SPECIFICATION

TITLE OF THE INVENTION

OPTICAL INFORMATION MEDIUM AND RECORDING METHOD THEREOF

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to an optical information medium, on which can be recorded information being optically readable, and in particular relates to the optical information medium being suitable for a high density recording medium on which the information can be recorded and read with red laser beam of short wavelength from 630 nm to 670 nm.

2. DESCRIPTION OF RELATED ART

With the recent advances in development and application of a short wavelength laser, standardization is proceeded on the standard for DVDs (Digital Versatile Discs) which enables recording and reading with high density, as well as the practical application thereof. On the DVD is provided a data recording area at least on one surface thereof, in which pits are formed as a means for recording information, and a reflection layer made of metal film is formed on the data recording area.

For the DVDs, a different standard for high density is determined, comparing to the standard for the optical information medium being the most general or popular now, such as a CD (Compact Disc). For example, according to the DVD standard, it is standardized that one piece of the disc has recording capacity of 4.7

GB at the maximum, in average thereof, i.e., video and audio information for 133 minutes long.

In the standardization of the DVD standard, it is determined at present only with DVDs for reading only, such as a DVD-video for use of video information and a DVD-ROM for use of data for a computer. Under such the situation is desired development of an optical information medium, on which recording is possible with high density at the maximum recording capacity of 4.7 GB on one piece of the disc.

With such the DVD, i.e., the high density recording medium as mentioned in the above, the recording is performed with high density, with a track pitch 0.74 μ m and the minimal pit size 0.4 μ m (0.44 μ m in case of double layer recording), comparing to the track pitch 1.6 μ m and the minimal pit size 0.83 μ m in the CD.

With the recordable DVDs, by using an optical information medium, in which a recording layer including organic dye is provided on a substrate having a groove(s) for tracking corresponding to the pitch 0.74 μ m as mentioned in the above, and further is provided a reflection layer, such as of Au or Al, etc., on the recording layer, wherein there is a necessity for recording to radiate a recording laser beam upon the recording layer so as to form the pits. For that purpose, the red laser of short wavelength from 630 nm to 670 nm is used, and the beam spot thereof must be focused onto a very narrow region, thereby to perform tracking servo with accuracy. For the tracking servo is used a phase difference method. An access is performed with using a tracking error signal of the phase difference and a radial contrast signal, therefore the access comes to be unstable when the radial contrast signal is small in the level. Where, the access means a jumping between

or over the track(s).

SUMMARY OF THE INVENTION

In accordance with the present invention, for dissolving the problems in the technology for recording on the optical information medium in conformity with such the high density recording, a first object is to provide an optical information medium, being able to record in a form of optically readable signals with density higher than the CD, wherein high radial contrast can be maintained and also stable access can be obtained. A second object, in accordance with the present invention, is to provide an optical information medium, with which can be formed desirable pits, being low in jitter thereof, in the recording method of the high density signals.

According to the present invention, for achieving the above-mentioned object, as a result of study, by paying attention in particularly to the shape of the land 4, i.e., the value of the width d of an upper surface of the land 4 is set within a range $0.3\ \mu m \leqq d \leqq 0.45\ \mu m$. Thereby, good radial contrast can be obtained. Here, the radial contrast means a difference in the averaged level of HF signals of the pits and the lands after recording, which is normalized by mean value of both.

Namely, an optical information medium, according to the present invention, comprises: a transparent substrate 1 for penetrating a recording laser beam therethrough; spiral-like grooves 3 for tracking, formed on a surface of the transparent substrate 1; lands 4, each being defined between the grooves 3; a recording layer 12 being formed on the surface of the transparent substrate 1, on which the grooves 3 and the lands 4 are formed; and a reflective layer 13 for reflecting the recording laser beam and/or reading laser beam thereupon, being

formed on the recording layer 12, thereby enabling to record optically readable signals by means of the recording laser beam being incident upon from said transparent substrate 1. And, it is characterized in that the width d of an upper surface of the land 4 is equal to or greater than 0.30 μ m and is equal to or less than 0.45 μ m (i.e., 0.30 μ m $\leqq$ d $\leqq$ 0.45 μ m). On this optical recording medium, the optically readable signals are recorded, while tracking the recording laser beam which is incident thereupon from the above-mentioned transparent substrate 1, along with the groove(s) for tracking mentioned above.

