

"Method & apparatus for the high speed analysis of precision surfaces"

Field of the Invention

5 This invention relates to a method and apparatus for the detection, location and analysis of abnormalities on precision surfaces. As used in this specification, the term "precision surface" is intended to refer to surfaces of devices which must exhibit a high degree of uniformity in order to ensure proper operation of the device. Examples of such surfaces include the surfaces of magnetic disks, and optical disks as well as the protective layer surfaces of
10 semi-conductor devices. The invention has application to the detection of abnormalities such as wear marks, indentations, asperities, changes in surface roughness, thinner overcoat, thicker lubricant layer and corrosion sites on these surfaces.

Background to the Invention

15 In the following description, the invention will primarily be described with reference to the analysis of magnetic storage disks, by way of example only. 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
20 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 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
25 or contamination may cause localised corrosion of disk material and as a consequence, data damage and failure of the disk.

 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,
30 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 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
5 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 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
10 consuming, contaminates the disk surface and is limited to the analysis of isolated large areas of damage.

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
15 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.

Similar difficulties exist in relation to the quality control of semi-conductor devices such
20 as microchips. Typically, microchips are protected by a surface coating layer of oxide or polymer about $10\mu\text{m}$ thick. Failure of the protective layer can be a result of corrosion, electric breakdown, and manufacturing failures such as holes, pits and composition breakdowns. The typical area size of surface abnormalities in the protective layers is of the order of $1\mu\text{m}$.

25 Disclosure of the Invention

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

Accordingly, in a first aspect, this invention provides a method for the high speed analysis of precision surfaces for abnormalities comprising the steps of irradiating the surface with a beam of light, detecting changes in the optical properties of light reflected from the surface to locate said abnormalities, determining the position of said abnormalities and
5 positioning a high resolution imaging device at the location of the determined position for the analysis of the abnormality.

In a second aspect, this invention provides an apparatus for the high speed analysis of precision surfaces for abnormalities, said apparatus comprising scanning means to sequentially
10 irradiate the surface with a beam of light, detecting means to detect changes in the optical properties of the light reflected from the surface indicative of said abnormalities, indexing means to index the position of detected abnormalities and to position a high resolution imaging device at the indexed position for analysis of the abnormality.

15 In one form of the invention, the scanning employs a beam of polarised light and the detected change in optical property is a change in the plane of polarisation. In an alternate form of the invention, the detected change in the optical property of the reflected light is a change in intensity. Preferably, the beam of light is directed at an oblique angle of incidence to the precision surface.

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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.

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

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

Brief Description of the Drawing

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

Modes for carrying out the Invention

Figure 1 shows an apparatus 1 for the analysis of magnetic storage disks 2. 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. 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. The use of Brewster angle of incidence enhances the sensitivity of the intensity measurements of reflected light to irregularities in the disk surface such as thinning and variations 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.

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. Abnormalities in the surface 4 result in change in the plane of polarisation of the reflected light monitored by detector and analyser 6. 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 translation stage provides for the radial positioning or motion so as to provide the scan of the whole disk surface by the optical 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
5 deg/sec, rotating stage provides the fine positioning of the damage 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
10 imaging analysis of the damaged area. The data obtained by the AFM can be stored and processed by computer.

It will be apparent that the above described technique allows a fast scanning of the surface of a disk 2 to detect the location of any abnormalities for analysis using the AFM
15 system. In a preferred arrangement, the SPM probe 8 and the scanning apparatus are 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.

It will be apparent that the AFM system also provides a means of measuring the
20 roughness of the surface. Roughness measurements are the major topographic parameter for quantifying surface finish and homogeneity, particularly for magnetic disks. Similarly, an AFM technique can be used to produce hardness measurements of surface coatings by analysis of nanoindentations made in the surface.

25 The method and apparatus of high speed analysis of precision surfaces according to this invention can be readily automated to provide for high throughput testing 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 be apparent that other suitable devices can equally be used.

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



CLAIMS

1. A method for the high speed analysis of precision surfaces for abnormalities comprising the steps of irradiating the surface with a beam of light, detecting changes in the optical properties of light reflected from the surface to locate said abnormalities, determining the position of said abnormalities and positioning a high resolution imaging device at the location of the determined position for the analysis of the abnormality.
2. A method as claimed in claim 1, wherein said beam of light is a polarised beam and the detected change in optical property is a change in the plane of polarisation of the reflected light.
3. A method as claimed in claim 1, wherein the detected change in optical property of the reflected light is a change in intensity.
4. A method as claimed in any one of claims 1 to 3, wherein said beam is directed at an oblique angle of incidence to the precision surface.
5. A method as claimed in any one of claims 1 to 4, wherein said high resolution imaging device comprises a scanning probe microscope.
6. A method as claimed in any one of claims 1 to 4, wherein said high resolution imaging device comprises an atomic force microscope.
7. An apparatus for the high speed analysis of precision surfaces for abnormalities, said apparatus comprising scanning means to sequentially irradiate the surface with a beam of light, detecting means to detect changes in the optical properties of the light reflected from the surface indicative of said abnormalities, indexing means to index the position of detected abnormalities and to position a high resolution imaging device at the indexed position for analysis of the abnormality.



8. An apparatus as claimed in claim 7, wherein said beam of light is a polarised beam and the detected change in optical property is a change in the plane of polarisation of the reflected light.
9. An apparatus as claimed in claim 7, wherein the detected change in optical property of the reflected light is a change in intensity.
10. An apparatus as claimed in any one of claims 7 to 9, in which said beam is directed at an oblique angle of incidence to the precision surface.
11. An apparatus as claimed in any one of claims 7 to 10, wherein said high resolution imaging device comprises a scanning probe microscope.
12. An apparatus as claimed in any one of claims 7 to 10, wherein said high resolution imaging device comprises an atomic force microscope.
13. An apparatus as claimed in any one of claims 7 to 12, wherein said scanning means and said high resolution imaging device traverse the surface of the disk in unison.