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TITLE OF THE INVENTION

OPTICAL RECORDING MEDIUM

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an optical recording medium, and more particularly, to a recordable optical disk of a single plate type comprising a recording layer containing a dye and a metal reflective layer overlying the recording layer which is recordable and has playability (i.e. capability of being reproduced) by commercially available compact disk players.

Description of the Related Art

An optical recording medium capable of writing comprising a recording layer containing a dye such as phthalocyanine dye and the like and a metal reflective layer overlying the recording layer for enhancing reflectivity is disclosed, for example, in U.S. Pat. No. 4,298,975. However, said U.S. Patent mentions nothing about playability by commercially available compact disk (CD) players.

Neither are disclosed conditions under which there is produced a medium excellent in jitter value and error rate when a pit length recording is conducted.

Optical recording mediums of a single plate type

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having a high reflectivity and playability by commercially available CD player have been recently proposed, for example, in Optical Data Storage 1989 Technical Digest Series, Vol. 145 (1989), EP 353393 and the like. In particular, there are disclosed dyes used as a recording layer and characteristics of the reflective layer for attaining a high reflectivity.

Further, U.S. Pat. No. 4,990,388 discloses a recording mechanism for a recording layer of an optical recording medium having playability by CD players.

In such optical recording mediums, it is necessary for the mediums to give tracking error signals for track control and radial contrast signals for access to an aimed track.

When a recording layer is formed by a vacuum technique such as sputtering and the like, the recording layer is formed strictly following the shape of groove of the substrate, and therefore, optimization of the above-mentioned tracking error signals and radial contrast signals can be effected by simulation.

However, in the case of an optical recording medium using a layer formed by coating a dye as a recording layer, the surface shape of the recording layer does not follow the groove shape of the substrate, and therefore, it is difficult to design the optimum shape by simulation

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as mentioned above, and the above-mentioned prior patents disclose nothing about it.

The relation between a tracking error signal and a groove shape of a substrate is disclosed, for example, in Japanese Patent Application Laid-open No. Hei 3-22224. However, the disclosure is not sufficient to attain a complete playability by commercially available CD players.

Among commercially available CD players, a player carrying a head of 3 beams has no problem, but the present inventors have found that playability by a player carrying a head of one beam is problematic though the reason is not clear.

In addition, with respect to radial contrast signals, the optimization has not yet been made, and radial contrast signals are not used for access, but an external sensor or the like is used though the access speed is slow.

According to the present inventors' investigation, with respect to playability by CD players and radial contrast signals, it is not enough to optimize the shape of groove.

In the case of an optical recording medium capable of recording comprising a recording layer containing a dye formed by a coating method and a metal reflective layer overlying the recording layer, the reflection at

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the interface of the recording layer and the reflective layer is predominant. Therefore the shape of the surface of the recording layer and the thickness of the recording layer on the groove and that on the land become important, but the shape of the surface of the recording layer and the thickness of the recording layer on the groove and that on the land vary depending on coating conditions such as concentration, surface tension and viscosity of the coating solution, boiling point and evaporation speed of the coating solvent, the manner of rotation is the case of spin coating, and the like even if the shape of groove of the substrate is the same. Therefore, the strict optimization has not yet been effected.

EP 0410183 discloses difference in light path length between the recording layer on the groove portion and that on the land portion and degree of modulation, but mentions nothing about the problem of playability by commercially available CD players and radial contrast signals.

On the contrary, there are generally two methods for recording information in an optical recording medium, that is, pit position recording and pit length recording. In the case of CD, pit length recording is effected with pits of 9 kinds of length. In pit pength recording, for the purpose of lessening error rate, it is very important

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to effect recording pits of various lengths with low jitter value (low fluctuation).

At present, various types of CD players are commercially available, but the regeneration signal characteristics are different from player to player, and therefore, the error rate is also different from each other. Therefore, it is required that the error rate is sufficiently small even when regeneration is effected by many types of commercially available CD players as far as possible.

However, the present inventors have found the following. It is said that the above-mentioned conventional optical recording mediums capable of recording can be regenerated by commercially available CD players. However, the jitter value of pit (hereinafter called "pit jitter value") and the jitter value of the part between consecutive pits (hereinafter called "land jitter value") are not always small. Some CD players fail to reduce sufficiently error rates. When audio information and the like are recorded, there is not so noticeable problem, but when code data and the like are recorded there are serious problems.

Further, such optical recording medium is required to be durable, but durability of conventional mediums is not always sufficient. For example, according to the

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present inventors' investigation, when conventional optical recording mediums are allowed to stand at 85°C at 95 % RH for a long time, characteristics of unrecorded portions hardly change while error rate at recorded portions is deteriorated to a great extent, and according to observation with a microscope of the region where error rate has been deteriorated, pits having defects of several microns with the pit at the center are found.

The present inventors have researched variously so as to eliminate drawbacks of the above-mentioned conventional recordable optical mediums having playability by CD players, and investigated the shape of groove, surface shape of recording layer containing a dye, thickness of recording layer at a groove portion and that at a land portion.

As a result, the present inventors have found particular conditions under which a sufficient radial contrast signal can be assured, there is playability by various commercially available CD players, jitter value and error rate are small and further, characteristics such as error rate and the like do not change when stood under condition of high temperature and high humidity for a long time.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an

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optical recording medium capable of assuring a sufficient radial contrast signal.

Another object of the present invention is to provide an optical recording medium playable by commercially available CD players.

A further object of the present invention is to provide an optical recording medium of small jitter value and small error rate.

Still another object of the present invention is to provide an optical recording medium of which characteristics such as error rate and the like are not adversely affected even when the medium is placed under high temperature and high humidity conditions for a long time.

According to the present invention, there is provided an optical recording medium of a single plate type capable of recording which comprises a transparent resin substrate having a groove and a land, the groove being 900 - 1800 Å in depth and 0.3 - 0.6 μm in width, a recording layer containing a dye overlying the substrate, a reflective layer overlying the recording layer and a protective layer overlying the reflective layer, the thickness of the recording layer being 800 - 1250 Å at the groove portion and 500 - 1100 Å at the land portion.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a schematical cross sectional view of

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an enbodiment of a part of the optical recording medium according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a recording layer 2 is formed by coating a substrate 1 having groove portions 3 and land portions 4 each of which is a region between two grooves with a recording layer material.
The difference in height (ΔT) between the surface of recording layer 3 on the groove portion and that on the land portion is indicated by 5.

As a transparent resin substrate used in the present invention, such substrate capable of transmitting a light used for recording signals and readout of recorded information is preferable. Preferable transmittance of light is 85 % or higher. Further, it is preferable that optical anisotropy of the substrate is small.

Examplary suitable substrates include thermoplastic resin substrates composed of acrylic resins, polycarbonate resins, polyamide resins, polyvinyl chloride, polyolefin resins or the like.

Among these resins, from the standpoints of mechanical strength of substrate, easy formation of grooves and pits and economy, acrylic resins, polycarbonate resins, or polyolefin resins are preferable, and polycarbonate

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resin is particularly preferable. These resins may be formed into the substrates by injection molding or cast molding.

The shape of the substrate may be in the form of plate or film, or circle or card. The surface of the substrate is provided with grooves for controlling the recording position. The surface may have partly some prepits for the information.

Such grooves and pits are preferably formed when the substrate is fabricated by injection molding or cast molding. Further they may be formed by applying an ultraviolet light curable resin to a substrate, superposing a stamper thereon and exposing to ultraviolet light.

According the present invention, the optical recording medium comprises a transparent resin substrate, and a recording layer containing a dye, a reflective layer and a protective layer subsequently superposed on the substrate.

The dyes used in the recording layer containing a dye may be dyes having absorption in the wavelength region of oscillation of semiconductor laser such as polymethine dye, phthalocyanine dye, naphthalocyanine dye, naphthoquinone dye, azulene dye, dithiol metal complex dye and the like.

These dyes may have various substituents so as to

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control the solubility of the dye in a solvent to a desirable range or impart desirable recording characteristics. The dyes may be used alone or in combination.

Among the dyes, phthalocyanine dye and naphthalocyanine dye are preferable from the standpoints of light resistance and durability.

According to the present invention, the recording layer containing a dye can be usually formed by a coating method such as spin coating, spraying, dipping and the like.

When the above-mentioned dye is formed into a layer by a coating method, the dye may be dissolved in a solvent not adversely affecting the substrate.
Such solvents are, for example, aliphatic or alicyclic hydrocarbons such as hexane, heptane, octane, decane, cyclohexane, methylcyclohexane, dimethylcyclohexane, cyclooctane and the like;
ether type non-polar solvents such as diethyl ether, dibutyl ether, diisopropyl ether and the like; and alcoholic polar solvents such as methyl alcohol, ethyl alcohol, isopropyl alcohol, allyl alcohol, methyl cellosolve, and the like.

According to the present invention, it is important to control the shape (depth and width) of groove of the substrate, thickness of recording layer at the groove

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portion, that at the land portion and the surface shape (ΔT) of the recording layer.

That is, for purposes of obtaining radial contrast signal satisfying the CD standard for both unrecorded portions and recorded portions, assuring playability by a commercially available CD players, and obtaining excellent jitter value and error rate, it is preferable that the groove in the substrate is 900 - 1800 Å in depth and 0.3 - 0.6 μm in width and the thickness of recording layer at the groove portion is 800 - 1250 Å and that at the land is 500 - 1100 Å. More preferably, the surface of recording layer at the land portion is higher than that at the groove portion by at least 500 Å.

When the thickness of recording layer at the groove portion is less than 800 Å or that at the land portion is less than 500 Å, radial contrast signal becomes small, and though the jitter value is small, the error rate becomes large.

The reason for increase in error rate despite of small jitter value appears to be that the length of 11T pit and length of 11T part between consecutive pits which are to be inherently equal to each other become fairly different.

When the difference in height between the surface of recording layer at the land portion and that at the

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groove portion (ΔT) is less than 500 Å, the radial contrast signal becomes small.

The thickness of recording layer at the groove portion exceeding 1250 Å is not preferable since the error rate increases to a great extent when the medium is allowed to stand under high temperature and high humidity conditions for a long time.

The thickness of recording layer at the land portion exceeding 1100 Å is not preferable since jitter value and error rate are deteriorated.

On the other hand, the upper limit of the difference in height between the surface of recording layer at the land portion and that at the groove portion is preferably 1200 Å. When the difference exceeds 1200 Å, the tracking error singnal becomes too large or assuring the reflectivity of groove of 60 % or more becomes difficult sometimes, and playability by commercially available CD player is not possible.

When the width of groove exceeds 0.6 μm, the pit jitter value and the land jitter value become so large that poor playability by commercially available CD players is obtained, and though playability by CD players carrying a 3 beam head can be assured, it is difficult to assure playability by CD players carrying a 1 beam head.

When the depth of groove is less than 900 Å, poor

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playability by commercially available CD players is obtained, and though playability by CD players carrying a 3 beam head can be assured, that carrying a 1 beam head is assured with difficulty. When regeneration (reproduction) is effected with a CD player carrying a 1 beam head, access is not possible or it takes a long time for access though it is possible to regenerate information sequentially from the beginning.

