Static and Dynamic Characteristics of Active-head Sliders

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Active-head sliders with a unimorph piezoelectric actuator for flying height control were experimentally evaluated. It was found that the normalized stroke of the actuator is 5.2 to 6 nm/V/mm without flying over the disk. However, the normalized adjustment range of flying height is about 1.6 nm/V/mm when the active-head slider is flying over the disk. This value is smaller than the measured value when the slider is not flying, because of the air pressure generated at the active pad when the pad approaches the disk surface.
Keywords : Active-head Sliders, Flying Height, Flying-height Adjustment

1. INTRODUCTION

Ever increasing recording densities requires that a slider in a hard disk drive must have an ultra-low flying height [1]. It is obvious that at such a low flying height, deviation in the flying height of individual sliders due to manufacturing tolerances will become a big issue. Active sliders, which enable flying height to be adjusted for contact recording [2] or load/unload on demand systems [3], have been developed. Pico-sized active-head sliders, which allow the flying height to be adjusted individually so that manufacturing tolerances can be compensated, have been developed in our previous research [4]. These sliders carry a unimorph piezoelectric micro-actuator and their flying height can be controlled. In the current study, static and dynamic characteristics of such active-head sliders were investigated by laser Doppler vibrometer, Wyko interferometer, and flying height tester.

2. EXPERIMENTS

Figure 1 illustrates the concept of an active-head slider. The slider has a unimorph piezoelectric actuator for adjusting its flying height. When an electric voltage is applied, the piezoelectric actuator drives the head upwards and downwards.

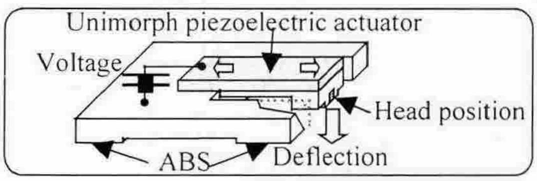


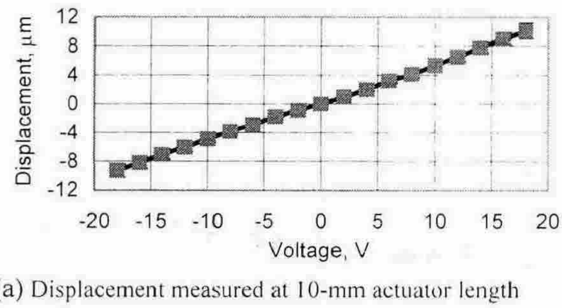
Fig. 1 Concept of an active-head slider

The active-head slider consists of a layer of bulk lead-zirconate-titanate (PZT) ceramic and a layer of silicon mono-crystal. The two layers are joined with adhesive. To model the active head, an actuator bar was fabricated. The stroke of the actuator bar was measured by laser displacement meter. The slider was fabricated by a silicon MEMS (micro electro-mechanical systems) process. Kurita et al. described the MEMS fabrication process in detail in [4]. The fabricated active-head slider was amounted on a suspension for 2.5-inch disk drives. The electrodes on the suspension flexure for the read/write heads are used to supply voltage to the actuator. The deformation characteristics of the sliders' active head were evaluated by Wkyo interferometer, and the flying height characteristics were evaluated by flying height tester.

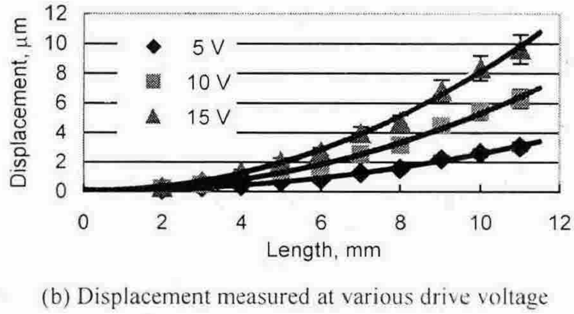
3. EXPERIMENTAL RESULTS

3.1 Stroke of actuator

Figure 2(a) shows the displacement of the actuator bar as a function of drive voltage for a 10-mm actuator length. It is clear that displacement increases linearly with increasing drive voltage. Figure 2 (b) shows the displacement of the actuator bar as a function of actuator length under DC drive voltage of 5, 10, or 15 V.



(a) Displacement measured at 10-mm actuator length



(b) Displacement measured at various drive voltage

Fig. 2 Displacement of the actuator bar as a function of drive voltage and actuator length

In principle, the displacement of the actuator, δ, can be described approximately by the following equation [5],

$$\delta = CL^2V \quad (1)$$

where L is the length of the actuator, V is drive voltage, and C is a constant. According to this equation, the normalized stroke of the actuator was calculated by extrapolating measured head displacement. The results show that the normalized stroke of the actuator is about 5.2 to 6 nm/V/mm, which agrees well with the numerical calculation.

