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TITLE OF THE INVENTION

STAMPER FOR MAGNETIC RECORDING MEDIA, METHOD OF
MANUFACTURING MAGNETIC RECORDING MEDIA USING THE SAME,
AND METHOD OF MANUFACTURING STAMPER FOR MAGNETIC
5 RECORDING MEDIA

BACKGROUND OF THE INVENTION

One embodiment of the present invention relates
to a stamper for a discrete track recording (DTR) type
magnetic recording media, a method of manufacturing a
10 DTR type magnetic recording media using the same, and
a method of manufacturing a stamper for a DTR type
magnetic recording media.

As a media for realizing high capacity recording,
many developments of discrete track recording type
15 magnetic recording media have done. Patterns of the
DTR type magnetic recording media are largely divided
into patterns of data area and patterns of servo
areas.

The data area includes a recording track portion.
20 The recording track portion is to form a user
recording area for recording and reproducing user data
by a head, and has patterns in which toric magnetic
tracks are arranged at a specified cycle (track pitch
Tp) via nonmagnetic guard bands. The magnetic track
25 is formed of a ferromagnetic material, for example,
CoCrPt. The nonmagnetic guard band is an unrecordable
area, and separates a data recording layer radially.



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Further, the toric magnetic track is divided into sectors in the circumferential direction by the servo areas, and formed so that a radial width T_w of the magnetic track is larger than that of the nonmagnetic guard band.

The servo areas are prebit areas in which patterns of magnetic material/nonmagnetic material corresponding to information necessary for positioning the head are formed. The shape of the servo areas is a circular arc to be the orbital of access of the head to a magnetic recording apparatus, and is formed such that the circumferential length thereof becomes long in proportion to the radial position.

The servo areas are generally comprising a preamble portion, an address portion, and a deviation detection burst portion (hereinafter, burst portion), and the servo areas are formed into patterns of magnetic material/nonmagnetic material in the same manner as the data area.

The occupancy rate of magnetic material factor varies in the data area and the servo areas.

An ultrafine structure of such a DTR media with the track pitch of 400 nm or less cannot be manufactured by a method using photolithography. Meanwhile, a method of manufacturing patterns on an entire disk surface by electron beam lithography or the like leads to low mass productivity. The DTR

media having such an ultrafine and large-area structure is manufactured by, for example, an imprint method. The imprint method, to be described in more details later, is a method in which a resist film is applied onto a recording layer formed on a substrate, a stamper having patterns with protrusions and recesses inverted with respect to patterns to be formed is pressed onto the resist film to transfer the patterns to the resist, and a magnetic film is processed according to the patterns.

A UV type imprint method and a hot embossing type imprint method have been known as the imprint method. The UV type imprint method is suitable for forming ultrafine and highly precise patterns. On the other hand, the hot embossing type imprint method is suitable for forming complicated shapes and high-aspect structures. However, the two methods have had the problem of their low throughput.

Examples of the imprint method for improving throughput include a high pressure type imprint method in which high pressure is applied to between a substrate and a stamper at room temperature to offset film thickness unevenness.

A stamper for a magnetic recording media to be used in the general imprint method can be manufactured by use of the electron beam lithography, X-ray lithography and the like, and for example, a master

disk can be also reproduced by use of the imprint method. Jpn. Pat. Appln. KOKAI Publication No. 2005-38477 discloses a method of manufacturing a stamper by use of the imprint method.

5 A stamper for a magnetic recording media has recesses corresponding to magnetic portions after completion of the media. By using stampers of different areas of the bases of the recesses corresponding to respective magnetic portions after
10 completion of the media, the above-described DTR type magnetic recording media having patterns with different occupancy rate of magnetic material can be manufactured.

 Herein, in the case where a normal stamper in
15 which the depths of recesses are equal is used in the manufacture of magnetic recording media, the spatial volumes of recesses vary with the respective areas of the base. The resist volume necessary for filling the space varies between areas of small spatial volume and
20 areas of large spatial volume. The difference in necessary resist volume is compensated in such a manner that the resist existing around the areas of large spatial volume moves to the spaces of the recesses in the area. As a result, there occurs
25 unevenness in the movement amounts of resists depending on pattern areas, and the film thickness of resist residues in patterns transferred by recesses of

large area of the base becomes thinner than that of resist residues in patterns transferred by recesses of small area of the base.

When unevenness occurs in the film thickness of resist residues, a problem arises in removing residues by reactive ion etching (RIE) of oxygen or the like. That is the problem that resist residues of thin film thickness are removed before resist residues of thick film thickness are removed, and accordingly, side etching is performed excessively on the portions where the resist residues have been removed first.