When the depth of groove exceeds 1800 Å, radial contrast signal becomes large, but reflectivity of groove becomes less than 60 % and therefore, playability by CD players is not possible.

It is substantially difficult and not practical to fabricate a substrate having a groove of 900 Å or more in depth and less than 0.3 μm in width.

The formation of the recording layer having a difference in height (ΔT) between the surface of recording layer at the land portion and that at the groove portion of 500 Å or higher may be effected by controlling or selecting the depth of groove in the substrate, type of solvent (boiling point, vaporization speed, and surface tension) used for coating or coating conditions (rotating conditions in the case of spin coating).

For example, when the groove is made deeper and the vaporization speed of solvent slower, the difference in

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layer thickness between the recording layer at the groove portion and that at the land portion becomes larger.

The shape (the depth and the width) of groove in the substrate and the shape (ΔT) of the surface of recording layer at the land portion and groove portion can be measured by means of a scanning type tunnel microscope or by observing the cross section of the substrate and recording layer with a microscope. The thickness of the recording layer at the groove portion and land portion can be measured by observing the cross section of the recording layer with a microscope.

The width of groove in the present invention is a half-value width, that is, the width at a position where the depth of groove is a half of the total depth.

On the other hand, the term "radial contrast signal" means a quotient of the division of the fluctuation of reflectivity by the average value of reflectivity when the light beam of a player traverses the track while the light beam is focused on the recording layer (focus control). That is, it is defined by the following formula:

Rc (radial contrast signal)

$$= 2 (I_{max} - I_{min}) / (I_{max} + I_{min})$$

where I_{max} and I_{min} are maximum reflectivity and minimum reflectivity when the beam traverses the track, respectively.

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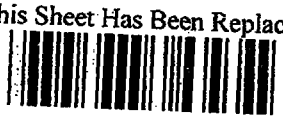
According to the CD standard, it is required that the Rc value is 0.05 or more at the unrecorded portion while it is 0.2 or more at the recorded portion.

When a recording layer containing a dye is prepared, in addition to the dye used in the present invention, there may be used resins such as nitrocellulose, ethylcellulose, acrylic resins, polystyrene resins, urethane resins and the like, leveling agents, deforming agents and the like in an amount which does not adversely affect the effect of the present invention, for example, about 20 % or less, preferably about 10 % or less.

As the reflective layer provided on the recording layer, in usual, a metal thin film is preferably used.

For purposes of imparting playability by ordinaly CD players to the medium of the present invention, the reflectivity of the medium is preferably 60 % or more. As preferable metals, there may be mentioned aluminum, gold, silver, copper, platinum, nickel and the like and alloys containing the metals as mentioned above as a component or components. The reflective layer made of the metal may be formed by vapor deposition, sputtering and the like. In usual, the thickness of reflective layer is preferably 500 - 2000 Å.

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In order to protect the metal reflective layer, a protective layer is formed on the reflective layer. As the protective layer, resins are usually used. In particular, from the standpoint of productivity, ultroviolet light curable resins are preferable. The thickness of the protective layer is preferably about 1 - 15 μm.

The optical recording medium of the present invention is irradiated with a laser beam through the substrate to record information signals or read out the information. Wavelength of the laser beam is preferably 640 - 850 nm. Semiconductor laser having an oscillatory wavelength of such range as above is preferably used. For recording, the laser output is made about 5 - 12 mW on the recording film while rotating the medium, and for readout, the laser output is made about 1/10 times that for recording.

Printing may be made on the protective layer of the optical recording medium of the present invention.

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The present invention is explained in detail in the following referring to examples, but should not be construed as limited by the examples.

As phthalocyanine dye used in Example 1, Pd-tetra-(t-butylcyclohexyloxy) phthalocyanine was prepared by using 3-(t-butylcyclohexyloxy)-1,2-dicyanobenzene and $PdCl_2$ according to a conventional method, for example, EP 232,427.

Then, one mole of the resulting Pd-tetra-(t-butylcyclohexyloxy)phthalocyanine was reacted with 3.3 moles of Br_2 in a solvent, methylene chloride and a phthalocyanine dye composed of Pd-tetra-(t-butylcyclohexyloxy) phthalocyanine having average 3.0 atoms of bromine per one molecule of said phthalocyanine was obtained.

In Example 2 et seq., the dyes were prepared in a manner similar to the above-mentioned procedure.

Example 1

A 3.1 wt. % solution of a brominated (average 3.0 atoms/molecule) Pd-tetra-(t-butylcyclohexyloxy) phthalocyanine in methylcyclohexane was dropped on the center portion of the surface having a groove (1400 Å in depth, 0.5 μm in width, 1.6 μm in pitch) of an injection molded polycarbonate resin substrate of 1.2 mm thick and 120 mm in diameter. Then the resin substrate was rotated at a

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speed of 1000 rpm for 10 sec. The resin substrate was dried at 40°C for 10 min. and a recording layer substantially composed of a phthalocyanine dye was formed on a resin substrate.

The thickness and surface shape of the recording layer was measured by obserbing the cross section by means of an electron microscope. The thickness at the groove portion and that at the land portion of the recording layer were 1100 Å and 700 Å, respectively, and the surface of the recording layer at the land portion was higher than that at the groove portion by 1000 Å (ΔT = 1000 Å).

On the recording layer was formed a gold thin film of 80 nm thick as a reflective layer by means of sputtering, and further an ultraviolet ray-cured resin layer of 5 μm thick was formed on a reflective layer to produce an optical recording medium.

While the resulting optical recording medium was placed on a turntable and rotated at a linear speed of 1.4 m/s, there was used a drive provided with an optical head carrying a semiconductor laser having an oscillation wavelength of 780 nm and a laser beam was controlled such that the laser beam focused on the recording layer through the resin substrate. Thus there were measured reflectivity on the groove and radial contrast signal at the unrecorded portion with a laser output of 1 mW on the recording surface. Table 1 shows the result.

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Then the laser output was made the optimum recording condition of this medium, 7 mW, and a music was recorded with the same EFM modulation signal as that used in CD, and then the output of laser was made 1 mW. There were measured radial contrast signal, 3T pit jitter value, 3T land jitter value and error rate at the recording portion. The result was summarized in Table 1. Further, for purposes of investigating playability by commercially available CD player, regeneration of record was effected by the following CD player. The regenerated result was summarized in Table 2.

No.	Manufacturer	Type of CD Player	Type of Head
A	Sony	CDP - C900	3 beams
B	Marantz Japan	CD - 50	3 beams
C	Marantz Japan	CD - 99SE	1 beam
D	Yamaha	CDX - 1050	3 beams
E	Matsushita Denki Sangyo	SL - PA10	1 beam
F	Matsushita Denki Sangyo	SL - P550	1 beam

Durability of the medium was investigated by allowing the medium to stand for 1000 hours under condition of

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85°C and 95 % RH and then measuring the jitter value and error rate.

Table 2 shows the result.

Examples 2 - 4 and Comparative Examples 1 - 5

The procedure of Example 1 was repeated using the same dye as in Example 1 except that there were used a substrate having a groove of a shape, a solvent, a concentration of the solution and a rotating speed as shown below, and a medium was produced and evaluated.

The recording laser power was the optimum power for each medium. Table 1 and Table 2 show the results.

Example	Shape of groove Depth (Å)	Width (μm)	Solvent	Concentration (% by weight)	Rotating speed (rpm)
2	950	0.35	Methylcyclohexane	2.8	1000
3	1400	0.50	Dibutyl ether	3.1	700
4	950	0.35	Octane	3.1	700
Comparative Example					
1	950	0.35	Octane	3.5	700
2	950	0.35	Methylcyclohexane	3.0	1100
3	800	0.35	Methylcyclohexane	3.1	1100
4	1900	0.58	Ethylcyclohexane	2.1	1000
5	950	0.70	Methylcyclohexane	3.1	1000

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Examples 5 and 6

The procedure of Example 1 was repeated except that there were used a substrate having a groove of a shape, a solution having a concentration of a brominated (average 3.5 atoms/molecule) Pd-tetra-(t-butylcyclohexyloxy)phthalocyanine dye in a solvent and a rotating speed as shown below, and a medium was produced and evaluated.

The recording laser power was the optimum power for each medium. Tables 1 and 2 show the results.

Example	Shape of groove Depth (Å)	Width (μm)	Solvent	Concentration (% by weight)	Rotating speed (rpm)
5	1600	0.5	Dibutyl ether	4.0	700
6	1600	0.5	Ethylcyclohexane	4.0	700

Examples 7 - 8 and Comparative Examples 6 - 8

The procedure of Example 1 was repeated except that there were used a substrate having a groove of a shape, a solution having a concentration of a brominated (average 3.5 atoms/molecule) Pd-tetra-(2,4-dimethyl-pentan-3-oxy) phthalocyanine in a solvent and a rotating speed as shown below, and a medium was produced and evaluated.

The recording laser power was the optimum power for each medium. Table 1 and 2 show the results.

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Example	Shape of groove Depth (Å)	Width (μm)	Solvent	Concentration (% by weight)	Rotating speed (rpm)
7	1250	0.45	Dimethyl-cyclohexane	3.1	1000
8	1250	0.45	Dimethyl-cyclohexane	3.5	700
Comparative Example					
6	950	0.35	Dibutyl ether	3.1	700
7	950	0.35	Methylcyclo-hexane	4.0	700
8	1250	0.45	Octane	3.0	700

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Table 1

Example	Layer thickness (Å) Groove	Land	ΔT (Å)	Reflectivity (%)	Rc Rcb	Rca	Jitter value (ns) Pit	Land	Error rate (%)
1	1100	700	1000	67	0.09	0.57	19	20	0.08
2	950	600	600	68	0.06	0.38	18	19	0.04
3	1150	550	800	69	0.07	0.42	16	18	0.02
4	1250	1000	700	71	0.06	0.34	19	20	0.10
5	1150	650	1100	67	0.10	0.62	15	18	0.06
6	1200	600	1000	68	0.09	0.55	17	18	0.04
7	850	600	1000	73	0.06	0.45	16	16	0.01
8	1250	900	900	67	0.08	0.50	18	21	0.02
Comparative Example									
1	1450	1100	600	69	0.06	0.36	20	22	0.20
2	750	500	700	68	0.00	0.10	18	20	2.8
3	850	550	500	71	0.05	0.23	21	24	0.09
4	1200	500	1200	55	0.12	0.55	21	23	0.1
5	1050	700	600	71	0.05	0.35	32	36	3.8
6	1050	550	450	70	0.03	0.15	18	22	0.03
7	1600	1300	650	65	0.06	0.40	31	33	3.2
8	1100	450	600	69	0.03	0.18	19	25	3.5

ΔT : Difference in level between land and groove at the surface of recording layer

Rc : Radial contrast signal

$Rc = 2(I_{max} - I_{min})/(I_{max} + I_{min})$

I max: Maximum value of reflectivity upon traversing the track

I min: Minimum reflectivity upon traversing the track

Rcb : Radial contrast signal at unrecorded portion

Table 2

Example	Playability by CD players A	B	C	D	E	F	Jitter value (ns) Pit	Land	Error rate (%)
1	o	o	o	o	o	o	20	22	0.08
2	o	o	o	o	o	o	18	21	0.05
3	o	o	o	o	o	o	18	19	0.03
4	o	o	o	o	o	o	20	21	0.1
5	o	o	o	o	o	o	17	19	0.08
6	o	o	o	o	o	o	18	20	0.04
7	o	o	o	o	o	o	16	17	0.02
8	o	o	o	o	o	o	18	20	0.02
Comparative Example									
1	o	o	o	o	o	o	23	26	5.8
2	o	o	o	o	o	o	19	20	3.2
3	o	o	x	o	x	x	23	25	0.11
4	x	o	x	x	x	x	22	24	0.2
5	o	o	x	o	x	x	33	36	4.0
6	o	o	o	o	o	o	20	22	0.05
7	o	o	o	o	o	o	35	40	15
8	o	o	o	o	o	o	21	28	4.5

Playability by CD players was tested by regenerating using commercially available CD players A - F as mentioned in Example 1.

o : No problem

x : Access to an aimed track is not possible.

