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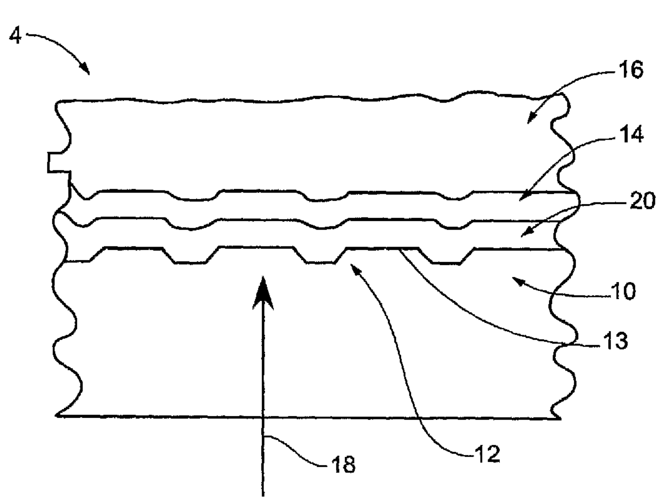

(57) Abstract: An optical disc having machine-readable, information encoding features includes a coating comprising a dye irreversibly bleachable by light. The dye, once bleached, is operative to change the index of refraction of the dye to inhibit reading of the information encoding features.

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LIMITED PLAY OPTICAL DISCS

FIELD OF THE INVENTION

Embodiments of the invention generally relate to optical discs rendered unreadable after a limited number of plays.

BACKGROUND OF THE INVENTION

Conventional optical discs have reached widespread acceptance as a low-cost, reliable storage medium for digital information including music, video, and data. One of the traditional advantages of optical discs is their ability to be played thousands of times without degrading the digital information. However, in some applications, this aspect of the conventional optical disc represents a disadvantage by allowing the digital information to be used or copied more than the creator of the digital information desires. Although some discs have been provided with features to frustrate unlimited use, these discs have typically only temporarily rendered the disc unreadable. Further, known discs that are rendered permanently unusable have generally been rendered unreadable in response to time, such as by oxidation after the removal of a barrier layer. Such discs do not provide optimum qualities of rendering a disc permanently unreadable in response to the number of uses.

BRIEF SUMMARY OF THE INVENTION

Some embodiments of the invention include a limited play optical disc comprising a substrate having machine-readable information encoding features and a coating comprising a dye irreversibly bleachable by light. In such embodiments, the information encoding features are machine-readable prior to bleaching of the dye, which may be activated by light. The bleached dye, however, alters the disc to inhibit further reading of the information encoding features. The dye can be bleached by a number of readings of the disc, as for example by exposure to light associated with reading of the disc. Embodiments of the optical discs have a relatively short effective life, limited by the number of times the disc is played (e.g. one, two, three or more times). Embodiments of the invention also include methods of making and using a limited play optical disc.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a cross section view of a disc in accordance with some embodiments of the invention.

Figure 2(a) shows information encoding features in accordance with some embodiments of the invention.

Figure 2(b) shows an enlarged view of a portion of Figure 2(a).

Figure 2(c) shows a read pattern in accordance with some embodiments of the invention.

Figure 3 shows read patterns in accordance with some embodiments of the invention.

Figure 4(a) shows a dispersion curve for polycarbonate in accordance with some embodiments of the invention.

Figure 4(b) shows optical constants for a cyanine dye in accordance with some embodiments of the invention.

Figure 5(a) shows an absorbance curve for a cyanine dye in accordance with some embodiments of the invention.

Figure 5(b) shows an absorbance curve for a cyanine dye in accordance with some embodiments of the invention.

Figure 6(a) shows an absorbance curve for a triarylmethane dye in accordance with some embodiments of the invention.

Figure 6(b) shows an absorbance curve for a triarylmethane dye in accordance with some embodiments of the invention.

Figure 7 shows a cyanine dye and a photobleach accelerator in accordance with some embodiments of the invention.

Figure 8 shows absorbance curves for a film and solution of the cyanine dye of Figure 4b.

DETAILED DESCRIPTION OF THE INVENTION

The following detailed description should be read with reference to the drawings, in which like elements in different drawings are numbered identically. The drawings, which are not necessarily drawn to scale, depict selected embodiments and are not intended to limit the scope of the invention. Several forms of the embodiments will be shown and described, and other forms will be apparent to those skilled in the art. It will be understood that embodiments shown in drawings and described are merely for illustrative purposes and are not intended to limit the scope of the embodiments as defined in the claims that follow.

Optical discs enable high storage capacity coupled with a reasonable price per megabyte of storage. Use of optical media has become widespread in audio, video, and computer data applications in such formats as, for example, compact disc (CD), compact disc read only memory (CD ROM), digital versatile disc (DVD) including multi-layer structures like DVD-5, DVD-9, and multi-sided formats such as DVD-10, and DVD-18, magneto-optical disc (MO), other write-once and re-writable formats such as CD-R, CD-RW, DVD-R, DVD-RW, DVD+RW, DVD-RAM, high definition optical discs such as Blu-ray and HD DVD, volumetric playback structures, and the like.

Figure 1 shows a highly schematic cross section of an optical disc 4 in accordance with some embodiments of the invention. The disc 4 of Figure 1 includes a substrate 10, which may be formed of any suitable material (e.g., polycarbonate). The substrate 10 may include an array of information encoding features. As used herein, the term "information encoding features" is intended broadly to encompass the widest possible range of such features, regardless of the particular encoding mechanism or reading beam interaction mechanism that is used. For example, the information encoding features may include pits 12 and lands 13. In some embodiments the pits and lands define one or more outputs selected from the group consisting of a song, movie, software and combinations thereof. The disc 4 may also include a reflective layer 14, which may include, for example, aluminum and/or gold. The reflective layer 14 may be covered with a protective layer 16, such as a lacquer, which protects the reflective layer 14 from oxidation and physical damage. A reading beam aligned with the arrow 18 may be incident on the surface of the substrate 10 opposite the information encoding features to read the information contained therein.

During use, the reading beam (sometimes referred to herein as an incident beam) 18 passes through the substrate 10, is reflected by the reflective layer 14, and passes out through the substrate 10 and the information encoding features as a reflected beam for detection by a reading device. In some embodiments the reading device is selected from the group consisting of a disc drive, CD player, and DVD player. The reading device may include an optical source, such as a laser, that directs the reading beam against the disc 4. A detector senses returning radiation (i.e., the reflected beam) from the disc 4.

As shown in Figure 1, some embodiments of the disc 4 comprise a coating 20 that includes a dye irreversibly bleachable by light. In such embodiments, the information encoding features are machine-readable prior to bleaching of the dye. The dye, once bleached by light, is operative to change the index of refraction of the dye to inhibit further reading of the information encoding features. Unlike many coatings adapted to inhibit further reading of a disc by changing absorbance upon bleaching, changing the index of refraction is irreversible, thereby making the disc permanently unreadable if so desired.

