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(54) **ELECTRO-DEPOSITED PASSIVATION COATINGS FOR PATTERNED MEDIA**

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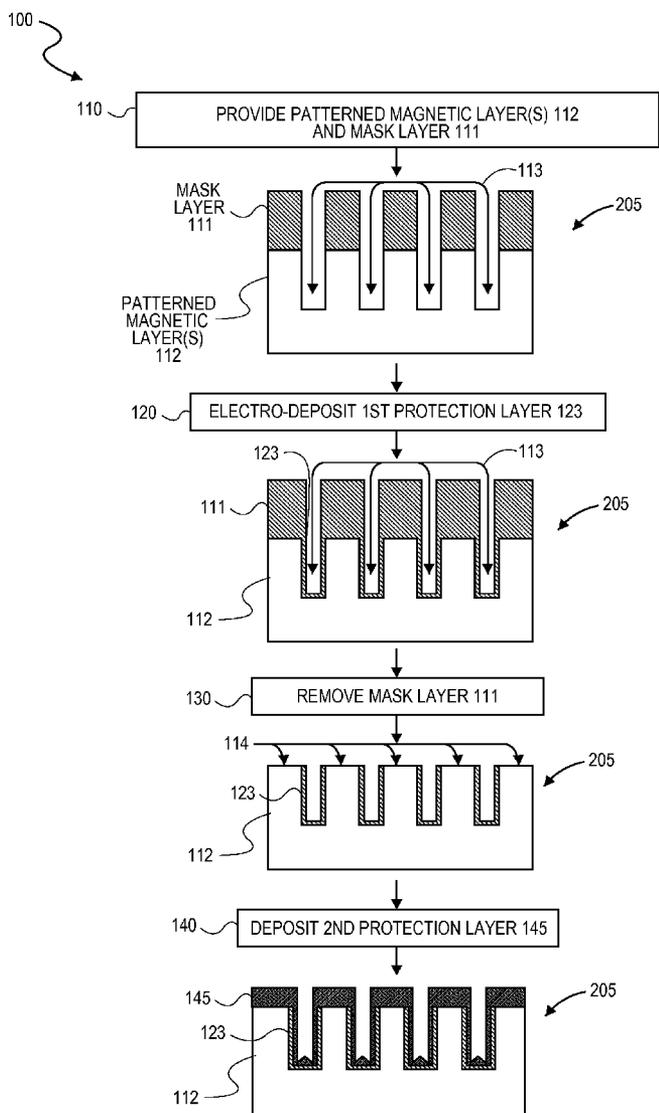
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(57) **ABSTRACT**

A method of fabricating a patterned magnetic recording disk is described. The method may include electrodepositing a protection layer on the magnetic recording layer of the disk.

