**Title:** PRODUCTION PROCESS AND PRODUCTION LINE FOR MANUFACTURING MULTILAYER OPTICAL DISCS

**Abstract:** Production process and production line for manufacturing multilayer optical discs are proposed. The technology allows producing of multilayer optical reflective discs of any format CD ROM, DVD ROM, Blue Ray, HD-DVD, DVD-R, DVD-RW, etc., and particularly Versatile Multilayer Disc (VMD) using mostly existing CD/DVD production lines with reasonable upgrading.
PRODUCTION PROCESS AND PRODUCTION LINE
FOR MANUFACTURING MULTILAYER OPTICAL DISCS

BACKGROUND OF THE INVENTION

Field of invention
This invention is generally related to multilayer optical disc technologies and, more particularly, to manufacturing process and designs of corresponding production lines providing mass production of Versatile Multilayer Disc (VMD).

Discussion of Related Art

HDTV, HD-video and high-speed Internet require inexpensive data carriers with high recording capacity. The data recording density on one layer can be increased by way of using a shorter laser wave length and, respectively, smaller pit sizes. Another way is to increase the number of data layers, that is, to use a multilayer disc. Conventional DVDs have at most 2 layers on one side of the disk.

Reading from optical information storage devices is usually carried out by a laser beam focused on one of the data layers with further registration of the reflected beam modulated with the pit-and-land pattern.

The U.S. Patents Nos. 4,090,031; 4,219,704 of Russell feature a multilayer optical disc with the layers containing recorded information on one side of the disk, and the laser beam scans the data recorded along the tracks either in the digital or analog form. The reading device of such a disc was designed so that the reading beam could focus on each layer in turn. The source of the reading light and detecting system were for the first time placed on one side of the disk. That was why, though they provided for the opportunity to make transparent layers (with different optical transmission capacities or made of different dyes or photo-luminescent materials), preference was given to reflective coatings. The reading device readjusted from one layer to another either by changing the lens focus or changing the light filters (if the layers were made of the materials containing different dyes or photo-luminescent materials).
The U.S. Patent No. 4,450,553 assigned to Philips mentions the chance to create a multi- (at least a two-) layer disc by covering the data layer relief with dielectric layer with the reflection factor from 20% to 60% depending on the layer's number, that doesn't absorb at the laser wave length, or with a thin metal coating whose thickness and material are determined so that each layer's signals were approximately equal (based on the public print data). The examples of dielectric coatings are zinc selenide, bismuth oxide, cadmium sulphide, cadmium telluride, and their combination.

The U.S. Patents Nos. 5,255,262; 5,202,875; 5,373,499; 5,446,723; 5,610,901; 5,666,344 assigned to the IBM relating to multilayer discs and respective drivers point out that all the prior systems used to be very complicated concerning reading the data from different layers by way of changing the lens' focus distance and removing cross talks from the neighboring layers and generation of the tracking signal. The authors offer a simpler system and physical grounds for the said schemes to function. At the same time the patents don't mention any definite technology of the disc manufacture.

Reference may be had to US Patent No. 5,255,262 which discloses an optical disc consisting of many substrates with information layers separated by either air or transparent 100-300-μm thick solid-state layers with a different refraction factor. Only the last data surface is covered with a folly reflective coating. The upper substrate (through which the laser signal comes) is 1.2 mm thick, the rest are 0.4 mm (generally from 0.2 to 0.8 mm) thick. As an option, the layers' transmission is 96% (no coating) leading to the reduction of spurious signals from neighboring layers. To reduce the necessary laser power the data layers are to be covered with dielectric coatings achieving the reflection from 4% (λ/2n) to 20% (λ/4n), with n - the reflection factor. ZrCh ZrS, SiN and the oxides mixtures are to be used as dielectric coatings. The patent also emphasizes an opportunity to make data layers like WORM and recordable type (phase-change, magneto-optics), as well as their combinations. It gives a detailed description of getting the tracking signal. The drive uses a semi-conductor laser with 780-nm wavelength and an aberration compensator; the position of the focusing lens (with NA 0.55) was set by the servo-system. The compensator had a stepped design, the first step was 0.4mm thick,
the second - 0.8mm and the third - 1.2mm thick (they consider different types of such compensators).