Figures 2(a)-(c), adapted from *The Compact Disc Handbook* by K. C. Pohlmann, A-R Editions, Inc., Madison, Wisconsin, 1992, show the information encoding features being read on a typical optical disc. As an example, Figure 2(a) schematically shows a 1.7um laser spot (780 nanometers (nm)) passing over CD pit features (e.g., approximately 0.5um wide by 100nm deep with a 1.6um track pitch). Figure 2(b) illustrates an incident beam aimed at a pit and land and the the collection optics receiving roughly equal amounts of light from a reflected beam from the land area and pit area of the information encoding features, the pit causing a wave phase shift (half wave double pass) compared to the land. The resulting interference yields the observed dark features on a bright background as shown in Figure 2(c) when the disc is read at 780nm, thereby transferring the information to a beam reader, such as a CD player. As another example, a similar readout would be observed for DVD pit structures with the wavelength at 650nm, smaller pit dimensions, and a 0.8um track pitch.

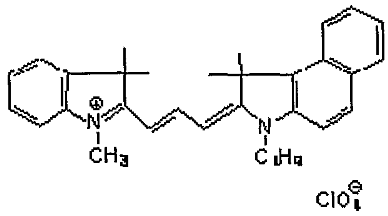
Upon sufficient exposure to the reading beam, the dye in the coating 20 undergoes a change in index of refraction to sharply reduce the information encoding feature contrast, resulting in unrecoverable data. As shown in Figure 3, uncoated information encoding features of an uncoated disc may be represented by dark spots 26. These spots are read by the incident light beam to reproduce the information contained in the information encoding features. The coating 20 containing the dye may be placed in apposition to the information encoding features (e.g., pits and lands). The pits 12 generally have the same locations and length as uncoated discs, but generally have a different (e.g., greater or lesser) depth. For example, the depth of the pit relative to the land may be greater than about 150 nm (e.g., between about 150 nm and about 300 nm). In some embodiments, the depth of the pit relative to the land is greater than about 200 nm. In yet other embodiments, the depth of the pit relative to the land is greater than about 250 nm. In other embodiments, the depth of the pit relative to the land is less than about 100 nm. In yet other embodiments, the depth of the pit relative to the land is less than about 75 nm. In other embodiments, the depth of the pit relative to the land is less than about 50 nm. These depths may be contrasted with typical discs, which generally have a pit depth of about 100 nm to about 130 nm relative to a land. The optimal pit depth may be determined for a given application by taking into account the optical properties of the dye, the thickness of the dye coating, and the extent the dye conforms to the underlying pit structure. As an example, according to theory, for a change in index of refraction of 3 and a 50% conformal coating, a desired pit depth would be about 63 nm. Before bleaching of the dye, the information encoding features appear as dark spots 28, and the information defined by the information encoding features remains readable. After bleaching of the dye, however, the resulting change in index of refraction causes the information encoding features to appear as low-contrasting light spots 30 to the interrogation beam, thereby rendering the information unreadable. Lights spots 30 only need to be light enough to reduce the contrast below that which renders the discs unreadable. It should be noted that dual layer discs with multiple layers of information encoding features also work as described above, with each layer of information encoding features being unreadable after a change in index of refraction of a dye coating layer.

Embodiments of the optical discs have a relatively short effective life, limited by the number of times the disc is played (e.g. one, two, three, five or more times). In some embodiments the disc is read more than once before further reading is inhibited. In some embodiments the disc is read more than twice before further reading is inhibited. Further, the dyes are useful for rendering the disc permanently unreadable after a limited number of uses. The number of times the disc is read before permanent bleaching may be pre-determined by the selection of dye and the presence or absence of bleaching accelerators. The dye coating may be of a sufficient thickness and sensitivity to bleach in response to the laser intensity typically emitted from a standard disc reader, in contrast to dye coatings having a thickness and sensitivity that can only be activated in response to the typically higher intensity lasers utilized in disc writers.

In some embodiments, the dye irreversibly bleachable by light is selected from the group consisting of cyanines and triarylmethanes. For example, the cyanine may be selected from the group consisting of carbocyanines, styrlcyanines, and hemicyanines. Cyanine dyes are particularly photoactive and the optically induced changes are permanent. Also, there are many cyanine dyes that are readily available and easily soluble in and coat well from common coating solvents (e.g., alcohol) using common techniques (e.g. spin coating). In addition, cyanines are inherently light sensitive and become more sensitive in the presence of electron donors (e.g., borates).

Representative examples of cyanines and their related absorbance curves are provided in Figures 5(a) and 5(b), and representative examples of triarylmethanes and their related absorbance curves are provided in Figures 6(a) and 6(b). For example, cyanines suitable for DVD embodiments include 3-butyl-2-[3-(3-butyl-1,3-dihydro-1,1-dimethyl-2H-benzo[e]indol-2-ylidene)-propenyl]-1,1-dimethyl-1H-benzo[e]indolium perchlorate, and cyanines useful for CD embodiments include 3-butyl-2-[5-(3-butyl-1,3-dihydro-1,1-dimethyl-2H-benzo[e]indol-2-ylidene)-penta-1,3-dienyl]-1,1-dimethyl-1H-benzo[e]indolium perchlorate. Other examples of suitable cyanines include 1-butyl-2-[5-(1-butyl-1,3-dihydro-3,3-dimethyl-2H-indol-2-ylidene)-penta-1,3-dienyl]-3,3-dimethyl-3H-indolium perchlorate, 2-[3-(1,3-dihydro-1,3,3-trimethyl-2H-indol-2-ylidene)-propenyl]-1,3,3-trimethyl-3H indolium perchlorate, 3-ethyl-2-[5-(3-ethyl-3H-benzothiazol-2-ylidene)-penta-1,3-dienyl]-benzothiazol-3-ium iodide and 3-ethyl-2-[3-(3-

ethyl-3H-benzothiazol-2-ylidene)-propenyl]-benzothiazolium iodide. An example of a cyanine particularly useful for DVD applications includes 3-Butyl-2-[3-(1,3-dihydro-1,3,3-trimethyl-2H-indol-2-ylidene)-propenyl]-1,1-dimethyl-1H-benzo[e]indolium perchlorate, which has an absorption maximum of about 565 nm, and is available as S360 from FEW Chemicals Germany. The structure of S360 is shown below:



Suitable triarylmethanes may include, for example, sodium 3-{[4-[(E)-[4-(diethylamino)phenyl]((4Z)-4-{(Z)-ethyl[(Z)-(3-sulfonatophenyl)methyl]iminio}-2-methyl-2,5-cyclohexadien-1-ylidene)methyl](ethyl)-3-methylanilino]methyl}benzenesulfonate, N-(4-{[4-(dimethylamino)phenyl][4-(dimethyl-lambda~5~-azanylidene)-2,5-cyclohexadien-1-ylidene]methyl}phenyl)-N,N-dimethylamine hydrochloride, 4-([4-(dimethylamino)phenyl]{4-[ethyl(methyl)iminio]-2,5-cyclohexadien-1-ylidene}methyl)-N,N,N-trimethylbenzenaminium dichloride, 2-[6-(dimethylamino)-3-(dimethyliminio)-3H-xanthen-9-yl]-5-(2,5-dioxo-2,5-dihydro-1H-pyrrol-1-yl)benzoate, N-(4-{[4-(diethylamino)phenyl][4-(diethyl-lambda~5~-azanylidene)-2,5-cyclohexadien-1-ylidene]methyl}phenyl)-N,N-diethylamine hydrochloride, N-(4-{[2-(acetylamino)-4-(diethylamino)phenyl][4-(dimethylamino)phenyl]methylene}-2,5-cyclohexadien-1-ylidene)-N-methylmethanaminium chloride compound with dichlorozinc (1:1), sodium 2-{[4-(dimethylamino)phenyl][4-(dimethyliminio)-2,5-cyclohexadien-1-ylidene]methyl}-5-[ethyl(3-sulfonatobenzyl)amino]benzenesulfonate, 4-{[4-(dimethylamino)phenyl][4-(dimethyliminio)-2,5-cyclohexadien-1-ylidene]methyl}-N-ethyl-N,N-dimethylbenzenaminium bromide chloride compound with dichlorozinc (1:1), sodium 3-{[4-([4-(dimethylamino)phenyl]{4-[ethyl(3-sulfonatobenzyl)iminio]-2,5-cyclohexadien-1-ylidene}methyl)(ethyl)anilino]methyl}benzenesulfonate, acid violet 17, and sodium 3-{[4-

