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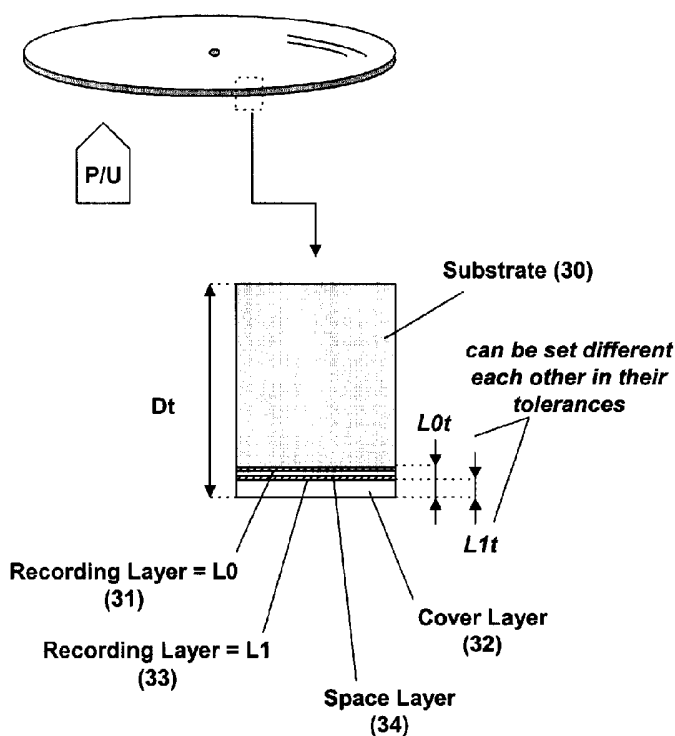
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(54) Title: MULTI-LAYER DISC

Dual Layer Blu-ray Disc (300)



(57) Abstract: A multi-layer disc is disclosed which includes a plurality of recording layers, as in a dual layer blu-ray disc. In the multi-layer disc, the tolerance of a transparent substrate thickness from a surface of a cover layer to each recording layer is set to be different from those of transparent substrate thicknesses to other recording layers within a range in which no degradation in the characteristics of recording and reproduction signals for each recording layer occurs. Accordingly, it is possible to more efficiently manufacture multi-layer discs, to achieve an improvement in the manufacturing yield of multi-layer discs, and to achieve a reduction in the manufacturing costs of multi-layer discs.



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# DESCRIPTION

## MULTI-LAYER DISC

### 1. Technical Field

The present invention relates to a multi-layer disc, and  
5 more particularly to a multi-layer disc in which the tolerance  
of a thickness from a surface of a cover layer to each recording  
layer in the disc is set to be different from those of thicknesses  
to other recording layers.

### 10 2. Background Art

High-density optical discs capable of recording or  
reproducing a large quantity of high-quality video and audio data,  
such as blu-ray discs (BDs), have been developed, and are expected  
to be made commercially available. Generally, such optical discs  
15 have a multi-layer structure in which a plurality of recording  
layers are formed on a single disc substrate, in order to achieve  
an increase in recording capacity.

Referring to FIG. 1, a single layer BD 100 is illustrated.  
The single layer BD 100 has a laminated disc structure including  
20 a substrate 10, a recording layer 11, and a cover layer 12.

Typically, the single layer BD 100, which has the  
above-mentioned disc structure, has a total thickness  $D_t$  of 1,200  
 $\mu\text{m}$ . The cover layer 12 has a thickness of 100  $\mu\text{m}$  when the radial  
position corresponding to a radius of 22 to 23 mm is set as a  
25 reference position, under the condition in which the cover layer  
12 has a refractive index of, for example, 1.6. Since the cover  
layer 12 has a thickness tolerance of  $\pm 5 \mu\text{m}$ , the thickness from  
an exposed surface of the cover layer 12 to the recording layer  
11,  $L_{0t}$ , ranges from 95  $\mu\text{m}$  to 105  $\mu\text{m}$ .

Referring to FIG. 2, a dual layer BD 200 is illustrated. The dual layer BD 200 has a laminated disc structure including a substrate 20, a first recording layer 21, a space layer 24, a second recording layer 23, and a cover layer 22.