Reference may be had to the U.S. Patent No. 5,373,499 considering rather a difficult method of spherical aberration elimination for a multilayer disc by way of selecting thicknesses and reflection factors so that the optical lengths were the same while reading each information layer.

Reference may also be had to the U.S. Patent No. 5,666,344 disclosing 2 layer disk, where the first data surface is deposited with some semi-conductor coating (containing C, Si, Ge, Sn, Pb or amorphous Si), as well as compounds like AB, with B = N, P, As, Sb, Bi, and A=B, Al, Ga, In, Tl, B, etc., and above them - with the protecting layer of a transparent dielectric. The layers' thickness was equal to 25 - 5000A. The co-inventors pointed out, that the intensity of the light reflected from each data layer had to be the same.

Producing conventional dual-layer discs DVD-9 one can use both the regular process of injection molding in conventional moulds (based on technology disclosed in, U.S. Patent No. 5,876,823 assigned to Matsushita Corporation), and the so-called STP - Surface Transfer Process (modified 2P process - stamping of photopolymer) and the modified so-called 2P process (stamping of photopolymer), disclosed in U.S. Patents Nos. 6,117,284 and 6,309,496 assigned to WAMO company. In the first case the information layer is stamped on the first DVD substrate (0.6mm) using an injecting molding, and further covered by deposited partially-reflective coating (e.g. Au, Ag or Si), and separately, the same method is used to make the relief of the second data layer on the second DVD-substrate (0.6mm), which is further covered with a fully reflective coating. Then both the substrates are glued "back to back".

In accordance with the second method, the substrate with the relief of the 1st data layer is first covered with a semi-reflective coating, then with a UV-cured photopolymer; then the second stamper is stamped into it, UV-cured, making as a result the second data layer. Later the stamper is separated, the second data layer is covered with a reflective
coating and a layer of adhesive. In case of DVD-9 the next step being sticking a blank substrate, and in case of DVD-14, the second substrate with a single information layer, and with DVD-18 - the second half of the "sandwich" including 3rd and 4th data layers manufactured in a similar way.

Difference between WAMO patents No. 6,117,284 and No. 6,309,496 is that in the first case the PMMA stamper with 2nd information layer has larger diameter than usual DVD diameter (120mm). It helps to separate this stamper from the substrate with the first layer and thin film with relief of the second layer. In the second patent used PMMA stamper had the same diameter.

To this end, manufacturing of DVD-9 (dual-layer, single-sided), injection molding in conventional moulds (Matsushita) method includes steps:
1. Injection molding of the polycarbonate substrate with the relief of the 1st data layer with the help of the 1st nickel stamper;
2. Deposition of a partially-reflective coating on the relief of the 1st data layer;
3. Injection molding of the 2nd polycarbonate substrate with the relief of the 2nd data layer using of the 2nd nickel stamper;
4. Deposition of a reflective coating on the relief of the 2nd data layer;
5. Gluing the two substrates with their information layers inside;

Manufacturing of DVD-9 in accordance with modified 2P process (WAMO) method includes steps:
1. Injection molding of the polycarbonate substrate with the relief of the 1st data layer using of the 1st nickel stamper;
2. Deposition of a partially-reflective coating on the relief of the 1 data layer;
3. Injection molding of the PMMA substrate with the relief of the 2nd data layer using of the 2nd nickel stamper;
4. Deposition of an adhesive UV-cured photopolymer on the 1st data layer;
5. Deposition of a fully reflective coating on the relief of the 2 data layer;
6. The UV-light curing of the photopolymer;
7. Separating the 2nd substrate, leaving the 1st one with the 1st and 2nd data layers with the respective reflective coatings;
8. Gluing a blank (without data layers) polycarbonate substrate above the relief of the 2nd data layer;

DVD-9 can be manufactured by both the 1st and 2nd methods, whereas DVD-14 and DVD-18 (double-sided 3- or 4-layer discs respectively) require only the WAMO technology. Some companies to produce DVD-9 and DVD-18 use it.