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As is clear from Table 1 and Table 2, the examples of the present invention all exhibit high reflectivity and sufficiently low jitter values and error rates. The radial contrast is large both at unrecorded portion and recorded portion. The mediums have a good playability by commercially available CD players. Even when the mediums are allowed to stand under high temperature and high humid conditions, they exhibit excellent characteristics such that the jitter values and error rates are hardly changed.

The comparative examples are summarized as shown below.

In Comparative Examples 1 and 7, the layer thickness of the recording layer at the groove portion is thick so that after the durability test, error rates increased to a great extent. When the mediums subjected to such durability test were observed with an electron microscope, it was found that a defect of about 2 μm was formed at the center of pit.

In Comparative Example 2, the layer thickness of the recording layer at the groove portion was so thin that error rate and radial contrast were very poor and therefore, the medium was not preferable.

In Comparative Example 3, the depth of the groove of the substrate is small so that playability after

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recording was poor.

In Comparative Example 4, the groove is so deep that reflectivity was lowered and there were many players which could not regenerate the record.

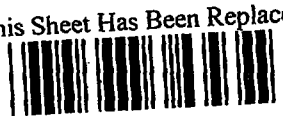
In Comparative Example 5, the groove was so wide that both jitter value and error rate were poor, and playability by commercially available CD players was poor.

In Comparative Example 6, the difference in height between the surface of recording layer at the land portion and that at the groove portion was so small that radial contrast was poor.

In Comparative Example 7, the thickness of recording layer on the land portion was so thick that jitter value and error rate were poor.

In Comparative EXample 8, the recording layer thickness at the land portion was so thin that error rate and radial contrast were poor.

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WHAT IS CLAIMED IS:

1. An optical recording medium of a single plate type capable of recording which comprises a transparent resin substrate having a groove and a land, the groove being 900 - 1800 Å in depth and 0.3 - 0.6 μm in width, a recording layer containing a dye overlying the substrate, a reflective layer overlying the recording layer and a protective layer overlying the reflective layer, the thickness of the recording layer being 800 - 1250 Å at the groove portion and 500 - 1100 Å at the land portion.

2. The optical recording medium according to claim 1 in which the surface of the recording layer at the land portion is higher than the surface of the recording layer at the groove portion by at least 500 Å.

3. The optical recording medium according to claim 2 in which the reflectivity at an unrecorded portion at the groove portion through the substrate is 60 % or more.

4. The optical recording medium according to claim 3 in which the recording layer contains a phthalocyanine dye.

5. The optical recording medium according to any one of claims 1 - 4 in which signals are recorded in the groove by pit length recording.

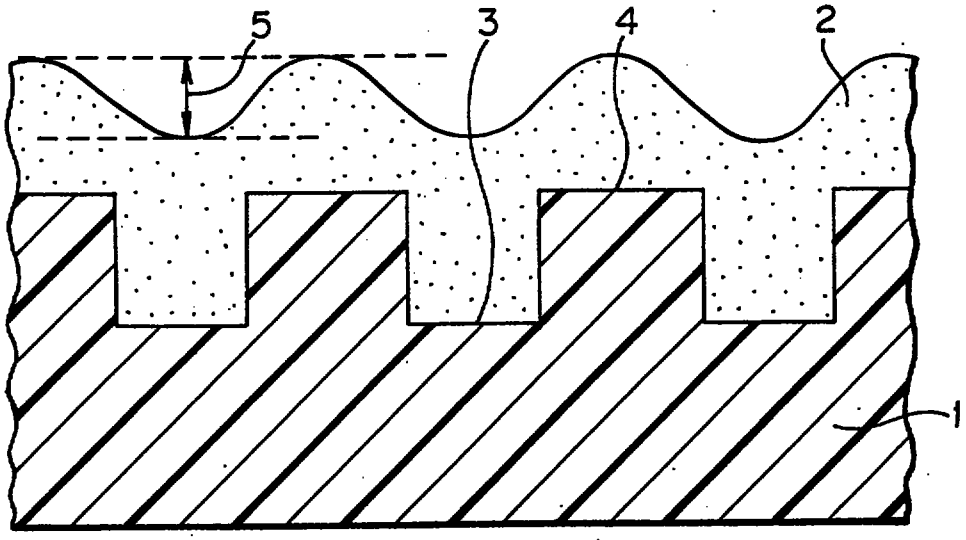
* C L M S *

ABSTRACT OF THE DISCLOSURE

An optical recording medium of a single plate type capable of recording comprises a transparent resin substrate having a groove of 900 - 1800 Å in depth and 0.3 - 0.6 μm in width, a recording layer containing a dye overlying the substrate, a reflective layer overlying the recording layer and a protective layer overlying the reflective layer, the thickness of the recording layer being 800 - 1250 Å at the groove portion and 500 - 1100 Å at the land portion.

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FIG. 1



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REPLACED SHEETS SG
☑ Description : paged ...1... to paged ...24...
☑ Claim(s) : paged ...27... to paged ...-...
☑ Drawing(s) : paged ...1/1... to paged ...-...
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REPLACEMENT SHEETS SG
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☑ Abstract : paged ..28.. to paged ..-..
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TITLE OF THE INVENTION

OPTICAL RECORDING MEDIUM

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an optical recording medium, and more particularly, to a recordable optical disk of a single plate type comprising a recording layer containing a dye and a metal reflective layer overlying the recording layer which is recordable and has playability (i.e. capability of being reproduced) by commercially available compact disk players.

Description of the Related Art

An optical recording medium capable of writing comprising a recording layer containing a dye such as phthalocyanine dye and the like and a metal reflective layer overlying the recording layer for enhancing reflectivity is disclosed, for example, in U.S. Pat. No. 4,298,975. However, said U.S. Patent mentions nothing about playability by commercially available compact disk (CD) players.

Neither are disclosed conditions under which there is produced a medium excellent in jitter value and error rate when a pit length recording is conducted.

Optical recording mediums of a single plate type

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having a high reflectivity and playability by commercially available CD player have been recently proposed, for example, in Optical Data Storage 1989 Technical Digest Series, Vol. 145 (1989), EP 353393 and the like. In particular, there are disclosed dyes used as a recording layer and characteristics of the reflective layer for attaining a high reflectivity.

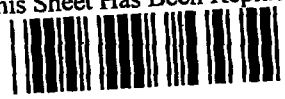
Further, U.S. Pat. No. 4,990,388 discloses a recording mechanism for a recording layer of an optical recording medium having playability by CD players.

In such optical recording mediums, it is necessary for the mediums to give tracking error signals for track control and radial contrast signals for access to an aimed track.

When a recording layer is formed by a vacuum technique such as sputtering and the like, the recording layer is formed strictly following the shape of groove of the substrate, and therefore, optimization of the above-mentioned tracking error signals and radial contrast signals can be effected by simulation.

However, in the case of an optical recording medium using a layer formed by coating a dye as a recording layer, the surface shape of the recording layer does not follow the groove shape of the substrate, and therefore, it is difficult to design the optimum shape by simulation

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as mentioned above, and the above-mentioned prior patents disclose nothing about it.

The relation between a tracking error signal and a groove shape of a substrate is disclosed, for example, in Japanese Patent Application Laid-open No. Hei 3-22224. However, the disclosure is not sufficient to attain a complete playability by commercially available CD players.

Among commercially available CD players, a player carrying a head of 3 beams has no problem, but the present inventors have found that playability by a player carrying a head of one beam is problematic though the reason is not clear.

In addition, with respect to radial contrast signals, the optimization has not yet been made, and radial contrast signals are not used for access, but an external sensor or the like is used though the access speed is slow.

According to the present inventors' investigation, with respect to playability by CD players and radial contrast signals, it is not enough to optimize the shape of groove.

In the case of an optical recording medium capable of recording comprising a recording layer containing a dye formed by a coating method and a metal reflective layer overlying the recording layer, the reflection at

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the interface of the recording layer and the reflective layer is predominant. Therefore the shape of the surface of the recording layer and the thickness of the recording layer on the groove and that on the land become important, but the shape of the surface of the recording layer and the thickness of the recording layer on the groove and that on the land vary depending on coating conditions such as concentration, surface tension and viscosity of the coating solution, boiling point and evaporation speed of the coating solvent, the manner of rotation is the case of spin coating, and the like even if the shape of groove of the substrate is the same. Therefore, the strict optimization has not yet been effected.

EP 0410183 discloses difference in light path length between the recording layer on the groove portion and that on the land portion and degree of modulation, but mentions nothing about the problem of playability by commercially available CD players and radial contrast signals.

On the contrary, there are generally two methods for recording information in an optical recording medium, that is, pit position recording and pit length recording. In the case of CD, pit length recording is effected with pits of 9 kinds of length. In pit pength recording, for the purpose of lessening error rate, it is very important

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to effect recording pits of various lengths with low jitter value (low fluctuation).

At present, various types of CD players are commercially available, but the regeneration signal characteristics are different from player to player, and therefore, the error rate is also different from each other. Therefore, it is required that the error rate is sufficiently small even when regeneration is effected by many types of commercially available CD players as far as possible.

However, the present inventors have found the following. It is said that the above-mentioned conventional optical recording mediums capable of recording can be regenerated by commercially available CD players. However, the jitter value of pit (hereinafter called "pit jitter value") and the jitter value of the part between consecutive pits (hereinafter called "land jitter value") are not always small. Some CD players fail to reduce sufficiently error rates. When audio information and the like are recorded, there is not so noticeable problem, but when code data and the like are recorded there are serious problems.