Patterns of protrusions and recesses transferred by use of a stamper broaden due to RIE for use in removing resist residues, Ar ion milling for use in processing a magnetic film, and the like. In the broadening, there occurs unevenness according to respective pattern areas if the above-described excessive side etching occurs. For this reason, there occurs a difference in broadening of patterns depending on pattern areas between a stamper pattern as a design value and the pattern after completion of media. As a result, it becomes difficult to design a stamper for manufacturing DTR type magnetic recording media of desired dimensions. The problem arising from the difference in resist movement amount does not happen in the UV type or hot embossing type imprint method, and it is the problem peculiar to the high

pressure type imprint method.

Jpn. Pat. Appln. KOKAI Publication No. 2005-38477
discloses a stamper for transferring patterns of
protrusions and recesses to a data recording area, but
5 there is description that the above "data recording
area" does not include an area where servo patterns
for tracking are recorded (servo area), a retreat area
of a magnetic head, or the like. In other words, the
stamper of the Jpn. Pat. Appln. KOKAI Publication
10 No. 2005-38477 does not take into consideration
transferring patterns to areas of different occupancy
rate of magnetic material.

J. Vac. Sci. Technol. B21 (1), Jan/Feb 2003
describes that, when aspect ratios are varied between
15 patterns in nano imprint, the amount of moving resists
changes together with aspect ratios, and the depth at
which resists are filled in recesses of the stamper
also changes. The literature describes that
adjustment is made by changing resist viscosity and
20 imprint time. In the literature, a stamper of
constant depth of recesses is employed.

BRIEF SUMMARY OF THE INVENTION

According to one embodiment of the present
invention, there is provided a stamper for a magnetic
25 recording media comprising patterns of protrusions and
recesses to manufacture a discrete track recording
type magnetic recording media comprising servo areas

including an address portion, a preamble portion and a
burst portion, and data areas including a recording
track portion, the patterns of protrusions and
recesses being formed at a pitch of 400 nm or less,
5 wherein a magnitude relation of depths of recesses
corresponding to the address portion, the preamble
portion, the burst portion and the recording track
portion is inverted to a magnitude relation of area
ratios of the recesses to the protrusions in the
10 address portion, the preamble portion, the burst
portion and the recording track portion.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

A general architecture that implements the
various feature of the invention will now be described
15 with reference to the drawings. The drawings and the
associated descriptions are provided to illustrate
embodiments of the invention and not to limit the
scope of the invention.

FIG. 1 is a schematic cross section of an example
20 of a stamper for a magnetic recording media according
to the present invention;

FIG. 2 is a view showing servo areas pattern of a
magnetic recording media including ABCD burst, to be
manufactured by the stamper for a magnetic recording
25 media according to the invention;

FIG. 3 is a view showing servo areas pattern of a
magnetic recording media including phase difference

burst, to be manufactured by the stamper for a magnetic recording media according to the invention;

FIG. 4 is a schematic cross section of an example of a stamper for a magnetic recording media including
5 ABCD burst according to the invention;

FIG. 5 is a schematic cross section of an example of a stamper for a magnetic recording media including phase difference burst according to the invention;

FIGS. 6A, 6B, 6C, 6D, 6E, 6F, 6G, 6H and 6I are
10 views showing an example of a method of manufacturing a magnetic recording media according to the present invention, the method using the stamper for a magnetic recording media according to the invention;

FIG. 7 is a graph showing broadenings of patterns
15 in respective pattern areas after completion of magnetic recording media manufactured by use of various stampers, from their respective stamper design values; and

FIGS. 8A, 8B, 8C, 8D and 8E are views showing an
20 example of a method of manufacturing a stamper for a magnetic recording media according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

Various embodiments according to the invention will be described hereinafter with reference to the
25 accompanying drawings.

The present inventors took into consideration the fact that the above problem comes from the difference

of spatial areas of respective recesses of the
stamper. Then, the inventors found that the above
problem can be solved by manufacturing a DTR type
magnetic recording media by use of a stamper where the
5 depths of recesses of patterns are changed according
to the areas of the bases of recesses in respective
pattern areas.

An example of a stamper according to the present
invention will be explained with reference to FIG. 1.

10 A stamper 100 has patterns of protrusions and
recesses formed at a pitch of 400 nm or less, and
includes a structure in which the area ratio of
protrusions to recesses is difference in adjacent
areas, for example, pattern areas 101, 102 and 103
15 shown in FIG. 1. The total values of areas of the
bases in recesses in the respective pattern areas have
the relation of $101 > 102 > 103$. In the present
invention, the depths H_{101} , H_{102} , H_{103} of recesses in
respective patterns in the pattern areas satisfy the
20 relation of $H_{101} < H_{102} < H_{103}$. Herein, it is
preferable that the difference between H_{101} and H_{102}
and between H_{102} and H_{103} is 5 to 15 nm. The reason
for this will be described later. Note that the
stamper in FIG. 1 is one example of the stamper
25 according to the invention, and the kinds of areas
where the area ratio of protrusions to recesses is
different are not limited to three kinds. Further,

the order in which pattern areas exist is not limited to 101, 102 and 103.