Reference may be had to US Patent No. 6,177,168 which discloses modified method of manufacturing a 4-layer sandwich (2 layers, 2 sides) with outer substrates with the 1st and last information relieves made in a conventional way - injection molding with further sputtering partially-reflective layers. The middle of the sandwich is made using the same equipment as for the 1st and last layers but stampers (with the relief of the 2nd and 3rd data layers) are fixed both from the press and the base sides of the mould, as a result these data relieves will be stamped on the inner-layer (made from the stuff of not compulsory optical quality) and later coated with a reflective material. Then the said layer is glued between the two substrates with the 1st and 4th data layers made beforehand and we have a four-layer disc (double-sided, with two layers on each side). Reference may also be had to US Patent No. 6,309,496 assigned to WAMO Corporation, which describes the technology of manufacturing DVD-14 and DVD-18 discs using a plastic matrix for transferring the data relief.

The WAMO Surface Transfer Process for producing double-sided 3- or 4-layer discs includes steps:

1. Injection molding of a 0.6 mm-thick polycarbonate substrate with the 1st data layer (mother-type) with the help of the 1st stamper (father-type);

2. Deposition of a partially-reflective coating on the relief of the 1st data layer;

3. Injection molding of PMMA substrate (making a plastic father-matrix) with the relief of the 2nd information layer using the nickel stamper (mother);

4. Deposition of fully reflective film (Al) on the surface of PMMA matrix with anti-adhesive coating (antiadhesive is optional);

5. Sticking the plastic matrix and substrate with the 1st layer using photopolynier cured with UV-light while rotating (similar to the DVD-bonding-process);
6. Separating the plastic matrix, releasing the "sandwich" — the substrate with the 1st data layer + Al film with relief of 2nd information layer transferred from the plastic matrix.

8. Gluing a single-layer (for DVD-14) or dual-layer (for DVD-18) sandwich manufactured in a similar way to this sandwich.

Currently, most lines producing 2-layers one-side DVD use Matsushita technology but for 3- and 4-layer two-side DVD the above-described WAMO technology could be used.

Referring now to Figs.1 and 2, a conventional WAMO method of a two-layer single-side DVD disc manufacturing is illustrated. Injection molding from the Ni-stamper is used to form a substrate of PMMA 101 with the data-carrying relief of the 2nd layer 102 forming a plastic stamper. Then the substrate is sputtered with a fully-reflective layer 103 (Al). Simultaneously, by way of injection molding a polycarbonate substrate 104 with the data-carrying relief of the 1st layer 105 is produced. Later, the substrate is sputtered with a partially reflective layer 106. The polycarbonate substrate 104 and plastic stamper 101 with respective information layers are glued by way of DVD-bonding with the data layers inside using the UV-cured photopolymeric glue 201. Afterwards, the matrix 101 is separated and the reflective layer 103 is transferred to the polycarbonate substrate 104.

The above-mentioned method of manufacturing multilayer discs has a number of disadvantages, namely: a low yield of valid discs connected with a high degree of faultiness while separating matrix 101 and transferring super thin reflective Al layer 103 to the polycarbonate substrate, as well as a chance of further breaking or deforming the reflective Al data layer 103 due to the shrinkage of photopolymeric glue 201. Moreover, this method is inapplicable to manufacturing discs with more than two layers on one side.
SUMMARY OF INVENTION

This invention offers a principle and methods of constructing of production line and production process for manufacturing single-sided multilayer reflective discs with high recording density in every layer, such as Versatile Multilayer Disc (VMD).