5 Typically, the dual layer BD 200 has a total thickness  $D_t$  of 1,200  $\mu\text{m}$ . The cover layer 22 has a thickness of 75  $\mu\text{m}$  when the radial position corresponding to a radius of 22 to 23 mm is set as a reference position, under the condition in which the cover layer 22 has a refractive index of, for example, 1.6. Since the  
10 cover layer 22 has a thickness tolerance of  $\pm 5 \mu\text{m}$ , the thickness from an exposed surface of the cover layer 22 to the second recording layer 23,  $L_{1t}$ , ranges from 70  $\mu\text{m}$  to 80  $\mu\text{m}$ .

Also, the thickness to the first recording layer 21,  $L_{0t}$ , corresponds to the sum of the thickness of the cover layer 22, second recording layer 23 ( $L_1$ ), and space layer 24, and ranges  
15 from 95  $\mu\text{m}$  to 105  $\mu\text{m}$ , as in the single layer BD.

Typically, either the single layer BD 100 or the dual layer BD 200 is designed to satisfy a thickness tolerance of  $\pm 2 \mu\text{m}$ . In order to satisfy this thickness tolerance, it is necessary to  
20 achieve an increased disc manufacture accuracy. However, this causes great degradation in manufacturing yield under the currently given manufacture conditions, thereby resulting in a great increase in disc manufacturing costs. On the other hand, when the thickness tolerance is undesirably increased,  
25 degradation in signal characteristics occurs. In this case, errors may be generated during recording and reproducing operations.

### 3. Disclosure of Invention

30 Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a multi-layer disc which is capable of achieving an enhancement in manufacture efficiency without causing

degradation in signal characteristics in recording and reproduction operations.

In accordance with an aspect of the present invention, the above and other objects can be accomplished by the provision of  
5 a multi-layer disc comprising: a plurality of recording layers, wherein a thickness from a surface of a cover layer of the disc to each of the recording layers has a tolerance determined such that a tolerance of the thickness associated with the recording layer more distant from the cover layer is larger than a tolerance  
10 of the thickness associated with the recording layer closer to the cover layer.

The thickness associated with an arbitrary recording layer may correspond to a thickness of the cover layer, or to a sum of the thickness of the cover layer, thicknesses of recording  
15 layers closer to the cover layer than the arbitrary recording layer, and thicknesses of space layers, while being closer to the cover layer than the arbitrary recording layer, formed between two recording layers.

The thickness associated with the recording layer more  
20 distant from the cover layer may have a tolerance of  $\pm 3 \mu\text{m}$ . The thickness associated with the recording layer closer to the cover layer may have a tolerance of  $\pm 2 \mu\text{m}$ . The thickness tolerance may be determined under conditions in which a radial position of the disc corresponding to a radius of 33 to 34 mm is set as  
25 a reference position, and the cover layer has a refractive index of 1.6.

In accordance with another aspect, the present invention provides a multi-layer disc having a laminated disc structure comprising a substrate, a first recording layer, a space layer,  
30 a second recording layer, and a cover layer, wherein the cover layer has a thickness tolerance of  $\pm 2 \mu\text{m}$  when the cover layer has a thickness of  $75 \mu\text{m}$ , and a sum of thicknesses of the cover layer, the second recording layer, and the space layer has a

tolerance of  $\pm 3 \mu\text{m}$  when the thickness sum is  $100 \mu\text{m}$ .

The tolerance of the sum of the thicknesses of the cover layer, the second recording layer and the space layer may be determined to satisfy a minimal limited equalizer (LEQ) jitter value of 6.5 %, and a LEQ jitter value of not more than 10% at a radial tilt of  $\pm 0.6$  degree, in associated with the first recording layer. The tolerance of the thickness of the cover layer may be determined to satisfy a minimal LEQ jitter value of 6.5 %, and a LEQ jitter value of not more than 10% at a radial tilt of  $\pm 0.6$  degree, in associated with the second recording layer.

#### 4. Brief Description of Drawings

The accompanying drawings, which are included to provide a further understanding of the invention, illustrate the preferred embodiments of the invention, and together with the description, serve to explain the principles of the present invention.