When a DTR type magnetic recording media is manufactured by using the stamper according to the invention shown in FIG. 1, it is possible to suppress the variability of resist movement amounts in the pattern areas 101, 102 and 103, and to uniform resist residues left in recesses of the respective pattern areas transferred. As a result, it is possible to uniform the broadenings of patterns after completion of a media from the stamper pattern as the design value irrespective of pattern areas.

Next, with reference to the drawings, a DTR media to be manufactured by use of the stamper according to the invention will be explained.

FIG. 2 is a view for explaining details of servo areas pattern in a DTR media having a burst servo. The servo area pattern is a surface type pattern of the portion that the head passes from the left to the right when the media is assembled in a drive.

Both the sides in FIG. 2 are data areas. A ratio of the width of a magnetic track to the width of a nonmagnetic guard band in a recording track portion configuring a data area is 2:1, namely, the occupancy rate of magnetic material in the data area is approximately 67%.

The servo areas are, as described previously,

roughly divided into a preamble portion, an address portion, and a burst portion. Hereinafter, the roles of these areas will be explained in details.

5 The preamble portion is provided for performing a phase-locked loop (PLL) process for synchronizing a servo signal reproduction clock and an automatic gain control (AGC) process for keeping the signal reproduction amplitude appropriately with respect to a time lag arising from rotation decentering and the like of a media. The preamble portion is formed of patterns in which magnetic materials and nonmagnetic materials are repeatedly arranged alternately in the circumferential direction, and the magnetic materials and the nonmagnetic materials expand radially in the radial direction so as to form circular arcs. A ratio of the magnetic material to the nonmagnetic material in the preamble portion is approximately 1:1. Namely, the occupancy rate of magnetic material in the preamble portion is approximately 50%. Meanwhile, the repetition cycle in the circumferential direction varies in proportion to the radial distance. However, it is a visible wavelength or less even at the outermost circumference, and it is difficult to identify the servo areas by optical diffraction, like the data area.

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15
20
25

 The address portion has a servo signal recognition code called servo mark, sector

information, cylinder information and the like, which are formed in Manchester code in the same pitch as the circumferential pitch of the preamble portion. In particular, the cylinder information is formed as
5 patterns whose information changes per servo track. For this reason, code conversion called Gray code where the change from adjacent tracks becomes minimum is carried out such that the influence of address reading mistakes at seek operation becomes small, and
10 then, the information is recorded in Manchester code. The occupancy rate of magnetic material of this area is approximately 50%.

The burst portion is an off-track detection area for detecting an off-track amount from an on-track
15 state of a cylinder address. Patterns of four marks called A, B, C and D bursts, among which there are pattern phases lag in the radial direction, are formed. In the respective bursts, plural marks are arranged in the circumferential direction at the same
20 pitch as that in the preamble portion. The cycle of each burst in the radial direction is in proportion to the cycle of the address pattern, i.e., the servo track cycle. For example, a pattern is formed in which each burst mark is formed for 10 cycles in the
25 circumferential direction and is repeated at twice the cycle of the servo track cycle in the radial direction. Since the burst marks are formed of a

nonmagnetic material, the occupancy rate of magnetic material in the ABCD burst is approximately 75%.

Further, the mark shape is intended to be formed into basically a square, and strictly a parallelogram in consideration of the skew angle at the time of head access. However, the shape becomes a bit round shape under the stamper processing precision and processing performances of transfer formation and the like. With regard to the position detection principle from the burst portion, although details are omitted, an average amplitude value of respective ABCD burst portion reproduction signals is calculated, and thereby the off-track amount is calculated.

As shown in FIG. 3, patterns may be arranged for performing phase difference servo control, and used as off-track amount detection means without using the ABCD burst. The occupancy rate of magnetic material in the phase difference servo pattern is approximately 50%.

In the case where a DTR type magnetic recording media is manufactured by the imprint method, a stamper is used in which magnetic material patterns of a magnetic recording media to be manufactured are formed as recesses. That is, the area ratio of the protrusions to the recesses in the stamper is inverted to the occupancy rate of magnetic material at respective portions of the magnetic recording media.

