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(54) Optical data record carrier and method of manufacturing such carrier

(57) An optical data record carrier comprises a substrate (21) of a transparent material (eg glass or synthetic resin) having a predetermined refractive index and two flat surfaces. A photosensitive layer (23) provided and developed on one of the flat surfaces of the substrate has a refractive index substantially equal to the refractive index of the substrate. A reflecting film (27) (eg of aluminium) is formed over the one flat surface of the substrate and over the reflecting film. A protective film (28) (eg of synthetic resin) is then formed over the reflecting film.

FIG. 2

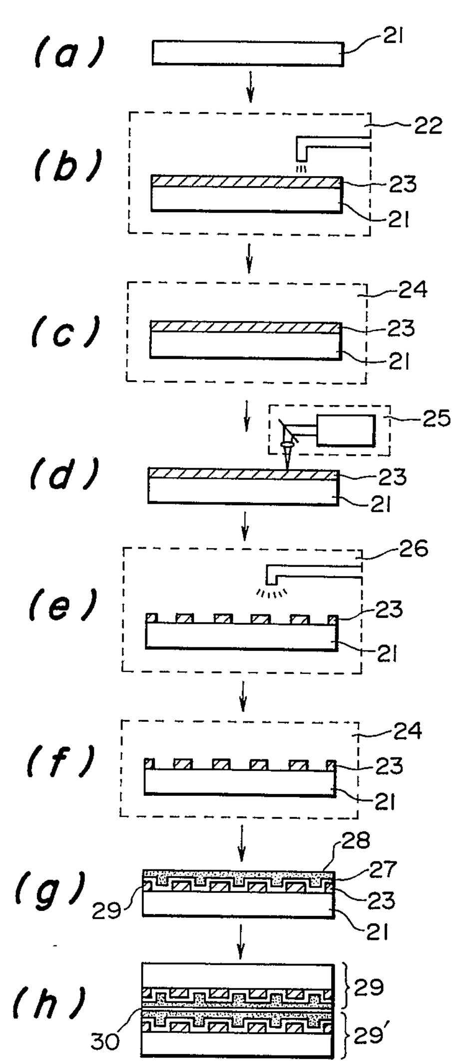

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FIG. 1

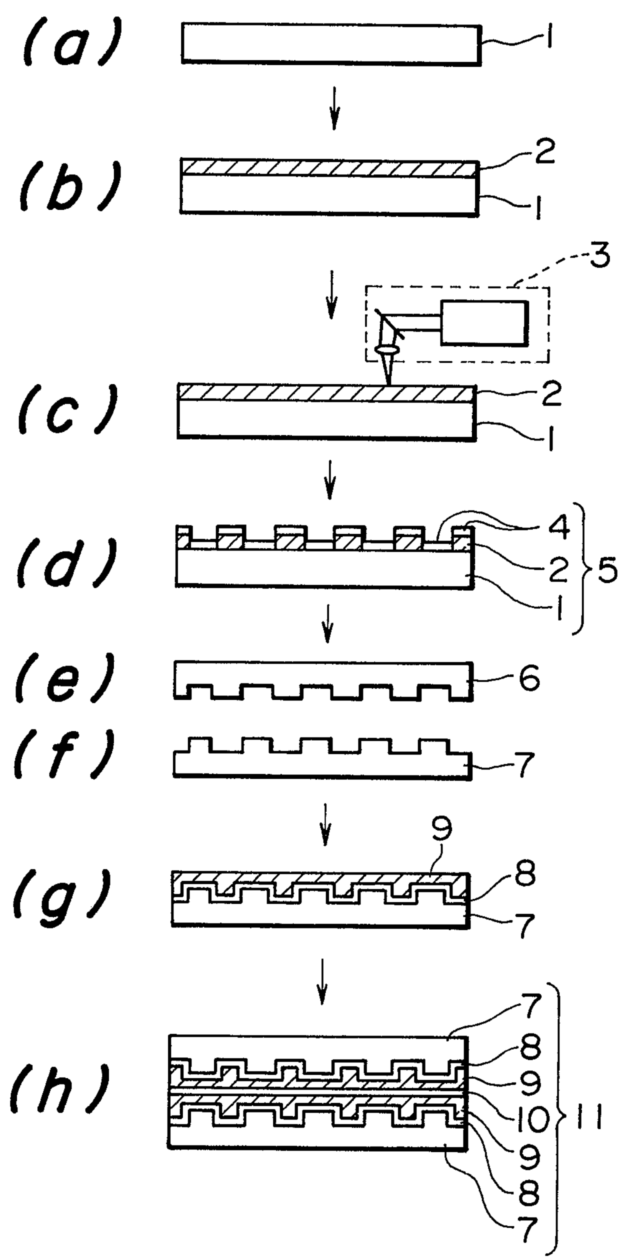
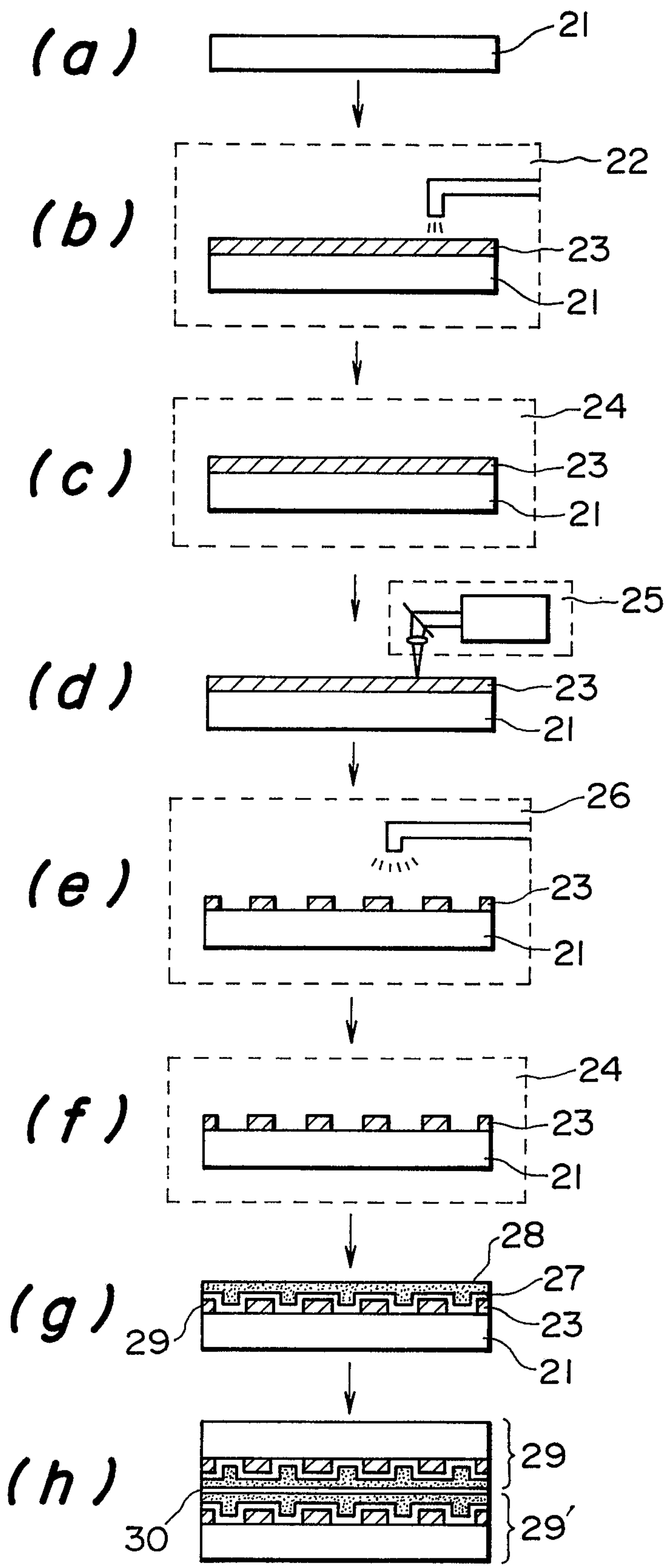


FIG. 2



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SPECIFICATION

Optical data record carrier and method of manufacturing such carrier

Field of the invention

This invention relates to an optical data record carrier such as an optical video disc or a digital audio disc and a method of manufacturing the same.

Background of the invention

Heretofore, optical video discs have been manufactured according to a manufacturing procedure as shown in Figure 1. First, a glass plate 1 having a thickness of 6 to 8 mm is cleaned, and its surface is activated for instance with a material essentially containing hexamethyldisilazane (such as 'OAP' manufactured by Tokyo Oka Co.). A thin layer of photosensitive resin 2 such as photo-resist is formed on the surface thus activated with a spinner or the like. The photosensitive resin layer 2 together with the glass plate is baked and then cooled. A recording device 3 utilizes a laser beam or like means with a modulated signal in order to record on the photosensitive resin layer 2. The thus exposed photosensitive resin layer 2 is developed, washed and dried.

