A SCANNING METHOD TO STUDY THE INFLUENCE OF ROUGHNESS, MICROWAVINESS, AND LUBRICANT THICKNESS VARIATION ON SLIDER DYNAMICS

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ABSTRACT

Flying height modulation maps and microwaviness maps are obtained by using laser Doppler vibrometry (LDV) and acoustic emission (AE) transducers which are moved radially over the complete disk surface. The sensitivity of the acoustic emission measurement is improved by applying a current to the write element, thereby increasing pole tip protrusion. Disk and slider displacement maps are obtained using a radially scratched disk. Acoustic emission maps are presented for a scratched disk and for a non-scratched disk. For the non-scratched disk, AE maps are obtained with an inactive and active write element.

INTRODUCTION

Microwaviness near the second slider pitch resonance frequency (P2) of approximately 250kHz causes flying height modulations. Depending on the rotational speed and the radius of the disk one finds that these wavelengths are typically in the range from 50\(\mu\)m to 250\(\mu\)m. The P2 frequency of a slider changes with flying height and pole tip protrusion of the read/write element. Zeng and Thornton [1, 3] have studied the influence of microwaviness on slider flying height modulation on a single track using glass and aluminum substrates. In this paper we extend their method from a single track to the entire disk. In addition, we investigate the effect of thermal pole tip protrusion on slider to disk compliance. To obtain measurements over the whole disk surface, we use a stepper motor which carries the slider/suspension assembly and the optical head of a laser Doppler vibrometer (LDV). The stepper motor allows positioning of the slider over the disk surface. The optical head is mounted rigidly relative to the slider.

As the slider disk clearance decreases, the disk roughness, microwaviness and lubricant distribution needs to become increasingly more uniform to minimize flying height modulation. Microwaviness variations over the disk surface or within one revolution of the disk can affect the slider flying behavior and may lead to increased lubricant pickup. Therefore, instrumentation is needed that allows the evaluation of slider dynamics over the entire disk.

EXPERIMENTAL SETUP

In Figure 1 a schematic of the experimental setup is shown. The setup consists of an air bearing spindle, a fixture for mounting the suspension/head assembly, a laser Doppler vibrometer (LDV), an acoustic emission (AE) sensor and a data acquisition system. The air bearing spindle is computer controlled to allow adjustment of the rotational speed of the disk. The spindle provides an index pulse for each rotation. The suspension is attached to the lower shaft of a computer controlled stepper motor assembly, while the laser head is connected to the upper shaft. The dual shaft stepper motor allows exact positioning of the slider and the laser above the disk surface, while preventing relative motion between the two components. An AE sensor is attached to the base of the suspension. An LDV was used to measure slider displacement. The stepper motor was controlled via the serial port of a data acquisition computer. MATLAB was used for data acquisition and processing and for the control of the stepper motor.
RESULTS

Figure 2a shows a polar plot of the disk topography using an LDV. Two well defined regions of high disk displacement are observed, corresponding to two radial scratches on the disk surface. Figure 2b shows a polar plot of the slider displacement. We observe that large vibration amplitudes of the slider are exited by the two scratches. The displacement of the slider was determined at radial positions for which the disk displacement was measured previously. Thus, the difference in the two displacement signals corresponds to the flying height modulation of the slider. Figure 2c shows a polar plot of the AE signal of the disk with the slider present. We observe a strong AE signal at the position of the scratches.

Figure 2. POLAR PLOTS: a) LDV OF DISK, b): LDV OF SLIDER, c): AE

Figure 3a and 3b show AE maps for a head/disk interface with and without thermal pole tip protrusion. The AE signal is plotted for a single revolution for a number of disk radii versus the angular position on the disk, i.e., from 0° to 360°. A new disk without scratches was used. In Figure 3a a variation in the AE signal is observed for all radii at an angular position of approximately 80° and 180°. This increase in the AE signal appears to be related to a variation in roughness, microwaviness, or lubricant thickness of the disk. No write current was applied during the AE measurement in Figure 3a. Figure 3b was obtained by using the same slider and disk but with a write current applied during the entire mapping process. Auxiliary measurements have shown that the write current that was used causes a pole tip protrusion of approximately 1nm, i.e., pole tip protrusion reduces the minimum head/disk spacing. The reduction in minimum spacing results in the increase of the AE signal at the angular positions 80° and 180°, i.e., increased pole tip protrusion increases the AE activity at the head/disk interface.

SUMMARY

A scanning technique was introduced that allows the investigation of roughness, microwaviness and lubricant variation on slider dynamics. The method was tested using a disk with a radial scratch. AE maps were obtained, showing the potential of the method for investigation of roughness, microwaviness or lubricant variation on the disk surface.

REFERENCES