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TEXTURING TECHNIQUE FOR SPUTTERED MAGNETIC DISK

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1. INTRODUCTION

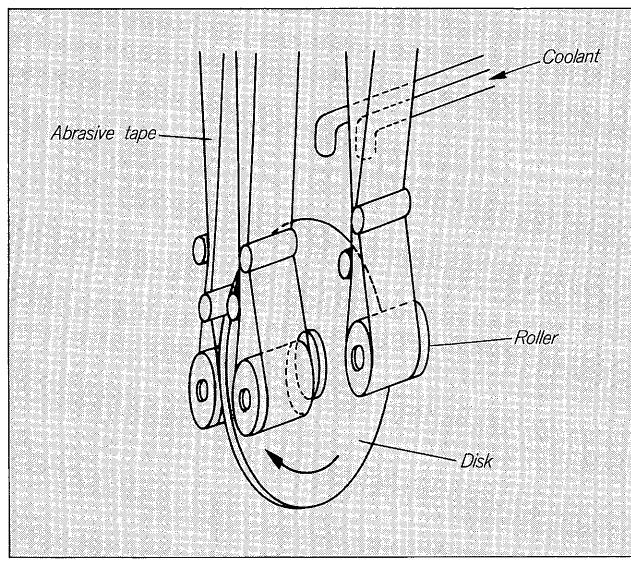
It is expected that the advance of miniaturization and lightening of hard disk drive systems will be accompanied by the increasing installation of hard disk systems to not only desktop type, but also laptop and handy type personal computers. Because turning on and off of the power supply and the application of shock of laptop type and other easy to carry personal computers are considered, in particular, keeping high reliability of the hard disk system is very important.

Generally, Al alloy is used as the substrate of sputtered magnetic disk. However, since Al alloy is soft, it is not durable against head shock. To counter this, an Ni-P plating film of about 10 μm is formed on the surface of the Al alloy. To maintain the durability of the disk surface against CSS, a roughness of several 10 Å is applied by a mechanical process known as "texturing". This texturing serves to reduce the stiction force and friction force between the head and sputtered magnetic disk and prevent wear and damage. It is known that another advantage of texturing is that it increases the magnetic characteristics, especially the coercivity and squareness in the texturing direction. This effect is also used extensively. Texturing plays an extremely important role from the standpoints of maintaining the reliability of CSS durability, etc. and the preferred orientation of the magnetic characteristics in the circumferential direction.

2. TEXTURING TECHNOLOGY

The Fuji Electric tape texturing process is shown in *Fig. 1*. Processing is performed by pressing abrasive tape wrapped around a roller against the surface of the rotating disk and dripping coolant between the disk and the tape. Fuji Electric performs this processing with two tapes based on the role of the separate functions. First, the roller at the right side of *Fig. 1* is pressed against the disk and texturing with a center line mean roughness Ra of several 10 Å is performed. Next, the right side roller is raised and at the same time, the left side roller is pressed against the disk and 2nd tape processing is performed. The purpose of 2nd tape processing is the removal of irregular projections generated during 1st tape processing.

Fig. 1 Tape texture processing method



The control factors by this processing system are:

- 1st and 2nd tapes (abrasive material, resin material, distribution of abrasive material, etc.)
- Coolant (liquid concentration, material)
- Tape traverse speed
- Disk rotating speed
- Contact pressure
- Roller hardness
- Processing time
- Oscillation

Because these factors are intertwined, to control the surface roughness, advanced techniques with which ample experience has been accumulated are necessary. The main control factors from among the items above are described below in detail.

2.1 Difference of texture due to process tape differences

The process tape generally used made by embedding an abrasive material in the resin coated on the surface of the tape. It is known that the grinding characteristic depends on the size, shape, and distribution of the grains.

