Description

This invention relates to thin film metal alloy magnetic recording disks and in particular to a CoPt alloy disk having low intrinsic media noise at high linear recording density.

One of the problems with thin film metal alloy media, including CoPt media, is that the intrinsic media noise increases with increasing linear recording density. Media noise arises from irregularities in the magnetic transitions and results in random shifts of the readback signal peaks. These random shifts are referred to as "peak jitter" or "time jitter". Thus, the higher the media noise, the higher the bit error rate. It is therefore desirable to develop a thin film metal alloy media which generates noise below a maximum acceptable level in order that data can be recorded at maximum linear density. The effect of intrinsic media noise, as measured by peak jitter and media signal-to-noise ratio (SNR), on the bit error rate in magnetic recording systems is described by Katz, et al., in "Effect of Bitshift Distribution on Error Rate in Magnetic Recording", IEEE Trans. on Magnetics, Vol. MAG-15, pp. 1050-1053, 1979. The measurement of media SNR is described by Belk, et al., in "Measurement of the Intrinsic Signal-to-Noise Ratio for High Performance Rigid Recording Media", J. Appl. Physics, 59(2), January 15, 1986, pp. 557-562.

U.S. Patent 4,789,598 describes a cobalt-platinum-chromium (CoPtCr) alloy magnetic recording disk wherein the high Cr concentration reduces the intrinsic media noise at high recording density.

Japanese Kokai 61-276116 describes a cobalt-nickel (CoNi) alloy disk with high SNR. The disk substrate is alumite-coated and the CoNi magnetic film is sputter deposited in the presence of either oxygen or nitrogen, after which the disk is heat treated, resulting in a disk with 20 to 50 atomic percent oxygen or nitrogen present in the CoNi magnetic film.

Three additional references describe various cobalt alloy thin film disks which appear to have either oxygen or nitrogen incorporated into the magnetic films in various amounts, but without any teaching of deliberately introducing oxygen during sputtering for the purpose of improving the SNR of the magnetic films. For example, Japanese Kokai 61-142523 describes a CoPt disk wherein the magnetic film is sputtered in the presence of nitrogen and then heat treated to crystallize the film and drive off the nitrogen, resulting in a CoPt film containing 0.5 to 5 atomic percent nitrogen. Japanese Kokai 61-253622 describes a CoCrX (X=Pt, Rh, Re, Pd, Ir, etc.) alloy disk wherein up to 5 atomic percent oxygen or nitrogen may be present in the magnetic film. U.S. patent 4,749,459 describes a CoPt disk which is formed by introducing very small amounts of nitrogen or an oxygen-containing gas during sputter deposition of the magnetic film, for the express purpose of reducing the coercivity of the resulting CoPt film.

The present invention is an improved CoPt alloy magnetic recording disk for horizontal recording, wherein the magnetic recording layer in the disk includes oxygen in an amount greater than approximately 5 atomic percent, preferably in the range of approximately 5 to 30 atomic percent. The disk is formed by introducing oxygen into argon during the sputter deposition of the CoPt alloy magnetic layer. The resulting disk structure has an intrinsic media noise at high linear recording density which is substantially less than that for comparable disk structures formed under similar conditions but without the introduction of oxygen during the sputter deposition of the CoPt magnetic layer. The SNR can be improved even further if the disks are heat treated following the sputter deposition fabrication process.

For a fuller understanding of the nature and advantages of the present invention reference should be made to the following detailed description taken in conjunction with the accompanying drawings.

Fig. 1 is a comparison of S_0NR versus linear recording density for CoPtCr disks made with and without the incorporation of oxygen into the magnetic layer;

Fig. 2 is a plot of S_0NR at 1000 flux reversals per millimeter (fr/mm) as a function of oxygen content in CoPtCr disks; and

Figs. 3A, 3B and 3C are graphs of remanence M_r, coercivity squareness S* and coercivity H_c, respectively, as a function of oxygen content in CoPtCr disks.

In order to illustrate the improved SNR for CoPt alloy disks with oxygen incorporated into the magnetic layer two CoPtCr disks were fabricated under identical conditions with the exception that oxygen was introduced during sputtering for one of the disks.