The above-mentioned d indicates a length of a flat portion of the upper surface of the land 4. In concrete, it indicates the length of the portion being parallel to an incident surface of the laser laser beam. And, the above-mentioned c indicates a length of a bottom surface of the land 4. In concrete, it indicates the length from the apex of the bottom surface of the groove 3 to that of the groove 3 being adjacent thereto.

When the above-mentioned d lies within the range of 0.30 μ m $\leqq$ d $\leqq$ 0.45 μ m, the recorded radial contrast of the optical information medium comes to be large, thereby enabling good tracking when reading. However, if the above-mentioned d is less than 0.30 μ m, the recorded radial contrast of the optical information medium comes to be small, therefore it is impossible to read with a player. Also, if the above-mentioned d is greater than 0.45 μ m, a sufficient width cannot be ensured or ascertained for the grooves, therefore it is impossible to perform the recording and/or reading.

The projecting size of the projection portion 15, which is formed at an outer edge of the upper surface of the above-mentioned land 4 when forming the transparent substrate 1 by injection mold, is preferable to be equal or less than 10

nm, and if it is larger than 10 nm, it is impossible to ensure or ascertain the width d of the upper surface of the land 4 to be equal or greater than 0.3 μ m.

Further, a ratio d/c, being defined between the width c of the lower surface of the above-mentioned land 4 and the width d of the upper surface thereof, is preferable to be equal or greater than 0.55 and is equal or less than 0.9 (i.e., $0.55 \leqq d/c \leqq 0.9$). If the ratio d/c between the width c of the lower surface of the above-mentioned land 4 and the width d of the upper surface thereof is smaller than 0.55, the push-pull value and the modulation amplitude come to be small, therefore it is impossible to perform the recording and/or reading with accuracy. Also, if the ratio d/c between the width c of the lower surface of the above-mentioned land 4 and the width d of the upper surface thereof is greater than 0.90, a reproducability of the substrate becomes bad when it is formed by the injection mold, thereby to be unable to maintain the sufficient width d on the upper surface of the land 4.

Further, with the optical information medium according to the present invention, the thermal conductivity ρ of the recording layer 12 is preferable to lie within a range $0.15 \text{ W/mK} \leqq \rho \leqq 0.25 \text{ W/mK}$. If the thermal conductivity ρ of the recording layer 12 is smaller than 0.15 W/mK, the jitter comes to be large. While, if the thermal conductivity ρ of the recording layer 12 is larger than 0.25 W/mK, it is impossible to obtain the good modulation amplitude therewith. The recording layer 12 is formed from organic dye, which is also including stabilizing agent, etc., however the conductivity ρ of the recording layer 12 can be varied with the materials, the composition and/or the thickness thereof. As preferable organic dye, there can be listed up, for example, cyanine group dye, phthalocyanine group dye, azo group dye, polymethine group dye,

triarylmethane group dye, pyrilium group dye, phenanethrene group dye, tetrahydrocholine group dye, triarylamine dye, croconic-methine group dye, merocyanine group dye, etc.

An index l = 1 - b/a is preferable to lie within a range $0.2 \leqq l \leqq 0.5$. When the index l lies within the range, the thermal conductivity ρ can be easily controlled within the range, 0.15 W/mK $\leqq \rho \leqq$ 0.25 W/mK. If the index l mentioned above is less than 0.2, the thermal conductivity ρ becomes large, then it is impossible to obtain the good modulation amplitude. Also, if the index l mentioned above is greater than 0.5, the thermal conductivity ρ becomes small, then the jitter is deteriorated. Here, the index l mentioned above is one being indicative of the degree of leveling on the recording layer 12 mentioned above. When the leveling is proceeded, the difference between the depth a of the pre-groove 3 and the depth b of the recording layer 12 in that pre-groove 3 becomes large, then the value of l also becomes large. Although it is impossible to occur actually, l = 0 means a case where the depth a of the pre-groove 3 is equal to the depth b of the recording layer 12 in that pre-groove 3, because no leveling is treated. While, l = 1 means a condition where the depth b of the recording layer 12 in the pre-groove 3 comes to be zero (0) as a result of the complete leveling thereof.

