

Method and apparatus for the high speed analysis of magnetic storage disks"

Field of the Invention

- 5 This invention relates to a method and apparatus for the detection, location and analysis of failed areas or areas of potential failure on magnetic disk storage media. The invention has application to all types of magnetic disk, including floppy diskettes and hard disk drives.

Background of the Invention

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In a magnetic disk drive, the magnetic reading head travels over the surface of the disk during the disk drive operation. The clearance between the head slider and the disk surface is typically less than 25nm. It is highly desirable to maintain a small clearance between the head and the disk surface because decreased clearance increases the disk storage capacity. Conversely
15 however, the decrease in clearance increases the probability of intermittent contacts between the head and the rotating disk surface. This can in turn lead to irrecoverable damage of the disk and loss of the data stored on the disk. Additionally, aggressive environmental factors such as high humidity or contamination may cause localised corrosion of disk material and as a consequence data damage and failure of the disk.

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Analysis of a failed disk provides valuable information as to the origin of the failure and thus, enables steps to be taken to prevent recurrence of the failure. Disk damage is however generally of very small physical dimensions and, for example, a scratch only 30nm deep will destroy the magnetic media layer on a typical disk. It is frequently extremely time consuming or impossible
25 to detect and localise damage using conventional optical or scanning electron microscopy. It is possible to detect disk damage using the spin stand which normally reads the data recorded on a disk. However, this technique does not provide any information about the damaged area or about the origin of the damage. One technique for the location of the damaged area on a disk involves the initial detection of data loss using the spin-stand, then recording of a special bit
30 pattern on the affected track, followed by visualisation and location of the damaged area using

a magnetic ink. The damaged area can then be studied using an optical microscope or using a scanning probe microscopy (SPM) technique. This approach is, however, time consuming, contaminates the disk surface and is limited to the analysis of isolated large areas of damage.

5 Another prior art technique for disk analysis involves the scanning of the entire surface of the disk using a SPM. This is, however, a time consuming procedure, which is subject to error due to the possibility of SPM tip damage, which affects the image accuracy. An additional disadvantage is that the translation of the SPM tip requires a complex and precise mechanical device.

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Disclosure of the Invention

It is the object of this invention to provide a method and apparatus for the high speed analysis of magnetic storage disks, which will overcome, or at least ameliorate, one or more of the above disadvantages.

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Accordingly, in a first aspect, this invention provides an apparatus for the high speed analysis of magnetic storage disks, said apparatus comprising scanning means to systematically traverse the disk surface and detect abnormalities in the magnetic field strength, and indexing means to index the position of abnormalities detected in the surface of the disk, and to position a high resolution imaging device for imaging and analysis of the indexed position of abnormalities.

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In a second aspect, this invention provides a method of analysing magnetic storage disks comprising the steps of systematically scanning the surface of the disk to detect abnormalities in the magnetic field strength, and positioning a high resolution imaging device to image and analyse detected abnormalities.

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In one form of the invention, the scanning employs Kerr rotation to provide a measure of magnetic field strength. In other forms of the invention, a magnetic sensor, an inductive or magnetoresistive sensor can be used to provide a measure of magnetic field strength.

30 Preferably, the scanning means and the high resolution imaging device traverse the media

surface in unison. In this way, the indexing of the position of any detected abnormality is assisted by the physical relationship between the scanning means and the imaging device.

The high resolution imaging device is preferably a SPM or more preferably an AFM.

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In the form of the invention utilising Kerr rotation as a measure of magnetic field strength, the Kerr rotation is preferably measured using a beam of polarised light directed at an oblique angle of incidence to the surface of the disk. The Kerr rotation effect can be generated by existing magnetic data on the disk, or by magnetisation of the magnetic media by the application of an external magnetic field associated with the scanning device. This field can be generated by an electromagnet or a permanent magnet.

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In a preferred form of the invention, an electro magnetic field is used to magnetise the magnetic media, and by cyclically varying the amplitude and direction of the field, and recording the consequent Kerr rotation signal amplitude, the coercivity of the magnetic media on the disk can be measured.

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Additionally, the changes in the intensity of the reflected polarised light can be used to detect physical abnormalities in the disk surface, for example, in the surface coating, which do not affect the magnetic field strength.

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Embodiments of the invention will now be described, by way of example only, with the reference to the accompanying drawings.