The disks were prepared in an RF-DC magnetron sputtering system (Varian S-gun). The base pressure was approximately 3×10^{-7} Torr (4×10^{-5} Pa) before deposition and was maintained at approximately 6 mTorr (0.8 Pa) of Ar for each deposition. Power to the system was 500 Watts and the Ar flow rate was 40 sccm. All depositions were conducted without substrate heat. The substrates were 5 1/4" AlMg/NiP disks. The surfaces of the substrates were RF discharge cleaned and Cr underlayers of 750 Angstroms thickness were formed over the NiP surface films. Magnetic layers having metal compositions of $Co_{77}Pt_6Cr_{17}$ were formed to a thickness of 160 Angstroms over the Cr underlayers. Thereafter protective carbon overcoats of 250 Angstroms thickness were formed over the CoPtCr magnetic layers. In one case oxygen was introduced into the sputtering chamber at a flow rate of approximately 5% of the Ar flow rate.

The comparison of the intrinsic media noise for these two disks is graphically illustrated in Fig. 1. The SNR term of S_0NR is defined as $20 \log(V_s/V_n)$ where

V_s is the isolated signal amplitude and V_n is the integrated RMS noise of the media. The disk made with oxygen incorporated into the CoPtCr magnetic layer shows marked improvement in S_0NR at all recording densities, with a 4.4 dB (38.5 dB vs. 34.1 doB) improvement at 2400 fr/mm.

In order to determine the SNR dependence on the oxygen content of the magnetic layer, various disks were fabricated under sputtering conditions similar to those stated above but with different oxygen flow rates. The disk structures were also different than that for the disks stated above only in that the CoPtCr layers were 600 Angstroms thick and were formed over 1000 Angstroms thick Cr underlayers. Some of the disks were fabricated on semiconductor grade single crystal silicon in addition to polished AlMg/NiP with identical recording results. Since the surface of the silicon substrate is smooth and amorphous with a native oxide, the results described here are believed to be also applicable to glass or glass-ceramic substrates. The oxygen content was determined by Rutherford backscattering. The dependence of oxygen content on the SNR, as measured by S_0NR, is depicted graphically in Fig. 2. The dependence of other magnetic properties on the oxygen content for these disks is illustrated in Figs. 3A, 3B and 3C. At approximately 30 atomic percent oxygen, the magnetic properties of the disks, especially the coercivity H_c, render the disks essentially unusable as magnetic recording media.

It has also been discovered that the SNR of CoPtCr disks formed in an oxygen-containing atmosphere can be improved even further if the completed disk is annealed. In one experiment disks with a $Co_{75}Pt_{12}Cr_{13}$ magnetic layer formed directly on a AlMg/NiP substrate were heated at 450 degrees F (232°C) for 90 minutes and allowed to cool slowly to ambient temperature. The thermal treatment was conducted in both air and an essentially oxygen-free atmosphere created by first purging the oven with nitrogen. The resulting disks exhibited a decrease of 9.8 microvolts RMS noise and an increase of 3.6 dB SNR at 2400 fr/mm over identical disks which were not heat treated.

The above description relates only to the inventive structure which forms a part of the recording media, and not to the conventional well-known portions of the media and the media fabrication processes. For example, in the fabrication of thin film metal alloy disks, it is known to provide a protective overcoat, such as a sputtered carbon film, over the magnetic film.

Claims

1. A magnetic recording disk for horizontal recording comprising:

   a substrate; and

   a magnetic layer formed over the substrate, the magnetic layer having a composition comprising cobalt, platinum and oxygen, the oxygen being present in the magnetic layer in an amount greater than 5 atomic percent.

2. A disk as claimed in claim 1 further comprising a non-magnetic underlayer between the substrate and the magnetic layer.

3. A disk as claimed in claim 2 wherein the underlayer is chromium.

4. A disk as claimed in any preceding claim wherein the magnetic layer includes chromium.

5. A disk as claimed in any preceding claim wherein the oxygen is present in the magnetic layer in an amount less than approximately 30 atomic percent.