Further, such optical recording medium is required to be durable, but durability of conventional mediums is not always sufficient. For example, according to the

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present inventors' investigation, when conventional optical recording mediums are allowed to stand at 85°C at 95 % RH for a long time, characteristics of unrecorded portions hardly change while error rate at recorded portions is deteriorated to a great extent, and according to observation with a microscope of the region where error rate has been deteriorated, pits having defects of several microns with the pit at the center are found.

The present inventors have researched variously so as to eliminate drawbacks of the above-mentioned conventional recordable optical mediums having playability by CD players, and investigated the shape of groove, surface shape of recording layer containing a dye, thickness of recording layer at a groove portion and that at a land portion.

As a result, the present inventors have found particular conditions under which a sufficient radial contrast signal can be assured, there is playability by various commercially available CD players, jitter value and error rate are small and further, characteristics such as error rate and the like do not change when stood under condition of high temperature and high humidity for a long time.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an

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optical recording medium capable of assuring a sufficient radial contrast signal.

Another object of the present invention is to provide an optical recording medium playable by commercially available CD players.

A further object of the present invention is to provide an optical recording medium of small jitter value and small error rate.

Still another object of the present invention is to provide an optical recording medium of which characteristics such as error rate and the like are not adversely affected even when the medium is placed under high temperature and high humidity conditions for a long time.

According to the present invention, there is provided an optical recording medium of a single plate type capable of recording which comprises a transparent resin substrate having a groove and a land, the groove being 900 - 1800 Å in depth and 0.3 - 0.6 μm in width, a recording layer containing a dye overlying the substrate, a reflective layer overlying the recording layer and a protective layer overlying the reflective layer, the thickness of the recording layer being 800 - 1250 Å at the groove portion and 500 - 1100 Å at the land portion.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a schematical cross sectional view of

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an enbodiment of a part of the optical recording medium according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a recording layer 2 is formed by coating a substrate 1 having groove portions 3 and land portions 4 each of which is a region between two grooves with a recording layer material.
The difference in height (ΔT) between the surface of recording layer 3 on the groove portion and that on the land portion is indicated by 5.

As a transparent resin substrate used in the present invention, such substrate capable of transmitting a light used for recording signals and readout of recorded information is preferable. Preferable transmittance of light is 85 % or higher. Further, it is preferable that optical anisotropy of the substrate is small.

Examplary suitable substrates include thermoplastic resin substrates composed of acrylic resins, polycarbonate resins, polyamide resins, polyvinyl chloride, polyolefin resins or the like.

Among these resins, from the standpoints of mechanical strength of substrate, easy formation of grooves and pits and economy, acrylic resins, polycarbonate resins, or polyolefin resins are preferable, and polycarbonate

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resin is particularly preferable. These resins may be formed into the substrates by injection molding or cast molding.

The shape of the substrate may be in the form of plate or film, or circle or card. The surface of the substrate is provided with grooves for controlling the recording position. The surface may have partly some prepits for the information.

Such grooves and pits are preferably formed when the substrate is fabricated by injection molding or cast molding. Further they may be formed by applying an ultraviolet light curable resin to a substrate, superposing a stamper thereon and exposing to ultraviolet light.

According the present invention, the optical recording medium comprises a transparent resin substrate, and a recording layer containing a dye, a reflective layer and a protective layer subsequently superposed on the substrate.

The dyes used in the recording layer containing a dye may be dyes having absorption in the wavelength region of oscillation of semiconductor laser such as polymethine dye, phthalocyanine dye, naphthalocyanine dye, naphthoquinone dye, azulene dye, dithiol metal complex dye and the like.

These dyes may have various substituents so as to

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control the solubility of the dye in a solvent to a desirable range or impart desirable recording characteristics. The dyes may be used alone or in combination.

Among the dyes, phthalocyanine dye and naphthalocyanine dye are preferable from the standpoints of light resistance and durability.

According to the present invention, the recording layer containing a dye can be usually formed by a coating method such as spin coating, spraying, dipping and the like.

When the above-mentioned dye is formed into a layer by a coating method, the dye may be dissolved in a solvent not adversely affecting the substrate.
Such solvents are, for example, aliphatic or alicyclic hydrocarbons such as hexane, heptane, octane, decane, cyclohexane, methylcyclohexane, dimethylcyclohexane, cyclooctane and the like;
ether type non-polar solvents such as diethyl ether, dibutyl ether, diisopropyl ether and the like; and
alcoholic polar solvents such as methyl alcohol, ethyl alcohol, isopropyl alcohol, allyl alcohol, methyl cellosolve, and the like.

According to the present invention, it is important to control the shape (depth and width) of groove of the substrate, thickness of recording layer at the groove

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portion, that at the land portion and the surface shape (ΔT) of the recording layer.

That is, for purposes of obtaining radial contrast signal satisfying the CD standard for both unrecorded portions and recorded portions, assuring playability by a commercially available CD players, and obtaining excellent jitter value and error rate, it is preferable that the groove in the substrate is 900 - 1800 Å in depth and 0.3 - 0.6 μm in width and the thickness of recording layer at the groove portion is 800 - 1250 Å and that at the land is 500 - 1100 Å. More preferably, the surface of recording layer at the land portion is higher than that at the groove portion by at least 500 Å.

When the thickness of recording layer at the groove portion is less than 800 Å or that at the land portion is less than 500 Å, radial contrast signal becomes small, and though the jitter value is small, the error rate becomes large.

The reason for increase in error rate despite of small jitter value appears to be that the length of 11T pit and length of 11T part between consecutive pits which are to be inherently equal to each other become fairly different.

When the difference in height between the surface of recording layer at the land portion and that at the

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groove portion (ΔT) is less than 500 Å, the radial contrast signal becomes small.

The thickness of recording layer at the groove portion exceeding 1250 Å is not preferable since the error rate increases to a great extent when the medium is allowed to stand under high temperature and high humidity conditions for a long time.

The thickness of recording layer at the land portion exceeding 1100 Å is not preferable since jitter value and error rate are deteriorated.

On the other hand, the upper limit of the difference in height between the surface of recording layer at the land portion and that at the groove portion is preferably 1200 Å. When the difference exceeds 1200 Å, the tracking error singnal becomes too large or assuring the reflectivity of groove of 60 % or more becomes difficult sometimes, and playability by commercially available CD player is not possible.

When the width of groove exceeds 0.6 μm, the pit jitter value and the land jitter value become so large that poor playability by commercially available CD players is obtained, and though playability by CD players carrying a 3 beam head can be assured, it is difficult to assure playability by CD players carrying a 1 beam head.

When the depth of groove is less than 900 Å, poor

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playability by commercially available CD players is obtained, and though playability by CD players carrying a 3 beam head can be assured, that carrying a 1 beam head is assured with difficulty. When regeneration (reproduction) is effected with a CD player carrying a 1 beam head, access is not possible or it takes a long time for access though it is possible to regenerate information sequentially from the beginning.

When the depth of groove exceeds 1800 Å, radial contrast signal becomes large, but reflectivity of groove becomes less than 60 % and therefore, playability by CD players is not possible.

It is substantially difficult and not practical to fabricate a substrate having a groove of 900 Å or more in depth and less than 0.3 μm in width.

The formation of the recording layer having a difference in height (ΔT) between the surface of recording layer at the land portion and that at the groove portion of 500 Å or higher may be effected by controlling or selecting the depth of groove in the substrate, type of solvent (boiling point, vaporization speed, and surface tension) used for coating or coating conditions (rotating conditions in the case of spin coating).

For example, when the groove is made deeper and the vaporization speed of solvent slower, the difference in

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layer thickness between the recording layer at the groove portion and that at the land portion becomes larger.

The shape (the depth and the width) of groove in the substrate and the shape (ΔT) of the surface of recording layer at the land portion and groove portion can be measured by means of a scanning type tunnel microscope or by observing the cross section of the substrate and recording layer with a microscope. The thickness of the recording layer at the groove portion and land portion can be measured by observing the cross section of the recording layer with a microscope.

The width of groove in the present invention is a half-value width, that is, the width at a position where the depth of groove is a half of the total depth.

On the other hand, the term "radial contrast signal" means a quotient of the division of the fluctuation of reflectivity by the average value of reflectivity when the light beam of a player traverses the track while the light beam is focused on the recording layer (focus control). That is, it is defined by the following formula:

Rc (radial contrast signal)

$= 2 (I_{max} - I_{min}) / (I_{max} + I_{min})$

where I_{max} and I_{min} are maximum reflectivity and minimum reflectivity when the beam traverses the track, respectively.

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According to the CD standard, it is required that the Rc value is 0.05 or more at the unrecorded portion while it is 0.2 or more at the recorded portion.

When a recording layer containing a dye is prepared, in addition to the dye used in the present invention, there may be used resins such as nitrocellulose, ethylcellulose, acrylic resins, polystyrene resins, urethane resins and the like, leveling agents, deforming agents and the like in an amount which does not adversely affect the effect of the present invention, for example, about 20 % or less, preferably about 10 % or less.

As the reflective layer provided on the recording layer, in usual, a metal thin film is preferably used.

For purposes of imparting playability by ordinaly CD players to the medium of the present invention, the reflectivity of the medium is preferably 60 % or more. As preferable metals, there may be mentioned aluminum, gold, silver, copper, platinum, nickel and the like and alloys containing the metals as mentioned above as a component or components. The reflective layer made of the metal may be formed by vapor deposition, sputtering and the like. In usual, the thickness of reflective layer is preferably 500 - 2000 Å.

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In order to protect the metal reflective layer, a protective layer is formed on the reflective layer. As the protective layer, resins are usually used. In particular, from the standpoint of productivity, ultroviolet light curable resins are preferable. The thickness of the protective layer is preferably about 1 - 15 μm.

The optical recording medium of the present invention is irradiated with a laser beam through the substrate to record information signals or read out the information. Wavelength of the laser beam is preferably 640 - 850 nm. Semiconductor laser having an oscillatory wavelength of such range as above is preferably used. For recording, the laser output is made about 5 - 12 mW on the recording film while rotating the medium, and for readout, the laser output is made about 1/10 times that for recording.

Printing may be made on the protective layer of the optical recording medium of the present invention.

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The present invention is explained in detail in the following referring to examples, but should not be construed as limited by the examples.

As phthalocyanine dye used in Example 1, Pd-tetra-(t-butylcyclohexyloxy) phthalocyanine was prepared by using 3-(t-butylcyclohexyloxy)-1,2-dicyanobenzene and $PdCl_2$ according to a conventional method, for example, EP 232,427.

Then, one mole of the resulting Pd-tetra-(t-butylcyclohexyloxy)phthalocyanine was reacted with 3.3 moles of Br_2 in a solvent, methylene chloride and a phthalocyanine dye composed of Pd-tetra-(t-butylcyclohexyloxy) phthalocyanine having average 3.0 atoms of bromine per one molecule of said phthalocyanine was obtained.

In Example 2 et seq., the dyes were prepared in a manner similar to the above-mentioned procedure.