25 **Brief description of the Drawings**

Figure 1 is a schematic perspective drawing of an apparatus for the analysis of a magnetic storage disk according to one embodiment of this invention;

Figure 1a is a schematic view of an enlarged portion of the apparatus shown in Figure 1.

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Figure 2 is a schematic perspective view of an apparatus for the analysis of magnetic storage disks according to a second embodiment of this invention.

Modes for carrying out the Invention

5 Figures 1 and 1a show an apparatus 1 for the analysis of magnetic storage disks 2 based on the measurement of Kerr rotation. A light source 3 which can be a helium-neon laser in combination with a polariser, such as a Glan-Thomson prism is used to direct a beam of polarised light on to the surface of disk 2. The beam is directed on to a selected area of the surface 4 containing a damaged region 4a (as shown in Figure 1a). An electromagnet 5,
10 magnetises the region 4 illuminated by the polarised light. The polarised light is incident on the surface disk at the Brewster angle and is reflected to a detector and analyser 6. The detector analyser can be a photo multiplier or photo diode in combination with a Glan-Thomson prism. A standard mirror and lens focusing system or a fibre optical system can be used for the illumination of the selected area and collection of the reflected light.

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The Brewster angle of incidence of the polarised light increases the amplitude of the Kerr rotation, that is, the rotation of the plane of polarisation of the light in proportion to the magnetisation of the media. This increase in rotation amplitude achieved by the oblique incidence increases the sensitivity of the detector. Additionally, the use of Brewster angle of
20 incidence enhances the sensitivity of the intensity measurements of reflected light to irregularities in the disk surface such as thinning and variation in thickness of the carbon protective overcoating. The diameter of the illuminated area is 10-50 microns so as to detect damage having a dimension of 1 micron or smaller. The intensity measurements are sufficiently sensitive to detect a 0.1nm thick contamination or wear area on the disk surface.

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Detector and analyser 6 is connected to a control unit 7, which is in turn, connected to the probe 8 of an AFM. The control unit 7 provides an output to a detector display 9 and to an AFM display 10. Changes in the magnetic field strength of the magnetic media are reflected by a change in the amount of Kerr rotation monitored by detector and analyser 6. These changes are
30 indicative of the presence of abnormalities in the magnetic media. A positioner 11 is used to

support the disk 2 and is provided with conventional means (not shown) for rotation and translation. The positioner has fast and slow scanning modes. During the fast scan operation the rotation of the disk is provided by a spindle motor. The translational stage provides for the radial positioning or motion so as to provide the scan of the whole disk surface by the optical
5 detector. The typical commercially available parameters; spindle motor rotation speed ~2000 rpm, radial positioning ~6mm/sec enable the scanning of the whole surface of a 5.2-inch magnetic disk in 30 seconds using a 50 micron laser beam spot size. Once the damaged area on the disk is detected by the changes of the signal from the analyser the radial stage motion freezes, and a slow, eg 30 deg/sec, rotating stage provides the fine positioning of the damage
10 area under the SPM sensor again using the detector as the feedback signal for the positioning. This enables the position of any abnormalities to be located for analysis under the AFM probe 8. In practice, this requires positioning of the abnormality within 0.1mm, since the typically scanning range of the AFM probe is about 0.1 by 0.1mm. The control unit 7 performs the lowering of the AFM tip and imaging analysis of the damaged area. The data obtained by the
15 AFM can be stored and processed by computer.

It will be apparent that the technique of measuring Kerr rotation allows a fast scanning of the surface of a disk 2 to detect the location of any abnormalities for analysis using the AFM system. In a preferred arrangement, the SPM probe 8 and the Kerr rotation apparatus are
20 mounted in a fixed physical relationship so that the relative position is known. This allows a simple positioning of any abnormality under the SPM probe.

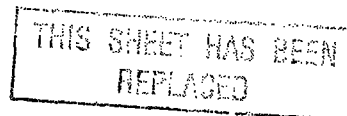
Figure 2 shows an alterhate embodiment of the invention, in which a direct measurement of the amplitude of the magnetic signal is performed. The same reference numerals indicate
25 components, the same as those described in relation to the embodiment of Figure 1. In the arrangement of Figure 2, an inductive or magnetoresistive sensor 12 is used to systematically traverse the disk 2 and locate any variations in magnetic field strength that are indicative of abnormalities in the magnetised media. Again, the control unit 7 effects movement of the positioner 11 to position any detected or abnormalities under the AFM probe 8 for analysis in
30 the same way as described above.

