Active Flying-height Control of Magnetic Head Slider using MEMS Thermal Actuator

Masayuki Kurita, Hitachi, Ltd.

Toshiya Shiramatsu, Hitachi, Ltd.

Koji Miyake, Hitachi Global Storage Technologies Japan, Ltd.

Hideaki Tanaka, Hitachi Global Storage Technologies Japan, Ltd.

Shozo Saegusa, Hitachi Global Storage Technologies Japan, Ltd. (Currently Hiroshima University)

1. Abstract

As the recording density of hard-disk drives (HDDs) has rapidly increased, the flying height of magnetic head sliders has to be decreased to less than 10 nm.

The wide distribution band of flying heights caused by wide manufacturing tolerances and environmental variations, was the largest obstacle to reducing the flying height (Fig. 1). To reduce the distribution band, we have developed a thermal flying-height control (TFC) technique. This technique can be used to adjust the flying heights of sliders on demand by means of a built-in micro-actuator. This new technique enhances the performance and improves the yield rate of HDDs.

2. Operational details

The margin of head/disk clearance for conventional magnetic head sliders is shown in Figure 1. To the hold flying slider not contact the disk, we had to keep the flying-height margin to cope with manufacturing tolerances and environmental variations.

The concept of the TFC technique is shown in Figure 2. The flying-height of the magnetic head slider is designed not to contact the disk, similarly as conventional sliders. The slider mounts a micro thermal actuator (resistive thin film) near the read/write elements so that the flying height can be controlled on demand. When an electric current is applied to the actuator, a thermal expansion caused by the heat generated in the actuator produces a nanometer-scale protrusion on the air-bearing surface. This protrusion controls the clearance between the head and disk.

By keeping the clearance minimum, we can significantly improve both performance and reliability. The features of this micro thermal actuator are listed below.

1) Actuator stroke is proportional to the power supply.

2) Power consumption is about 10 mW per 1 nm change in flying-height. Variations in flying height can be adjusted using a small amount of power.

3) Actuator response is fast enough to finish the movement during the head-change or track seeking interval. Time constant (time for 63% displacement) is less than 200 micro seconds.

The research and development of this technique are shown in Figure 3. At first, by using a variety of mechanical engineering skills, such as numerical simulations of heat transfer, deformation, and air bearing lubrication, we had designed the thermal actuator. Secondly, we mounted the actuator onto the head slider using a Micro Electro-Mechanical Systems (MEMS) fabrication process and it was tested by a spin stand to evaluate the performance. Finally, we integrated this new slider into a prototype HDD and evaluated the read/write performances.

This fabrication process is applicable to conventional wafer fabrication processes of magnetic heads. Comparing with the fabrication process of other actuator systems, such as piezoelectric actuators, this process has two main advantages: mass production capability with higher yield rate and lower integration costs.

3. Conclusion

After we had improved the actuator design on the basis of the R&D results shown in Fig. 3, we applied TFC technique to Hitachi HDD products. Starting with our award-winning 2.5" drive 'Travelstar 5K160' for laptop PC use, all Hitachi drives will be made with this technique. These drives include the 1-Terabyte 3.5" HDD, which is named the 'Deskstar 7K1000' and designed for desktop PC use, the 1.8" HDD, or 'Travelstar C3K80' for use in camcorders, and the 'Endurastar J4K50' for automotive applications that withstand sever temperature range, such as -30 to +85℃ (Fig. 4).

By using this technique, the reliability of drives may be enhanced and the cost may be decreasing, and the quality of our IT life will be increased much move.

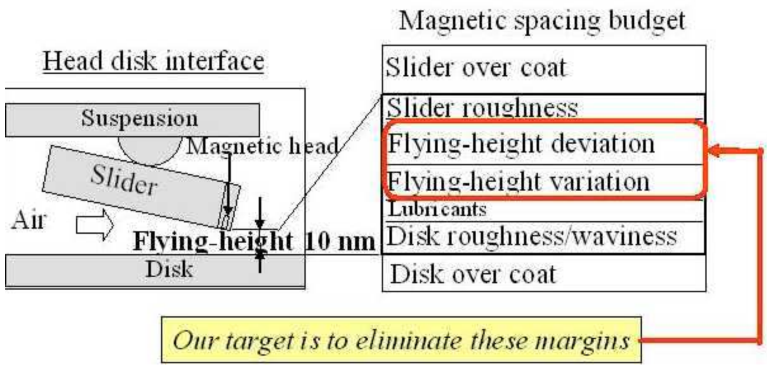
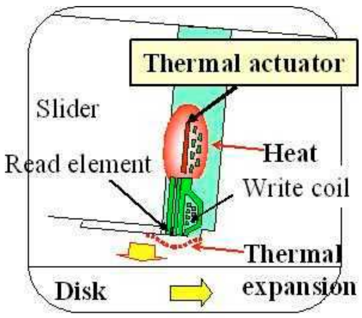


Fig. 1 Margin of magnetic spacing, and our target



- Adjust flying-height variation by thermal expansion
- Surpass the current limits of robust design

- Key features
  (1) Mass productivity, low integration cost
  (2) Low power consumption (10 mW/nm)
  (3) Fast response (time constant: less than 200 micro seconds)

Fig. 2 Concept and features of TFC technique

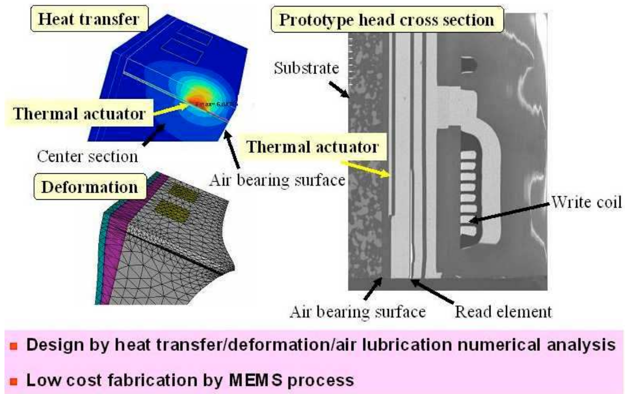


Fig. 3 Research and development (prototyping) of TFC technique

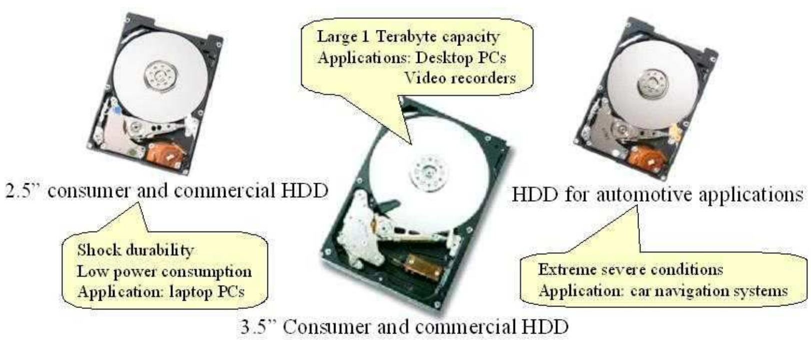


Fig. 4 HDD products that use TFC technique