Example 1

A 3.1 wt. % solution of a brominated (average 3.0 atoms/molecule) Pd-tetra-(t-butylcyclohexyloxy) phthalocyanine in methylcyclohexane was dropped on the center portion of the surface having a groove (1400 Å in depth, 0.5 μm in width, 1.6 μm in pitch) of an injection molded polycarbonate resin substrate of 1.2 mm thick and 120 mm in diameter. Then the resin substrate was rotated at a

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speed of 1000 rpm for 10 sec. The resin substrate was dried at 40°C for 10 min. and a recording layer substantially composed of a phthalocyanine dye was formed on a resin substrate.

The thickness and surface shape of the recording layer was measured by obserbing the cross section by means of an electron microscope. The thickness at the groove portion and that at the land portion of the recording layer were 1100 Å and 700 Å, respectively, and the surface of the recording layer at the land portion was higher than that at the groove portion by 1000 Å (ΔT = 1000 Å).

On the recording layer was formed a gold thin film of 80 nm thick as a reflective layer by means of sputtering, and further an ultraviolet ray-cured resin layer of 5 μm thick was formed on a reflective layer to produce an optical recording medium.

While the resulting optical recording medium was placed on a turntable and rotated at a linear speed of 1.4 m/s, there was used a drive provided with an optical head carrying a semiconductor laser having an oscillation wavelength of 780 nm and a laser beam was controlled such that the laser beam focused on the recording layer through the resin substrate. Thus there were measured reflectivity on the groove and radial contrast signal at the unrecorded portion with a laser output of 1 mW on the recording surface. Table 1 shows the result.

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Then the laser output was made the optimum recording condition of this medium, 7 mW, and a music was recorded with the same EFM modulation signal as that used in CD, and then the output of laser was made 1 mW. There were measured radial contrast signal, 3T pit jitter value, 3T land jitter value and error rate at the recording portion. The result was summarized in Table 1. Further, for purposes of investigating playability by commercially available CD player, regeneration of record was effected by the following CD player. The regenerated result was summarized in Table 2.

No.	Manufacturer	Type of CD Player	Type of Head
A	Sony	CDP - C900	3 beams
B	Marantz Japan	CD - 50	3 beams
C	Marantz Japan	CD - 99SE	1 beam
D	Yamaha	CDX - 1050	3 beams
E	Matsushita Denki Sangyo	SL - PA10	1 beam
F	Matsushita Denki Sangyo	SL - P550	1 beam

Durability of the medium was investigated by allowing the medium to stand for 1000 hours under condition of

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85°C and 95 % RH and then measuring the jitter value and error rate.

Table 2 shows the result.

Examples 2 - 4 and Comparative Examples 1 - 5

The procedure of Example 1 was repeated using the same dye as in Example 1 except that there were used a substrate having a groove of a shape, a solvent, a concentration of the solution and a rotating speed as shown below, and a medium was produced and evaluated.

The recording laser power was the optimum power for each medium. Table 1 and Table 2 show the results.

Example	Shape of groove Depth (Å)	Width (μm)	Solvent	Concentration (% by weight)	Rotating speed (rpm)
2	950	0.35	Methylcyclohexane	2.8	1000
3	1400	0.50	Dibutyl ether	3.1	700
4	950	0.35	Octane	3.1	700
Comparative Example					
1	950	0.35	Octane	3.5	700
2	950	0.35	Methylcyclohexane	3.0	1100
3	800	0.35	Methylcyclohexane	3.1	1100
4	1900	0.58	Ethylcyclohexane	2.1	1000
5	950	0.70	Methylcyclohexane	3.1	1000

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Examples 5 and 6

The procedure of Example 1 was repeated except that there were used a substrate having a groove of a shape, a solution having a concentration of a brominated (average 3.5 atoms/molecule) Pd-tetra-(t-butylcyclohexyloxy)phthalocyanine dye in a solvent and a rotating speed as shown below, and a medium was produced and evaluated.

The recording laser power was the optimum power for each medium. Tables 1 and 2 show the results.

Example	Shape of groove Depth (Å)	Width (μm)	Solvent	Concentration (% by weight)	Rotating speed (rpm)
5	1600	0.5	Dibutyl ether	4.0	700
6	1600	0.5	Ethylcyclohexane	4.0	700

Examples 7 - 8 and Comparative Examples 6 - 8

The procedure of Example 1 was repeated except that there were used a substrate having a groove of a shape, a solution having a concentration of a brominated (average 3.5 atoms/molecule) Pd-tetra-(2,4-dimethyl-pentan-3-oxy) phthalocyanine in a solvent and a rotating speed as shown below, and a medium was produced and evaluated.

The recording laser power was the optimum power for each medium. Table 1 and 2 show the results.

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Example	Shape of groove Depth (Å)	Width (μm)	Solvent	Concentration (% by weight)	Rotating speed (rpm)
7	1250	0.45	Dimethyl-cyclohexane	3.1	1000
8	1250	0.45	Dimethyl-cyclohexane	3.5	700
Comparative Example 6	950	0.35	Dibutyl ether	3.1	700
7	950	0.35	Methylcyclo-hexane	4.0	700
8	1250	0.45	Octane	3.0	700

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Table 1

Example	Layer thickness (Å) Groove	Land	ΔT (Å)	Reflectivity (%)	Rc Rcb	Rca	Jitter value (ns) Pit	Land	Error rate (%)
1	1100	700	1000	67	0.09	0.57	19	20	0.08
2	950	600	600	68	0.06	0.38	18	19	0.04
3	1150	550	800	69	0.07	0.42	16	18	0.02
4	1250	1000	700	71	0.06	0.34	19	20	0.10
5	1150	650	1100	67	0.10	0.62	15	18	0.06
6	1200	600	1000	68	0.09	0.55	17	18	0.04
7	850	600	1000	73	0.06	0.45	16	16	0.01
8	1250	900	900	67	0.08	0.50	18	21	0.02
Comparative Example									
1	1450	1100	600	69	0.06	0.36	20	22	0.20
2	750	500	700	68	0.00	0.10	18	20	2.8
3	850	550	500	71	0.05	0.23	21	24	0.09
4	1200	500	1200	55	0.12	0.55	21	23	0.1
5	1050	700	600	71	0.05	0.35	32	36	3.8
6	1050	550	450	70	0.03	0.15	18	22	0.03
7	1600	1300	650	65	0.06	0.40	31	33	3.2
8	1100	450	600	69	0.03	0.18	19	25	3.5

ΔT : Difference in level between land and groove at the surface of recording layer

Rc : Radial contrast signal

Rc = 2(I max - I min)/(I max + I min)

I max: Maximum value of reflectivity upon traversing the track

I min: Minimum reflectivity upon traversing the track

Rcb : Radial contrast signal at unrecorded portion

Rca : Radial contrast signal at recorded portion

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Table 2

Example	Playability by CD players A	B	C	D	E	F	Jitter value (ns) Pit	Land	Error rate (%)
1	o	o	o	o	o	o	20	22	0.08
2	o	o	o	o	o	o	18	21	0.05
3	o	o	o	o	o	o	18	19	0.03
4	o	o	o	o	o	o	20	21	0.1
5	o	o	o	o	o	o	17	19	0.08
6	o	o	o	o	o	o	18	20	0.04
7	o	o	o	o	o	o	16	17	0.02
8	o	o	o	o	o	o	18	20	0.02
Comparative Example									
1	o	o	o	o	o	o	23	26	5.8
2	o	o	o	o	o	o	19	20	3.2
3	o	o	x	o	x	x	23	25	0.11
4	x	o	x	x	x	x	22	24	0.2
5	o	o	x	o	x	x	33	36	4.0
6	o	o	o	o	o	o	20	22	0.05
7	o	o	o	o	o	o	35	40	15
8	o	o	o	o	o	o	21	28	4.5

Playability by CD players was tested by regenerating using commercially available CD players A - F as mentioned in Example 1.

o : No problem

x : Access to an aimed track is not possible.

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As is clear from Table 1 and Table 2, the examples of the present invention all exhibit high reflectivity and sufficiently low jitter values and error rates. The radial contrast is large both at unrecorded portion and recorded portion. The mediums have a good playability by commercially available CD players. Even when the mediums are allowed to stand under high temperature and high humid conditions, they exhibit excellent characteristics such that the jitter values and error rates are hardly changed.

The comparative examples are summarized as shown below.

In Comparative Examples 1 and 7, the layer thickness of the recording layer at the groove portion is thick so that after the durability test, error rates increased to a great extent. When the mediums subjected to such durability test were observed with an electron microscope, it was found that a defect of about 2 μm was formed at the center of pit.

In Comparative Example 2, the layer thickness of the recording layer at the groove portion was so thin that error rate and radial contrast were very poor and therefore, the medium was not preferable.

In Comparative Example 3, the depth of the groove of the substrate is small so that playability after

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recording was poor.

In Comparative Example 4, the groove is so deep that reflectivity was lowered and there were many players which could not regenerate the record.

In Comparative Example 5, the groove was so wide that both jitter value and error rate were poor, and playability by commercially available CD players was poor.

In Comparative Example 6, the difference in height between the surface of recording layer at the land portion and that at the groove portion was so small that radial contrast was poor.

In Comparative Example 7, the thickness of recording layer on the land portion was so thick that jitter value and error rate were poor.

In Comparative EXample 8, the recording layer thickness at the land portion was so thin that error rate and radial contrast were poor.

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WHAT IS CLAIMED IS:

1. An optical recording medium of a single plate type capable of recording which comprises a transparent resin substrate having a groove and a land, the groove being 900 - 1800 Å in depth and 0.3 - 0.6 μm in width, a recording layer containing a dye overlying the substrate, a reflective layer overlying the recording layer and a protective layer overlying the reflective layer, the thickness of the recording layer being 800 - 1250 Å at the groove portion and 500 - 1100 Å at the land portion.

2. The optical recording medium according to claim 1 in which the surface of the recording layer at the land portion is higher than the surface of the recording layer at the groove portion by at least 500 Å.

3. The optical recording medium according to claim 2 in which the reflectivity at an unrecorded portion at the groove portion through the substrate is 60 % or more.

4. The optical recording medium according to claim 3 in which the recording layer contains a phthalocyanine dye.

5. The optical recording medium according to any one of claims 1 - 4 in which signals are recorded in the groove by pit length recording.