The photosensitive resin layer 2 is then baked and cooled. As a result, pits form in the surface in correspondence to the signal recorded. An electrically conductive film 4 of silver or the like is then formed on the recorded surface having the pits formed thereon. The film may be formed by known conventional methods such as sputtering. Thus, an original disc 5 has been formed.

The recorded signal can be reproduced after the electrically conductive film 4 has been formed. The signal recorded on the original disc 5 is reproduced by an inspecting original disc player which inspects the original disc 5 for dropouts, etc. The original 5 is much larger in weight and size than a commercially available video disc which is produced therefrom. Accordingly, it is impossible for the ordinary, commercially available video disc player to reproduce the signal recorded on the original disc 5. If the original disc is found to be unsatisfactory as a result of the inspection, then the above-described manufacturing procedure must be repeated.

An original disc 5, which has passed inspection is covered with nickel or the like by electrocasting. The layer of nickel or the like is peeled off the original disc 5, to provide a stamper 6 to which the pits have been transferred. A replica 7 is made of synthetic resin with the stamper 6 as a mold and is then dried. A reflecting film 8 of aluminum or the like is formed on the signal transfer surface of the replica 7 by vacuum deposition or sputtering. A protective film 9 of synthetic resin is formed on the reflecting film 8. Another replica 7' is formed according to the same procedure. These replicas 7 and 7' are bonded together with an adhesive 10, and are further treated, for instance, to obtain a predetermined outside diameter. Accordingly, the desired video disc 11 has been manufactured and its signal can be reproduced by an ordinary video disc player.

Manufacturing a video disc 11 the signal of which can be reproduced by an ordinary video disc player takes about twenty-four working hours (or three working days with eight hours per working day). The above-described disc manufacturing method is advantageous in that, as a number of replicas 7 can be formed by using the stamper 6, the manufacturing time and cost per disc are reduced when manufacturing a large number of discs. However, when only a few discs are to be produced (for instance when a consumer records the data on a video disc which he has personally recorded), the manufacturing cost is considerably high. Thus, for economic reasons, it is substantially impossible for him to keep the data by personally recording it on a video disc.

A so-called DRAW (direct read after write) disc is also known in the art. In accordance with the recently developed method a laser bear or the like is applied to a data recording layer on a substrate such as a glass plate so that the data recording layer is locally removed, deformed or changed in quality, to substantially form pits. When manufacturing a small number of discs, this method is advantageous in that the data recorded by applying the laser beam can be reproduced immediately without any treatment. However, the data recording layer must form pits when a laser beam relatively high in energy level is applied thereto during a data recording operation, and not form pits but reflect when a laser beam relatively low in energy level is applied thereto. Accordingly, highly specialized material is required for the data recording layer. In addition, only a small amount of the material is needed. Since the need for producing personal data discs is relatively small the production of such discs remains costly.

The material of the data recording layer for the DRAW disc made using a replica, (the S/N ratio of which is equivalent to or higher than that of the material of the data recording layer of the disc) is manufactured on a large scale. Accordingly, if personal data is recorded on the present DRAW disc, the disc is very low in quality making the disc commercially undesirable.

It should be noted that commercially available disc players have no recording function, such as a laser modulator. Therefore, if the owner of such a player wants a copy he must ask the video disc manufacturer to record the personal data recorded, for instance, on commercially available video tape.

Even if the disc manufacturer is requested to manufacture such a large number of discs that the discs can be manufactured by using a replica, the manufacturer may have to deliver several testing discs to the person who has made the order. This may need to done without delay before the discs are manufactured on a large scale. If, in this case, the several discs are manufactured by the same method described above wherein discs are generally manufactured on a large scale, the manufacturer can not make a profit. If the above-described DRAW disc is used for recording data, then the quality is unsatisfactory.

In view of the foregoing, an object of the present invention is to provide an optical data record carrier which can be manufactured at low cost in a short time.

Another object is to provide such a method which will be profitable even if the number of optical data record carriers is small.

Yet another object of the present invention is to provide such a method which can produce a commercial commodity of high quality.