FIG. 1 is a schematic view illustrating a general single layer blu-ray disc (BD);

FIG. 2 is a schematic view illustrating a general dual layer BD;

FIG. 3 is a schematic view illustrating a dual layer BD according to the present invention;

FIG. 4 is a schematic view illustrating a procedure for manufacturing the dual layer BD according to the present invention;

FIG. 5 is a graph depicting limited equalizer (LEQ) jitter characteristics of a first recording layer in the dual layer BD according to the present invention; and

FIG. 6 is a graph depicting limited equalizer (LEQ) jitter characteristics of a second recording layer in the dual layer BD according to the present invention.

Features, elements, and aspects of the invention that are

referenced by the same numerals in different figures represent the same, equivalent, or similar features, elements, or aspects in accordance with one or more embodiments.

## 5 5. Modes for Carrying out the Invention

Hereinafter, preferred embodiments of a multi-layer disc according to the present invention will be described in detail with reference to the annexed drawings.

The present invention is applicable to multi-layer discs  
10 of various types in which a plurality of recording layers are laminated over a single substrate.

Referring to FIG. 3, a dual layer blu-ray disc (BD) 300 is illustrated. The dual layer BD 300 has a laminated disc structure including a substrate 30, a first recording layer 31 (L0), a space  
15 layer 34, a second recording layer 33 (L1), and a cover layer 32.

The dual layer BD 300 has a total thickness  $D_t$  of 1,200  $\mu\text{m}$ . The sum of the thicknesses of the cover layer 32, second recording layer 33 and space layer 34, which corresponds to the thickness  
20 from an exposed surface of the cover layer 32 to the first recording layer 31, namely, a thickness  $L_{0t}$ , is 100  $\mu\text{m}$  with a tolerance of  $\pm 3 \mu\text{m}$  when the radial position corresponding to a radius of 33 to 34 mm is set as a reference position, under the condition in which the cover layer 32 has a refractive index of,  
25 for example, 1.6.

The thickness of the cover layer 32, which corresponds to the thickness from the exposed surface of the cover layer 32 to the second recording layer 33, namely, a thickness  $L_{1t}$ , is 75  $\mu\text{m}$  with a tolerance of  $\pm 2 \mu\text{m}$  when the radial position  
30 corresponding to the radius of 33 to 34 mm is set as the reference position, under the condition in which the cover layer 32 has a refractive index of, for example, 1.6.

That is, the first recording layer 31 more distant from the

cover layer 32, has a relatively large thickness tolerance of  $\pm 3 \mu\text{m}$ , whereas the second recording layer 33 closer to the cover layer 32, has a relatively small thickness tolerance of  $\pm 2 \mu\text{m}$ . Hereinafter, the procedure for manufacturing the dual layer BD  
5 in which the recording layers have different thickness tolerances, as described above, will be described in detail.

FIG. 4 illustrates a procedure for manufacturing the dual layer BD according to the present invention.

In the disc manufacturing procedure, a pit array is first  
10 formed on the substrate 30 which may be injection-molded. A reflective film is then coated over the pit array formed on the substrate 30 in accordance with a sputtering process, to form the first recording layer 31 (S10). An ultraviolet (UV) resin is pressed on the first recording layer 31, to form the space  
15 layer 34 (S11).

Thereafter, a stamper 40, which has a pit array, is accurately positioned on the space layer 34 (S12). A pressure is then applied to the stamper 40, thereby causing the stamper 40 to form a pit array on the space layer 34 (S13). In this case,  
20 the thickness of the space layer 34 is maintained to be 20 to  $30 \mu\text{m}$ .

Subsequently, UV rays are irradiated onto the substrate 30. The stamper 40 is then removed. Thereafter, a reflective film is coated over the pit array formed on the space layer 34 in  
25 accordance with a sputtering process, to form the second recording layer 33 (S14).

Next, a cover sheet is attached to the second recording layer 33 using a UV resin, and is then fixed to the second recording layer 33 by irradiating the UV resin with UV rays, and  
30 thus, curing the UV resin (S15). In this case, the cover layer 32 has a thickness of about  $75 \mu\text{m}$  including the thickness of the UV resin.