According to an aspect of the present invention, there is provided a production line for manufacturing multilayer optical discs having at least four information layers comprising: a first injection molding module for producing first polycarbonate substrate with relief of first layer, a second injection molding module for producing second polycarbonate substrate with relief of fourth layer, at least one sputtering module for partially reflecting layer sputtering on said first and second substrate, at least one bonding module for bonding said first sputtered substrate to a first nonexpendable plastic stamper of a second information layer forming first sandwich-like structure and said second sputtered substrate to a second nonexpendable plastic stamper of a third information layer forming second sandwich-like structure, at least one separation module for separating said first sandwich-like structure and said first nonexpendable plastic stamper forming first blank and separating said second sandwich-like structure and nonexpendable plastic stamper forming second blank, at least one washing module for washing said first blank and washing said second blank, at least one additional washing module for washing said first nonexpendable plastic stamper and washing said second nonexpendable plastic stamper, at least one sputtering module for sputtering of partially reflecting layer on the first blank forming a first sandwich and on the second blank forming a second sandwich, a third bonding module for gluing said first and second sandwiches forming said optical discs having at least four information layers.

According to another aspect of the present invention, there is provided a continuous production process for manufacturing multilayer optical discs including the steps:

- providing a first injection molding module and producing first polycarbonate substrate with relief of first layer, providing a second injection molding module and producing second polycarbonate substrate with relief of fourth layer, providing at least one
sputtering module and sputtering on said first and second substrate partially reflecting layer, providing at least one bonding module and bonding said first sputtered substrate to a first nonexpendable plastic stamper of a second information layer and said second sputtered substrate to a second nonexpendable plastic stamper of a third information layer, providing at least one separation module and separating said first sandwich-like structure from said first plastic stamper and forming first blank and separating said second sandwich-like structure from said plastic stamper and forming second blank, providing at least one washing module and washing said first blank and washing said second blank, providing at least one additional washing module and washing said first plastic stamper and washing said second plastic stamper, providing at least one sputtering module and sputtering of partially reflecting layer on the first blank forming a first sandwich and on the second blank forming a second sandwich, and providing a bonding module and gluing said first and second sandwiches forming said multilayer optical disc.

By invented method in the framework of every format of a single-/ dual-layer disc its manufacture technology may be changed so that there appears a chance to increase the number of data layers without changing their optical properties and hence, double, triple, quadruple, etc. the volume of data on the disc compared with a single-layer disc. The recording format on each layer can remain the same as it used to be on a respective single-layer disk. Besides, the said technology applies technological methods that make it possible to set up production lines manufacturing multilayer disks by way of just upgrading the lines designed for the respective single/dual- layer discs.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Figs. 1 and 2 depict a prior art WAMO technology of producing two-layer single-side (DVD) disc;

Fig. 3 schematically illustrates VMD production line;

Fig. 4 shows a sectional view of a substrate with relief of first (or fourth) information layer sputtered with semi-reflective film bonded with cured photopolymer layer with relief of second (third) information layer (blanks 1, 2);

Fig 5 schematically illustrates production process of four-layer VMD with use of
non-expandable plastic stampers;

Figs. 6A and 6B schematically illustrate separation of plastic stamper from blank

Fig. 7 shows a sectional view of a four-layer assembled VMD disc;

Fig. 8 illustrates off-line facilities for plastic stamper production.

Fig. 9 A, B, C schematically illustrates integrated production line suitable for mass production of VMD-discs

Fig. 10 schematically illustrates main cyclic part of production line suitable for manufacturing three and more layered VMD discs.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Proposed production process and production line for manufacturing multilayer optical disks enables to produce multilayer discs with number of layers more than two readable from one side, and on the other hand it mostly enables to use the conventional DVD equipment (injecting molding, bonding, deposition, etc.) for manufacturing multi-layer optical discs, preferably single-sided VMD discs.

The VMD production line with accordance with one aspect of the present invention, using standard equipment, is shown in Fig. 3.

Referring to Fig. 3 there are shown an injection molding module 301 for substrate with the first layer, sputtering unit 302 for the first layer, DVD9 bonding/curing module 303 for bonding substrate with the first layer and plastic stamper of the second layer 307, separation module 304 for the first blank and plastic stamper of the second layer, washing module 305 for the first blank, washing module 306 for plastic stamper of second layer, plastic stamper of the second layer 307, sputtering module 308 for the second layer, injection molding 309 for substrate with the fourth layer, sputtering module 310 for fourth layer, bonding/curing module 311 for plastic stamper of the third layer and substrate with the fourth layer, separation module 312 for second blank and plastic stamper of third layer, washing module 313 for plastic stamper of third layer, washing module 314 for second blank, plastic stamper of third layer 315, sputtering module 316 of third layer.