Figure 3 shows that the air-bearing surface (ABS) of the fabricated active-head slider measured by Wyko interferometer. The displacements were also measured by Wyko interferometer, when a DC voltage was applied to the fabricated active-head sliders. The measured stroke was about 6 nm/V/mm, which is consistent with the value measured using the actuator bar. An AC voltage was applied to the actuator and the movement was measured by a laser Doppler vibrometer (LDV). Figure 4 shows the frequency response of the fabricated active-head slider. The maximum peak indicates that the resonant frequency is 243 kHz. This value suggests that the response of the head movement to drive voltage is fast enough for tracking the run-out of the disk surface.

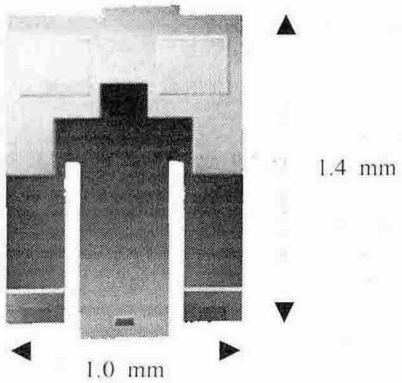


Fig. 3 ABS of the fabricated active-head slider measured by Wyko

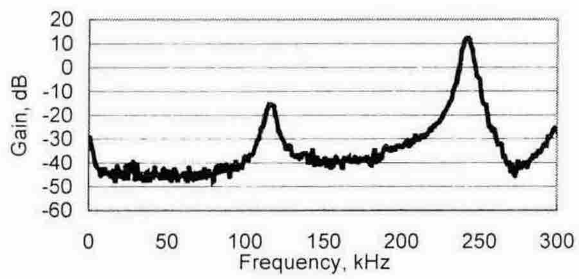


Fig. 4 Frequency response of fabricated active-head sliders

3.2 Flying height test

Figure 5 shows flying height as a function of drive voltage. It is clear that the flying height of the central trailing pad decreases with increasing drive voltage, while the flying height of the outer trailing pad increases with increasing drive voltage. This result shows that the flying height can be adjusted by applying a voltage to the piezoelectric actuator. The flying height of the central trailing pad decreases from 14 to 8 nm under a drive voltage of 15 V. The normalized adjustment of the flying height is about 1.6 nm/V/mm when the active-head slider is flying over the disk. This is significantly smaller than the measured value when the slider is not flying.

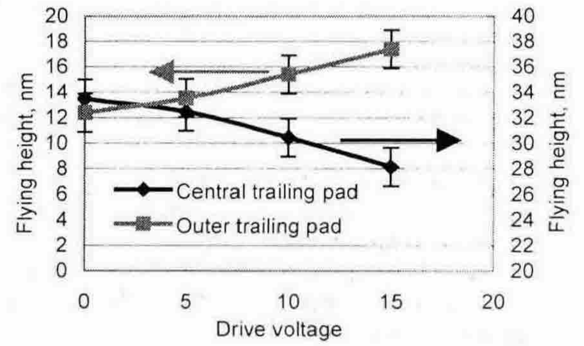


Fig. 5 Flying height as a function of drive voltage

4. DISCUSSION

The range of the flying height adjustment less than the stroke of the non-flying head is because of the air pressure generated at the active pad (central trailing pad). That is, the air pressure on the active pad (central trailing pad) increases when the pad approaches the disk surface (i.e., flying height decreases). This pressure increase results in a partial reversal of the decrease in flying height, and it should be taken into account in future active-head slider designs.

5. CONCLUSIONS

Active-head sliders with a unimorph piezoelectric actuator for flying height control were fabricated and experimentally evaluated. The following conclusions were drawn.

1) The measured stroke of the actuator is 5.2 to 6 nm/V/mm when the slider is not flying.

2) The normalized adjustment range of flying height is about 1.6 nm/V/mm when active slider is flying over disk.

5. REFERENCES

[1] Menon, A.K., "Interface Tribology for 100 Gb/in^2", Tribology International, Vol. 33, pp. 299–308, 2000

[2] Yeack-Scranton, C.E., Khanna, V.D., Etzold, K.F., and Praino, A.P., "An Active Slider for Practical Contact Recording", IEEE Trans. Magn., Vol. 26, No. 5, pp. 2478-2483, 1990

[3] Tagawa, N., Seki, H., Kitamura, K., and Mori, A., "Development of Novel PZT Thin Films for Active Sliders Based on Head Load/Unload on Demand Systems", ASME 12th Annual Symposium on Information Storage and Processing Systems, 2001

[4] Kurita, M., Yamazaki, T., Kohira, H., Matsumoto, M., Tsuchiyama, R., Xu, J., Harada, T., Inoue, Y., Su, L.Z., and Kato, K., "An Active-head Slider with a Piezoelectric Actuator for Controlling Flying Height", presented at Intermag 2002

[5] Yeack-Scranton, C.E., Khanna, V.D., and Praino, A.P., "Mechanical Aspects of Active Sliders for Contact Recording in Rigid Disk Files", Tribology and Mechanics of Magnetic Storage Systems, Vol. VII, STLE SP-29, pp. 158-164, 1990