([4-(diethylamino)-2-methylphenyl]{4-[ethyl(3-sulfonatobenzyl)iminio]-2,5-cyclohexadien-1-ylidene}methyl)(ethyl)anilino]methyl}benzenesulfonate.

Further, cyanines also possess large refractive indices and produce large index changes upon bleaching, allowing for relatively thinner coatings than dyes exhibiting smaller changes in index of refraction. As shown in Figure 4(a), the index of refraction for a polycarbonate disc is about 1.6 in the 650 to 800 nanometer range. As shown in Figure 4(b), the index of refraction of a representative cyanine (3-butyl-2-[5-(3-butyl-1,3-dihydro-1,1-dimethyl-2H-benzo[e]indol-2-ylidene)-1,3-dienyl]-1,1-dimethyl-1H-benzo[e]indolium perchlorate) is about 2 to 3 in this range. Upon bleaching, the dye will have an index of refraction similar to the polycarbonate, resulting in a large change in the index of refraction. For example, some cyanines may provide a decrease of index of refraction of more than about 0.3 (e.g., about 0.4). As another example, some cyanines may provide a decrease of index of refraction of more than about 0.5 (e.g., about 0.7). In some embodiments, the cyanines may provide a decrease of index of refraction of more than about 1 (e.g., about 1.5) before bleaching and after bleaching.

The coating may have any thickness sufficient to provide the operable change in index of refraction without obscuring the information encoding features. In some embodiments, the coating has a thickness of less than about one micron. In some embodiments, the coating has a thickness of about 50 to about 300 nanometers. In yet further embodiments, the coating has a thickness of between about 100 to about 250 nanometers. The coating thickness may be chosen to correspond with the pit depth to achieve the one-half wave phase shift discussed above.

Further, the coating may be relatively conformal with the information encoding features. Conformality can be defined as the depth of the dye coated pit divided by the depth of the undyed pit. In some embodiments, the coating is about 25% to about 100% conformal with the information encoding features, and in some embodiments may be about 35% to about 65% (e.g., 50%) conformal. In such embodiments, the resulting dye filled pit depth may be a corresponding percentage of the uncoated pit depth.

In addition, in some embodiments the coating 20 does not significantly decrease the reflectivity of the optical disc. For example, in some embodiments, the reflectively of the disc and coating is greater than about 65%. Such embodiments are useful for reflecting light to be read by a common beam reader.

Suitable cyanine dyes are available commercially, from sources such as Sigma-Aldrich, FEW and H.W. Sands. These sources may also provide the wavelengths at which the dyes are most active, thereby making them readily selectable by wavelength activity for certain applications. The source may list the wavelength data of the dye in solution. However, applicants have determined that some of these dyes have an optimum activity wavelength that depends on whether the dye is in solution or provided in a coating. As an example, absorbance curves for the cyanine dye shown in Figure 4(b) are provided in Figure 8. As shown in Figure 8, the maximum absorbance of the dye occurs at a slightly longer wavelength when the dye is provided in a coating than when it is provided in solution. This difference in optimal wavelength activity may be taken into account when selecting a dye for a particular application.

The coating 20 may be placed in any suitable position on or within the disc 4. In some embodiments the coating is in apposition to the substrate and/or information encoding features. Further, the coating 20 may be in apposition to the reflective layer 14, as shown in Figure 1. In some embodiments the coating is deposited to cover a portion of the information encoding features, such as features defining a table of contents. In such embodiments, the disc becomes functionally unreadable although some of the information encoding features are readable.

In some embodiments, the coating is activated in response to light having a wavelength of about three hundred nanometers to about eight hundred nanometers. In some embodiments the coating is activated in response to light having a wavelength of about four hundred nanometers to about eight hundred nanometers (e.g., about 600 nm to about 800 nm). For example, the coating may show optimal change of index of refraction at about 650 nm in embodiments where the coating is provided on a DVD. In examples where the coating is provided on a CD, the coating may have an optimal change of index of refraction at about 780 nm. Of course, other wavelengths may be chosen. For example, activity in wavelength ranges of about 400 to about 425 nm may be useful in Blu-ray and/or HD DVD applications. In embodiments having a substrate comprising polycarbonate, the wavelength at which the polycarbonate absorbs an unacceptable amount of the light can set the lower limit of the wavelength.

In some embodiments, the coating may include one or more additives. For example, a photobleach accelerator may be provided. Such accelerators are useful for optimizing the rate at which the dye will bleach in response to light. An example of such an accelerator includes a borate as shown in Figure 7 and may include an organoborate, tetra phenyl boron, and/or n-butyl triphenylboron. Other accelerators include quinones as discussed in U.S. Patent No. 4,201,588, the relevant contents of which are hereby incorporated by reference. Generally, accelerators having a charge opposite that of the dyes form one to one salts and are used directly as such. Accordingly, a 1:1 ratio of accelerator to dye molecules may be provided. Uncharged accelerators (such as, for example, the quinones cited above or trialkylamines such as Bis-tris (2,2-bis(hydroxymethyl)-2,2',2''-nitrilotriethanol) can be utilized in any ratio (e.g., 9:1 dye to accelerator to 1:9 dye to accelerator).

Embodiments of the invention also include a method for inhibiting reading of an optical disc comprising the steps of providing any of the various embodiments of optical discs described above. In some embodiments the information encoding features are stamped into the substrate and the coating is deposited onto the substrate in apposition to the information encoding features. The coating may be deposited by any suitable method (e.g., spin coating), and the dye may be suspended in solution of various suitable solvents (e.g., alcohol) to facilitate deposition. The solvent may then be evaporated to leave behind a coating containing the dye.

Some embodiments of the invention include a method for inhibiting reading of an optical disc comprising the steps of acquisitioning any of the various discs described above and reading the disc with a reading device comprising a source of light and concurrently bleaching the dye to inhibit further reading of the information encoding features. The reading device comprises a source of optical radiation to read the disc and concurrently activate the coating to inhibit further reading of the information encoding features.

Embodiments of the invention as described above may be utilized in many applications. For example, in the DVD movie rental industry, the need for the customer to return the DVD after viewing is obviated because the disc would be rendered unreadable after a pre-determined number of viewings. Another example of a suitable application includes CDs. Such coated CDs would be useful for sending promotional CDs to a target audience, who would be able to play the songs a limited number of times before deciding whether to buy the uncoated version of the CD. As another example, unauthorized software downloading and file sharing could be reduced. For discs in accordance with embodiments of the invention containing software, a user would have a limited number of plays (e.g., three) to fully download the software before the disc is rendered unreadable. Therefore, the user would be discouraged from allowing others to download the software because it would permanently lose one of the plays.