Brief description of the drawings

Figure 1 is an schematic cross-sectional view diagram showing the steps of manufacturing a conventional disc.

Figure 2 is a schematic cross-sectional view diagram showing the steps of manufacturing a disc according to the present invention.

Detailed description of the invention

The present invention will now be described with reference to a specific instance wherein the technical concept of the invention is applied to an optical video disc. Figure 2 shows the steps of manufacturing a video disc according to the invention. First, a transparent substrate 21 of glass, synthetic resin of the like is prepared. One example of the synthetic resin is an acrylic resin (PMMA (polymethylmethacrylate)). The acrylic resin may be of injection type; however, it is preferably an acrylic resin of cast type which is high in its degree of polymerization.

The substrate 21 is substantially equal in dimension to the replica 7 (Figure 1) including the pits, which is formed during mass production. For instance, the substrate 21 may be in the form of a disc which is 300 mm in outside diameter and has a circular hole 35 mm in diameter at the center. The thickness of the substrate 21 might be in the range of about 1.2 to 1.3 mm. Both surfaces of the substrate 21 have excellent flatness.

The substrate 21 is placed in a photo-resist coating device 22. A photo-resist is then applied. For instance, a positive type photo-resist may be applied to the substrate 21 to a thickness of 1400±200 Å to form a photo-sensitive resin layer 23 on the substrate. When photo-resist is applied to synthetic resin, swelling may occur. However, if the substrate 21 is comprised of an acrylic resin "Kurarekksu S or Kurarekkso W (translated phonetically)" manufactured by Nitto Resin Co. and a photo-resist "OFPR" manufactured by Tokyo Oka Co. is used, swelling scarcely occurs. Even if swelling does occur, it does not serioulsy effect the disc according to the present invention. What is important for the present invention is that the substrate 21 is substantially (approximately) equal to the photo-sensitive resin layer 23 in refractive index with respect to a reading laser beam. In the above-described specific example, the refractive index of the substrate 21 was about 1.5, and the refractive index of the photosensitive resin layer 23 was about 1.6.

The substrate 21 on which the photosensitive resin layer 23 has been formed is then put in a clean oven 24. It is baked at about 80°C for thirty minutes and then cooled. A recording device 25 is operated so that a laser beam modulated with a recording signal is applied to the photosensitive resin layer 23 to record data thereon. In this operation, the laser beam may have a wavelength of 4579 Å and an output of 10 to 20 mW on the disc.

A developing device 26 is operated, so that the exposed photosensitive resin layer 23 is developed with a developing solution. If the developing step takes an excessively long period of time, the photosensitive resin layer 23 may come off the substrate 21. In order to prevent this, the substrate 21 may be activated before the photo-resist is applied thereto. However, the activation may be omitted. The peeling of the photosensitive resin layer can also be prevented by observing the degree of development. In order to observe the degree of development, a relatively weak laser beam is applied to the disc which is turned while being sprayed with the developing solution. The ratio in the quantity of light of the zeroth-order and first-order beams thereof is then detected by a photo-detector. Immediately after the development starts, only the zeroth-order beam exists and the quantity of light of the first-order beam is zero because no pits have been formed yet. However, as development advances and forms pits, diffraction takes place so that the first-order beam is provided. The ratio of the zeroth-order and first-order beams is obtained from the outputs of the photo-detector which are provided respectively when the zeroth-order and first-order beams are detected thereby.

If development is stopped when the ratio reaches a predetermined value, then peeling of the photo-resist scarcely occurs. The predetermined value, i.e., the light quantity ratio, can be readily obtained through experiment. The quantity of light of the first-order beam which is a diffraction beam may be compared with a reference value. However, this method is liable to be adversely affected if the output of the light source changes or the quantity of light is changed by dust in the light path or by particles floating in the developing solution. Accordingly, it is preferable that the signal obtained by the diffraction beam (first-order beam) and the reference beam (first-order beam) be divided and compared with a reference value.

When the ratio of the diffraction beam to the reference beam reaches the predetermined value, spraying the developing solution is stopped, and the disc is washed with water. The disc thus treated is baked in the clean oven 24, for instance, at 80°C for fifteen minutes, and cooled.

The above-described step of covering the disc with nickel by electrocasting is not carried out in the method of the present invention. A reflecting film 27 of metal (such as aluminum) is formed directly on the photosensitive resin layer 23, in which the pits have been formed. The film is formed to a thickness of 1000 to 1500Å by vacuum depositing or sputtering, so that it has a predetermined reflection factor.