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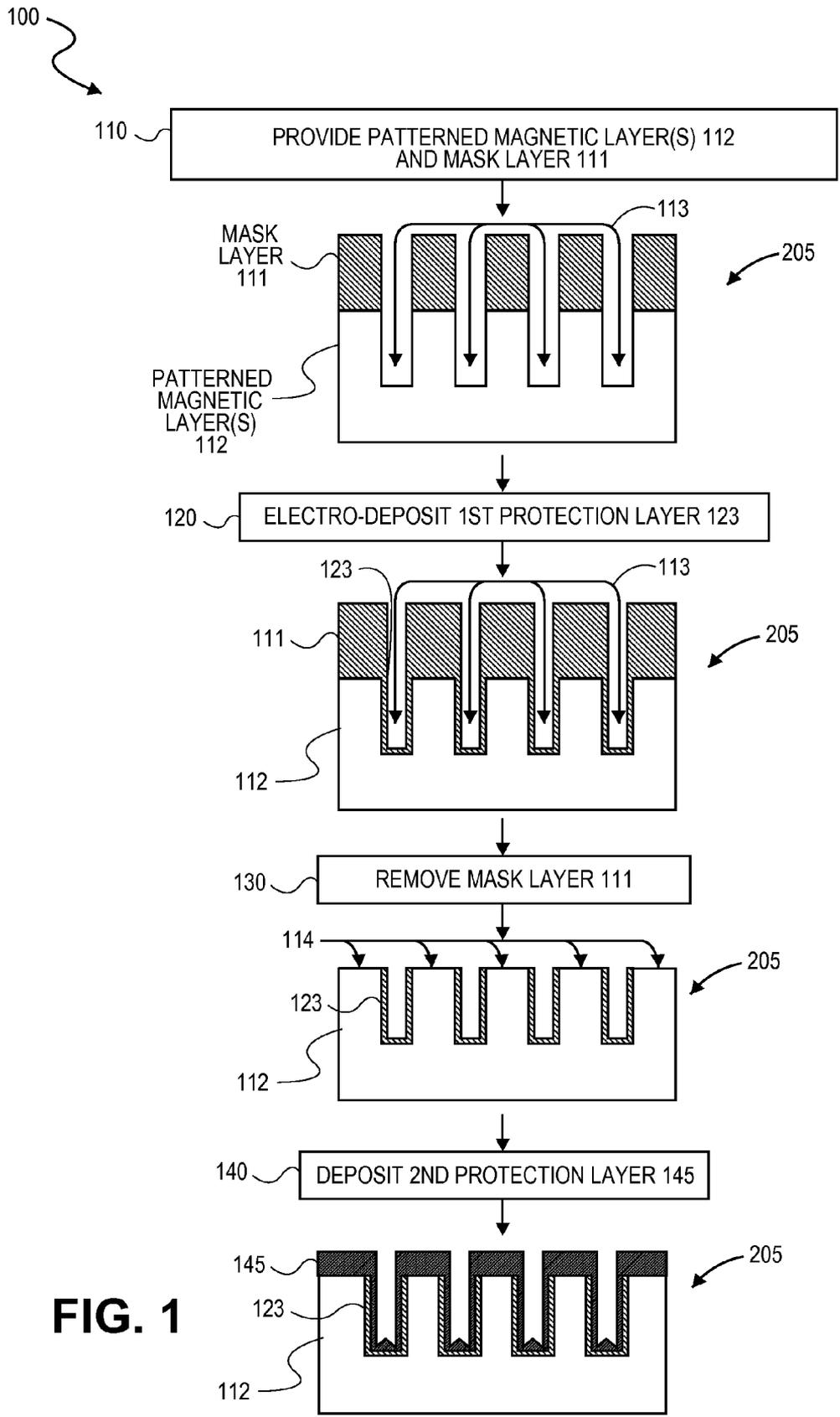