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OPTICAL RECORDING MEDIUM

ABSTRACT OF THE DISCLOSURE

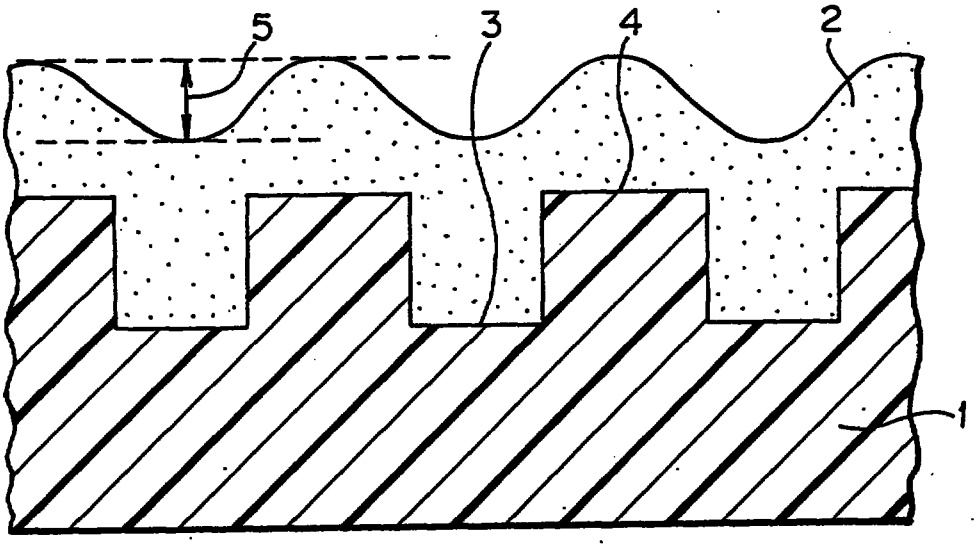
An optical recording medium of a single plate type capable of recording comprises a transparent resin substrate having a groove of 900 - 1800 Å in depth and 0.3 - 0.6 μm in width, a recording layer containing a dye overlying the substrate, a reflective layer overlying the recording layer and a protective layer overlying the reflective layer, the thickness of the recording layer being 800 - 1250 Å at the groove portion and 500 - 1100 Å at the land portion.

FIGURE 1.

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FIG. 1



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OPTICAL RECORDING MEDIUM

Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an optical recording medium, and more particularly, to a recordable optical disk of a single plate type comprising a recording layer containing a dye and a metal reflective layer overlying the recording layer which is recordable and has playability (i.e. capability of being reproduced) by commercially available compact disk players.

Description of the Related Art

An optical recording medium capable of writing comprising a recording layer containing a dye such as phthalocyanine dye and the like and a metal reflective layer overlying the recording layer for enhancing reflectivity is disclosed, for example, in U.S. Pat. No. 4,298,975. However, said U.S. Patent mentions nothing about playability by commercially available compact disk (CD) players.
Neither are disclosed conditions under which there is produced a medium excellent in jitter value and error rate when a pit length recording is conducted.

Optical recording mediums of a single plate type having a high reflectivity and playability by commercially available CD player have been recently proposed, for example, in Optical Data Storage 1989 Technical Digest Series, Vol. 145 (1989), EP 353393 and the like. In particular, there are disclosed dyes used as a recording layer and characteristics of the reflective layer for attaining a high reflectivity.

Further, U.S. Pat. No. 4,990,388 discloses a recording mechanism for a recording layer of an optical recording medium having playability by CD players.

In such optical recording mediums, it is necessary for the mediums to give tracking error signals for track control and radial contrast signals for access to an aimed track.

When a recording layer is formed by a vacuum technique such as sputtering and the like, the recording layer is formed strictly following the shape of groove of the substrate, and therefore, optimization of the above-mentioned tracking error signals and radial contrast signals can be effected by simulation.

However, in the case of an optical recording medium using a layer formed by coating a dye as a recording layer, the surface shape of the recording layer does not follow the groove shape of the substrate, and therefore, it is difficult to design the optimum shape by simulation as mentioned above, and the above-mentioned prior patents disclose nothing about it.

The relation between a tracking error signal and a groove shape of a substrate is disclosed, for example, in Japanese Patent Application Laid-open No. Hei 3-22224. However, the disclosure is not sufficient to attain a complete playability by commercially available CD players.

Among commercially available CD players, a player carrying a head of 3 beams has no problem, but the present inventors have found that playability by a player carrying a head of one beam is problematic though the reason is not clear.

In addition, with respect to radial contrast signals, the optimization has not yet been made, and radial contrast signals are not used for access, but an external sensor or the like is used though the access speed is slow.

According to the present inventors' investigation, with respect to playability by CD players and radial contrast signals, it is not enough to optimize the shape of groove.

In the case of an optical recording medium capable of recording comprising a recording layer containing a dye formed by a coating method and a metal reflective layer overlying the recording layer, the reflection at the interface of the recording layer and the reflective layer is predominant. Therefore the shape of the surface of the recording layer and the thickness of the recording layer on the groove and that on the land become important, but the shape of the surface of the recording layer and the thickness of the recording layer on the groove and that on the land vary depending on coating conditions such as concentration, surface tension and viscosity of the coating solution, boiling point and evaporation speed of the coating solvent, the manner of rotation is the case of spin coating, and the like even if the shape of groove of the substrate is the same. Therefore, the strict optimization has not yet been effected.

EP-041083 discloses a optical recording medium which comprises a substrate having a groove, a recording layer containing a dye, a reflective layer and a protective layer successively formed on the substrate, wherein the difference in light path length between the recording layer on the groove portion and that on the land portion is specified. And this European Patent Application discloses that the depth of the groove is more than 50nm (claims 2 and 5) or 40nm (claim 8), and that both the thickness of the recording layer at the groove portion and at the land portion are 90 - 350 nm (claim 6 and 7). However, the depth of the groove and the thickness of the recording layer at the groove portion

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and at the land portion specified in the Patent Application are requisites but not sufficient conditions for meeting the standards of CD in reflectivity, degree of modulation and push-pull (tracking error) signals before and after recording. In other words, even if the optical recording medium meets the above-mentioned conditions, there are still some problems that it can not record accurately and not be well reproducible by some commercially available CD or CD - ROM players.

On the contrary, there are generally two methods for recording information in an optical recording medium, that is, pit position recording and pit length recording. In the case of CD, pit length recording is effected with pits of 9 kinds of length. In pit pength recording, for the purpose of lessening error rate, it is very important to effect recording pits of various lengths with low jitter value (low fluctuation).

At present, various types of CD players are commercially available, but the regeneration signal characteristics are different from player to player, and therefore, the error rate is also different from each other. Therefore, it is required that the error rate is sufficiently small even when regeneration is effected by many types of commercially available CD players as far as possible.

However, the present inventors have found the following. It is said that the above-mentioned conventional optical recording mediums capable of recording can be regenerated by commercially available CD players. However, the jitter value of pit (hereinafter called "pit jitter value") and the jitter value of the part between consecutive pits (hereinafter called "land jitter value") are not always small. Some CD players fail to reduce sufficiently error rates. When audio information and the like are recorded, there is not so noticeable problem, but when code data and the like are recorded there are serious problems.

Further, such optical recording medium is required to be durable, but durability of conventional mediums is not always sufficient. For example, according to the present inventors' investigation, when conventional optical recording mediums are allowed to stand at 85°C at 95 % RH for a long time, characteristics of unrecorded portions hardly change while error rate at recorded portions is deteriorated to a great extent, and according to observation with a microscope of the region where error rate has been deteriorated, pits having defects of several microns with the pit at the center are found.

The present inventors have researched variously so as to eliminate drawbacks of the above-mentioned conventional recordable optical mediums having playability by CD players, and investigated the shape of groove, surface shape of recording layer containing a dye, thickness of recording layer at a groove portion and that at a land portion.

As a result, the present inventors have found particular conditions under which a sufficient radial contrast signal can be assured, there is playability by various commercially available CD players, jitter value and error rate are small and further, characteristics such as error rate and the like do not change when stood under condition of high temperature and high humidity for a long time.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an optical recording medium capable of assuring a sufficient radial contrast signal.

Another object of the present invention is to provide an optical recording medium playable by commercially available CD players.

A further object of the present invention is to provide an optical recording medium of small jitter value and small error rate.

Still another object of the present invention is to provide an optical recording medium of which characteristics such as error rate and the like are not adversely affected even when the medium is placed under high temperature and high humidity conditions for a long time.

According to the present invention, there is provided an optical recording medium of a single plate type as defined in claim 1.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a schematical cross sectional view of an enbodiment of a part of the optical recording medium according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG.1, a recording layer (2) is formed by coating a substrate (1) having groove portion (3) and land portion (4). A reflective layer (6) is formed on the recording layer and a protective layer (7) is formed on the reflective layer. The groove depth and width are indicated respectively by (8) and (9). The thickness of the recording layer at the groove portion and land portion are indicated by (10) and (11). The difference in height (ΔT) between the surface of

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the recording layer on the land portion (4) and that on the groove portion (3) is indicated by (5).

As a transparent resin substrate used in the present invention, such substrate capable of transmitting a light used for recording signals and readout of recorded information is preferable. Preferable transmittance of light is 85 % or higher. Further, it is preferable that optical anisotropy of the substrate is small.

Examplary suitable substrates include thermoplastic resin substrates composed of acrylic resins, polycarbonate resins, polyamide resins, polyvinyl chloride, polyolefin resins or the like.

Among these resins, from the standpoints of mechanical strength of substrate, easy formation of grooves and pits and economy, acrylic resins, polycarbonate resins, or polyolefin resins are preferable, and polycarbonate resin is particularly preferable. These resins may be formed into the substrates by injection molding or cast molding.

The shape of the substrate may be in the form of plate or film, or circle or card. The surface of the substrate is provided with grooves for controlling the recording position. The surface may have partly some prepits for the information.

Such grooves and pits are preferably formed when the substrate is fabricated by injection molding or cast molding. Further they may be formed by applying an ultraviolet light curable resin to a substrate, superposing a stamper thereon and exposing to ultraviolet light.

According the present invention, the optical recording medium comprises a transparent resin substrate, and a recording layer containing a dye, a reflective layer and a protective layer subsequently superposed on the substrate.

The dyes used in the recording layer containing a dye may be dyes having absorption in the wavelength region of oscillation of semiconductor laser such as polymethine dye, phthalocyanine dye, naphthalocyanine dye, naphthoquinone dye, azulene dye, dithiol metal complex dye and the like.

These dyes may have various substituents so as to control the solubility of the dye in a solvent to a desirable range or impart desirable recording characteristics. The dyes may be used alone or in combination.

Among the dyes, phthalocyanine dye and naphthalocyanine dye are preferable from the standpoints of light resistance and durability.

According to the present invention, the recording layer containing a dye can be usually formed by a coating method such as spin coating, spraying, dipping and the like.

When the above-mentioned dye is formed into a layer by a coating method, the dye may be dissolved in a solvent not adversely affecting the substrate.

Such solvents are, for example, aliphatic or alicyclic hydrocarbons such as hexane, heptane, octane, decane, cyclohexane, methylcyclohexane, dimethylcyclohexane, cyclooctane and the like;

ether type non-polar solvents such as diethyl ether, dibutyl ether, diisopropyl ether and the like; and alcoholic polar solvents such as methyl alcohol, ethyl alcohol, isopropyl alcohol, allyl alcohol, methyl cellosolve, and the like.

According to the present invention, it is important to control the shape (depth and width) of groove of the substrate, thickness of recording layer at the groove portion, that at the land portion and the surface shape (ΔT) of the recording layer.