A protective film 28 of synthetic resin is formed on the reflecting film 27 by spraying, to provide a disc piece 29 on one side of which signals have been recorded. Another disc piece 29' is formed according to the same manufacturing procedure, which also have signals recorded on its one side. The disc pieces 29 and 29' are bonded together in such a manner that the protective films 28 and 28 are confronted with each other through an adhesive layer 30, to form a complete disc. If the disc only has signals recorded on one side, the disc 29' may be replaced by a dummy disc piece of synthetic resin which is shaped as required.

The disc thus manufactured is inspected. Thus, all the manufacturing steps have been carried out. The manufacturing steps take about eight hours (one working day). Accordingly, the time required for producing a disc assembly is about one-third that required with the conventional method.

The disc thus manufactured has on one or two sides the substrate 21 which is substantially equal in configuration and dimension to the replica 7 formed from the stamper 6 by injection for mass production and which has two flat sides and is transparent (enough to sufficiently transmit a laser beam). The photosensitive resin layer 23 is formed on the substrate 21 so that the substrate 21 is exposed only at the pits. The layer 23 is substantially equal in refractive index to the substrate 21. The reflecting film 27 covers the exposed portions of the substrate 21 as well as the photosensitive resin layer 23. The protective film 28 is composed of synthetic resin and formed on the reflecting film 27. Accordingly, when a laser beam is applied to the reflecting film 27 through the substrate 21 for reading the signals, the photo-sensitive resin layer 23 is optically equivalent to that which is formed integral with the substrate 21, because the refractive index of the photosensitive resin layer 23 is substantially equal to that of the substrate 21. Thus, the disc assembly is substantially equal in structure to that which is mass-produced. Further, it is not fundamentally different in structure from that such as the DRAW disc which is produced on a large scale. Therefore, the disc produced according to the present invention can be reproduced by a commercially available video disc player, similarly to a mass-produced disc. The disc of the invention, unlike the mass-produced disc, does not employ the step of transferring the signal surface. Accordingly, the former has a better S/N ratio than the latter. It goes without saying that the disc of the invention is better in S/N ratio than the DRAW disc.

The materials and devices for manufacturing the disc in accordance with the present invention are substantially the same as those for the mass-produced disc. Therefore, manufacturing costs are not as high as that of the DRAW disc. By using the method of the present invention, the manufacture of a very small number of discs can be commercially profitable. The present invention can be used to make test discs used as preliminary discs for mass production as well as personal discs.

CLAIMS

1. An optical data record carrier comprising a substrate of a transparent material having a predetermined refractive index and two flat surfaces; a photosensitive resin layer of a photosensitive resin having a refractive index substantially equal to the refractive index of the substrate, the photosensitive resin layer being developed on one of the flat surfaces of the substrate to provide pits at which parts of the one flat surface are exposed; a reflecting film covering the one flat surface including the exposed pits and the photosensitive resin layer, the reflecting film being capable of sufficiently reflecting a reading beam of a signal reproducing device; and a protective film a synthetic resin positioned on the reflecting film.

2. A record carrier according to claim 1, wherein the substrate is of an acrylic resin.

3. A record carrier according to claim 2, wherein the resin is polymethylmethacrylate.

4. A record carrier according to any one of the preceding claims, wherein the substrate is in the form of a disc having an outside diameter of substantially 300 mm.

5. A record carrier according to claim 4, wherein the disc has a hole in the centre having a diameter of substantially 35 mm.

6. A record carrier according to any one of the preceding claims, wherein the substrate has a thickness of between 1.2 and 1.3 mm.

7. A record carrier according to any one of the preceding claims, wherein the photosensitive layer has an thickness in the range of 200Å to 1600Å.

8. A record carrier according to any one of the preceding claims, wherein the reflecting film has a thickness in the range of 1000 to 1500Å.

9. A record carrier according to any one of the preceding claims, wherein the substrate has a refractive index of substantially 1.5 and the photosensitive resin layer has a refractive index of substantially 1.6.