Fig. 2 SEM images of tape surface

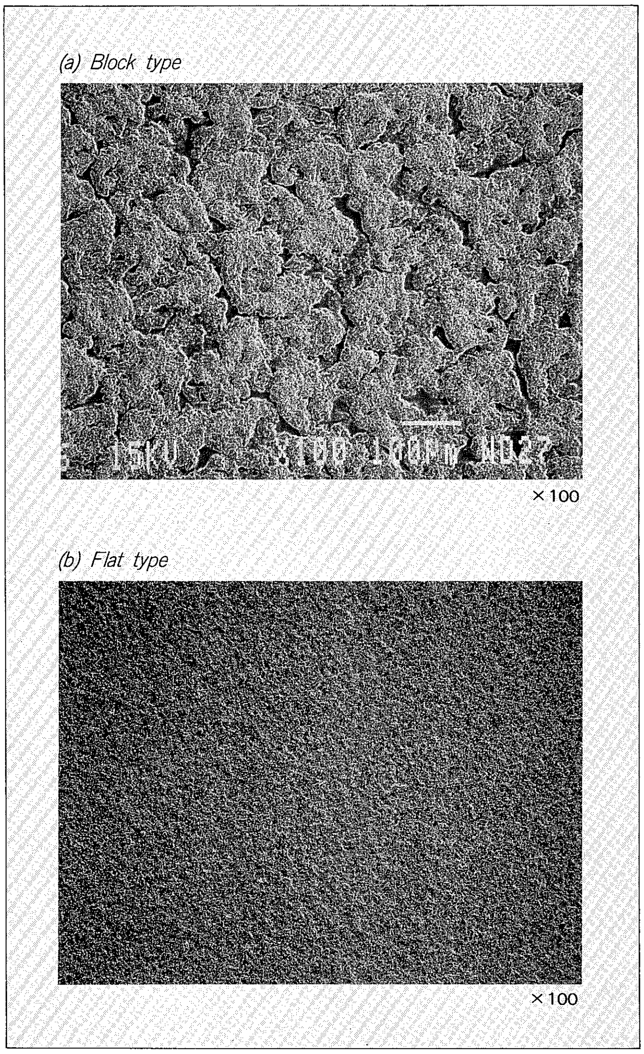
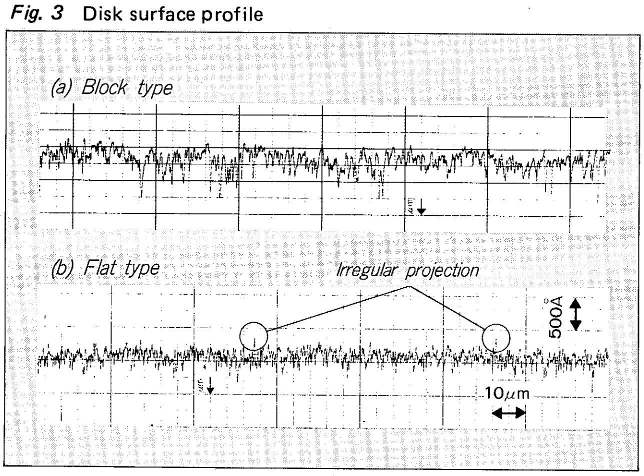


Fig. 3 Disk surface profile



For instance, *Fig. 2* compares the SEM images of the surface of tape whose grain distribution has a block type aggregate structure (block type) and tape whose grain distribution has a mean distribution (flat type). *Figure 3* shows the results of measurement of the surface profile

Fig. 4 Roller contact pressure dependence of R_a and t_p (10%–1%)

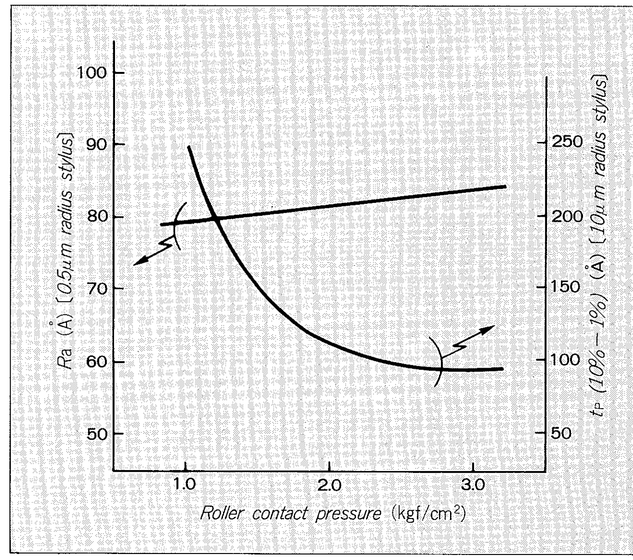
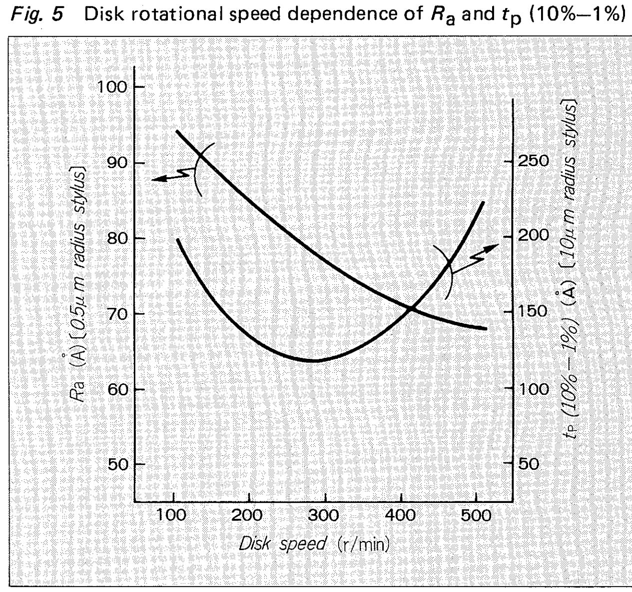