Accordingly, the area ratios of the protrusions to the recesses in the preamble portion, the address portion and the phase difference burst portion are each 50%, the area ratios of the protrusions to the recesses in the ABCD burst portion is 25%, and the area ratios of the protrusions to the recesses in the recording track portion is 33%.

FIG. 4 is a schematic cross section of a stamper 400 for forming patterns of protrusions and recesses of a DTR type magnetic recording media including an ABCD burst area. Herein, patterns transferred by the imprint method are isotropically etched around 10 nm also in the horizontal direction at the time of etching for processing the media. For this reason, the average area ratio of the actual pattern after completion of the media becomes a larger value than the above-described average area ratio. The average area ratio of the stamper changes depending on the track pitch, and is not limited to the above area ratio. However, the magnitude relation of the average area ratios of the protrusions to the recesses in the respective patterns of the stamper does not change. More specifically, the relation of the preamble portion, the address portion pattern area 401 > the recording track portion pattern area 403 > the burst portion pattern area 402 is satisfied. Accordingly, note that, on the contrary to the magnitude relation

of the average area ratios of the respective pattern areas, the magnitude relation of the total values of the areas of the bases of the recesses of these areas satisfies the relation of the preamble portion, the
5 address portion pattern area 401 < the recording track portion pattern area 403 < the burst portion pattern area 402. On the other hand, in the stamper shown in FIG. 4, the depths of the recesses in the patterns in respective pattern areas, on the contrary to the
10 magnitude relation of the total values of areas of the bases of recesses of the respective pattern areas, satisfies the relation of $H_{401} > H_{403} > H_{402}$.

Herein, it is preferable that the difference of depths of recesses of patterns between the preamble
15 portion, the address portion pattern area 401 and the recording track portion pattern area 403, and the difference of depths of recesses of patterns between the recording track portion pattern area 403 and the burst portion pattern area 402 are in the ranged from
20 5 to 15 nm. If it is below 5 nm, there occurs variability due to pattern areas in the broadening of patterns after completion of a media from the stamper pattern as the design value, in the same manner as the case where a stamper with no difference in depth is
25 employed. On the other hand, if it exceeds 15 nm, the patterns of the preamble portion, the address portion after completion of a media broaden on the contrary to

the case when a stamper with no different in depth is employed. As a result, in this case also, there occurs variability in the broadening of patterns due to pattern areas.

5 In the stamper in FIG. 4, there is a inverse correlation between the depths of recesses of respective patterns and the total value of areas of the bases of recesses in the pattern areas including thereof. If the difference of depths of recesses of
10 patterns between different pattern areas is in the range from 5 to 15 nm, the difference in spatial volume between the respective pattern areas can be reduced, so that the variability of the resist movement amounts at the time of imprint due to pattern
15 areas can be suppressed. As a consequence, it is possible to uniform resist residues irrespective of pattern areas, and to uniform the broadenings of patterns after completion of a media from the stamper pattern as the design value irrespective of pattern
20 areas.

 FIG. 5 is a schematic cross section of a stamper 500 for forming patterns of protrusions and recesses of a DTR type magnetic recording media including a phase difference burst area. An average area ratio of
25 protrusions to recesses in respective pattern areas satisfies a relation of preamble portion, address portion, burst portion pattern area 501 > recording

track portion pattern area 502. Accordingly, the
magnitude relation of the total values of areas of the
bases of recesses in the respective pattern areas
becomes the preamble portion, the address portion, the
5 burst portion pattern area 501 < the recording track
portion pattern area 502. Further, in the stamper
shown in FIG. 5, the depths of recesses of patterns in
the respective pattern areas satisfies the relation
 $H_{501} > H_{502}$, on the contrary to the magnitude relation
10 of the total values of areas of the bases of recesses
of the respective pattern areas.

Herein, it is preferable that the difference of
depths of recesses of patterns between the preamble
portion, the address portion, the burst portion
15 pattern area 501 and the recording track portion
pattern area 502 is in the range from 5 to 15 nm. If
it is below 5 nm, there occurs variability due to
pattern areas in the broadening of patterns after
completion of a media from the stamper pattern as the
20 design value, in the same manner as the case where a
stamper with no difference in depth is employed. On
the other hand, if it exceeds 15 nm, the patterns of
the preamble portion, the address portion, and the
burst portion after completion of a media are
25 broadened, on the contrary to the case where a stamper
with no different in depth is employed. As a result,
there occurs variability in pattern broadenings due to

pattern areas.

Also in the stamper in FIG. 5, there is a inverse correlation between the depths of recesses of respective patterns and the total value of areas of the bases of recesses in the pattern areas including thereof. If the difference of depths of recesses of patterns between different pattern areas is in the range from 5 to 15 nm, the difference in spatial volume between the respective pattern areas can be reduced, so that the variability of the resist movement amounts at the time of imprint due to pattern areas can be suppressed. As a consequence, it is possible to uniform resist residues irrespective of pattern areas, and to uniform the broadenings of patterns after completion of a media from the stamper pattern as the design value irrespective of pattern areas.