FIG. 1

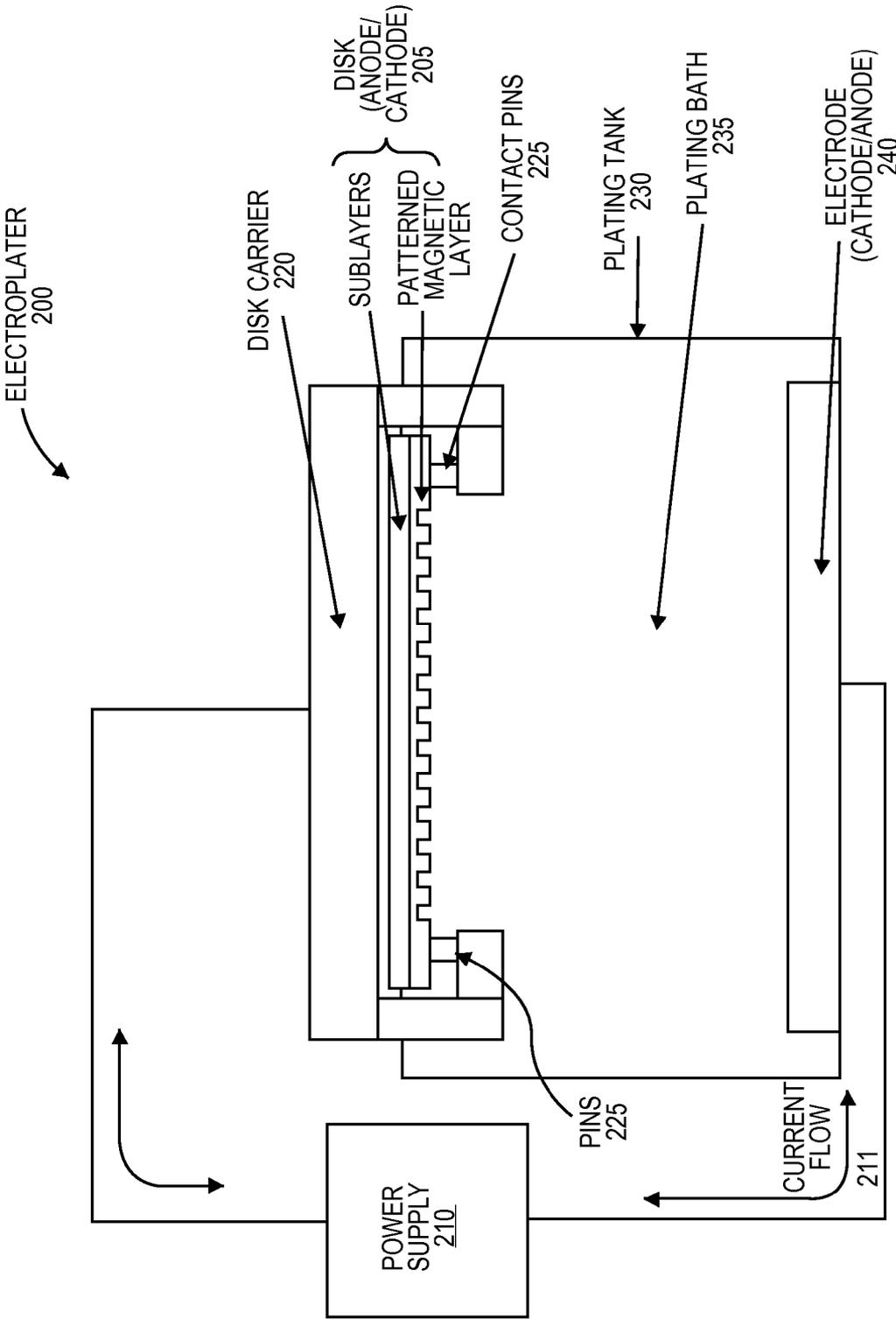


FIG. 2

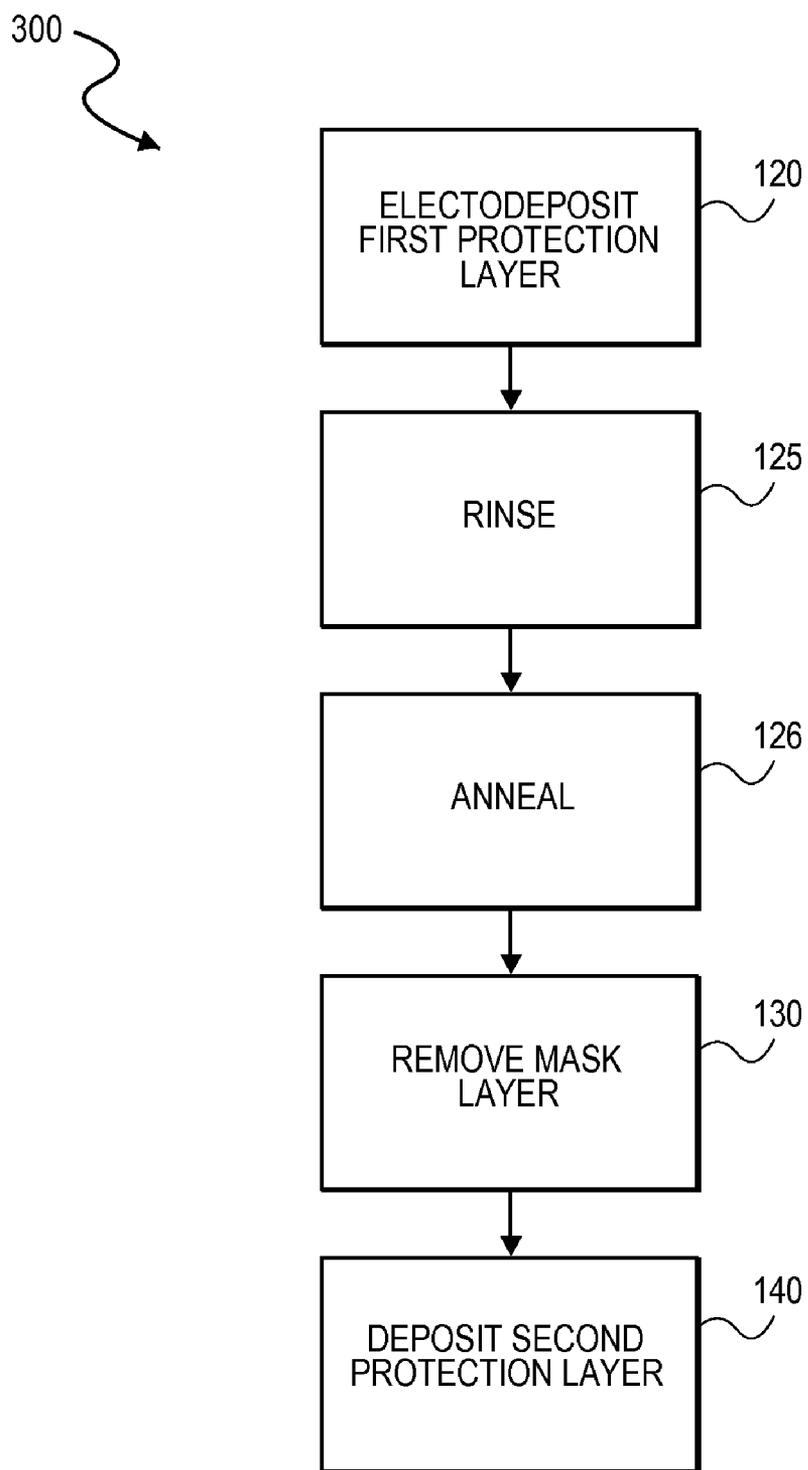


FIG. 3

ELECTRO-DEPOSITED PASSIVATION COATINGS FOR PATTERNED MEDIA

TECHNICAL FIELD

[0001] Embodiments described herein relate to the field of patterned media, and, in particular, to electro-deposited passivation of pattern media.

BACKGROUND

[0002] Patterned media poses unique challenges to the tribological properties of hard disks because typical fabrication processes can involve producing topography (e.g., grooves) in the magnetic media layers. The non-planar media surface can adversely affect a disk drive's performance in terms of both head flyability and corrosion. In conventional hard disk media, the head flies over a very smooth surface and the magnetic layers, which are composite metal films, are capped with a thin diamond-like carbon (DLC) film to protect against corrosion. In patterned media, a DLC film is also typically required to cap the magnetic layers, but the presence of topography in the magnetic layers can result in poor conformal coverage (e.g., groove sidewalls and corners) resulting in inadequate corrosion performance.

[0003] In conventional fabrication process for patterned media, the DLC film is applied to the pattern features of the discrete track recording (DTR) disk, also referred to as discrete track media (DTM). One type of DTM structure utilizes a pattern of concentric discrete zones for the recording medium. When data are written to the recoding medium, the discrete magnetic areas correspond to the data tracks. The substrate surface areas not containing the magnetic material isolate the data tracks from one another. The discrete magnetic zones (also known as hills, lands, elevations, etc.) are used for storing data and the non-magnetic zones (also known as troughs, valleys, grooves, etc.) provide inter-track isolation to reduce noise. The lands have a width less than the width of the recording head such that portions of the head extend over the troughs during operation. The lands are sufficiently close to the head to enable the writing of data in the magnetic layer. Therefore, with DTM, data tracks are defined both physically and magnetically