Dye coater unit from CD-R or DVD-R line or lacquer unit from CD line can be used as a washing modules 305, 306, 313, 314. Surfaces of just separated blanks which is
illustrated in Fig. 4 and plastic stampers should be washed with isopropanol or ethyl alcohol for antistatic treatment and for removing of trace uncured photopolymer. More strong solvents should not be used for washing because they can dissolve and harm surface of polycarbonate. Washing modules for washing plastic stampers preferably are connected by disc transporter and/or robotic handles to bonding/curing module 303 in order to cyclically use washed plastic stampers. Referring to Fig. 5 there is illustrated a sectional view of a substrate with relief of first (or fourth) information layer sputtered with semi-reflective film bonded with cured photopolymer layer with relief of second (third) information layer (blank 1, 2).

Sputtering of the reflection layer is performed by, for example, UNAXIS CUBE LITE sputter or some other sputtering unit used in DVD industry and capable of Si or other semiconductors sputtering. The thin reflective film is deposited onto polycarbonate substrate 401 under technical regimes for achieving required coefficients of reflection (1-10%). It is worth to notice that to obtain the same jitter during read out we should have approximately the same signal from every layer (actually signal from the first layer should be slightly lower) The same reflection from the reflective layer is achieved if more energy is used during sputtering onto cured photopolymer surface compared to polycarbonate surface.

Reflection of fourth layer should be higher than third, reflection of third layer is higher than second and reflection of second layer is higher than first.

The proposed principal scheme of production line for manufacturing multilayer disks enables to use the conventional DVD machinery (injection molding, modules 301,309, sputtering, modules 302, 310, 308,316; bonding/curing, modules 303, 311, 317, separation modules 304,312, washing modules 305,306,313,314.) for manufacturing single-sided multi-layer optical discs such as VMD. This production line may be built up from commercially available DVD modules with several specific modules which are described furtherbelow. The machine is capable of producing all types of DVD discs as well. The machine can be easily upgraded to produce multilayer HD DVD.
It is worth to notice that the thickness of the photopolymer glue set to be about 20-40 µm. After bonding discs are placed into curing station for photopolymerization. A photopolymer glue, may be for example, a mixture of bis-(methacryloxyethylene carbonate) diethylene glycol (OCM-2), Ebecryl 2002 (Cytek ) and photoinitiator is used. Photopolymer, preferably, should have good resolution, i.e. replicate a stamper relief without distortion and it should have good adhesion to reflective layer. Photopolymer also should have good solubility in isopropanole or ethyl alcohol, which should be used for washing after separation of cured halves.

In final bonding/curing module 317 two sandwiches are glued together. In this case normal photopolymer glue for DVD-9 can be used.

As a result, final 4-layer VMD disc (Fig 7) is manufactured.

Modules of invented production line are preferably connected by disc transporter and/or robotic handles.

Fig. 5 schematically illustrates production process of four-layer VMD, using of non-expandable plastic stampers performed by the production line of Fig. 3. Nickel Stamper of the first layer (normal direction of rotation) is placed into DVD Injection molding unit 301 and polycarbonate substrates with relief of the first layer 501 of required thickness is produced. Further, step 502, sputtering of reflection film onto substrate 501, with relieves of first information layer is performed, giving the substrate with relief of layer 1 covered with reflection coating 503.

Plastic substrate 504 with relief of 2nd information layer is manufactured in the off-line injection molding module. It is sputtered with anti-adhesive coating (procedure 505) and as a result the plastic stamper 307 is formed. Bonding/curing 506 of this plastic stamper and polycarbonate substrate with 1 layer covered with reflective film is performed to give the sandwich-like structure 507. After separation process 508 plastic stamper 307 returns to the cycle and released blank 1 is transferred to the sputtering module.