In the above-described disc manufacturing procedure, the

first recording layer 31 is first formed, the space layer 34 having the thickness of 20 to 30  $\mu\text{m}$  is formed, the second recording layer 33 is formed, and the cover layer 32 having the thickness of about 75  $\mu\text{m}$  is finally formed. In this case, the tolerance of the thickness from the exposed surface of the cover layer 32 to the first recording layer 31, namely, the thickness  $L_{0t}$  (100  $\mu\text{m}$ ), results from the accumulation of the thickness tolerance of the space layer 34 and the tolerance of the thickness from the exposed surface of the cover layer 32 to the second recording layer 33, namely, the thickness  $L_{1t}$  (75  $\mu\text{m}$ ).

In this regard, the tolerance of the thickness  $L_{0t}$  associated with the first recording layer 31, for example, a tolerance  $D_0$ , the tolerance of the thickness  $L_{1t}$  associated with the second recording layer 33, for example, a tolerance  $D_1$ , and the tolerance of the thickness of the space layer 34, for example, a tolerance  $S$ , have a relation expressed by " $|D_0| = \sqrt{D_1^2 + S^2}$ ".

Referring to this relation, it can be seen that the tolerance of the thickness  $L_{0t}$  associated with the first recording layer 31, namely, the tolerance  $D_0$ , is larger than the tolerance of the thickness  $L_{1t}$  associated with the second recording layer 33, namely, the tolerance  $D_1$ .

Meanwhile, FIG. 5 illustrates a variation in limited equalizer (LEQ) jitter characteristics depending on a variation in the thickness  $L_{0t}$  associated with the first recording layer 31 ( $L_0$ ) when the first recording layer 31 has a storage capacity of 25 GB. When the thickness  $L_{0t}$  associated with the first recording layer 31 is 100  $\mu\text{m}$ , and has a tolerance ranging within  $\pm 3 \mu\text{m}$ , the condition, in which the minimal LEQ jitter value should be less than 6.5 %, is satisfied, as shown in FIG. 5. Also, the LEQ jitter value is not more than 10% at a radial tilt of  $\pm 0.6$  degree. Accordingly, a desired margin of signal reproduction characteristics can be secured. However, referring to FIG. 5,

it can be seen that, when the thickness  $L_{0t}$  has a tolerance of  $\pm 4 \mu\text{m}$ , it is impossible to satisfy the condition in which the minimal LEQ jitter value should be less than 6.5 %.

Thus, the first recording layer 31 can satisfy required  
5 signal characteristics so long as the thickness  $L_{0t}$  associated with the first recording layer 31 has a tolerance of  $\pm 3 \mu\text{m}$ .

FIG. 6 illustrates a variation in limited equalizer (LEQ) jitter characteristics depending on a variation in the thickness  $L_{1t}$  associated with the second recording layer 33 when the second  
10 recording layer 33 ( $L_1$ ) has a storage capacity of 25 GB. When the thickness  $L_{1t}$  associated with the second recording layer 33 is  $75 \mu\text{m}$ , and has a tolerance ranging within  $\pm 2 \mu\text{m}$ , the condition, in which the minimal LEQ jitter value should be less than 8.5 %, is satisfied, as shown in FIG. 6. Also, the LEQ jitter value  
15 is not more than 10% at a radial tilt of  $\pm 0.6$  degree. Accordingly, a desired margin of signal reproduction characteristics can be secured. However, referring to FIG. 5, it can be seen that, when the thickness  $L_{0t}$  has a tolerance of  $\pm 3 \mu\text{m}$ , it is impossible to satisfy the condition in which the minimal LEQ jitter value  
20 should be less than 8.5 %.

Thus, the second recording layer 33 can satisfy required signal characteristics so long as the thickness  $L_{1t}$  associated with the second recording layer 33 has a tolerance of  $\pm 2 \mu\text{m}$ .