6. A disk as claimed in any preceding claim further comprising a protective overcoat formed over the magnetic layer.

7. A process for the fabrication of a thin film magnetic recording disk for horizontal recording : the disk being of the type having a magnetic layer comprising cobalt and platinum wherein the magnetic layer is formed by sputter deposition, the process comprising the step of introducing oxygen into the sputtering atmosphere during the deposition of the magnetic layer in an amount sufficient to incorporate oxygen into the magnetic layer in an amount greater than 5 atomic percent.

8. A process as claimed in claim 8 further comprising the step of heat treating the disk after the sputter deposition of the magnetic layer.

Patentansprüche

1. Eine magnetische Aufzeichnungsplatte zur horizontalen Aufzeichnung, die enthält:
   ein Substrat; und
   eine Magnetschicht, die über dem Substrat gebildet wird, wobei die Magnetschicht eine Mischung aus Kobalt, Platin und Sauerstoff enthält und der in der Magnetschicht vorhandene Sauerstoff größer als 5 Atomprozent ist.

2. Eine Platte wie in Anspruch 1, die außerdem eine nicht magnetische Unterlage zwischen dem Substrat und der Magnetschicht enthält.

3. Eine Platte wie in Anspruch 2, wobei die Unterla-

* C L M S *

V_s is the isolated signal amplitude and V_n is the integrated RMS noise of the media. The disk made with oxygen incorporated into the CoPtCr magnetic layer shows marked improvement in S_0NR at all recording densities, with a 4.4 dB (38.5 dB vs. 34.1 doB) improvement at 2400 fr/mm.

In order to determine the SNR dependence on the oxygen content of the magnetic layer, various disks were fabricated under sputtering conditions similar to those stated above but with different oxygen flow rates. The disk structures were also different than that for the disks stated above only in that the CoPtCr layers were 600 Angstroms thick and were formed over 1000 Angstroms thick Cr underlayers. Some of the disks were fabricated on semiconductor grade single crystal silicon in addition to polished AlMg/NiP with identical recording results. Since the surface of the silicon substrate is smooth and amorphous with a native oxide, the results described here are believed to be also applicable to glass or glass-ceramic substrates. The oxygen content was determined by Rutherford backscattering. The dependence of oxygen content on the SNR, as measured by S_0NR, is depicted graphically in Fig. 2. The dependence of other magnetic properties on the oxygen content for these disks is illustrated in Figs. 3A, 3B and 3C. At approximately 30 atomic percent oxygen, the magnetic properties of the disks, especially the coercivity H_c, render the disks essentially unusable as magnetic recording media.

It has also been discovered that the SNR of CoPtCr disks formed in an oxygen-containing atmosphere can be improved even further if the completed disk is annealed. In one experiment disks with a $Co_{75}Pt_{12}Cr_{13}$ magnetic layer formed directly on a AlMg/NiP substrate were heated at 450 degrees F (232°C) for 90 minutes and allowed to cool slowly to ambient temperature. The thermal treatment was conducted in both air and an essentially oxygen-free atmosphere created by first purging the oven with nitrogen. The resulting disks exhibited a decrease of 9.8 microvolts RMS noise and an increase of 3.6 dB SNR at 2400 fr/mm over identical disks which were not heat treated.

The above description relates only to the inventive structure which forms a part of the recording media, and not to the conventional well-known portions of the media and the media fabrication processes. For example, in the fabrication of thin film metal alloy disks, it is known to provide a protective overcoat, such as a sputtered carbon film, over the magnetic film.

Claims

1. A magnetic recording disk for horizontal recording comprising:

   a substrate; and

   a magnetic layer formed over the substrate, the magnetic layer having a composition comprising cobalt, platinum and oxygen, the oxygen being present in the magnetic layer in an amount greater than 5 atomic percent.

2. A disk as claimed in claim 1 further comprising a non-magnetic underlayer between the substrate and the magnetic layer.

3. A disk as claimed in claim 2 wherein the underlayer is chromium.

4. A disk as claimed in any preceding claim wherein the magnetic layer includes chromium.

5. A disk as claimed in any preceding claim wherein the oxygen is present in the magnetic layer in an amount less than approximately 30 atomic percent.