10. An optical data record carrier, substantially as described with reference to Figure 2 of the accompanying drawings.

11. A method of manufacturing an optical data record carrier comprising the steps of providing a substrate of a transparent material having a predetermined refractive index and two flat surfaces; forming a photosensitive layer on one of the two flat surfaces, the photosensitive layer having a refractive index substantially equal to the refractive index of the substrate; exposing the photosensitive layer to a beam with modulated signals in order to record on the photosensitive layer; developing the exposed photosensitive layer with a developing solution in order to expose portions of the one flat surface of the substrate; forming a reflecting film on the one flat surface of the substrate, the reflecting film covering the substrate and the photosensitive layer, and the reflecting film being capable of reflecting the reading beam of a signal reproducing device; and forming on the reflecting film a protective film of a synthetic resin.

12. A method according to claim 11, wherein the photosensitive layer is formed by applying a photosensitive resin to the one flat surface of the substrate and baking for substantially 30 minutes at substantially 80°C.

13. A method according to claim 11 or claim 12, wherein the exposing of the photosensitive layer is carried out with a laser beam having a wavelength of substantially 4579Å and an output in the range of between 10 and 20 mW.

14. A method according to any one of claims 11 to 13, wherein the reflecting film is provided by vacuum depositing or sputtering.

15. A method of manufacturing an optical data

record, substantially as described with reference to the accompanying drawings.

16. An optical data record carrier, comprising a first substrate having a surface in which pits are formed; a reflecting film covering the surface of the first substrate in which the pits are formed; a protected film covering the reflecting film; a second substrate which is substantially equal in dimension to the first substrate, the second substrate being comprised of a transparent material having a predetermined refractive index and two flat surfaces; a photosensitive resin layer comprised of a photosensitive resin having a refractive index substantially equal to the refractive index of the second substrate, the photosensitive resin layer being formed on one of the flat surfaces of the second substrate in such a manner that only the pits of the one flat surface are exposed; a reflecting film covering the one flat surface including the exposed pits and the photosensitive resin layer, the reflecting film being capable of sufficiently reflecting the reading beam of a signal reproducing device; and a protective film comprised of a synthetic resin positioned on the reflecting film.

17. An optical data record carrier as claimed in claim 16, wherein the second substrate is comprised of an acrylic resin.

18. An optical data record carrier as claimed in claim 17, wherein the resin is polymethlmethacrylate.

19. An optical data record carrier as claimed in claim 16, wherein the first substrate and the second substrate are in the form of a disc having an outside diameter of about 300 mm.

20. An optical data record carrier as claimed in claim 19, wherein the disc has a hole in the centre having a diameter of about 35 mm.

21. An optical data record carrier as claimed in claim 20, wherein the first substrate has a thickness of about 1.2 to 1.3 mm.

22. An optical data record carrier as claimed in claim 16, wherein the photosensitive layer has a thickness in the range of about 200Å to 1600Å.

23. An optical data record carrier as claimed in claim 16, wherein the first substrate has a refractive index of about 1.5 and the photosensitive resin layer positioned thereon has a refractive index of about 1.6.

24. A method of manufacturing an optical data record carrier, comprising the steps of providing a first substrate having a surface in which pits are formed; providing a reflecting film on the surface of the first substrate; providing a protective film on the reflecting film; providing a second substrate which is substantially equal in dimension to the first substrate, the second substrate being comprised of a transparent material having a predetermined refractive index and having two flat surfaces; forming a photosensitive layer on one of the two flat surfaces, the photosensitive layer having a refractive index substantially equal to the refractive index of the second substrate; exposing the photo-resist layer to a beam with modulated signals in order to record on the photosensitive layer; developing the exposed photosensitive layer with a developing solution in order to expose portions of the one flat surface of the substrate; forming a reflecting film on the one flat surface of the second substrate, the reflecting film covering the substrate and the photosensitive layer, the reflecting film being capable of refracting the reading beam of a signal reproducing device; and forming a protective film on the reflecting film, the protecting film comprising a synthetic resin.

25. A method of manufacturing an optical data record carrier as claimed in claim 24, wherein the photosensitive layer is formed by applying a photosensitive resin to the one flat surface of the second substrate and baking for about 30 minutes at about 90°C.

26. A method of manufacturing an optical data record carrier as claimed in claim 24, wherein the exposing of the photosensitive layer is carried out with a laser beam having a wavelength of about 4579Å and an output in the range of about 10 to about 20mW.

27. A method of manufacturing an optical data record carrier as claimed in claim 24, wherein the reflecting film is provided such that it has a thickness in the range of about 1000 to 1500Å.

28. A method of manufacturing an optical data record carrier as claimed in claim 24, wherein the reflecting film is provided by a method selected from the group consisting of vacuum depositing and sputtering.

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