[0004] In conventional fabrication of DTM, the recessed (e.g., grooves) and non-recessed regions (e.g., lands) of the patterned area are coated at the same time using the same diamond-like carbon (DLC) deposition process. As a result, the coating of the recessed regions will be thinner and less uniform than the non-recessed regions because of shadowing effects and a larger surface area in the recessed regions. Consequently, the potential for corrosion in the recessed regions of the patterned media is greater than the non-recessed regions and likewise greater than standard non-patterned media.

[0005] One conventional DTM fabrication approach uses a physical vapor deposition (PVD) technique to coat the entire surface of patterned magnetic layer. Such an approach may involve multi-steps of depositing and etching back films to completely fill recessed regions of the patterned media and achieve a flyable surface.

[0006] Another conventional DTM fabrication method described in US 2008/0187779 utilizes atomic layer deposition (ALD) to deposit a DLC film over the entire surface of the patterned magnetic recording layer, after installing a resin mold mask on the surface of magnetic recording layer. The

ALD fills not only the grooves but also covers the resin mold mask on the lands of the magnetic recording layer. Then, the resin mold mask is removed together with the ALD protective layer above the lands of the magnetic recording layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Embodiments are illustrated by way of example, and not limitation, in the figures of the accompanying drawings in which:

[0008] FIG. 1 is a conceptual illustration of the manufacturing method and resulting disk structure of a patterned magnetic recording disk having an electrodeposited protection layer, according to embodiments of the present invention.

[0009] FIG. 2 illustrates one embodiment of electroplater according to one embodiment of the present invention.