Thus, embodiments of the Limited Play Optical Disc are disclosed. One skilled in the art will appreciate that the present invention can be practiced with embodiments other than those disclosed. The disclosed embodiments are presented for purposes of illustration and not limitation, and the present invention is limited only by the claims that follow.

What is claimed is:

1. A limited play optical disc, comprising:

a substrate having machine-readable information encoding features and supporting a reflective layer; and

a coating comprising a dye irreversibly bleachable by light supported by the substrate, the coating adapted to allow the information encoding features to be machine-readable prior to bleaching of the dye, the dye bleachable by the light, and operative, once bleached, to change the index of refraction of the dye to inhibit further reading of the information encoding features.

2. The disc of claim 1, wherein the information encoding features comprise pits and lands defining one or more outputs selected from the group consisting of a song, movie, software and combinations thereof.

3. The disc of claim 1, wherein the dye irreversibly bleachable by light is selected from the group consisting of cyanines and triarylmethanes.

4. The disc of claim 3, the cyanine selected from the group consisting of carbocyanines, styrlcyanines, and hemicyanines.

5. The disc of claim 1, further comprising a photobleach accelerator including a borate.

6. The disc of claim 1, the coating having a thickness of less than about one micron.

7. The disc of claim 1, wherein the disc is selected from the group consisting of a CD, DVD, and CD ROM.

8. The disc of claim 1, wherein the coating covers a portion of the information encoding features.

9. The disc of claim 1, wherein the index of refraction is reduced by more than about 0.5 upon bleaching.

10. The disc of claim 1, wherein the information encoding features include relatively deep pits and lands having a depth of greater than about 150 nanometers relative to the lands.

11. The disc of claim 1, wherein the coating is in apposition to and about twenty-five percent to about one-hundred percent conformal with the information encoding features.

12. A method for inhibiting reading of an optical disc, comprising the steps of:

providing an optical disc comprising a substrate having machine-readable information encoding features and a coating comprising a dye irreversibly bleachable by light, the information encoding features being machine-readable prior to bleaching of the dye, the dye bleachable by light and operative, once bleached, to change the index of refraction of the dye to inhibit further reading of the information encoding features.

13. The method of claim 12, wherein the information encoding features are stamped into the substrate.

14. The method of claim 12, wherein the coating is spin coated onto the substrate.

15. The method of claim 12, wherein the coating covers a portion of the information encoding features.

16. The method of claim 12, wherein the information encoding features comprise pits and lands defining one or more outputs selected from the group consisting of a song, movie, software and combinations thereof.

17. The method of claim 12, wherein the dye irreversibly bleachable by light is selected from the group consisting of cyanines and triarylmethanes bleachable in response to light having a wavelength of about six hundred nanometers to about eight hundred nanometers, the cyanines being selected from the group consisting of carbocyanines, styrlcyanines, and hemicyanines.

18. The method of claim 12, wherein the dye irreversibly bleachable by light is selected from the group consisting of cyanines and triarylmethanes bleachable in response to light having a wavelength of about three hundred nanometers to about eight hundred nanometers, the cyanines being selected from the group consisting of carbocyanines, styrlcyanines, and hemicyanines.

19. The method of claim 12, wherein the disc is selected from the group consisting of a CD, DVD, and CD ROM.

20. The method of claim 12, wherein the index of refraction is reduced by more than about 0.5 upon bleaching.

21. The method of claim 12, wherein the index of refraction is reduced by more than about 0.3 upon bleaching.

22. A method for inhibiting reading of an optical disc, comprising the steps of:

acquisitioning an optical disc comprising a substrate having machine-readable information encoding features and a coating comprising a dye irreversibly bleachable by light; and

reading the disc with a reading device comprising a source of light and concurrently bleaching the dye to inhibit further reading of the information encoding features.

23. The method of claim 22, wherein the disc is read more than once before further reading is inhibited.

24. The method of claim 22, wherein the disc is read more than twice before further reading is inhibited.

25. The method of claim 22, wherein the coating covers a portion of the information encoding features.

26. The method of claim 22, wherein the information encoding features comprise pits and lands defining one or more outputs selected from the group consisting of a song, movie, software and combinations thereof.

27. The method of claim 22, wherein the dye irreversibly bleachable by light is selected from the group consisting of cyanines and triarylmethanes bleachable in response to light having a wavelength of about six hundred nanometers to about eight hundred nanometers, the cyanines being selected from the group consisting of carbocyanines, styrlcyanines, and hemicyanines.

28. The method of claim 22, wherein the dye irreversibly bleachable by light is selected from the group consisting of cyanines and triarylmethanes bleachable in response to light having a wavelength of about three hundred nanometers to about eight hundred nanometers, the cyanines being selected from the group consisting of carbocyanines, styrlcyanines, and hemicyanines.

29. The method of claim 22, wherein the disc is selected from the group consisting of a CD, DVD, and CD ROM.

30. The method of claim 22, wherein the reading device is selected from the group consisting of a disc drive, CD player, and DVD player.