Hereinafter, an example of a method of manufacturing a DTR type magnetic recording media using a stamper according to the invention will be explained with reference to FIGS. 6A to 6I.

Herein, as a substrate 1, a crystallized glass substrate with a diameter of 2.5 inches is used. Lithium system crystallized glass may be used as the crystallized glass.

First, the substrate 1 is cleaned and introduced into a spatter apparatus, and a magnetic film 2

comprising a soft underlayer and a recording layer of CoCrPt system alloy is formed on the substrate 1.

Then, as shown in FIG. 6A, a resist film 3, for example, S1801 manufactured by Rohm & Haas Co. is spin-coated onto the magnetic film 2 at a rotation speed of 4000 rpm. A raw material for the resist 3 may be selected from a wide range. Spin-on-glass (SOG) or the like may be also used.

Then, as shown in FIG. 6B, patterns of protrusions and recesses are transferred to the resist film 3 by use of the stamper 100 for a magnetic recording media according to the invention.

Before the imprint process is carried out, the stamper 100 for a magnetic recording media according to the invention is process as described below.

First, in order to increase the adhesion between a perfluoroalkil derivative and the stamper 100 made of nickel, the stamper 100 is oxidized by an asher at 40°C or higher for five minutes. By using, as the perfluoroalkil derivative, a louver containing a solution obtained by diluting perfluoropolyether ($\text{HOOC-CF}_2\text{-O-(CF}_2\text{-CF}_2\text{-O)}_m\text{-(CF}_2\text{-O)}_n\text{-(CF}_2\text{-COOH)}$) by GALDEN-HT70 (manufactured by Solvay Solexis), the stamper 100 is covered with the perfluoroalkil derivative. Thereafter, the stamper is annealed at 150 °C for 10 minutes in a nitrogen atmosphere. By covering the stamper 100 with the perfluoroalkil

derivative as a fluoro system remover in this manner, release property from mold at the time of imprint is increased.

After the above process, the stamper 100 is
5 pressed for one minute at 2000 bar, whereby the
patterns are transferred to the resist 3. After the
stamper 100 is removed as shown in FIG. 6C, the resist
film 3 to which the patterns have been transferred is
UV radiated for five minutes, and then heated at 160°C
10 for 30 minutes.

When the stamper 100 is removed as shown in
FIG. 6C, it is possible to uniform resist residues
left in recesses in respective pattern areas in the
case where the stamper 100 of the invention is used in
15 the imprint method.

Next, as shown in FIG. 6D, resist residues left
in the recesses are removed. For removing the
residues, RIE using oxygen gas is employed. In order
to remove residues without changing protrusion and
20 recess shapes transferred to the resist film 3, low
pressure, high density plasma source RIE is
preferable, and it is preferable to use an inductively
couple plasma (ICP) or electron cyclotron resonance
(ECR) etching apparatus. For example, oxygen RIE is
25 used in an ICP etching apparatus under the condition
of etching pressure around 2 mTorr, whereby residues
are removed. By using the stamper 100 of the

invention in the imprint method, the variability of resist residues left in recesses due to pattern areas is suppressed. Consequently, in removing residues, it is possible to prevent excessive side etching, and to
5 uniform the broadenings of patterns after completion of a media from the stamper pattern as the designed value irrespective of pattern areas.

Subsequently, as shown in FIG. 6E, the magnetic film 2 is etched by Ar ion milling. To eliminate
10 damage on the ferromagnetic recording layer, etching is carried out while varying an ion incident angle from 30 degrees to 70 degrees so as to prevent a redeposit phenomenon. Along with the prevention of the redeposit phenomenon, a taper angle around
15 40 degrees to 75 degrees is made at a pattern side wall.

After etching the magnetic material, oxygen RIE is used for removing the etching mask as shown in FIG. 6F. In order to remove the mask effectively, it
20 is preferable to use high pressure, high power oxygen plasma. For example, oxygen RIE is performed under conditions of 400W, around 1 Torr to remove the etching mask.

After removal of the resist, recesses are filled
25 with a nonmagnetic material 4. In embedding, a nonmagnetic material is formed into a film by a sputtering method. The nonmagnetic material can be

selected widely from oxides such as SiO_2 , TiO_x and Al_2O_3 , nitrides such as Si_3N_4 , AlN and TiN , carbides such as TiC , borons such as BN , and simple substances such as C and Si . Herein, RF 200W was applied to C target, and bias sputtering was carried out at 9 Pa. When the surface of a discrete track media having a nonmagnetic film of around 100 nm formed thereon was observed by an atomic force microscope (AFM), preferable filling at surface roughness $R_a = 0.6$ nm, that is, in which there are little protrusions and recesses, was made.