[0010] FIG. 3 illustrates a method of manufacturing a patterned magnetic recording disk having an electrodeposited protection layer, according to alternative embodiments of the present invention.

DETAILED DESCRIPTION

[0011] Embodiments of the apparatus and methods are described herein with reference to figures. However, particular embodiments may be practiced without one or more of these specific details, or in combination with other known methods, materials, and apparatuses. In the following description, numerous specific details are set forth, such as specific materials, dimensions and processes parameters etc. to provide a thorough understanding. In other instances, well-known manufacturing processes and equipment have not been described in particular detail to avoid unnecessarily obscuring the claimed subject matter. Reference throughout this specification to "an embodiment" means that a particular feature, structure, material, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. Thus, the appearances of the phrase "in an embodiment" in various places throughout this specification are not necessarily referring to the same embodiment. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments.

[0012] Embodiments of a method of electro-depositing a coating to reside in the recessed areas (grooves) of a patterned magnetic film are described. Electro-deposition of the coating in these topographical grooves may be performed in order to passivate the surfaces of these patterned grooves and prevent corrosion. In one particular embodiment, such a coating layer is only electro-deposited in the patterned grooves so that no additional spacing loss is added to the top magnetic surface. In one embodiment, depending on the coating layer thickness, the effect on head flyability can also be mitigated by either partially or completely filling the grooves to planarize the media. Improved corrosion performance as well as flyability of the patterned media may result from embodiments of the invention discussed herein.

[0013] In one embodiment, the electro-deposition process is performed after the features have been etched by some means into the media layers but before a mask layer is stripped so that only the exposed conductive surfaces are the recessed features. Consequently, material is only deposited in the recessed areas (i.e., grooves) of the patterned magnetic layers(s) during the electro-deposition process. After depositing the first coating in the etched features, the masking layer

is then stripped and second protection layer (e.g., DLC film) can be deposited over the entire surface of the patterned magnetic layer(s). As a result, the recessed regions of the pattern will have two layers of protection (i.e., electro-deposited film and vacuum deposited DLC) while the non-recessed regions (i.e., lands) of the pattern will have only the second protection layer (e.g., the DLC film).

[0014] As one of ordinary skill in the art will appreciate, different deposition methods may provide distinct material properties of the deposited layer. For example, one of ordinary skill in the art would understand CVD carbon to have material properties that are distinct from PVD carbon. Thus, a CVD carbon layer would not be considered structurally equivalent to a PVD carbon layer. As another example, a DLC film formed by a CVD method is denser and harder than a DLC film formed by a sputtering method. ALD is similar in chemistry to CVD, except that the ALD reaction breaks the CVD reaction into two half-reactions, keeping precursor materials separate during the reaction. A layer produced by electro deposition has different material properties than a layer of produced by ALD. As such, embodiments of the deposition method may be discussed herein at times in reference to the physical properties of a layer produced by the particular deposition method as well as a description of the deposition process. In one embodiment, the electro-deposited layer may have a crystalline structure. Alternatively, the electro-deposited layer may have an amorphous structure.

[0015] FIG. 1 is a conceptual illustration of the manufacturing method 100 and resulting disk 205 structure of a patterned magnetic recording disk, according to embodiments of the present invention. Embodiments of the method of the present invention begin after patterning of the magnetic layer(s) of a DTM disk. The patterning may be accomplished by any one of several means (e.g., imprint lithography, e-beam lithography, ion beam etching, reactive ion etching, sputter etching, etc.) that are well known in the art; accordingly, a detailed discussion is not provided. After patterning of the magnetic layer(s) 112, a mask (e.g., resist) layer 111 may remain above the lands of the pattern. In embodiments where a mask layer does not remain after patterning of layer(s), the method 100 includes the deposition and etching of a mask layer to form openings above the grooves 113 of the magnetic layer(s) as illustrated in the FIG. 1. The deposition and etching of a mask layer is known in the art; accordingly, a detailed discussion is not provided herein.

[0016] After the patterned magnetic layer(s) 112 and mask layer 111 have been provided, operation 110, the method 100 then proceeds with electro-depositing a protection layer 123 within the grooves 113 of the patterned magnetic layer(s) 112, operation 120. Next, mask layer 111 is removed, operation 130, followed by the depositing of a second protection layer 145 over both the grooves 113 and lands 114 of the patterned magnetic layer(s) 112, step 140. Further details of each of the operations of FIG. 1 are provided below.