31. The method of claim 22, wherein the index of refraction is reduced by more than about 0.5 upon bleaching.

32. The method of claim 22, wherein the index of refraction is reduced by more than about 0.3 upon bleaching.

Fig. 1

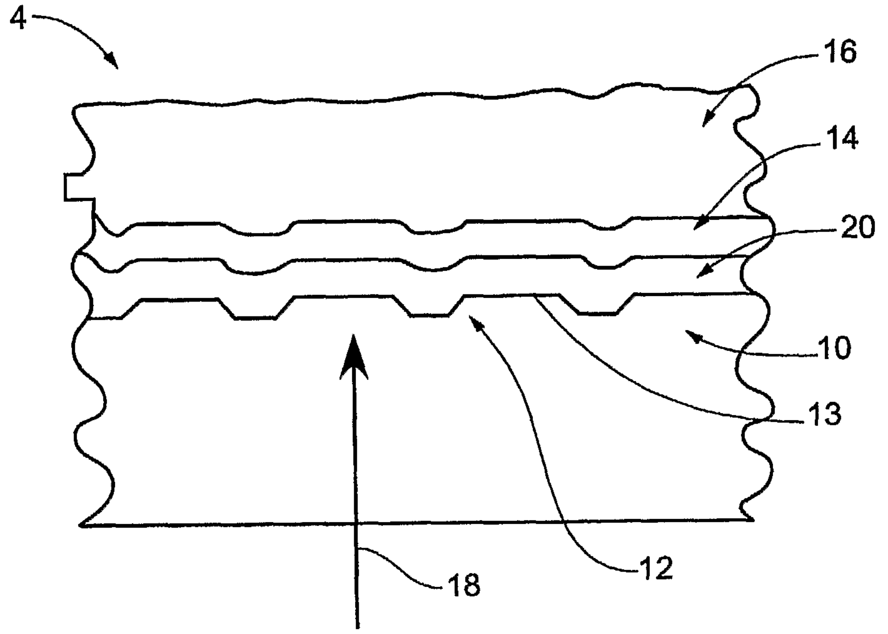


Fig. 2A

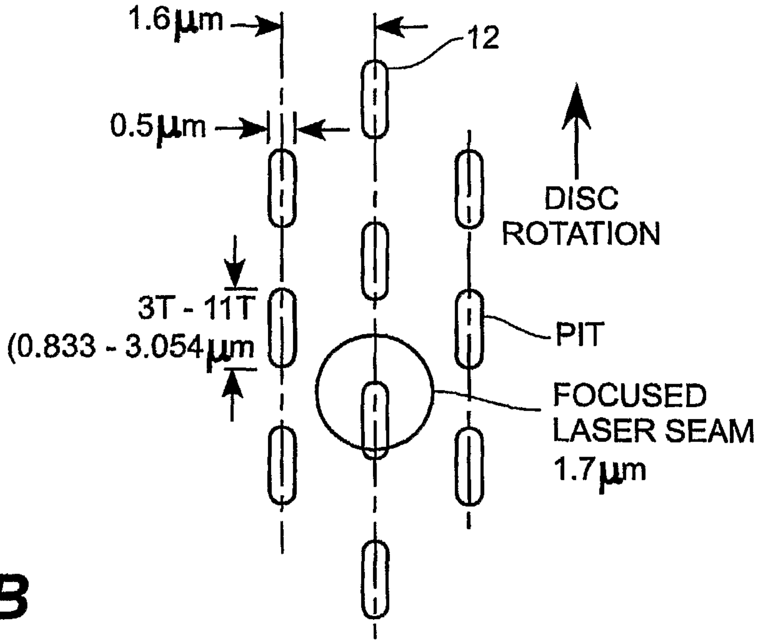


Fig. 2B

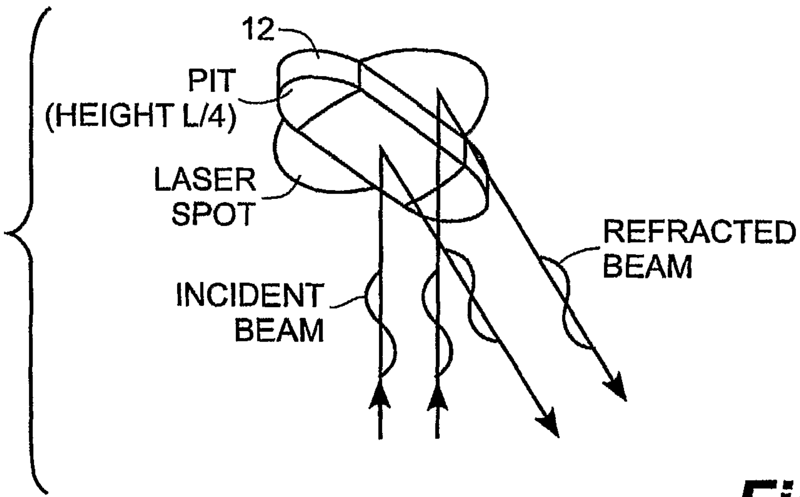
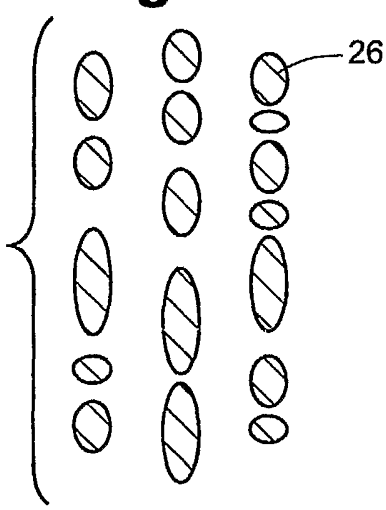


Fig. 2C



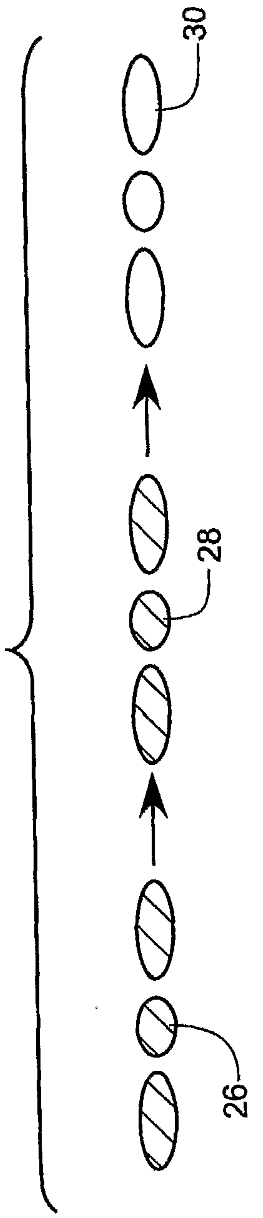


Fig. 3

Fig. 4a

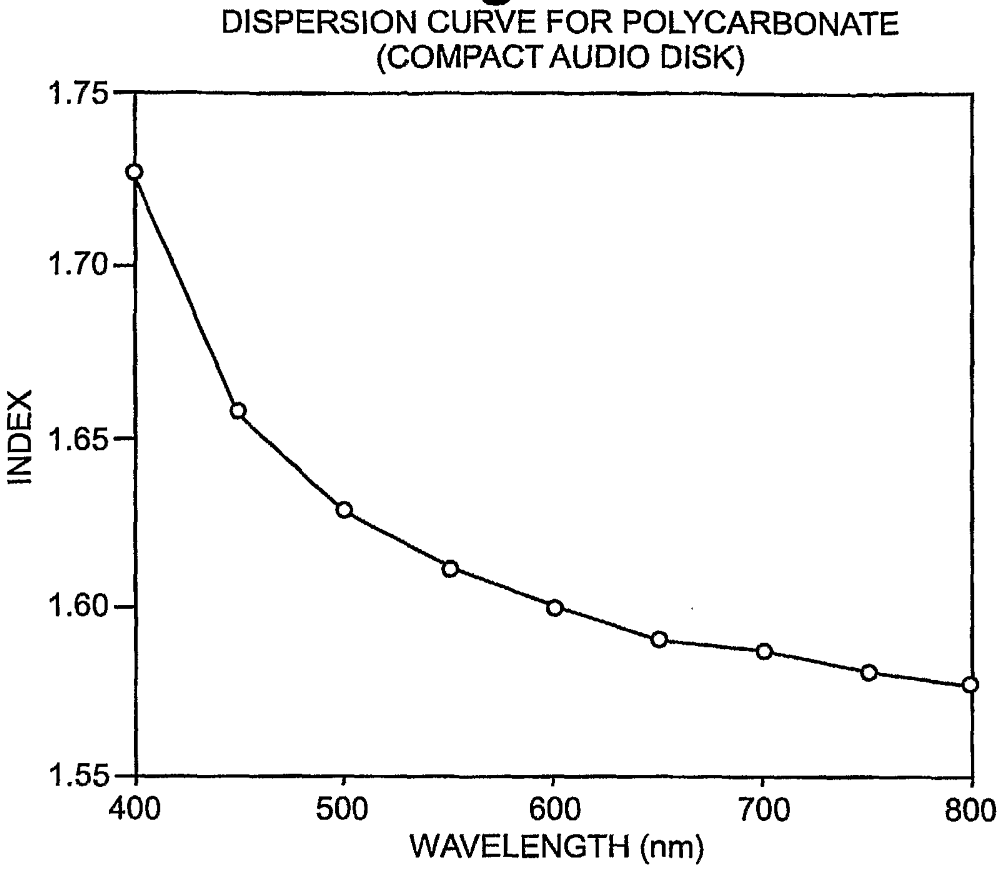

DISPERSION CURVE FOR POLYCARBONATE
(COMPACT AUDIO DISK)
1.75
1.70
1.65
1.60
1.55
INDEX
400
500
600
700
800
WAVELENGTH (nm)