That is, for purposes of obtaining radial contrast signal satisfying the CD standard for both unrecorded portions and recorded portions, assuring playability by a commercially available CD players, and obtaining excellent jitter value and error rate, it is preferable that the groove in the substrate is 90 - 180 nm (900 - 1800 Å) in depth and 0.3 - 0.6 μm in width and the thickness of recording layer at the groove portion is 80 - 125 nm (800 - 1250 Å) and that at the land is 50 - 110 nm (500 - 1100 Å.) More preferably, the surface of recording layer at the land portion is higher than that at the groove portion by at least 50 nm (500 Å.)

When the thickness of recording layer at the groove portion is less than 80 nm (800 Å) or that at the land portion is less than 50 nm (500 Å,) radial contrast signal becomes small, and though the jitter value is small, the error rate becomes large.

The reason for increase in error rate despite of small jitter value appears to be that the length of 11T pit and length of 11T part between consecutive pits which are to be inherently equal to each other become fairly different.

When the difference in height between the surface of recording layer at the land portion and that at the groove portion (ΔT) is less than 50 nm (500 Å,) the radial contrast signal becomes small.

The thickness of recording layer at the groove portion exceeding 125 nm (1250 Å) is not preferable since the error rate increases to a great extent when the medium is allowed to stand under high temperature and high humidity conditions for a long time.

The thickness of recording layer at the land portion exceeding 110 nm (1100 Å) is not preferable since jitter value and error rate are deteriorated.

On the other hand, the upper limit of the difference in height between the surface of recording layer at the land portion and that at the groove portion is preferably 120 nm (1200 Å.) When the difference exceeds 120 nm (1200 Å,) the tracking error singnal becomes too large or assuring the reflectivity of groove of 60 % or more becomes difficult sometimes, and playability by commercially available CD player is not possible.

When the width of groove exceeds 0.6 μm, the pit jitter value and the land jitter value become so large that poor

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playability by commercially available CD players is obtained, and though playability by CD players carrying a 3 beam head can be assured, it is difficult to assure playability by CD players carrying a 1 beam head.

When the depth of groove is less than 90 nm (900 Å), poor playability by commercially available CD players is obtained, and though playability by CD players carrying a 3 beam head can be assured, that carrying a 1 beam head is assured with difficulty. When regeneration (reproduction) is effected with a CD player carrying a 1 beam head, access is not possible or it takes a long time for access though it is possible to regenerate information sequentially from the beginning.

When the depth of groove exceeds 180 nm (1800 Å,) radial contrast signal becomes large, but reflectivity of groove becomes less than 60 % and therefore, playability by CD players is not possible.

It is substantially difficult and not practical to fabricate a substrate having a groove of 90 nm (900 Å) or more in depth and less than 0.3 μm in width.

The formation of the recording layer having a difference in height (ΔT) between the surface of recording layer at the land portion and that at the groove portion of 50 nm (500 Å) or higher may be effected by controlling or selecting the depth of groove in the substrate, type of solvent (boiling point, vaporization speed, and surface tension) used for coating or coating conditions (rotating conditions in the case of spin coating).

For example, when the groove is made deeper and the vaporization speed of solvent slower, the difference in layer thickness between the recording layer at the groove portion and that at the land portion becomes larger.

The shape (the depth and the width) of groove in the substrate and the shape (ΔT) of the surface of recording layer at the land portion and groove portion can be measured by means of a scanning type tunnel microscope or by observing the cross section of the substrate and recording layer with a microscope. The thickness of the recording layer at the groove portion and land portion can be measured by observing the cross section of the recording layer with a microscope.

The width of groove in the present invention is a half-value width, that is, the width at a position where the depth of groove is a half of the total depth.

On the other hand, the term "radial contrast signal" means a quotient of the division of the fluctuation of reflectivity by the average value of reflectivity when the light beam of a player traverses the track while the light beam is focused on the recording layer (focus control). That is, it is defined by the following formula:

$$\text{Rc (radial contrast signal)} = 2 (I_{max} - I_{min}) / (I_{max} + I_{min})$$

where I max and I min are maximum reflectivity and minimum reflectivity when the beam traverses the track, respectively.

According to the CD standard, it is required that the Rc value is 0.05 or more at the unrecorded portion while it is 0.2 or more at the recorded portion.

When a recording layer containing a dye is prepared, in addition to the dye used in the present invention, there may be used resins such as nitrocellulose, ethylcellulose, acrylic resins, polystyrene resins, urethane resins and the like, leveling agents, deforming agents and the like in an amount which does not adversely affect the effect of the present invention, for example, about 20 % or less, preferably about 10 % or less.

As the reflective layer provided on the recording layer, in usual, a metal thin film is preferably used.

For purposes of imparting playability by ordinaly CD players to the medium of the present invention, the reflectivity of the medium is preferably 60 % or more. As preferable metals, there may be mentioned aluminum, gold, silver, copper, platinum, nickel and the like and alloys containing the metals as mentioned above as a component or components. The reflective layer made of the metal may be formed by vapor deposition, sputtering and the like. In usual, the thickness of reflective layer is preferably 50 - 200 nm (500 - 2000 Å.)

In order to protect the metal reflective layer, a protective layer is formed on the reflective layer. As the protective layer, resins are usually used. In particular, from the standpoint of productivity, ultroviolet light curable resins are preferable. The thickness of the protective layer is preferably about 1 - 15 μm.

The optical recording medium of the present invention is irradiated with a laser beam through the substrate to record information signals or read out the information. Wavelength of the laser beam is preferably 640 - 850 nm. Semiconductor laser having an oscillatory wavelength of such range as above is preferably used. For recording, the laser output is made about 5 - 12 mW on the recording film while rotating the medium, and for readout, the laser output is made about 1/10 times that for recording.

Printing may be made on the protective layer of the optical recording medium of the present invention.

The present invention is explained in detail in the following referring to examples, but should not be construed as limited by the examples.

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As phthalocyanine dye used in Example 1, Pd-tetra-(t-butylcyclohexyloxy) phthalocyanine was prepared by using 3-(t-butylcyclohexyloxy)-1,2-dicyanobenzene and $PdCl_2$ according to a conventional method, for example, EP 232,427.

Then, one mole of the resulting Pd-tetra-(t-butylcyclohexyloxy)phthalocyanine was reacted with 3.3 moles of Br_2 in a solvent, methylene chloride and a phthalocyanine dye composed of Pd-tetra-(t-butylcyclohexyloxy) phthalocyanine having average 3.0 atoms of bromine per one molecule of said phthalocyanine was obtained.

In Example 2 et seq., the dyes were prepared in a manner similar to the above-mentioned procedure.

Example 1

A 3.1 wt. % solution of a brominated (average 3.0 atoms/molecule) Pd-tetra-(t-butylcyclohexyloxy) phthalocyanine in methylcyclohexane was dropped on the center portion of the surface having a groove 140 nm (1400 Å in depth, 0.5 µm in width, 1.6 µm in pitch) of an injection molded polycarbonate resin substrate of 1.2 mm thick and 120 mm in diameter. Then the resin substrate was rotated at a speed of 1000 rpm for 10 sec. The resin substrate was dried at 40°C for 10 min. and a recording layer substantially composed of a phthalocyanine dye was formed on a resin substrate. The thickness and surface shape of the recording layer was measured by obserbing the cross section by means of an electron microscope. The thickness at the groove portion and that at the land portion of the recording layer were 110 nm (1100 Å) and 70 nm (700 Å), respectively, and the surface of the recording layer at the land portion was higher than that at the groove portion by 100 nm (1000 Å) (ΔT = 100 nm (1000 Å)).

On the recording layer was formed a gold thin film of 80 nm thick as a reflective layer by means of sputtering, and further an ultraviolet ray-cured resin layer of 5 µm thick was formed on a reflective layer to produce an optical recording medium.

While the resulting optical recording medium was placed on a turntable and rotated at a linear speed of 1.4 m/s, there was used a drive provided with an optical head carrying a semiconductor laser having an oscillation wavelength of 780 nm and a laser beam was controlled such that the laser beam focused on the recording layer through the resin substrate. Thus there were measured reflectivity on the groove and radial contrast signal at the unrecorded portion with a laser output of 1 mW on the recording surface. Table 1 shows the result.

Then the laser output was made the optimum record-condition of this medium, 7 mW, and a music was recorded with the same EFM modulation signal as that used in CD, and then the output of laser was made 1 mW. There were measured radial contrast signal, 3T pit jitter value, 3T land jitter value and error rate at the recording portion. The result was summarized in Table 1. Further, for purposes of investigating playability by commercially available CD player, regeneration of record was effected by the following CD player. The regenerated result was summarized in Table 2.

No.	Manufacturer	Type of CD Player	Type of Head
A	Sony	CDP - C900	3 beams
B	Marantz Japan	CD - 50	3 beams
C	Marantz Japan	CD - 99SE	1 beam
D	Yamaha	CDX - 1050	3 beams
E	Matsushita Denki Sangyo	SL - PA10	1 beam
F	Matsushita Denki Sangyo	SL - P550	1 beam

Durability of the medium was investigated by allowing the medium to stand for 1000 hours under condition of 85°C and 95 % RH and then measuring the jitter value and error rate.
Table 2 shows the result.

Examples 2 - 4 and Comparative Examples 1 - 5

The procedure of Example 1 was repeated using the same dye as in Example 1 except that there were used a substrate having a groove of a shape, a solvent, a concentration of the solution and a rotating speed as shown below, and a medium was produced and evaluated.

The recording laser power was the optimum power for each medium. Table 1 and Table 2 show the results.

Example	Shape of groove			Solvent	Concentration (% by weight)	Rotating speed (rpm)
	Depth (Å)	(nm)	Width (µm)			
2	(950)	95	0.35	Methylcyclohexane	2.8	1000

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(continued)

Example	Shape of groove			Solvent	Concentration (% by weight)	Rotating speed (rpm)
	Depth (Å)	(nm)	Width (μm)			
3	(1400)	140	0.50	Dibutyl ether	3.1	700
4	(950)	95	0.35	Octane	3.1	700
Comparative Example						
1	(950)	95	0.35	Octane	3.5	700
2	(950)	95	0.35	Methylcyclohexane	3.0	1100
3	(800)	80	0.35	Methylcyclohexane	3.1	1100
4	(1900)	190	0.58	Ethylcyclohexane	2.1	1000
5	(950)	95	0.70	Methylcyclohexane	3.1	1000

Examples 5 and 6

The procedure of Example 1 was repeated except that there were used a substrate having a groove of a shape, a solution having a concentration of a brominated (average 3.5 atoms/molecule) Pd-tetra-(t-butylcyclohexylexy) phthalocyanine dye in a solvent and a rotating speed as shown below, and a medium was produced and evaluated.

The recording laser power was the optimum power for each medium. Tables 1 and 2 show the results.

Example	Shape of groove			Solvent	Concentration (% by weight)	Rotating speed (rpm)
	Depth (Å)	(nm)	Width (μm)			
5	(1600)	160	0.5	Dibutyl ether	4.0	700
6	(1600)	160	0.5	Ethylcyclohexane	4.0	700

Examples 7 - 8 and Comparative Examples 6 - 8

The procedure of Example 1 was repeated except that there were used a substrate having a groove of a shape, a solution having a concentration of a brominated (average 3.5 atoms/molecule) Pd-tetra-(2,4-dimethyl-pentan-3-oxy) phthalocyanine in a solvent and a rotating speed as shown below, and a medium was produced and evaluated.