[0017] FIG. 2 illustrates one embodiment of electroplater 200 that may be used in the electro-deposition operation 120 according to one embodiment of the present invention. Electroplater 200 includes a power supply 210 coupled to a disk carrier 220 and a plating tank 230, containing a plating bath 235, to provide an electric current flow 211 in order to electroplate the first protection layer on the patterned magnetic recording layer. Contact pins 225 are used to provide electrical contact to the disk 205. In this particular embodiment, disk 205 is held in the tank upside down by the disk carrier 220.

[0018] In the electro-deposition process, the disk 205 as a work piece is made into either an anode or a cathode depending on the material to be deposited. A wide variety of materials can be electrodeposited into the recessed areas of the magnetic recording pattern including both metals and insulators. The materials which can be electro-deposited in this fashion include, for example, metals such as Au or silicates such as sodium silicate (Na_2SiO_3), potassium silicate (K_2SiO_3). In one embodiment, the deposited film may be a cross-linked silicate (silica) film free of sodium or potassium. In the case of sodium silicate, the electro-deposited film can then be converted to silica by baking the coating after deposition, as illustrated by operation 120 in FIG. 1.

[0019] In alternative embodiments, other metallic materials such as aluminum (Al), gold (Au), chromium (Cr), ruthenium (Ru), platinum (Pt), rhodium (Rh) and Copper (Cu) may be used. In general, metals are not magnetically sensitive and provide good adhesion, corrosion resistance and mechanical strength can also be employed. In yet other embodiments, aluminates can also be used similarly as silicate to be electrochemically deposited to the recessed areas 113. It should be noted that alloys can also be employed for formation of the first protection layer 123. In addition, multiple materials can also be electro-deposited in sequence to obtain desired adhesion, corrosion resistance, and mechanical properties.

[0020] When metallic materials are to be deposited into the grooves 113, the disk 205 is made a cathode and the tank electrode 240 is made an anode. When silicates or aluminates are to be used, the disk 205 is made an anode and the tank electrode 240 is made a cathode. In one embodiment, the electro deposition is carried out in a DC mode. In alternative embodiments, other plating modes may be used, for example, a positively pulsed mode, or a reversely pulsed mode (positive and negative). It should be noted that other types and configurations of electroplaters may be used in alternative embodiments of the present invention. Electroplating equipment is known in the art; accordingly, a further discussion is not provided herein. In one embodiment, the electro-deposition operation may be performed using electroless plating techniques.

[0021] The thickness of the first protection layer 123 can be controlled so that the groove 113 depth can be controlled to render the disk good flyability as well as good corrosion resistance. In the case of the metal coatings, relatively thick coatings can be achieved to even planarize the patterned features. In the case of silicates or aluminates, the coating thickness is self-limiting because the coating becomes non-conductive after a few nm and the deposition process stops.

[0022] Parameters such as electroplating bath composition, temperature, pH, voltage, pulse time and frequency (if pulsed), deposition time, etc all should be controlled to obtain optimum film properties. In order to limit the deposited film into grooves, the resist on the land area is non-conductive according to one embodiment. This can be done through controlling the resist thickness or selecting resist of high electrical resistance.

[0023] FIG. 3 illustrates a method 300 of manufacturing a patterned magnetic recording disk having an electro-deposited protection layer, according to alternative embodiments of the present invention. In one embodiment, one or more rinse operations, operation 125, (e.g., with water) may follow the electro-deposition operation 120 to clean the disk 205 free of possible loose deposits in the electrolytes. In one embodiment, an annealing operation 126 may be performed before

the final stripping of mask layer in operation 130 to improve on the adhesion and mechanical properties of the electro deposited films. Annealing should not be too severe to hinder the final resist stripping operation. Rinse and annealing operations are known in the art; accordingly, detailed discussions of such operations are not provided.

[0024] Referring to both FIGS. 1 and 3, in operation 140, another, second protective film 145 may be deposited over the electro-deposited layer 123. In one embodiment, such additional protective layer 145 is vacuum deposited DLC film. In such vacuum deposited embodiments, the DLC film may be deposited with processes such as, but not limited to, ion beam deposition (IBD), physical vapor deposition (PVD), or chemical vapor deposition (CVD), such as low pressure (LP) CVD or plasma enhanced (PE) CVD. In a particular embodiments, the DLC film may be bi-layer formed. In alternative embodiments, other materials may be used for the second protection layer 145, for example, a nitride film, an oxide film such as SiO₂ film, etc.