With the optical information medium, according to the present invention mentioned above, in which signals of high density can be recorded in the form of the optically readable signals, it is possible to provide the optical information medium, on which accessing operation can be obtained with stability.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is an exploded perspective view of two pieces of substrates in an example of an optical information medium according to the present invention, under a condition before they are pasted together, including a partial cross-section view thereof;

Fig. 2 is a perspective view of showing the same optical information medium, including a partial cross-section view thereof;

Fig. 3 is a vertical side cross-section view of showing a principle portion of a recording region of the same optical information medium;

Fig. 4 is an enlarged vertical side cross-section view of showing sizes and angles in the principle portion of the recording region of the same optical information medium; and

Figs. 5 (a) to (c) are AFM images of showing shapes in the cross-section of examples of transparent substrates of the optical information mediums, in a radial direction on the surfaces of thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, detailed explanation of the embodiments according to the present invention will be given by referring to attached drawings.

A write once optical information medium is shown in Figs. 1 and 2, which is pasted on both surfaces and is recordable and readable from the one surface thereof, as an example of the optical information medium according to the present invention.

A transparent substrate 1 is made from a substrate of a disc-like shape, having a center hole 8 in the central portion thereof. This transparent substrate 1 is most preferably to be made of transparent resin, such as polycarbonate,

polymethyl metacrylate (PMMA), etc.

On the one surface of the transparent substrate 1 having the transparency, and in the outside of the above-mentioned center hole 8 is provided a clamping area which will be mentioned later, and the further in an outside thereof is formed a data recording area. In the data recording area on the transparent substrate 1 is formed a spiral-like groove(s) 3 for tracking, and is formed a land 4 between those spiral-like grooves 3. The pitch of the groove 3 for tracking is 0.74 μ m at the standard.

Further, on the portion of the main surface of the above-mentioned data recording area of the transparent substrate 1 is formed or coated a recording layer 12. The recording layer 12 is formed, for example, by applying organic dye by means of a spin coat method or the like. Furthermore, on the recording layer 12 is formed a reflection layer 13 made of metal film of gold, aluminum, silver, copper or an alloy thereof. On the reflection layer 13 is formed a protection film 14, such as of ultraviolet ray curable resin.

Moreover, other piece of substrate 5 is prepared other than the transparent substrate 1. This substrate 5 is made of the same material as the transparent substrate 1, as well as has the same sizes, however, is not provided with such the recording layer 12 and the reflection layer on the main surface thereof, as be provided on the transparent substrate 1 mentioned above. Of course, otherwise, the other substrate 5 may be provided with the recording layer 12 and the reflection layer 13 and so on, in the similar manner of the transparent substitute 1 mentioned above.

Next, those two pieces of substrates 1 and 5 are filed up and pasted together. For example, reactive curable resin is applied to or coated on the main surface of

at least one of those two pieces of substrates 1 and 5 as adhesive, by means of the spin coat method or the like, and is hardened after they are piled up and pasted together with opposing those surfaces to each other. In this manner, those two pieces of substrates 1 and 5 are bonded together upon the main surfaces thereof, with the adhesive layer 11 formed by hardening the above-mentioned reactive curable resin. In this instance, the transparent substrate 1 is adhered on the surface, on which the recording layer 12 and the reflective layer 13 are formed.

In the example mentioned above, upon the transparent substrate 1 having the recording layer 12 and the reflection layer 13 on the surface thereof formed with the groove 3, is pasted the other substrate 5 having no such the recording layer 12 and the reflection layer 13 thereon. In this instance, the recording and/or reading is able only on one side surface thereof. The other substrate 5 may have no transparency, or be colored for maintaining a durability against laser beam, or have a region on the surface where letters or patterns can be written in.

On the other hand, by preparing two pieces of the transparent substrates 1, each having the recording layer 12 and the reflection layer 13 on the surface thereof formed with the groove 3, it is also possible to past them together opposing the recording layer 12 and the reflection layer 13 to each other, so as to obtain an optical information medium, with which the recording and/or reading can be performed on both surfaces thereof.

However, in Figs. 1 and 2, a reference numeral 9 indicates a ring-like convex formed in the outside of the data recording area on the side surface of the transparent substrate 1, upon which side the recording laser beam is incident. This is for the purpose of protecting the recording surface of the optical information medium from touching with the surface of other one, when the plurality of the

optical information media are filed up.