The recording laser power was the optimum power for each medium. Table 1 and 2 show the results.

Example	Shape of groove			Solvent	Concentration (% by weight)	Rotating speed (rpm)
	Depth (Å)	(nm)	Width (μm)			
7	(1250)	125	0.45	Dimethylcyclohexane	3.1	1000
8	(1250)	125	0.45	Dimethylcyclohexane	3.5	700
Comparative Example						
6	(950)	95	0.35	Dibutyl ether	3.1	700
7	(950)	95	0.35	Methylcyclohexane	4.0	700
8	(1250)	125	0.45	Octane	3.0	700

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Table 1

Example	Layer thickness Groove nm	Groove Å	Land nm	ΔT Land Å	Å	nm	Reflectivity (%)	Rc Rcb	Rca	Jitter value (ns) Pit	Land	Error rate (%)
1	110	(1100)	70	(700)	(1000)	100	67	0.09	0.57	19	20	0.08
2	95	(950)	60	(600)	(600)	60	68	0.06	0.38	18	19	0.04
3	115	(1150)	55	(550)	(800)	80	69	0.07	0.42	16	18	0.02
4	125	(1250)	100	(1000)	(700)	70	71	0.06	0.34	19	20	0.10
5	115	(1150)	65	(650)	(1100)	110	67	0.10	0.62	15	18	0.06
6	120	(1200)	60	(600)	(1000)	100	68	0.09	0.55	17	18	0.04
7	85	(850)	60	(600)	(1000)	100	73	0.06	0.45	16	16	0.01
8	125	(1250)	90	(900)	(900)	90	67	0.08	0.50	18	21	0.02
Comparative Example												
1	145	(1450)	110	(1100)	(600)	60	69	0.06	0.36	20	22	0.20
2	75	(750)	50	(500)	(700)	70	68	0.00	0.10	18	20	2.8
3	85	(850)	55	(550)	(500)	50	71	0.05	0.23	21	24	0.09
4	120	(1200)	50	(500)	(1200)	120	55	0.12	0.55	21	23	0.1
5	105	(1050)	70	(700)	(600)	60	71	0.05	0.35	32	36	3.8
6	105	(1050)	55	(550)	(450)	45	70	0.03	0.15	18	22	0.03
7	160	(1600)	130	(1300)	(650)	65	65	0.06	0.40	31	33	3.2
8	110	(1100)	45	(450)	(600)	60	69	0.03	0.18	19	25	3.5

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ΔT : Difference in level between land and groove at the surface of recording layer

Rc : Radial contrast signal

$Rc = 2(I_{max} - I_{min})/(I_{max} + I_{min})$

I_{max}: Maximum value of reflectivity upon traversing the track

I_{min}: Minimum reflectivity upon traversing the track

Rcb : Radial contrast signal at unrecorded portion

Rca : Radial contrast signal at recorded portion

Table 2

Example	Playability by CD players						Jitter value (ns) Land	Jitter value (ns) Pit	Error rate (%)
	A	B	C	D	E	F			
1	o	o	o	o	o	o	20	22	0.08
2	o	o	o	o	o	o	18	21	0.05
3	o	o	o	o	o	o	18	19	0.03
4	o	o	o	o	o	o	20	21	0.1
5	o	o	o	o	o	o	17	19	0.08
6	o	o	o	o	o	o	18	20	0.04
7	o	o	o	o	o	o	16	17	0.02
8	o	o	o	o	o	o	18	20	0.02
Comparative Example									
1	o	o	o	o	o	o	23	26	5.8
2	o	o	o	o	o	o	19	20	3.2
3	o	o	x	o	x	x	23	25	0.11
4	x	o	x	x	x	x	22	24	0.2
5	o	o	x	o	x	x	33	36	4.0
6	o	o	o	o	o	o	20	22	0.05
7	o	o	o	o	o	o	35	40	15
8	o	o	o	o	o	o	21	28	4.5

Playability by CD players was tested by regenerating using commercially available CD players A - F as mentioned in Example 1.

o : No problem

x : Access to an aimed track is not possible.

As is clear from Table 1 and Table 2, the examples of the present invention all exhibit high reflectivity and sufficiently low jitter values and error rates. The radial contrast is large both at unrecorded portion and recorded portion. The mediums have a good playability by commercially available CD players. Even when the mediums are allowed to stand under high temperature and high humid conditions, they exhibit excellent characteristics such that the jitter values and error rates are hardly changed.

The comparative examples are summarized as shown below.

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In Comparative Examples 1 and 7, the layer thickness of the recording layer at the groove portion is thick so that after the durability test, error rates increased to a great extent. When the mediums subjected to such durability test were observed with an electron microscope, it was found that a defect of about 2 μm was formed at the center of pit.

In Comparative Example 2, the layer thickness of the recording layer at the groove portion was so thin that error rate and radial contrast were very poor and therefore, the medium was not preferable.

In Comparative Example 3, the depth of the groove of the substrate is small so that playability after recording was poor.

In Comparative Example 4, the groove is so deep that reflectivity was lowered and there were many players which could not regenerate the record.

In Comparative Example 5, the groove was so wide that both jitter value and error rate were poor, and playability by commercially available CD players was poor.

In Comparative Example 6, the difference in height between the surface of recording layer at the land portion and that at the groove portion was so small that radial contrast was poor.

In Comparative Example 7, the thickness of recording layer on the land portion was so thick that jitter value and error rate were poor.

In Comparative EXample 8, the recording layer thickness at the land portion was so thin that error rate and radial contrast were poor.

Claims

1. An optical recording medium of a single plate type capable of recording which comprises a transparent resin substrate (1) having a groove (3) and a land (4), a recording layer (2) containing a dye overlying the substrate, a reflective layer (6) overlying the recording layer and a protective layer (7) overlying the reflective layer, and the thickness of the recording layer of which is 80 - 125 nm at the groove portion (10) and 50 - 110 nm at the land portion (11) characterized in that the groove depth (8) is 90 - 180 nm and the groove width (9) is 0.3 - 0.6 μm and the difference in height (5) between the surface of the recording layer on the land portion and that on the groove portion is 50 - 120 nm.

2. The optical recording medium according to claim 1 in which the reflectivity at an unrecorded portion at the groove portion through the substrate is 60 % or more.

3. The optical recording medium according to claim 2 in which the recording layer contains a phthalocyanine dye.

4. The optical recording medium according to any one of claims 1 - 3 in which signals are recorded in the groove by pit length recording.

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In Comparative Examples 1 and 7, the layer thickness of the recording layer at the groove portion is thick so that after the durability test, error rates increased to a great extent. When the mediums subjected to such durability test were observed with an electron microscope, it was found that a defect of about 2 μm was formed at the center of pit.

In Comparative Example 2, the layer thickness of the recording layer at the groove portion was so thin that error rate and radial contrast were very poor and therefore, the medium was not preferable.

In Comparative Example 3, the depth of the groove of the substrate is small so that playability after recording was poor.

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In Comparative Example 6, the difference in height between the surface of recording layer at the land portion and that at the groove portion was so small that radial contrast was poor.

In Comparative Example 7, the thickness of recording layer on the land portion was so thick that jitter value and error rate were poor.

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Claims

1. An optical recording medium of a single plate type capable of recording which comprises a transparent resin substrate (1) having a groove (3) and a land (4), a recording layer (2) containing a dye overlying the substrate, a reflective layer (6) overlying the recording layer and a protective layer (7) overlying the reflective layer, and the thickness of the recording layer of which is 80 - 125 nm at the groove portion (10) and 50 - 110 nm at the land portion (11) characterized in that the groove depth (8) is 90 - 180 nm and the groove width (9) is 0.3 - 0.6 μm and the difference in height (5) between the surface of the recording layer on the land portion and that on the groove portion is 50 - 120 nm.

2. The optical recording medium according to claim 1 in which the reflectivity at an unrecorded portion at the groove portion through the substrate is 60 % or more.

3. The optical recording medium according to claim 2 in which the recording layer contains a phthalocyanine dye.

4. The optical recording medium according to any one of claims 1 - 3 in which signals are recorded in the groove by pit length recording.

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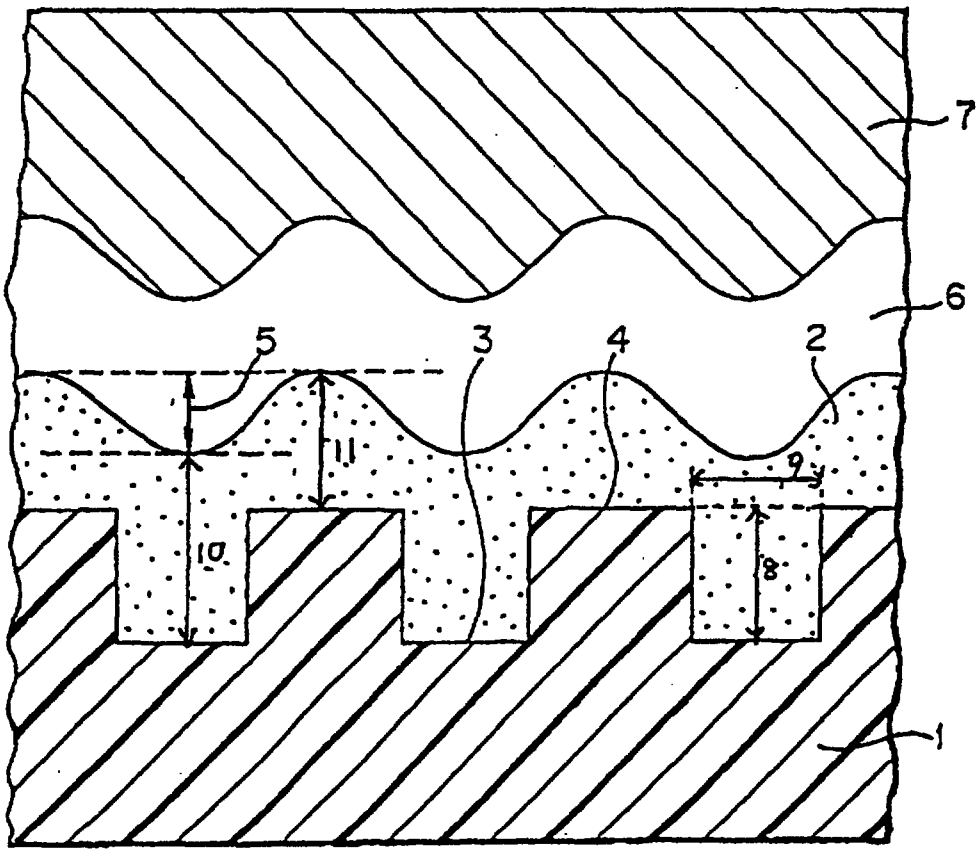


FIG. 1

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