As apparent from the above description, in accordance with  
25 the present invention, it is possible to more efficiently manufacture a multi-layer disc by setting the tolerance of the thickness from the exposed surface of the cover layer to each recording layer in the disc to be different from those of thicknesses to other recording layers. Accordingly, it is  
30 possible to achieve an enhancement in disc manufacturing yield, and thus, a reduction in disc manufacturing costs.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those

skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

# CLAIMS

1. A multi-layer disc comprising:

a plurality of recording layers,

wherein a thickness from a surface of a cover layer of the  
5 disc to each of the recording layers has a tolerance determined  
such that a tolerance of the thickness associated with the  
recording layer more distant from the cover layer is larger than  
a tolerance of the thickness associated with the recording layer  
closer to the cover layer.

10

2. The multi-layer disc as set forth in claim 1, wherein  
the thickness associated with an arbitrary recording layer  
corresponds to a thickness of the cover layer, or to a sum of  
the thickness of the cover layer, thicknesses of recording layers  
15 closer to the cover layer than the arbitrary recording layer,  
and thicknesses of space layers, while being closer to the cover  
layer than the arbitrary recording layer, formed between two  
recording layers.

20

3. The multi-layer disc as set forth in claim 1, wherein  
the thickness associated with the recording layer more distant  
from the cover layer has a tolerance of  $\pm 3 \mu\text{m}$ , and the thickness  
associated with the recording layer closer to the cover layer  
has a tolerance of  $\pm 2 \mu\text{m}$ .

25

4. The multi-layer disc as set forth in claim 1, wherein  
the thickness tolerance is determined under conditions in which  
a radial position of the disc corresponding to a radius of 33  
to 34 mm is set as a reference position, and the cover layer has  
30 a refractive index of 1.6.

5. The multi-layer disc as set forth in claim 1, wherein the multi-layer disc is a blu-ray disc having a first recording layer and a second recording layer.

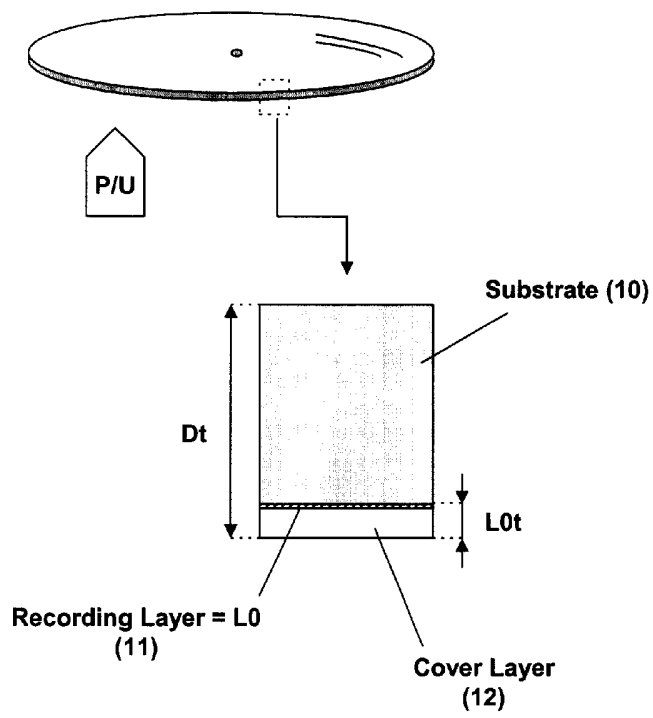
5        6. The multi-layer disc as set forth in claim 5, wherein, under conditions in which a radial position of the disc corresponding to a radius of 33 to 34 mm is set as a reference position, and the cover layer has a refractive index of 1.6, the thickness associated with the first recording layer has a  
10 tolerance of  $\pm 3 \mu\text{m}$ , and the thickness associated with the second recording layer has a tolerance of  $\pm 2 \mu\text{m}$ .