Nickel Stamper of the fourth layer (reverse direction of rotation) is placed into DVD Injection molding unit and polycarbonate substrates with relief of the fourth layer 509 required thickness is produced. Further, step 510, sputtering of reflection film onto
substrate 509, with relief of fourth information layer is performed, providing the substrate 511 with relief of layer 4 covered with reflection coating.

Plastic substrate 512 with relief of third information layer is manufactured in the off-line injection molding module. It is sputtered with antiadhesive coating (step 513) and as a result the plastic stamper 315 is formed. Step of bonding/curing 514 of this plastic stamper and polycarbonate substrate with fourth layer covered with reflective film is performed to provide a sandwich-like structure 515. After separation step 51,6 plastic stampers 307, 315 returns to the cycle and released second blank 520 is transferred to the sputtering module.

Further, first blank 517) is sputtered (step 518) with reflective coating, preferably Si providing first sandwich 519.

Second blank 520 is sputtered (step 521) with reflective coating preferably Si providing second sandwich 522.

Finally step of gluing 523 of the first and second sandwiches is performed in final bonding/curing module giving final 4-layer VMD-disc 524.

Referring to Figs. 6A and 6B, there are illustrated an example of step of separation or pulling away plastic stamper 307 (315) from first (second) blank 517, 520

Separation of cured blanks 517, 520 may be performed using two vacuum chucks 601 attached preferably to the central portions of both sides of sandwich-like structure 507, 515

OFF-line equipment

Fig.8 illustrates an off-line facilities for plastic stamper production.

Referring to Fig. 8 there are shown an injection molding module 801, plasma enhanced chemical vapor deposition (PECVD) module 802 for antiadhesive layer deposition, lacquering unit for antiadhesive treatment 803, buffer 804 for plastic stampers with anti adhesive.

Injection molding unit 801 is used for making plastic stampers 307, 315 for second and third information layers (in case of four-layers VMD).

PECVD unit 802 is used for antiadhesion treatment of plastic stampers 307, 315.
Lacquering unit 803 is used for formation of antiadhesion coating and
Buffer for plastic stampers 804 provides storing of ready plastic stampers.

Plastic stampers are made in off-line modules and can be used in in-line
production line repeatedly.

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**Plastic stampers manufacturing.**

a) Injection molding of plastic stampers for second and third layers (in case of
four layers VMD).

Polycarbonate (or other polymeric) substrates of about 0.6 mm thickness and 120
mm diameter are made using DVD injection molding (module 801) from the stamper of
the second layer 402. Polycarbonate substrates of about 0.6 mm thickness and 120 mm
diameter are made using DVD injection molding from the Stamper of the third layer 402.

b) Antiadhesive coating.

The surface of plastic stampers preferably is treated to obtain antiadhesive
properties. This is necessary for multiple using of plastic stampers and increasing of yield
for 2P process. Low adhesion of plastic stampers eliminates delaminating of cured
photopolymer from Si layer during separation process. The surface of substrate becomes
chemically modified in module 803 to decrease adhesion to photopolymer layer to be
placed on the plastic stamper. So, the plastic stamper 406 is ready to multiple using
without loosing of antiadhesive properties and quality of 2P replication, it is transferred
to the buffer 804.

**Integrated production line for 4-layer VMD mass production**

Referring to Fig.9, there is schematically illustrated an example of integrated
production line suitable for 4-layer VMD mass production. The principle structure of the
integrated line, basic modules and sequence of operation are similar to those of production
line of Fig. 3 as described with reference to Fig.5. But in this case, all production
modules are combined in a single plant.