Fig. 5 Disk rotational speed dependence of R_a and t_p (10%–1%)



of disk processed with the two types of tape shown in *Fig. 2* with a stylus radius $R = 0.5\ \mu m$ stylus profiler. For the block type, the peak value spacing is wide and a comparatively large waviness is seen. One feature of the block type is the small number of irregular projections. The flat type, on the other hand, has a comparatively large number of irregular projections and has substantially different features than the block type. Because the block type has a block type aggregate organization and the distribution of the grains in the block is not uniform, as shown in *Fig. 2*, texturing is performed in the state in which pressure is concentrated at several specific points per unit area. It is thought that the waviness, R_a, etc. show a large value at the pressure concentration points because the disk surface appears to have been cut with a cutter with a sharp blade. With the flat type, on the other hand, a state in which pressure is applied evenly to many grains is achieved. It is thought that the differences previously mentioned are the result of these circumstances.

2.2 Effect of processing conditions on surface roughness

Figure 4 shows the dependence of R_a (center line mean roughness) and the difference, t_p (10%–1%), of the cutting depth corresponding to 10% and 1% of the bearing length on the curve of the profile bearing length ratio on the roller contact pressure. In the region where the pressure is low, the t_p value tends to rise. A large t_p value means that the number of irregular projections is large. Generally, because the formation of valleys increases as the number of turn-ups increases, it is thought that the higher the contact pressure, the larger the valley formation. Therefore, when the contact pressure is reduced, texturing is performed at the part sharper than the head of the grain and the number of turn-ups is small and, therefore, valley formation is small. Conversely, since the energy of the cutting edge of the individual grains increases relative to the texturing surface, the surplus energy is converted to heat and irregular projection are thought to be formed by the abundant melting and adhesion of scraps.

Figure 5 shows the dependence of R_a and t_p (10%–1%) on the disk rotation speed. R_a and t_p (10%–1%) both show minimum values at a certain rotation region. As the speed increases, the grinding character curve rises because the energy is large. On the other hand, since the effect of centrifugal force causes a liquid layer to form between the tape and disk, the grinding character curve drops. The surface roughness is selected by balancing these two characteristics. In the 100 to 300 r/min region, the effect of the former is thought to be greater. At rotation speeds above 300 r/min, the t_p (10%–1%) tends to again increase noticeably. This is thought to be due to melting and adhesion of scraps previously mentioned caused by an increase in the thickness of the liquid film between the tape and disk and a subsequent drop in the effective contact pressure.

3. SURFACE PROFILE MEASUREMENT

To form a surface with excellent friction and flying height characteristics, not only process technique, but also a positive grasp of the surface profile are necessary. The disk surface can be measured by the stylus profiler method, optical profiler that uses the reflection of a laser beam, etc. instead of a stylus, a method using optical interference such as that represented by WYKO products, STM/AFM, SEM, and other methods. Of these methods, the extremely beneficial stylus profiler and STM/AFM methods actually used by Fuji Electric in management and analysis are described.