Fig. 4b

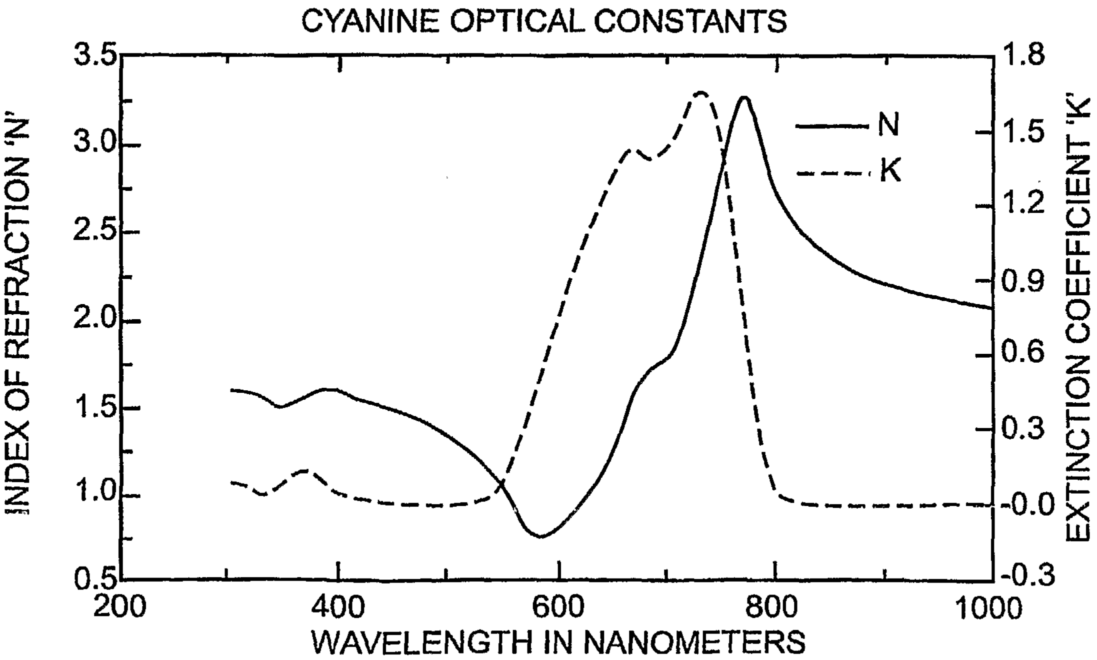

CYANINE OPTICAL CONSTANTS
3.5
3.0
2.5
2.0
1.5
1.0
0.5
INDEX OF REFRACTION 'N'
1.8
1.5
1.2
0.9
0.6
0.3
-0.0
-0.3
EXTINCTION COEFFICIENT 'K'
N
K
200
400
600
800
1000
WAVELENGTH IN NANOMETERS

Fig. 5a

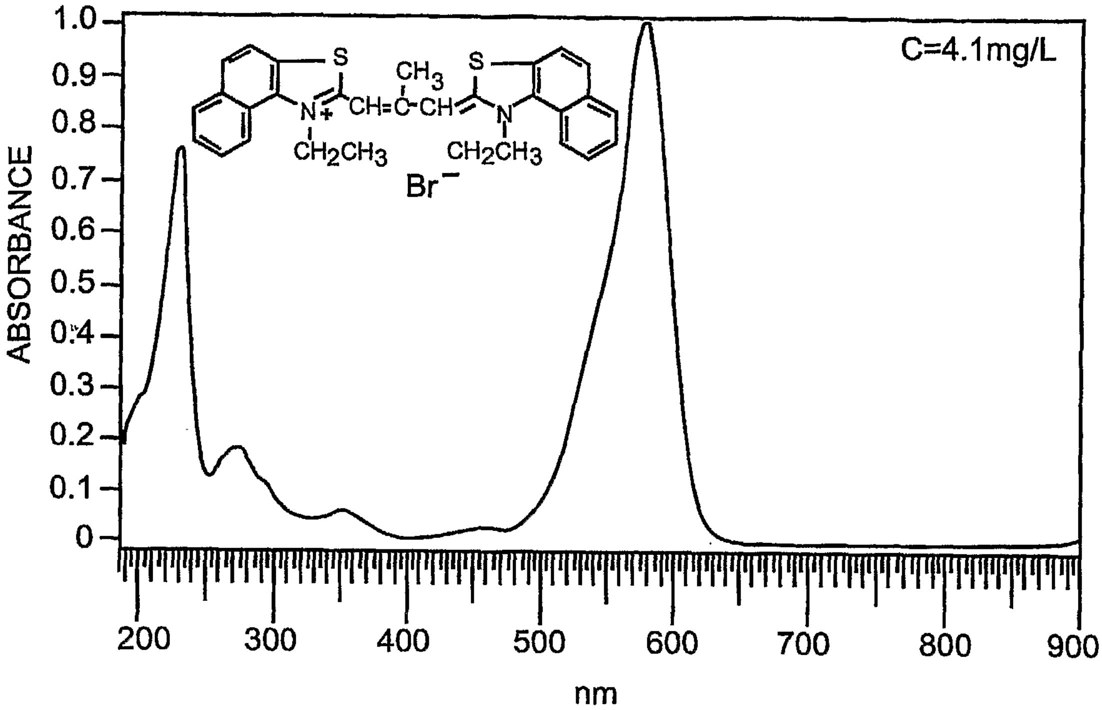

C=4.1mg/L
ABSORBANCE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
200
300
400
500
600
700
800
900
nm
S
CH3
S
N+
CH=C-CH=
N
CH2CH3
CH2CH3
Br−