Fig. 3 is a vertical cross-section view of showing a principle portion, in particular, a portion of a recording area of the optical information medium, where the above-mentioned recording layer 12 and the reflection layer 13 are formed. Fig. 4 shows an enlarged cross-section view of the portion of those recording layer 12 and the reflection layer 13, further in details thereof.

As shown in Fig. 4, the spiral-like groove 3 for tracking is provided on the surface of the transparent substrate 1, on which side the recording layer 12 is formed, wherein an inclination angle θ at the both end surfaces with respect to the surface of the transparent substrate 1 upon which the recording laser beam is incident, is preferable to be from 55 to 80 ° .

Also, though not shown in the figures, so-called land pre-pits may be formed on the upper surface of the land 4, thereby obtaining the good-shaped land including the land pre-pits thereof, according to the present invention.

Further, a leveling index which can be expressed by equation 1 - b/a when assuming that the depth of the groove 3 for tracking on the transparent substrate 1 is a and the depth of the recording layer 12 at position of this groove 3 is b, is selected to be from 0.2 to 0.5. This leveling index $l = 1 - b/a$ indicates a degree of leveling on the recording layer 12 when applying the organic dye on the transparent substrate having the groove 3 for tracking, by means of the spin coating thereof. The larger the numerical value, the more the leveling proceeds. Namely, it indicates that the difference between the depth of the groove on the surface of the recording layer 12 and the depth of the groove 3 on the surface of the transparent substrate 1 is large. This leveling index can be varied or changed depending upon such as the condition of the spin coating and the property of the

recording layer.

Also half-width w of the groove 3 for tracking on the transparent substrate 1 is preferable to be from one-third (1/3) to a half (1/2) of pitch p of the groove 3. The half-width of the groove 3 means the width of the groove 3 at the position where the depth is a half (1/2) of the depth a of the groove 3 for tacking formed on the transparent substrate 1.

Further in the DVD, the tracking pitch p shown in Fig. 4 is p=0.74 μ m, however within the range of this tracking pitch, a width c of a bottom surface portion of the above-mentioned land 4 is selected to be from 0.31 μ m to 0.53 μ m, while the width d of an upper surface portion thereof from 0.30 μ m to 0.45 μ m.

For satisfying such the conditions in the sizes on the land 4, also the shapes of the groove 3 and the land 4 come to be large factors thereof. Figs. 5 (a) to (c) show the cross-sectional configurations of the groove 3 and the land 4 in the radical direction, being obtained by scanning the surface of the transparent substrate 1 in the radial direction thereof, by means of an AFM (an Atomic Force Microscope, Nanoscope IIIa, product of Digital Instruments Co., Ltd.). A portion being depressed indicates the groove 3 for tracking, and a portion projecting like a mountain and laying between them indicates the land 4.

Fig. 5 (a) shows the configurations of the groove 3 for tracking and the land 4 in the radial direction of the transparent substrate 1, in particular in a case when they are in normal in the shapes thereof, wherein the groove 3 and the land 4 are rectangular in the shapes thereof. This can be realized by separating the transparent substrate 1 from a stamper, in a direction being vertical to a forming surface of the land 4, when forming the transparent substrate 1 by injection

molding.

Fig. 5 (b) shows the configuration in which a peak-like projecting portion 15 is formed at an outer edge on the upper surface portion of the land 4, and also a slope is formed at the outer edge on the upper surface portion of the land 4. The projecting portion 15 mentioned above is formed at the outer edge on the upper surface portion of the land 4, mainly when separating the transparent substrate 1 from the mold in the injection molding thereof, however in this regard, the projection from the upper surface of the land 4 in the projecting portion 15 is preferable to be equal or less than 10 nm in the length or size thereof.

Fig. 5 (c) shows the configuration in which the projection in the projecting portion 15 is further enlarged in the length or size thereof, and an inclination angle α at the outer edge on the upper surface of the land is also increased up considerably, thereby being completely collapsed in the configuration of the land 4, in particular at a top portion thereof. In this case, no good radial contrast can be obtained, therefore a tracking error may be caused easily.

Next, examples of the present invention will be explained by referring concrete numerical values thereof.