The method and apparatus of high speed analysis of magnetic storage disks according to this invention can be ready automated to provide for high throughput testing of disks without the need for operator control. In the above description, the invention has been described in connection with use of an AFM system for high precision analytical analysis, however, it will
5 be apparent that other suitable devices can equally be used.

The foregoing describes only some embodiments of this invention and modifications can be made without departing from the scope of the invention.



CLAIMS



1. An apparatus for the high speed analysis for magnetic storage disks, said apparatus comprising scanning means to systematically traverse the disk surface and detect abnormalities in the magnetic field strength, and indexing means to index the position of abnormalities detected in the surface of the disk, and to position a high resolution imaging device for imaging and analysis of the indexed position of abnormalities.
2. An apparatus as claimed in claim 1, wherein said scanning means employs Kerr rotation to determine the magnetic field strength.
3. An apparatus as claimed in claim 2, wherein said Kerr rotation is measured using a beam of polarised light directed at an oblique angle of incidence to the surface of the disk.
4. An apparatus as claimed in claim 2 or claim 3, wherein the measurement of Kerr rotation is performed by magnetising a section of the disk using an electromagnet.
5. An apparatus as claimed in claim 2 or claim 3, wherein the measurement of Kerr rotation is performed by magnetising a section of the storage disk using a permanent magnet.
6. An apparatus as claimed in claim 2 or claim 3, wherein the measurement of Kerr rotation is performed using the magnetisation of the disk surface through the storage of data.
7. An apparatus as claimed in any one of claims 2 to 6, wherein abnormalities are detected by a decrease in the amplitude of the Kerr rotation below a selected threshold.
8. An apparatus as claimed in claim 4, wherein the amplitude and direction of the field produced by the electromagnetic is varied cyclically to produce a measure of coercivity





of the magnetic media on the disk.

9. An apparatus as claimed in any one of claims 1 to 8, wherein the intensity of that portion of the beam of polarised light reflected from the surface of the disk is used to detect physical abnormalities in the disk surface.
10. An apparatus as claimed in claim 1, wherein said scanning means comprises a magnetoresistive sensor.
11. An apparatus as claimed in claim 1, wherein said scanning means comprising a magnetic sensor.
12. An apparatus as claimed in any one of claims 1 to 11, wherein said high resolution imaging device comprises a scanning probe microscope.
13. An apparatus as claimed in any one of claims 1 to 11, wherein said high resolution imaging device comprises an atomic force microscope.
14. An apparatus as claimed in any one of claims 1 to 12, wherein said scanning means and said high resolution imaging device traverse the surface of the disk in unison.
15. A method of analysing magnetic storage disks comprising the steps of systematically scanning the surface of disk to detect abnormalities in the magnetic field strength, and positioning a high resolution imaging device to image and analyse detected abnormalities.
16. A method as claimed in claim 14, wherein said scanning employs Kerr rotation to determine the magnetic field strength.
17. A method as claimed in claim 15, wherein said Kerr rotation is measured using a beam



of polarised light directed at an oblique angle of incidence to the surface of the disk.

18. A method as claimed in claim 15 or claim 16, wherein the measurement of Kerr rotation is performed by magnetising a section of the disk using an electromagnet.
19. A method as claimed in claim 15 or claim 16, wherein the measurement of Kerr rotation is performed by magnetising a section of the storage disk using a permanent magnet.
20. A method as claimed in claim 15 or claim 16, wherein the measurement of Kerr rotation is performed using the magnetisation of the disk surface through the storage of data.
21. A method as claimed in any one of claims 15 to 19, wherein abnormalities are detected by a decrease in the amplitude of the Kerr rotation below a selected threshold.
22. A method as claimed in claim 17, wherein the amplitude and direction of the field produced by the electromagnetic is varied cyclically to produce a measure of coercivity of the magnetic media on the disk.
23. A method as claimed in any one of claims 14 to 21, wherein the intensity of that portion of the beam of polarised light reflected from the surface of the disk is used to detect physical abnormalities in the disk surface.
24. A method as claimed in claim 14, wherein said scanning uses a magnetoresistive sensor.
25. A method as claimed in claim 14, wherein said scanning uses a magnetic sensor.
26. A method as claimed in any one of claims 14 to 24, wherein said high resolution imaging device comprises a scanning probe microscope.
27. A method as claimed in any one of claims 14 to 24, wherein said high resolution imaging device comprises an atomic force microscope.