Fig. 5b

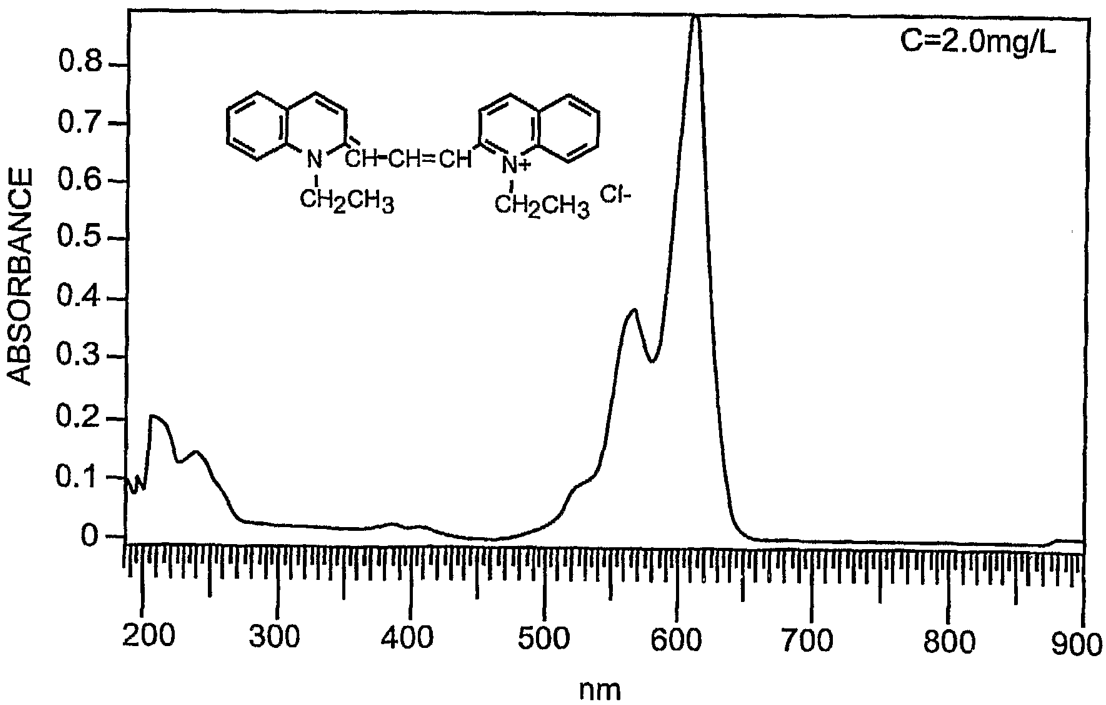

C=2.0mg/L
ABSORBANCE
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
200
300
400
500
600
700
800
900
nm
N
CH-CH=CH
N+
CH2CH3
CH2CH3
Cl-

Fig. 6a

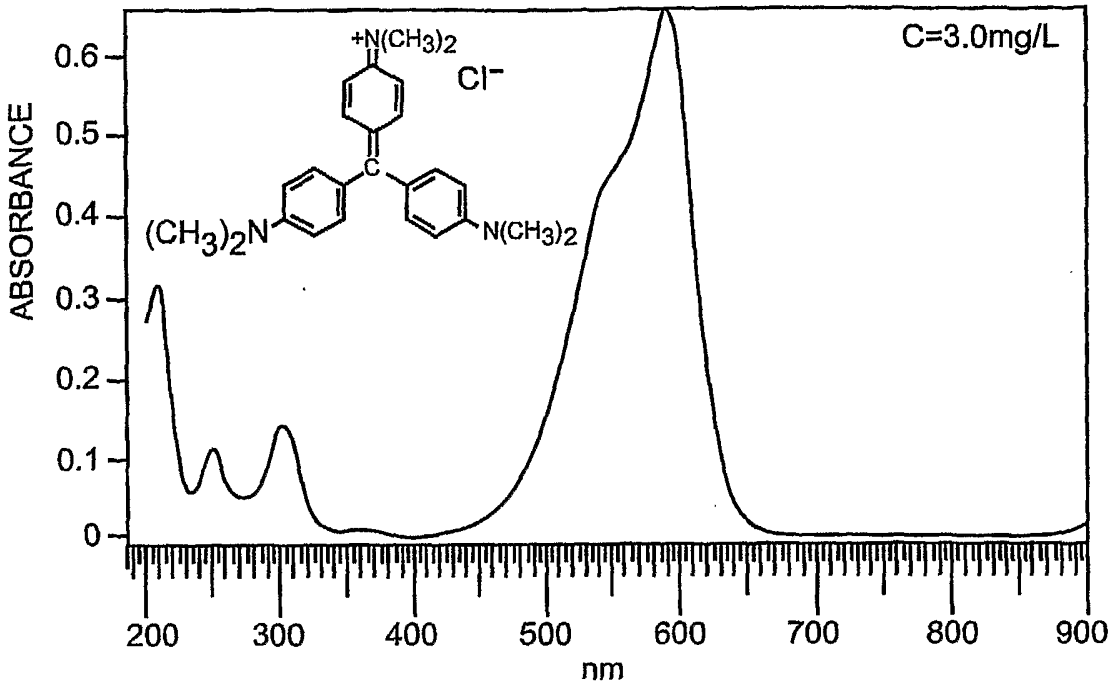

C=3.0mg/L
+N(CH3)2
Cl⁻
C
(CH3)2N
N(CH3)2
ABSORBANCE
0.6
0.5
0.4
0.3
0.2
0.1
0
200
300
400
500
600
700
800
900
nm

Fig. 6b

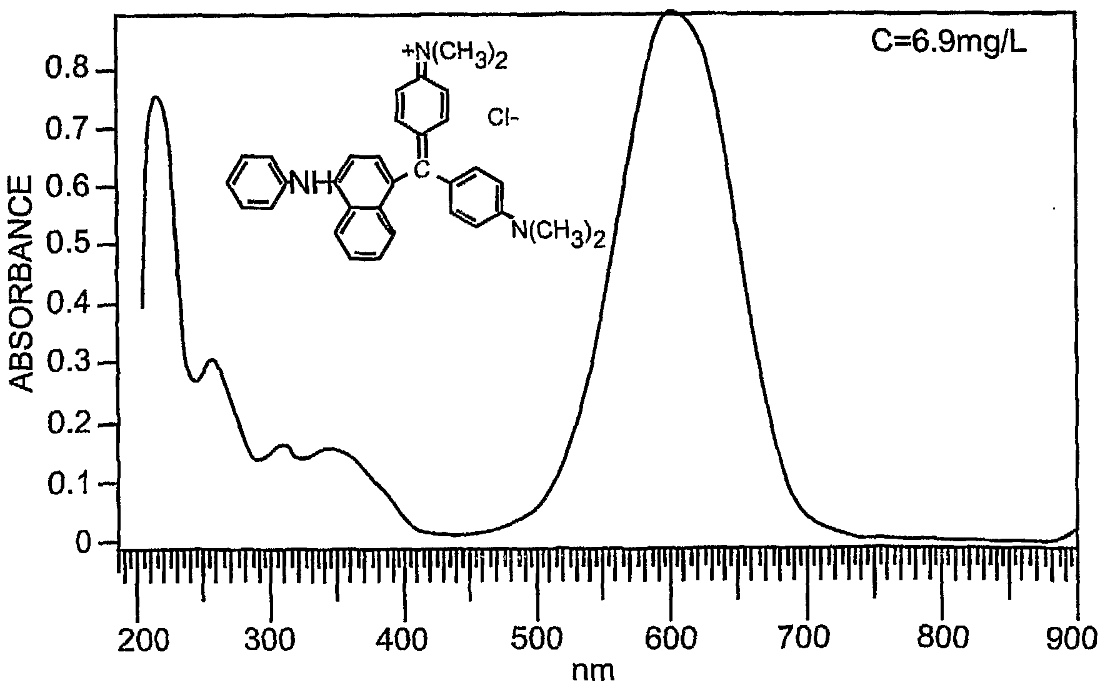

C=6.9mg/L
+N(CH3)2
Cl-
NH
C
N(CH3)2
ABSORBANCE
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
200
300
400
500
600
700
800
900
nm