6. A disk as claimed in any preding claim further comprising a protective overcoat formed over the magnetic layer.

7. A process for the fabrication of a thin film magnetic recording disk for horizontal recording : the disk being of the type having a magnetic layer comprising cobalt and platinum wherein the magnetic layer is formed by sputter deposition, the process comprising the step of introducing oxygen into the sputtering atmosphere during the deposition of the magnetic layer in an amount sufficient to incorporate oxygen into the magnetic layer in an amount greater than 5 atomic percent.

8. A process as claimed in claim 8 further comprising the step of heat treating the disk after the sputter deposition of the magnetic layer.

Patentansprüche

1. Eine magnetische Aufzeichnungsplatte zur horizontalen Aufzeichnung, die enthält:
   ein Substrat; und
   eine Magnetschicht, die über dem Substrat gebildet wird, wobei die Magnetschicht eine Mischung aus Kobalt, Platin und Sauerstoff enthält und der in der Magnetschicht vorhandene Sauerstoff größer als 5 Atomprozent ist.

2. Eine Platte wie in Anspruch 1, die außerdem eine nicht magnetische Unterlage zwischen dem Substrat und der Magnetschicht enthält.

3. Eine Platte wie in Anspruch 2, wobei die Unterla-

* C L M S *

ge aus Chrom ist.

4. Eine Platte wie in irgendeinem der vorhergehenden Ansprüche, wobei die Magnetschicht Chrom enthält.

5. Eine Platte wie in irgendeinem der vorhergehenden Ansprüche, wobei der Sauerstoff in der Magnetschicht kleiner als etwa 30 Atomprozent ist.

6. Eine Platte wie in irgendeinem der vorhergehenden Ansprüche, die außerdem eine Schutzummantelung enthält, die über der Magnetschicht gebildet wurde.

7. Ein Verfahren zur Herstellung eines dünnen Films auf der magnetischen Aufzeichnungsplatte zur horizontalen Aufzeichnung, wobei die Platte eine Magnetschicht aus Kobalt und Platin enthält, die Magnetschicht durch Sputtern gebildet wird, das Verfahren den Schritt zur Zufuhr von Sauerstoff in einer ausreichenden Menge in die Sputteratmosphäre während des Aufdampfens der magnetischen Schicht enthält, um so der Magnetschicht Sauerstoff in einer Menge beizugeben, die größer als 5 Atomprozent ist.

8. Ein Verfahren wie in Anspruch 8, das außerdem den Schritt zur Wärmebehandlung der Platte nach dem Sputtern der Magnetschicht enthält.

Revendications

1. Disque d'enregistrement magnétique pour enregistrement horizontal comprenant :

   un substrat ; et

   une couche magnétique formée sur le substrat, la couche magnétique ayant une composition à base de cobalt, de platine et d'oxygène, l'oxygène étant présent dans la couche magnétique en une concentration atomique supérieure à 5%.

2. Disque selon la revendication 1 comprenant en outre une couche sous-jacente non magnétique entre le substrat et la couche magnétique.

3. Disque selon la revendication 2 dans lequel la couche sous-jacente est formée de chrome.

4. Disque selon l'une des revendications précédentes dans lequel la couche magnétique comprend du chrome.

5. Disque selon l'une des revendications précédentes dans lequel l'oxygène est présent dans la couche magnétique en une quantité représentant une concentration atomique inférieure à 30% environ.

6. Disque selon l'une des revendications précédentes comprenant en outre une couche protectrice formée sur la couche magnétique.

7. Procédé de fabrication d'un disque d'enregistrement magnétique à film mince pour enregistrement horizontal, ledit disque étant du type ayant une couche magnétique comprenant du cobalt et du platine dans lequel la couche magnétique est formée par dépôt par pulvérisation, le procédé comprenant les étapes d'introduction d'oxygène dans l'atmosphère de pulvérisation durant les dépôts de la couche magnétique en une quantité suffisante pour incorporer de l'oxygène dans la couche magnétique en une concentration atomique supérieure à 5%.

8. Procédé selon la revendication 7 comprenant en outre l'étape de chauffage du disque après dépôt par pulvérisation de la couche magnétique.