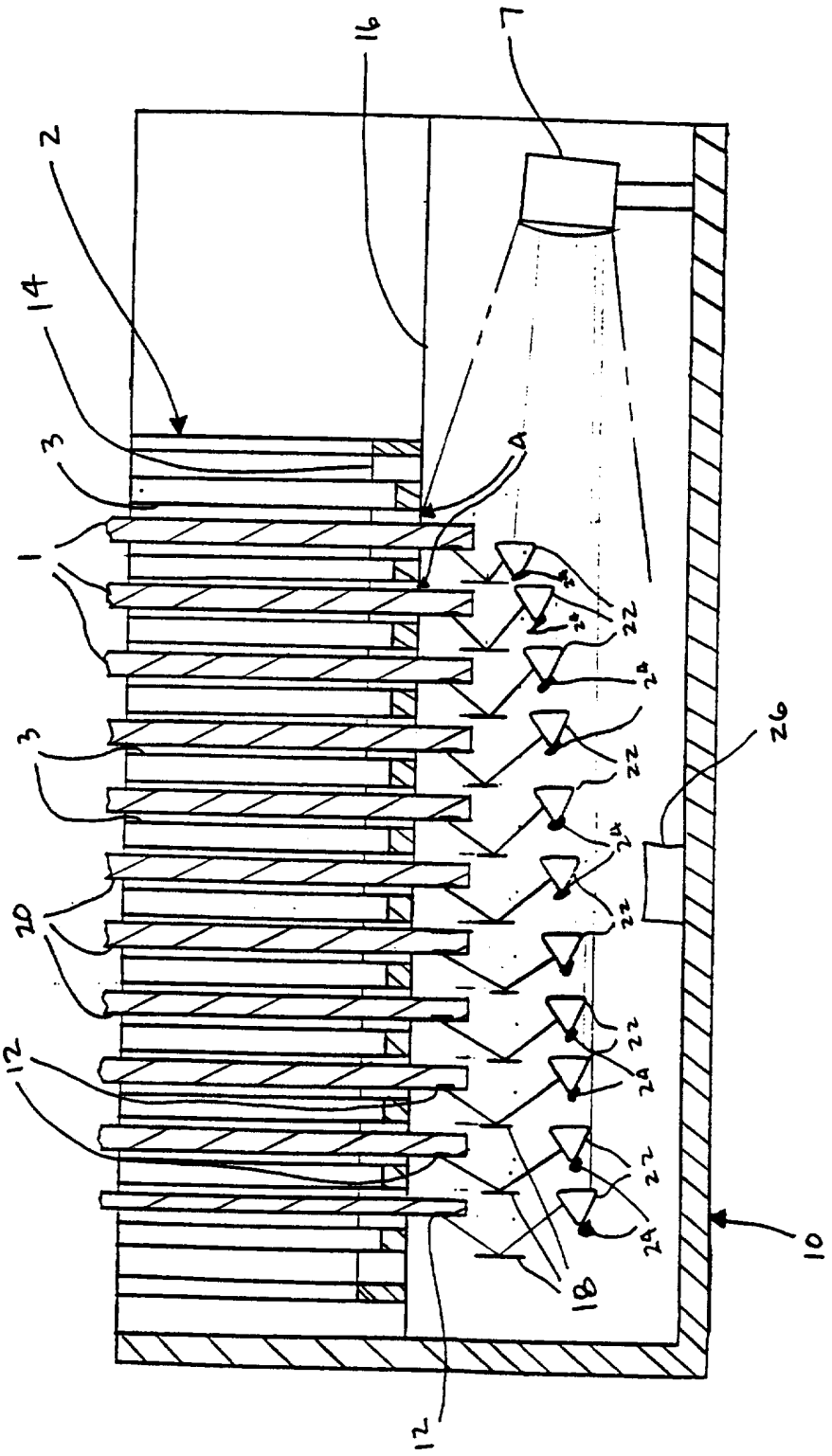


FIG. 1

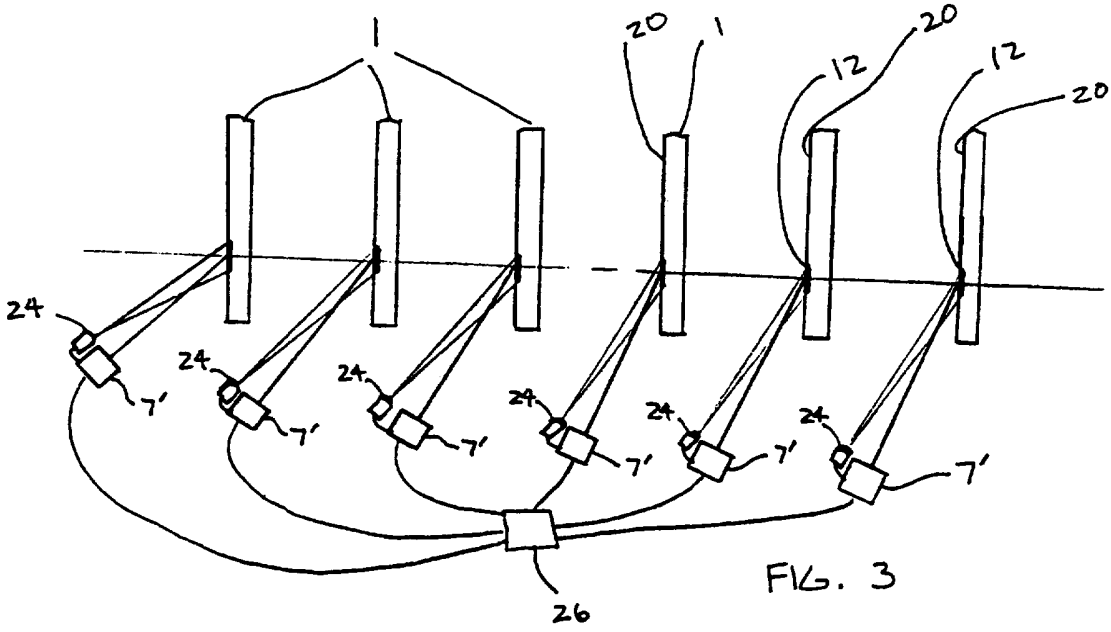

1
20
1
12
20
12
20
24
24
24
24
24
24
7'
7'
7'
7'
7'
7'
26

FIG. 3

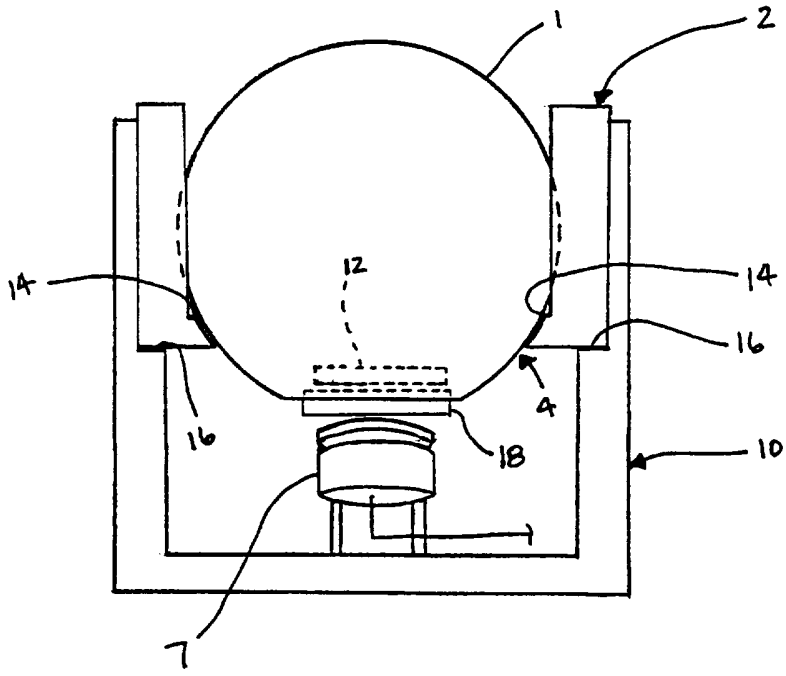

1
2
14
12
14
16
16
4
18
10
7

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/20380

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G01N 21/86; H01J 40/14
US CL :250/559.44; 414/331, 935
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. : 250/559.44, 222.1, 208.2, 216; 414/331, 935, 936, 937, 938, 273, 417; 377/8, 10, 53

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)

APS
search terms: wafer, substrate, cassette, marks, identification, code

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,859,993 A (KAGAMI et al.) 22 August 1989, see entire document.	1-15
A	US 4,892,455 A (HINE) 09 January 1990, see entire document.	1-15
A	US 5,225,691 A (POWERS et al.) 06 July 1993, see entire document.	1-15
A	US 5,003,188 A (IGARI) 26 March 1991, see entire document.	1-15
A	US 5,231,536 A (WILT et al.) 27 July 1993, see entire document.	1-15
A	US 5,265,170 A (HINE et al.) 23 November 1993, see entire document.	1-15

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

*	Special categories of cited documents:	"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
"A"	document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier document published on or after the international filing date	"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
"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)	"&"	document member of the same patent family
"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		

Date of the actual completion of the international search	Date of mailing of the international search report
03 MARCH 1997	11 MAR 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JOHN R. LEE Telephone No. (703) 308-0956

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/20380

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 5,418,382 A (BLACKWOOD et al.) 23 May 1995, see entire document.	1-15