Fig. 7

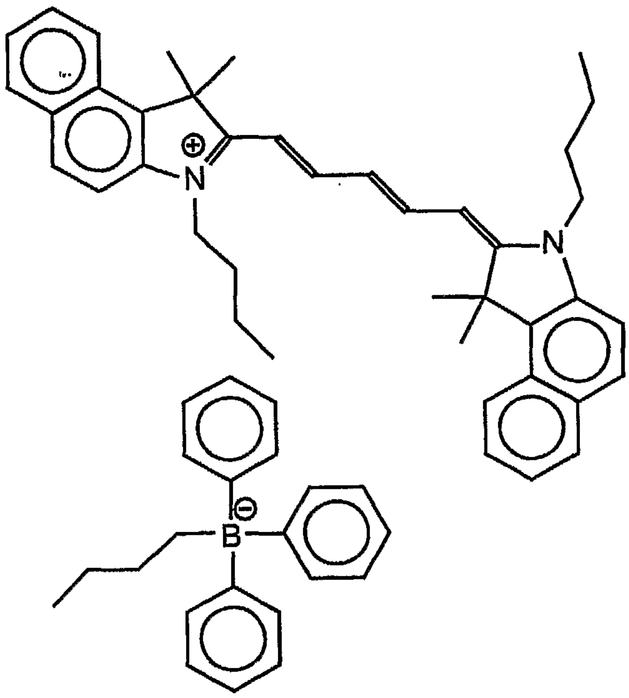
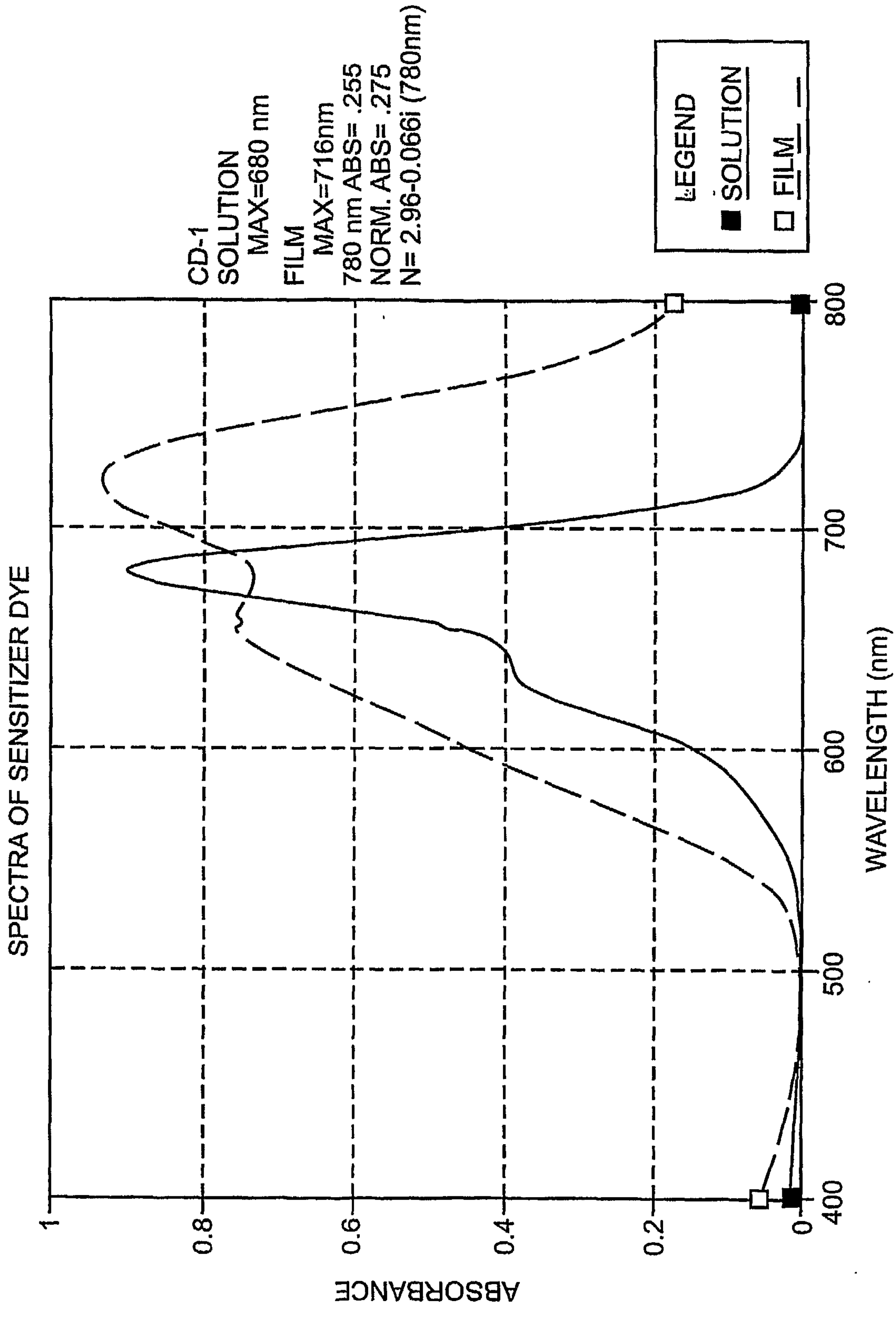


Fig. 8


SPECTRA OF SENSITIZER DYE
ABSORBANCE
1
0.8
0.6
0.4
0.2
0
400
500
600
700
800
WAVELENGTH (nm)
CD-1
SOLUTION
MAX=680 nm
FILM
MAX=716nm
780 nm ABS= .255
NORM. ABS= .275
N= 2.96-0.066i (780nm)
LEGEND
SOLUTION
FILM

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2006/020524

A. CLASSIFICATION OF SUBJECT MATTER
INV. G11B7/24 G11B7/248 G11B23/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2003/081521 A1 (SOLOMON MERRILL [US] ET AL) 1 May 2003 (2003-05-01) paragraphs [0064] - [0089]	1-9, 12-32 10,11
X	WO 99/41738 A (MAZER, TERRENCE, B) 19 August 1999 (1999-08-19) pages 6-11 pages 17-18	1,12,22
A	WO 02/49010 A (SPECTRADISC CORPORATION) 20 June 2002 (2002-06-20) pages 4-5; claims 1-6	1-32
A	US 2004/209034 A1 (TOMPSON ROBERT F ET AL) 21 October 2004 (2004-10-21) paragraphs [0039] - [0097]	1,12,22

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"E" earlier document but published on or after the international filing date

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 September 2006	05/10/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Stemmer, Michael

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2004/115385 A1 (DREW JEFFREY M ET AL) 17 June 2004 (2004-06-17) paragraphs [0077] - [0100]	1,12,22
A	WO 00/56529 A (FLEXPLAY TECHNOLOGIES, INC; BAKOS, YANNIS; BRYNJOLFSSON, ERIK; HELLER,) 28 September 2000 (2000-09-28) page 4, lines 15-18	1,12,22

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2006/020524

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			CA 2431175	A1	20-06-2002
			EP 1358061	A2	05-11-2003
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			CA 2415094	A1	10-01-2002
			EP 1303858	A2	23-04-2003
			JP 2004503043	T	29-01-2004
			MX PA03000112	A	13-09-2004
			WO 0203106	A2	10-01-2002
WO 0056529	A	28-09-2000	NONE		