Integrated production line preferably comprises:
injection molding module 901 for molding substrate for first layer and 912 for fourth layer,
sputtering module 902 for sputtering first and module 913 for sputtering fourth information layers,
bonding module 903 for bonding first layer with plastic stamper 307 and module 914 for bonding fourth layer with plastic stamper 315.
UV-curing stations 904 and 915 (for bonding substrates with 1 and 4 layers with plastic stampers of 2nd and 3th layers consequently) for glue photopolymerization.,
Separation modules 905, 916 for pulling away plastic stampers
washing module 906 for washing plastic stamper 307 and module 917 for washing plastic stamper 315
Stamper inspection module 907 for testing stampers 307 and module 918 for testing stampers 315 . It also includes
buffer 908 for plastic stampers 307, from where rejected plastic stampers are transferred to bin 909, instead of rejected stamper a good one from buffer is substituted in the cycle. The same block should be placed in the second part of line using plastic stampers of 3d layer 315 (modules 919, 920 consequently).
washing stations 910 for blanks 1 and 921 for blanks 2,
sputtering module for second (911)and third (922) layers. ,
Inspection modules 923 and 927, bins 924 and 928 for sandwiches 1 and 2 consequently. Fitted sandwiches 1 and 2 are glued in bonding/curing 925 module
buffer 926 for fitted sandwiches 1 substituting rejected during inspection of first sandwiches, buffer 929 for fitted sandwiches 2 substituting rejected during inspection sandwiches 2
output buffer 930 for fitted VMD discs,
In principle further integration is possible.

3-and more-layer VMD disc production lines
Fig. 10. schematically illustrates cyclic part of production line suitable for manufacturing more than 3-layer VMD discs by adding every new layer in cycle.

The principle structure of 5- and more-layer VMD production lines is the same as described above for 4-layer VMD technological line and 4 layer VMD line for mass production. The only difference is that one should simply repeat the operations required for adding of every next layer. All basic modules which are required for such repeating are the same as described for 4-layer VMD lines (Fig. 9).

In accordance with this embodiment production line comprises:

1001 - Loading module of "i-th" blank
1002 - Sputtering of Layer i
1003 - Bonding blank i and plastic stamper of next (i+1) layer
1004 - UV-curing station
1005 - Separation module
1006 - Washing station for plastic stampers
1007 - Stampers inspection module (optional)
1008 - Buffer for plastic stampers
1009 - Bin for rejected plastic stampers
1010 - Washing station for blanks
1011 - Sputtering of Layer "i+1"
1012 - Inspection station of sputtered blanks with layer "i+1" (optional)
1013 - Bin for rejected sputtered blanks with layer i+1
1014 - Output module for fitted sputtered blanks with layer i+1

For adding another layer sputtered blank i+1 returns to the module 1001 (loading of blank i). As a final operation these blanks with sputtered blank with i+1 layer are glued with blanks without information layers.

In final construction similar blocks can be integrated for maximal simplifying the whole design to make it similar to that used in modern commercial DVD lines.

It is obvious to those skilled in the art that various changes and modifications are possible, without departing from the spirit and scope of the invention, e.g. for performing similar manufacturing steps (molding, sputtering, bonding, etc.) at least
one common manufacturing module can be used, due to desired throughput and/or capital investment, or all information layers can be formed consequently on one substrate, different types (CD ROM, DVD ROM, Blue Ray, HD-DVD, DVD-R, DVD-RW, etc.). and configurations (number of layers) of optical discs may be manufactured and that what is briefly claimed is just an example that in any way may limit the inventor rights.

Those skilled in the art will readily appreciate that various modifications and changes may be applied to the embodiment of the invention as hereinbefore exemplified without departing from its scope defined in and by the appended claims.
1. A production line for manufacturing multilayer optical discs having at least four information layers comprising:
   a first injection molding module for producing first polycarbonate substrate with relief of first layer,
   a second injection molding module for producing second polycarbonate substrate with relief of fourth layer,
   at least one sputtering module for partially reflecting layer sputtering on said first and second substrate,
   at least one bonding module for bonding said first substrate to a first nonexpendable plastic stamper of a second information layer and said second substrate to a second nonexpendable plastic stamper of a third information layer,
   at least one separation module for separating said first substrate from said first nonexpendable plastic stamper and forming first blank and separating said second substrate from said second nonexpendable plastic stamper and forming second blank,
   at least one washing module for washing said first blank and washing said second blank,
   at least one additional washing module for washing said first nonexpendable plastic stamper and washing said second nonexpendable plastic stamper which are repeatedly used in production cycle,
   at least one sputtering module for sputtering of partially reflecting layer on the first blank forming a first sandwich and on the second blank forming a second sandwich,
   a third bonding module for gluing said first and second sandwiches forming said optical discs having at least four information layers.