3.1 Stylus profiler

Since the stylus profiler measures the surface roughness by running a stylus along the surface of the magnetic disk, the measured value varies considerably with the change of shape of the stylus due to wear, differences in the shape of

Fig. 6 Surface profile by stylus profiler

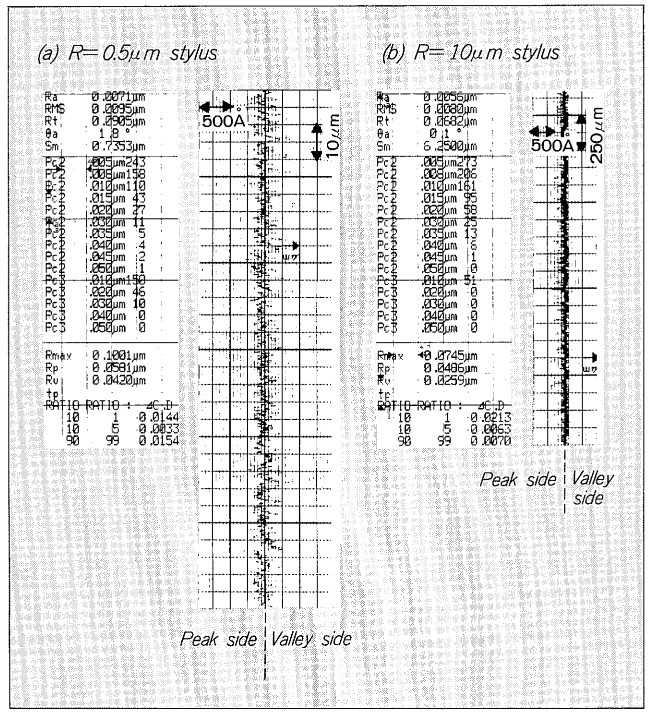
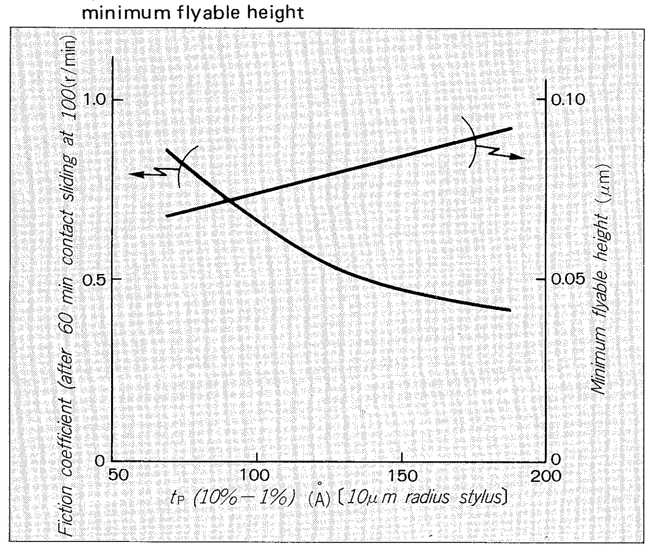


Fig. 7 t_p (10%–1%) dependence of friction coefficient and minimum flyable height



individual styluses, etc. In addition, ample consideration must be given to stylus management. Except for this, however, it is an effective technique from the standpoint of line control because measurement can be made at a comparatively fast speed without selecting whether the objective is on the Ni-P plating layer or the C layer. Fuji Electric carries out management and analysis by combining two types with stylus radiuses R of 10 μm and 0.5 μm. *Figure 6* shows a comparison of the profiles when the same objective was measured using styluses with a radius R of 10 μm and 0.5 μm. For the R = 10 μm stylus, since the end of the stylus is thick, the stylus does not enter shallow