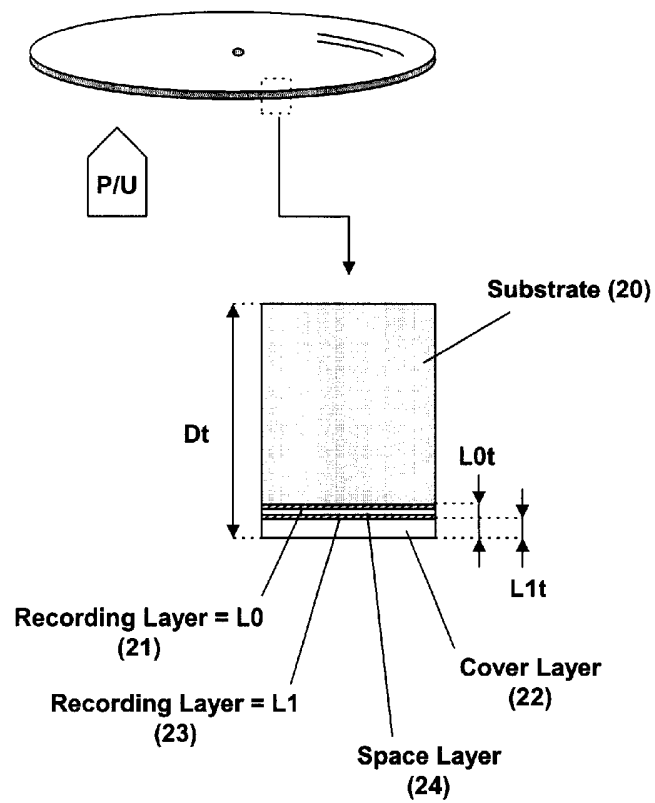
7. A multi-layer disc having a laminated disc structure comprising a substrate, a first recording layer, a space layer,  
15 a second recording layer, and a cover layer,  
      wherein the cover layer has a thickness tolerance of  $\pm 2 \mu\text{m}$  when the cover layer has a thickness of  $75 \mu\text{m}$ ,  
      wherein a sum of thicknesses of the cover layer, the second recording layer, and the space layer has a tolerance of  $\pm 3 \mu\text{m}$   
20 when the thickness sum is  $100 \mu\text{m}$ .

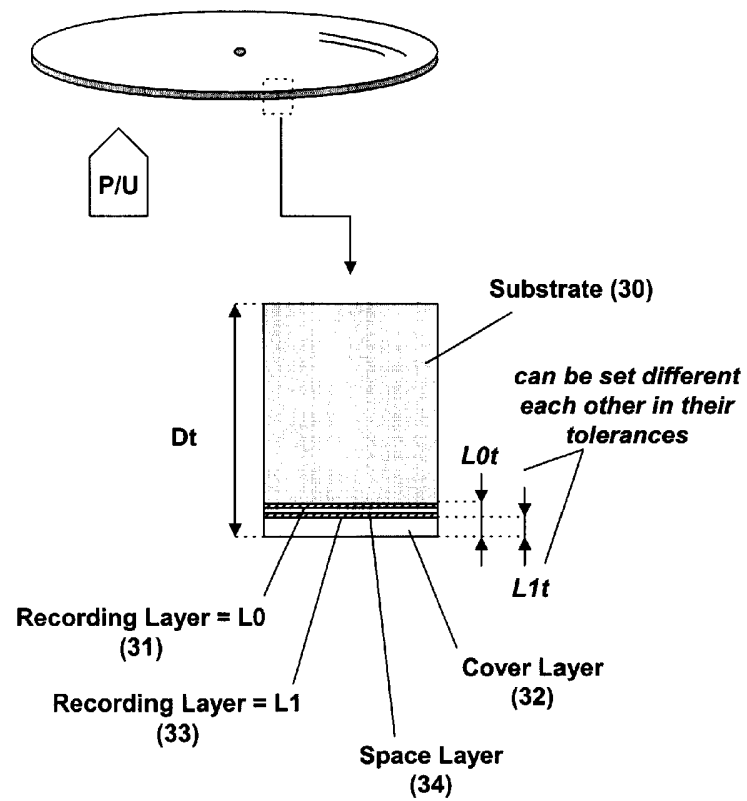
8. The multi-layer disc as set forth in claim 7, wherein the tolerance of the sum of the thicknesses of the cover layer, the second recording layer and the space layer is determined to  
25 satisfy a minimal limited equalizer (LEQ) jitter value of 6.5 %, and a LEQ jitter value of not more than 10% at a radial tilt of  $\pm 0.6$  degree, in associated with the first recording layer.