2. The production line of claim 1, further comprising at least one disc transporter for transferring a plurality of said first and second nonexpendable plastic stampers from said washing module for plastic stampers to the first and second bonding modules for continuous usage in production line.

3. The production line of claim 1, further comprising at least one robotic handle for transferring a plurality of said first and second nonexpendable plastic stampers from said third and fourth washing module to the first and second bonding modules for continuous usage in production line.
4. The production line of claim 1 further comprising a plurality of disc transporters connecting said modules.

5. The production line of claim 1 further comprising a plurality of disc robotic handles connecting said modules.

6. The production line of claim 1 further comprising off-line module for producing said first and second nonexpendable plastic stampers including:
   a first injection molding sub-module, a PECVD sub-module for anti-adhesive layer deposition on the surface of said stampers, a lacquering sub-module for further antiadhesive treatment.

7. The production line of claim 1 comprising at least two separate sputtering modules for partially reflecting layer sputtering on said first and second substrates.

8. The production line of claim 1 comprising at least two separate sputtering modules for sputtering partially reflecting layer on the first and second blanks.

9. The production line of claim 1 comprising at least two separate bonding modules for bonding said first substrate with sputtered partially reflective layer to a first nonexpendable plastic stamper of a second information layer forming first sandwich-like structure and said second substrate with sputtered partially reflective layer to a second nonexpendable plastic stamper of a third information layer forming second sandwich-like structure.

10. The production line of claim 1 comprising at least two separating modules for separating said first sandwich-like structure forming first blank and first nonexpendable plastic stamper and separating said second sandwich-like structure and forming second blank and said second nonexpendable plastic stamper.

11. The production line of claim 1 comprising at least two separate washing modules for washing said first blank and washing said second blank.
12. The production line of claim 1 comprising at least two separate washing modules for washing said first nonexpendable plastic stamper and washing said second nonexpendable plastic stamper.

13. A production process for manufacturing multilayer optical discs, the process including the steps:
providing a first injection molding module and producing first polycarbonate substrate with relief of first layer,
providing a second injection molding module and producing second polycarbonate substrate with relief of fourth layer,
providing at least one sputtering module and sputtering on said first and second substrates partially reflecting layer,
providing at least one bonding module and bonding said first sputtered substrate to a first nonexpendable plastic stamper of a second information layer forming first sandwich-like structure and said second sputtered substrate to a second nonexpendable plastic stamper of a third information layer forming second sandwich-like structure,
providing at least one separation module and separating said first sandwich-like structure forming first blank and first nonexpendable plastic tamper and separating said second sandwich-like structure forming second blank and said second nonexpendable plastic stamper,
providing at least one washing module and washing said first blank and washing said second blank,
providing at least one additional washing module and washing said first nonexpendable plastic stamper and washing said second nonexpendable plastic stamper,
providing at least one sputtering module and sputtering of partially reflecting layer on the first blank forming a first sandwich and on the second blank forming a second sandwich, providing a bonding module and gluing said first and second sandwiches forming said multilayer optical disc.

14. The production process of claim 13 further comprising forming at least one additional information layer by bonding sandwich consisting of plurality of information layers with nonexpendable plastic stamper of next layer with final bonding with empty blank.

15. The production process of claim 13 wherein said partially reflecting layer is formed by sputtering of dielectric material.

16. The production process of claim 13 wherein said partially reflecting layer is formed by sputtering of semiconductor material.

17. The production process of claim 16 wherein said semiconductor material is Si.
18. The production process of claim 13 wherein said disc is DVD.
19. The production process of claim 13 wherein said disc is VMD.
20. The production process of claim 13 wherein said disc is HD DVD disc.
FIG 4