Fig. 8 R_a dependence of coercivity and squareness

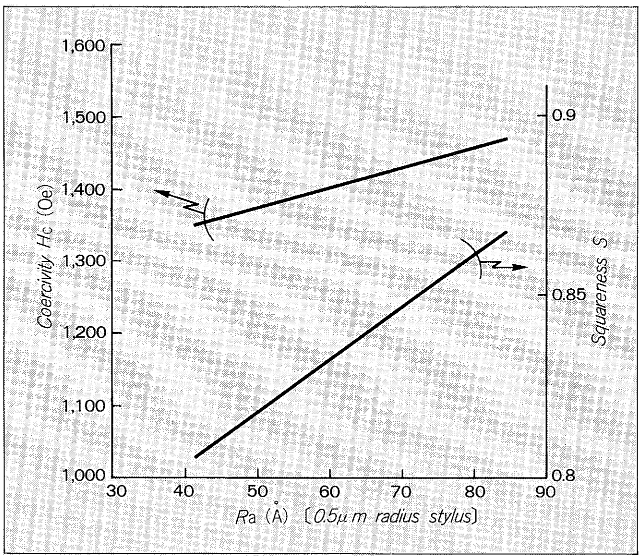
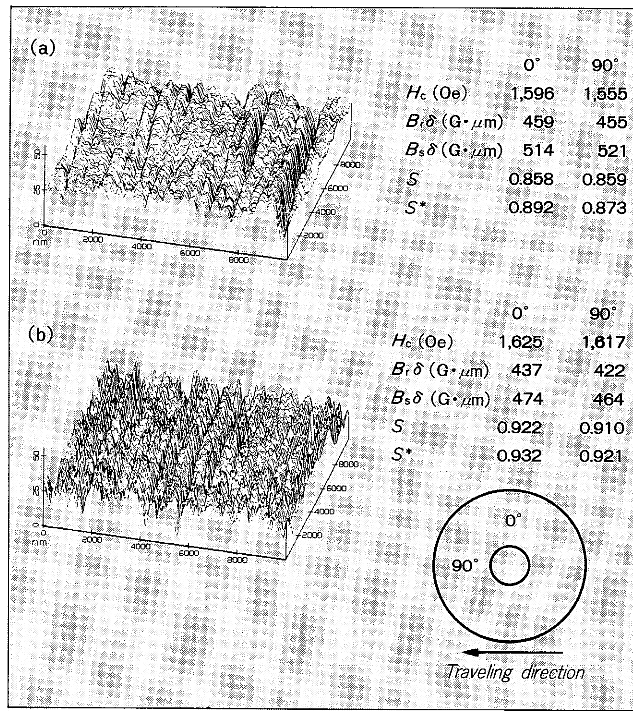


Fig. 9 STM image and magnetic characteristics of disk surface



valleys, but its sensitivity to peak information is high. The $R = 0.5$ μm stylus, on the other hand, has high valley side sensitivity and low peak side sensitivity. Needless to say, since these sensitivity differences are caused by line scan, this problem can be solved by two dimensional scanning. However, in this case, the high-speed advantage is lost. Therefore, the combined use previously mentioned is desirable. *Figure 7* shows the dependence of the friction coefficient and minimum flyable height on t_p (10%–1%) when surface roughness was measured with an $R = 10$ μm stylus. In this case, it is obvious that the friction coefficient and minimum flyable height are closely related to t_p (10%–1%). However, this relationship is not discerned when the surface roughness was measured with an $R = 0.5$ μm stylus. *Figure 8* shows the dependence of coercivity and squareness on R_a when the surface roughness was measured with an $R = 0.5$ μm stylus. Regarding the magnetic characteristics, magnetization occurs easily in the preferred orientation along the texture grooves. This effect is especially large for deep grooves. The relationship between these is also difficult to grasp when an $R = 10$ μm stylus is used.

3.2 STM/AFM

Whereas the stylus profiler is suitable for comparatively macro reading, there is a method using STM/AFM as a technique which allows more micro reading. Since STM performs detection using the tunnel current generated between the tip of the stylus and the specimen and, theoretically, an atomic image can be captured, it is sufficient for viewing the disk surface.

Figure 9 shows the STM image and magnetic characteristics values of the surface when processed with different abrasive material. Generally, for an in-line sputtering machine, when a textured substrate is used, uniaxial anistropy occurs easily in the direction parallel to the traveling direction and a two peaks cycle change appears in the playback signal envelop. *Figure 9* (a) is an example in which this characteristic appears clearly. The 0° position circumferential direction coercivity and squareness are larger than those at the 90° position. Conversely, *Fig. 9* (b) is an example in which the difference in the magnetic characteristics at the 0° and 90° positions is small. Perhaps condition (b) generates texture traces at a smaller pitch as seen in the STM image. It is thought that there is a stronger orientation along the texture grooves. Such profile differences cannot be grasped with the stylus profilers and other techniques.

4. AFTERWORD

Controlling the surface roughness at a level of several Å to several 10 Å and accurately measuring the surface profile require extremely advanced technology. To realize these in the demand for low flying and high reliability, new technology must be challenged. Processing using a slurry is one of the methods Fuji Electric is currently focusing attention on as next generation technology. The feature of this method is that lowering the flying height is comparatively easy. In the future, Fuji Electric will carry out design considering the balance with the CSS characteristics and wants to establish mass production techniques.