<Example 1>

A transparent substrate 1, being made from a polycarbonate substrate of 120 mm Φ in an outer diameter, 15 mm Φ in an inner diameter, 0.597 mm in a thickness, and of a refractive index of 1.59, is prepared, on the one side of the main surfaces of which is formed the groove 3 for tracking, which has the half-width w = 0.31 μ m, the depth a = 140 nm, the inclination angle θ = 65 $^\circ$ at both side surfaces, and the pitch P = 0.74 μ m. The width d of the upper surface of this land 4 is d = 0.32 μ m. And, the width c of the lower surface of

the land 4 of the transparent substrate 1 is c = 0.53 μ m, then a ratio d/c is 0.60.

On the side surface of the transparent substrate 1, having the groove 3 thereon, the recording layer 12 is formed by the spin coat film forming of a solution of cyanine dye (trimethine dye).

The leveling index in this recording layer 12 is l = 1 - b/a = 0.25. Also, the thermal conductivity in this recording layer 12 is 0.23 W/mK.

Further, Au is spattered onto the recording layer 12 so as to form the reflection layer 13 therewith. On this, ultraviolet ray curable resin (SD 211 of Dainippon Ink Chemical Industry Co., Ltd.) is coated by the spin coating and is hardened by irradiating the ultraviolet ray on it, so as to form the protection layer 14 therewith. On this protection layer 14, being applied with an adhesive of ultraviolet ray curable resin, the substrate is piled up and pasted together, which has the same material and sizes as that of the mentioned above but other than that it does not have the groove thereon, thereby producing the optical information medium.

On the optical information medium produced in this manner, EFM-Plus signal (8-16 modulation signal) is recorded at a recording power of 10 mW and at wavelength of 635 nm, with using an optical pickup having the objective lens o of NA 0.6. The value of a radial contrast is 0.18, the value of a push-pull is 0.3, a modulation amplitude is 64%, the maximum value of length error between the pit and the land is 6.0 nsec for each signal, the jitter is 7.5%, and the reflectivity is 65%, respectively, thereby obtaining a good or preferable result therefrom.

<Example 2>

The optical information medium is produced in the same manner to that of the example 1 mentioned above, but the groove 3 for tracking on the upper

surface of the land 4 is determined to be 0.38 μ m in the width. In this instance, the ratio d/c is d/c = 0.72.

The leveling index of this recording layer 12 is l = 1-b/a = 0.33, and the thermal conductivity of the recording layer 12 is 0.2 W/mK.

On the optical information medium produced in this manner, the EFM-Plus signal is recorded at the recording power of 12 mW and at the wavelength of 635 nm, with using the optical pickup having the objective lens o of NA 0.6, in the same manner as in the example 1 mentioned above. After the recording, the optical information medium is read ten (10) times, by repeating the operations of loading and unloading with the DVD player which is available on a market, then no reading error of the signal occurs, i.e., a stable reading can be obtained. The radial contrast value is 0.20, the push-pull value is 0.35, the modulation amplitude of the recorded signal is 70%, the maximum value of lengths errors of the pit and land is 5.0 nsec for each signal, the jitter is 6.7%, and the reflectivity is 63%, respectively, thereby obtaining good or preferable results.

<Example 3>

The optical information medium is produced in the same manner to that of the example 1 mentioned above, but the width d on the upper surface of the land 4 is d = 0.42 μ m. In this instance, the ratio d/c is d/c = 0.79.

Further, the leveling index of this recording layer 12 is l= 1-b/a = 0.38, and the thermal conductivity of the recording layer 12 is 0.18 W/mK.

On the optical information medium produced in this manner, the EFM-Plus signal is recorded at the recording power of 10 mW and at the wavelength of 635 nm, with using the optical pickup having the objective lens o of NA 0.64, in the same manner as in the example 1 mentioned above. After the recording, the

optical information medium is read ten (10) times, by repeating the operations of loading and unloading with the DVD player which is available on a market, then no reading error of the signal occurs, i.e., a stable reading can be obtained. The radial contrast value is 0.21, the push-pull value is 0.38, the modulation amplitude of the recorded signal is 75%, the maximum value of lengths errors of the pit and land is 5.0 nsec for each signal, the jitter is 6.7%, and the reflectivity is 58%, respectively, thereby obtaining good or preferable results.

<Comparison 1>

The optical information medium is produced in the same manner to that of the example 1 mentioned above, but the width d of the upper surface of the land 4 of the transparent substrate 1 is d = 0.25 μ m. In this instance, the ratio is d/c = 0.47.