Thereafter, etch-back is carried out until the tops of the magnetic film 2 is exposed. The roughness (R_a) of the media surface after the etch-back was 0.6 nm. It is preferable that the etch-back process is carried out by use of Ar ion milling. Further, it may be carried out by use of oxygen RIE. Herein, under the conditions of the acceleration voltage of 400V and the ion incidence angle of 30 degrees, ion milling was carried out for 20 minutes, and etch-back was carried out until the tops of protrusions of the ferromagnetic material were exposed completely (FIG. 6G).

After processing the magnetic material, a carbon protective film 5 is formed as a protective film, as shown in FIG. 6H. As the carbon protective film 5, DLC with a large rate of sp^3 -bonded carbon is

preferable. The DLC can be formed into a film by sputtering using graphite target, and chemical vapor deposition (CVD). CVD is preferable for forming a film of DLC with richer sp^3 -bonded carbon. It is better that the film thickness of the carbon protective film 5 is as thinner as possible. However, if it is too thin, the coverage of a media becomes deteriorated, and therefore, the film thickness is preferably 3 to 4 nm.

As shown in FIG. 6I, a liquid lubrication layer 6 is applied onto the manufactured discrete track media by a dip method. The media is dipped into a container filled with a lubricating agent (for example, perfluoropolyether), and the layer thickness of the lubricating agent is controlled by controlling the pull-out speed. As the pull-out speed is slower, the lubricating agent film thickness becomes thinner. It is preferable that the lubricating agent film thickness is thinner. However, if it is too thin, the free layer becomes small, and self-repairing cannot be made, which is not preferable. It is preferable that the film thickness is around 1 nm.

By use of the method shown in FIG. 6, a DTR type magnetic recording media including ABCD burst area was actually manufactured. Herein, in the process in FIG. 6B, a stamper in which the difference of depths of recesses of patterns between different pattern

areas was 0 nm (a normal stamper with no difference in depth), and a stamper according to the invention in which the depth difference was 10 nm were used.

Table 1 shows the differences between the widths of design values of recesses of pattern areas of the stamper and the widths of protrusions of the pattern-formed magnetic recording media by means of AFM measurement. It is known that patterns after process are broadened around 10 to 17 nm from patterns before process due to oxygen RIE at removal of resist residues carried out at processing of the magnetic recording media, and Ar ion milling at etching the magnetic film.

Table 1

	preamble	adress	burst	track
stamper with recesses, in which there are no different in depth	+10 nm	+11 nm	+17 nm	+14 nm
stamper with recesses, in which the diffrence of depths of recesses of patterns between different areas is 10 nm	+11 nm	+10 nm	+11 nm	+10 nm

Table 1 shows that when the normal stamper of identical depths of recesses is used, the difference of broadenings of patterns among the preamble portion, the address portion and the burst portion after completion of a media is 7 nm, and the difference of broadenings of patterns is large. The reason is

considered as follows. That is, when the normal
stamper of identical depths of recesses is used, the
resist residues of the burst portion whose resist
residual film thickness is thin are removed before
5 residues of the preamble portion and the address
portion whose resist residual film thickness is thick
are removed by RIE. Accordingly, side etching is
carried out excessively to the burst portion from
which resist residues have been removed first.

10 On the other hand, it is found that, when the
stamper in which the depths of recesses of patterns
are different with pattern areas is used, the
difference among pattern areas, of broadenings of
patterns after completion of a media from the stamper
15 pattern is within 1 nm. This is because, by the use
of the stamper of the invention in which the depths of
recesses are different according to pattern areas, it
is possible to uniform the thicknesses of resist
residues left in recesses irrespective of pattern
20 areas, and to prevent excessive side etching.

Next, by use of a stamper in which the
differences of depths of recesses of patterns among
the pattern areas are 3 nm, 5m, 15 nm and 20 nm, a DTR
magnetic recording media was manufactured, and
25 broadenings of patterns after completion of a media
from the stamper patterns as the design values were
measured, respectively. The result is shown in

FIG. 7, together with the results obtained by use of the stamper without difference of depths of recesses and the stamper whose depth difference is 10 nm.

As shown in FIG. 7, when the difference of depths of recesses is 3 nm, the difference of broadenings of patterns spreads approximately 4 nm between the preamble portion and the burst portion. On the other hand, when the difference of depths of recesses is 20 nm, excessive side etching occurs in the preamble portion, on the contrary to the case using the stamper with no difference in depth. For this reason, the difference of broadenings of patterns spreads approximately 4 nm.