[0025] Embodiments of the methods described above may be used to fabricate a DTR perpendicular magnetic recording (PMR) disk having a soft magnetic film disposed above a substrate. The soft magnetic film may be composed of a single soft magnetic underlayer (SUL) or multiple soft magnetic underlayers having interlayer materials, such as ruthenium (Ru), disposed there between. In particular embodiments, both sides of the substrate may be processed, in either simultaneous or consecutive fashion, to form disks with double sided DTR patterns.

[0026] The terms “over,” “under,” “between,” and “on” as used herein refer to a relative position of one layer with respect to other layers. As such, for example, one layer deposited or disposed over or under another layer may be directly in contact with the other layer or may have one or more intervening layers. Moreover, one layer deposited or disposed between layers may be directly in contact with the layers or may have one or more intervening layers. In contrast, a first layer “on” a second layer is in contact with that second layer. Additionally, the relative position of one layer with respect to other layers is provided assuming the initial workpiece is a starting substrate and the subsequent processing deposits, modifies and removes films from the substrate without consideration of the absolute orientation of the substrate. Thus, a film that is deposited on both sides of a substrate is “over” both sides of the substrate.

[0027] Although these embodiments have been described in language specific to structural features and methodological acts, it is to be understood that the invention defined in the appended claims is not necessarily limited to the specific features or acts described in particular embodiments. The specific features and acts disclosed are to be understood as particularly graceful implementations of the claimed invention in an effort to illustrate rather than limit the present invention.

What is claimed is:

- 1. A method of fabricating a magnetic recording disk, comprising:
 - providing a magnetic recording layer having a pattern of raised areas and recessed areas formed thereon;
 - providing a mask layer on the raised areas of the magnetic recording layer;
 - electrodepositing a first protection layer on the magnetic recording layer;
 - removing the mask layer; and

depositing a second protection layer above the first protection layer.

2. The method of claim 1, wherein electrodepositing comprises electroplating.

3. The method of claim 2, wherein electroplating comprises depositing material of the first protection layer only in the recessed areas of the magnetic recording layer.

4. The method of claim 3, the first protection layer comprises a metal.

5. The method of claim 3, wherein the first protection layer comprises aluminum.

6. The method of claim 3, wherein the first protection layer comprises a silicate.

7. The method of claim 3, wherein the first protection layer comprises an insulator.

8. The method of claim 7, further comprising baking the first protection layer after electrodepositing and before depositing the second protection layer.

9. The method of claim 3, where the first protection layer comprises an aluminate.

10. The method of claim 3, wherein the first protection layer comprises a material selected from a group consisting of aluminum, gold, copper, chromium, ruthenium, platinum and rhodium.

11. The method of claim 3, wherein after electroplating the method further comprises:

- rinsing the first protection layer; and
- annealing the first protection layer before removing the masking layer.

12. The method of claim 11, wherein the masking layer comprises a non-conductive material.

13. The method of claim 3, wherein the first protection layer has a thickness less than 1 micron.

14. The method of claim 3, further comprising electrodepositing one or more additional films on the first protection layer before depositing the second protection layer.

15. The method of claim 1, wherein electrodepositing comprises electroless plating the first protection layer on the mask layer and the recessed areas of the magnetic recording layer; and wherein removing the mask layer comprises, removing the mask layer to lift off overlying first protection layer.

16. A magnetic recording disk, comprising: a magnetic recording layer having a pattern of raised areas and recessed areas; an electrodeposited first protection layer disposed only on the recessed areas; and a second protection layer disposed on the electrodeposited first protection layer and the raised areas of the magnetic recording layer.

17. The magnetic recording disk of claim 16, wherein the electrodeposited layer comprises a metal.

18. The magnetic recording disk of claim 16, wherein the electrodeposited layer comprises a silicate.

19. The magnetic recording disk of claim 16, wherein the electrodeposited layer comprises an aluminate.

20. The magnetic recording disk of claim 16, wherein the electrodeposited layer comprises a material selected from a group consisting of aluminum, gold, copper, chromium, ruthenium, platinum and rhodium.

21. The magnetic recording disk of claim 16, wherein the electrodeposited layer comprises a material having a crystalline structure.

22. The magnetic recording disk of claim 16, wherein the electrodeposited layer comprises a material having an amorphous structure.