Further, the leveling index of this recording layer 12 is l = 1-b/a = 0.18, and the thermal conductivity of the recording layer 12 is 0.27 W/mK.

On the optical information medium produced in this manner, the EFM-Plus signal is recorded at the recording power of 10 mW and at the wavelength of 635 nm, with using the optical pickup having the objective lens o of NA 0.6, in the same manner as in the example 1 mentioned above. After the recording, the optical information medium is tried to be read ten (10) times, by repeating the operations of loading and unloading with the DVD player which is available on a market, however the read-out is impossible at seven (7) times among ten (10) times of the trials of read-out. The radial contrast value is 0.07, the push-pull value is 0.20. The modulation amplitude of the recorded signal is 70%, the jitter is 14% and the reflectivity is 45%, respectively. According to the standard for the DVD, the value of the jitter is determined to be equal or less than 8%, however

the jitter value mentioned above does not satisfy that standard.

<Comparison 2>

The optical information medium is produced in the same manner to that of the example 2 mentioned above, but the width d of the upper surface of the land 4 of the transparent substrate 1 is d = 0.48 μ m. In this instance, the ratio is d/c = 0.91.

Further, the leveling index of this recording layer 12 is l = 1-b/a = 0.52, and the thermal conductivity of the recording layer 12 is 0.13 W/mK.

On the optical information medium produced in this manner, the EFM-Plus signal is recorded at recording power of 10 mW and at the wavelength of 635 nm, with using the optical pickup having the objective lens o of NA 0.6, in the same manner as in the example 1 mentioned above. After the recording, the optical information medium is tried to be read ten (10) times, by repeating the operations of loading and unloading with the DVD player which is available on a market, however the read-out is impossible at seven (7) times among ten (10) times of the trials of read-out. The radial contrast value is 0.07, the push-pull value is 0.10. The modulation amplitude of the recorded signal is 50%, the jitter is 8% and the reflectivity is 68%, respectively. According to the standard for the DVD, the modulation amplitude of the signal is determined to be equal or greater than 60%, however the modulation amplitude mentioned above does not satisfy that standard.

What is claimed is:

1. An optical information medium, comprising:

a transparent substrate (1) for penetrating a recording laser beam therethrough;

a groove (3) for tracking, formed on a surface of said transparent substrate (1);

a lands (4) adjoining the groove (3);

a recording layer (12) being formed on the surface of said transparent substrate (1), on which the groove (3) and the land (4) are formed; and

a reflective layer (13) formed on the recording layer (12) to reflect the recording laser beam, wherein a width d of an upper surface of said land (4) is equal to or greater than 0.30 μ m and is equal to or less than 0.45 μ m (0.30 μ m $\leqq$ d $\leqq$ 0.45 μ m).

2. An optical information medium as defined in the claim 1, wherein a ratio between a width c of a lower surface of said land (4) and the width d of the upper surface of said land (4) is equal to or greater than 0.55 and is equal to or less than 0.9 (0.55 $\leqq$ d/c $\leqq$ 0.9).

3. An optical information medium as defined in the claim 1, wherein a thermal conductivity ρ of the recording layer (12) is equal to or greater than 0.15 W/mK and is equal to or less than 0.25 W/mK (0.15 $\leqq \rho \leqq$ 0.25 W/mK).

4. An optical information medium as defined in the claim 1, wherein a

leveling index l (l = 1-b/a) is equal to or greater than 0.2 and is equal to or less than 0.5 ($0.2 \leqq l \leqq 0.5$), where a indicates a height of the land (4) and b indicates a height of the recording layer (12) in the land (4).

5. A recording method for recording optically readable signals onto an optical information medium, wherein the optical information medium comprises:

a transparent substrate (1) for penetrating a recording laser beam therethrough;

a grooves (3) for tracking, formed on a surface of the transparent substrate (1);

a land (4) adjoining the groove (3);

a recording layer (12) being formed on the surface of the transparent substrate (1), on which the grooves (3) and the lands (4) are formed; and

a reflective layer (13) formed on the recording layer (12) to reflect the recording and/or reading laser beam, thereby enabling to record the optically readable signals by means of the recording laser beam being incident upon from the transparent substrate, wherein on any one of the optical information media described in the claims 1 - 4, the optically readable signals are recorded while tracking the recording laser beam being incident upon from a side of the transparent substrate (1) along a tracking guide (3).