If the difference of depths of recesses of patterns between different pattern areas is 5 nm to 15 nm, it is possible to control the variability of broadenings of patterns to around 2 nm or less. Consequently, it is possible to reduce difficulties of stamper design. Accordingly, it is preferable that the difference of depths of recesses of patterns between different pattern areas is 5 nm to 15 nm.

Next, a method of manufacturing a stamper for a magnetic recording media according to the present invention will be explained hereinafter with reference to the drawings.

The above-described stamper according to the invention is manufactured by the imprint method by use

of a normal stamper having equal depths of recesses. In order to manufacture a stamper having different depths of recesses by use of a smatter having equal depths of recesses, it is necessary to adjust the imprint pressure.

In order to find out imprint pressure preferable for manufacturing the stamper of the invention, a stamper was manufactured while changing raw materials of resist and imprint pressures, and the depths of recesses were evaluated. As the resist, Photo Resist (manufactured by Rohm & Haas Co., S1801), organic SOG (manufactured by Tokyo Ohka Kogyo Co., Ltd., OCD-T7-5500T, 8000T, 12000T), and inorganic SOG (manufactured by Tokyo Ohka Kogyo Co., Ltd., OCD-T2) were used. The imprint pressure was changed to 50, 100, 150 and 200 MPa. Table 2 shows the difference of the depths of recesses between the recording track portion and the address portion, in the case where the resist raw materials and the imprint pressures were changed, respectively. The depths of recesses in the recording track portion and the address portion were observed by AFM. Herein, the values in Table 2 are the values of depths of recesses of patterns, and imprint residues are not included. Further, the above depth are the values of depths of recesses when a 1.8-inch disk is imprinted, and the disk size and pressure are not specifically limited.

Table 2

	S1801	SOG (5500T)	SOG (8000T)	SOG (12000T)	T2
50 MPa	3 nm	5 nm	3 nm	3 nm	1 nm
100 MPa	5 nm	10 nm	8 nm	5 nm	2 nm
150 MPa	3 nm	5 nm	3 nm	3 nm	2 nm
200 MPa	0 nm	0 nm	0 nm	0 nm	0 nm

As is apparent from Table 2, sufficient depth differences could not be obtained in the case where the pressure was 50 MPa even with use of any raw material. In addition, at 150 and 200 MPa, the pressure saturated, and sufficient depth differences could not be attained either. On the other hand, in the case of 100 MPa almost half the saturation pressure, it has been confirmed that the difference of depths of recesses between the recording track portion and the address portion becomes largest. Accordingly, in order to manufacture a stamper having different depths of recesses, it is preferable to imprint it at the pressure around half the saturation pressure (pressure higher than 25% and lower than 75%).

On the basis of the above results, herein SOG (manufactured by Tokyo Ohka Kogyo Co., Ltd., OCD-Type7-8000T) was used as the resist, and 100 Mpa, which is half the normal pressure, was used as the imprint pressure.

As a substrate 801, a glass substrate with a diameter of 2.5 inches was used. Herein, since the substrate size is changed according to the size of a

stamper to be manufactured, it is not limited to
2.5 inches. Further, examples of the raw material of
the substrate may include silicon, GaAs, and aluminum
as well as glass, but not specifically limited
5 thereto.

On the substrate 801, SOG (manufactured by Tokyo
Ohka Kogyo Co., Ltd., OCD-Type7-8000T) as a resist 802
is spin coated at 6000 rpm. Spin coat is generally
used as the method of applying the resist 802.
10 However, a dipping method, an ink jet method or scan
type application may be employed. Further, as the
resist, not only SOG but also aluminum alkoxide and
photo resist or the like for use in semiconductor
manufacture process may be employed. Thereafter,
15 prebaking is performed at 100°C, and as shown in
FIG. 8A, the resist is imprinted under the above-
described conditions by use of a stamper 803 having
equal depths of recesses.

On the resist after imprint shown in FIG. 8B, a
20 metal such as nickel is formed into a film of around
20 nm by use of a sputtering method, as a conductive
film 804 as shown in FIG. 8C. Herein, nickel was used
as the conductive film 804. Pure nickel was used as a
target. A chamber was vacuumed to 8×10^{-3} Pa, and
25 then, argon gas was introduced into the chamber to
adjust the pressure to 1 Pa. In the chamber, DC power
of 400W was applied to carry out sputtering for

40 seconds, and a conductive film of 30 nm was obtained.