9. The multi-layer disc as set forth in claim 7, wherein  
30 the tolerance of the thickness of the cover layer is determined to satisfy a minimal limited equalizer (LEQ) jitter value of 6.5 %, and a LEQ jitter value of not more than 10% at a radial tilt of  $\pm 0.6$  degree, in associated with the second recording layer.

1/6

**FIG. 1****Single Layer Blu-ray Disc (100)**

**FIG. 2****Dual Layer Blu-ray Disc (200)**

**FIG. 3****Dual Layer Blu-ray Disc (300)**

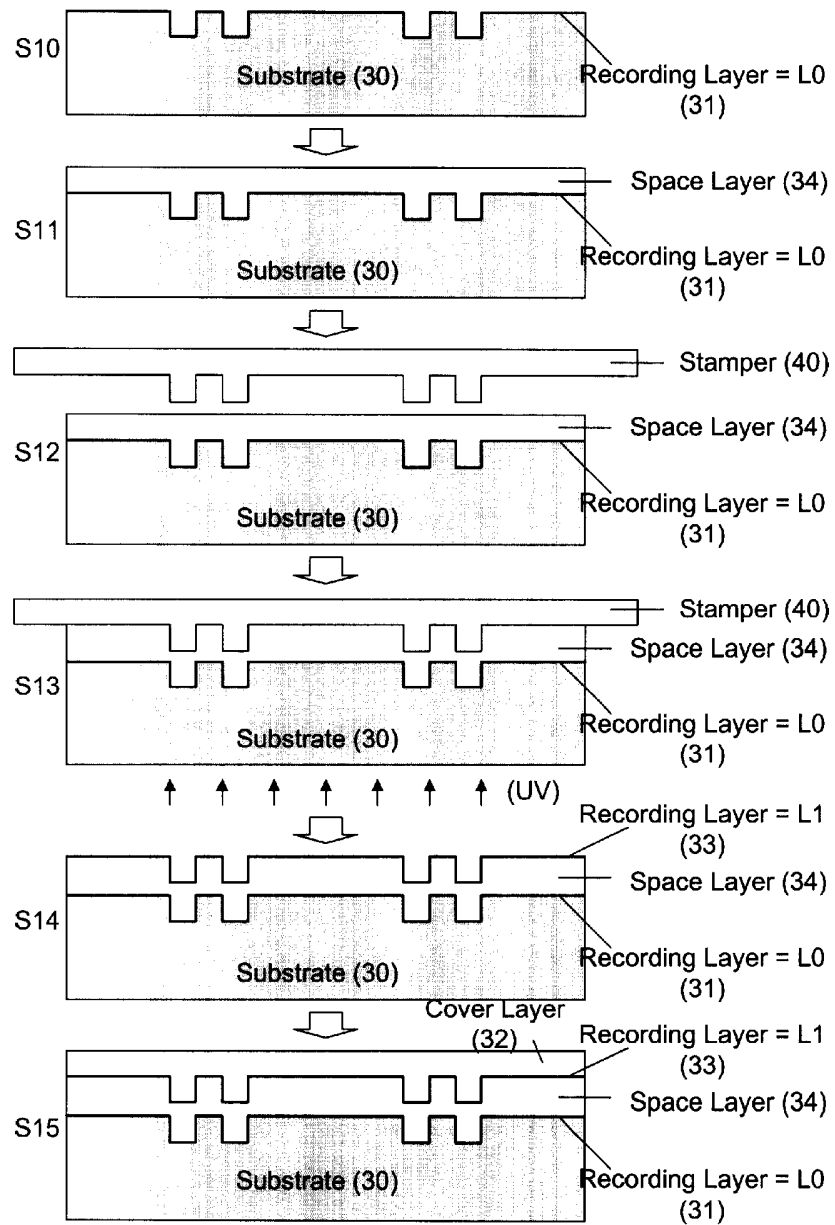
**FIG. 4**

FIG. 5

Recording Layer = L0

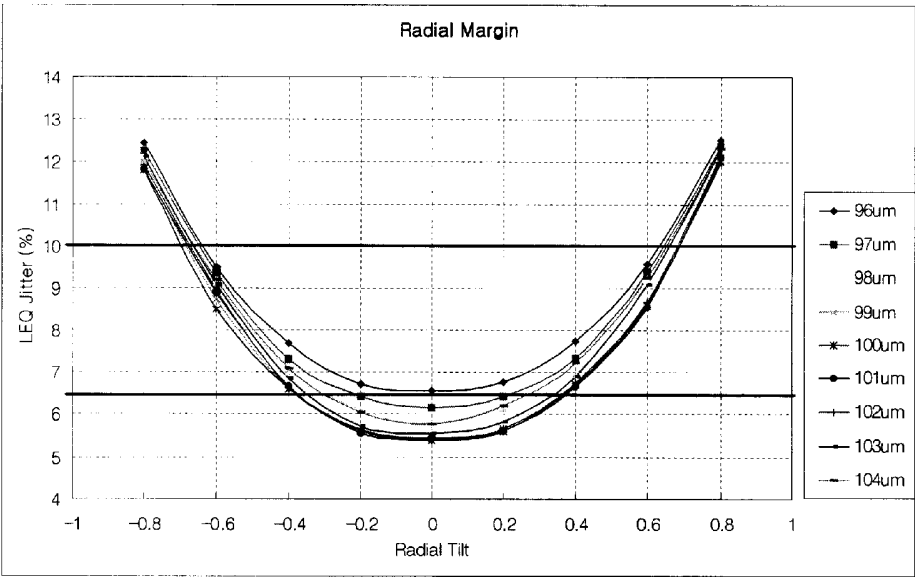
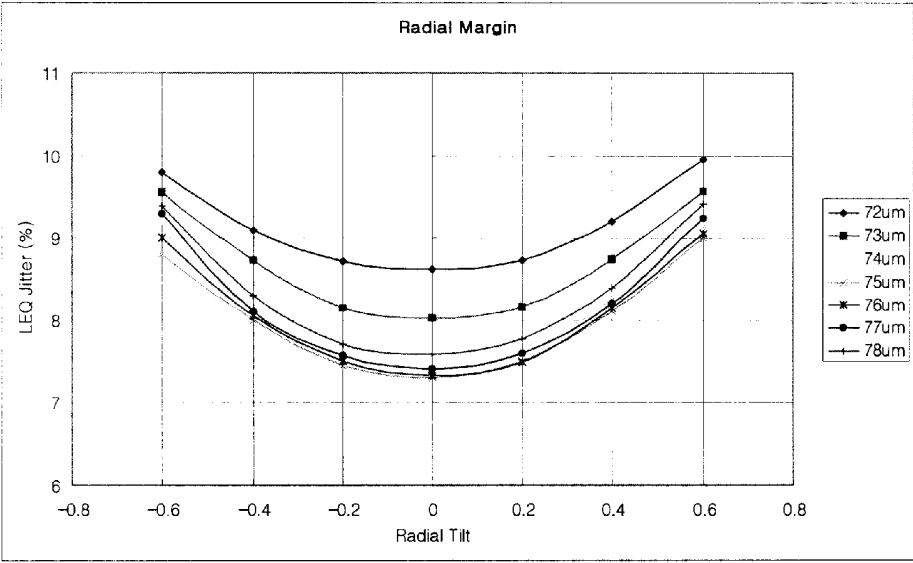


FIG. 6

Recording Layer = L1



## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/KR2005/003712

**A. CLASSIFICATION OF SUBJECT MATTER***G11B 7/24(2006.01)i*

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)

G11B 7/24(2006.01)i

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)  
wpi,paj"thickness", "resolution", "multi", "recording", "cover", "space", "jitter", "substrate"

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------|-----------------------|
| A         | D1=JP 02-236834 (CANON INC.)19. SEPT. 1990.<br>See abstract.                       | 1                     |
| A         | D2=JP 09-063123(SONY CORP.) 07 MAR. 1997<br>See abstract.                          | 1                     |
| A         | D3=JP11-154352(NEC CORP.)08 JUNE 1999.<br>See abstract                             | 1                     |

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

☐ See patent family annex.

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Date of the actual completion of the international search

14 FEBRUARY 2006 (14.02.2006)

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