Thereafter, as shown in FIG. 8D, a plating process is carried out with the conductive film 804 as an electrode to thereby form an electroforming film 805 having a thickness of around 200 μm . Examples of a nickel plating bath for use in nickel electroforming include a Watts bath with addition of a specific organic additive, a normal nickel sulfamate bath, and a rich nickel sulfamate bath (high speed bath), but not limited thereto. Herein, by use of a nickel sulfamate plating liquid (manufactured by Showa Chemical Industry Co., Ltd., NS-160), electroforming was carried out for 90 minutes. The electroforming conditions are as follows.

Nickel sulfamate: 600 g/L, boric acid: 40 g/L, surfactant (sodium lauryl sulfate): 0.15 g/L, liquid temperature: 55°C, pH: 4.0, current density: 20 A/dm².

The thickness of the formed electroforming film 805 was 300 μm .

Then, the substrate is removed to obtain a stamper having the conductive film 804, the electroforming film 805 and resist residues for imprint.

Thereafter, the resist residues are removed by RIE. For example, RIE is carried out in an ICP etching apparatus by use of CF₄ gas with an etching

pressure of around 5 mTorr, whereby residues are removed. After the removal of resist residues, the stamper of the invention, having the conductive film 804 and the electroforming film 805, as shown in
5 FIG. 8E can be obtained.

As described above, by use of the stamper of the invention, it is possible to uniform broadenings of patterns after completion of a media from stamper patterns as design values irrespective of pattern
10 areas, and to manufacture a DTR type magnetic recording media by the high pressure imprint method advantageous in the viewpoint of throughput.

Moreover, by use of a method of manufacturing a stamper for a magnetic recording media according to
15 the invention, it is possible to manufacture a stamper in which depths of recesses are different depending on pattern areas, the stamper being difficult to be manufactured by laser beam and ion beam etching, in such a manner that a master disk is manufactured by
20 imprinting a normal stamper having equal depths of recesses in a simple manner with preferable mass productivity.

While certain embodiments of the inventions have been described, these embodiments have been presented
25 by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel methods and systems described herein may be embodied

in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein may be made without departing from the spirit of the inventions.

5 The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

WHAT IS CLAIMED IS:

1. A stamper for a magnetic recording media,
comprising:

patterns of protrusions and recesses to
5 manufacture a discrete track recording type magnetic
recording media comprising servo areas including an
address portion, a preamble portion and a burst
portion, and data areas including a recording track
portion, the patterns of protrusions and recesses
10 being formed at a pitch of 400 nm or less,

wherein a magnitude relation of depths of
recesses corresponding to the address portion, the
preamble portion, the burst portion and the recording
track portion is inverted to a magnitude relation of
15 area ratios of the recesses to the protrusions in the
address portion, the preamble portion, the burst
portion and the recording track portion.

2. The stamper for a magnetic recording media
according to claim 1, wherein the servo areas includes
20 an address portion, a preamble portion and an ABCD
burst portion, and the depth of recesses corresponding
to the address portion and the preamble portion is 5
to 15 nm larger than that of recesses corresponding to
the recording track portion, and the depth of recesses
25 corresponding to the recording track portion is 5 to
15 nm larger than that of recesses corresponding to
the ABCD burst portion.

3. The stamper for a magnetic recording media according to claim 1, wherein the servo areas includes an address portion, a preamble portion, and a phase difference burst portion, and the depth of recesses
5 corresponding to the address portion, the preamble portion and the phase difference burst portion is 5 to 15 nm larger than that of recesses corresponding to the recording track portion.

4. A method of manufacturing a magnetic
10 recording media, comprising:
forming a magnetic recording film on a substrate;
forming a resist layer on the magnetic recording film;

forming patterns of protrusions and recesses
15 corresponding to servo areas and data areas on the resist by use of the stamper according to claim 1 with an imprint method; and

processing the magnetic recording film by etching according to the formed patterns, and thereby forming
20 patterns of protrusions and recesses on the magnetic recording film.

5. A method of manufacturing a stamper for a magnetic recording media according to claim 1, comprising:
25 forming a resist on a substrate;
by use of a parent stamper having patterns of protrusions and recesses corresponding to an address

portion, a preamble portion, a burst portion and a
recording track portion respectively, the respective
recesses having cross sectional areas of the address
portion, the preamble portion, the burst portion and
5 the recording track portion, and the depths of all the
recesses being identical, forming patterns of
protrusions and recesses on the resist by a imprint
method at pressure that is higher than 25%, and lower
than 75% of saturation pressure at which all the
10 recesses of the parent stamper are filled with the
resist;

forming a conductive film on the resist on which
the patterns are formed;

performing a plating process with the conductive
15 film as an electrode and forming a electroforming film
on the conductive film; and

removing the resist on which the protrusions and
recesses are formed, from the electroforming film.