# Investigation of Demnum-based PFPE lubricant thickness tendency with mixture of additive on magnetic hard disk head-disk interface (HDI) tribological performance

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ABSTRACT – A series of lube thickness matrix using Demnum-typed perfluoropolyether (PFPE) lubricant embedded with small traces of additive (ADOH) were evaluated so as to determine the head-disk interface (HDI) tribological performance of magnetic disks. The thickness of the main PFPE coated on the magnetic disks was varied from 6.5Å to 10.5Å, with the increment of 1.0Å for each condition. HDI tribological performance of these thin films in terms of flying characteristic and media durability were investigated based on the head touchdown, altitude-drag and burnish. The results obtained revealed that the HDI performance were strongly dependent on the lubricant thickness.

## 1. INTRODUCTION

To date, with the requirement of achieving anticipated areal density capacity of future rigid magnetic disk, the spacing between the read-write element and the rigid disk surface in hard disk drives has become critically small and narrow (1-2 nm) [1]. The magnetic layer in recording media is protected by a diamond-like carbon over coat together with a layer of lubricant applied on top of it. The boundary lubricant of choice in today hard-disk drives (HDDs) continues to be perfluoropolyether (PFPE), preferably with functional end groups. This is to enhance its absorption to the magnetic disk carbon overcoat thin film. This allows the lubricant to be retained onto the disk surface for extended period in an extreme environment such as high temperature and high rotation rates [2]. Hence, in the current hard-disk drive systems, a molecularly thin film of 1.0-1.5 nm perfluoropolyether lubricant is topically applied to the carbon overcoat of the magnetic recording media to reduce the stiction force and wear when the head-disk contact each other [3].

Magnetic disks of 65mm in diameter were coated with different thickness of PFPE lubricant with mixture of additive. HDI flyability performance was evaluated based on the touchdown power of the head slider when the slider's pole tip area was thermally expanded and protruded until it touched the disk surface. The HDI reliability was measured based on the head burnish of slider trailing edge after continuous contact between slider and disk surface. The altitude drag measurement of magnetic disk under low pressure condition to obtain the failure point from the interface friction between disk and head was introduced as the durability test. The work reported herein addresses some of the advantages and

drawback of lubricant thickness towards HDI properties and thus provide a trade-off balance and direction for the optimization of the HDI performance. In particular, we investigate the HDI flyability and durability as a function of D4OH film thickness with traces of ADOH additive as there are relatively few studies on this kind of lubricant mixture in the tribology application of magnetic disk.

### 2. METHODOLOGY

The PFPE lubricant and additive used in this work were commercially obtained from Moresco Corporation (Japan) under the tradename of D4OH and ADOH. The lubricants were applied to the disks from the solution of fluorinated solvent (known by its trade name Vertrel) marketed by Dupont using a standard dip-coating method in which the film thickness after dipping was quantified using FT-IR spectroscopy method (grazing angle). Table 1 shows the lubricant conditions matrix of the magnetic disks used in this study. Lubricant bonding ratio (%) was represented by the percentage ratio of residual lubricant thickness after rinsing with Vertrel to the initial lubricant thickness before rinse. The magnetic media used in this experiment were 65-mm diameter rigid glass disks. They were sputtered with layers of chromium and cobalt-based magnetic recording alloy, and nominally of amorphous nitrogenated carbon overcoat, CNx. Surface energy profile of PFPElubricated disk was determined using water ( $\gamma_l^d = 21.8$ mN/m,  $\gamma_1^p = 51.0$  mN/M) and *n*-hexadecane ( $\gamma_1^d = 27.5$ mN/m). The contact angles (θ) made between a liquid and a solid surface were measured through the sessile drop method using a Kyowa contact angle meter. The Giriflaco-Good-Fowkes-Young equation was used to calculate the surface energies from the measured contact angle data [3].

Table 1 PFPE lubricant, additive thickness and bonded ratio used to investigate the film thickness effect.

No.	D4OH thickness (Å)	ADOH thickness (Å)	Bonded ratio (%)
1	6.5	1.5	75%
2	7.5	1.5	75%
3	8.5	1.5	75%
4	9.5	1.5	75%
5	10.5	1.5	75%

### 3. RESULTS AND DISCUSSION

The measured surface energy of the lubricated media disk was outlined in figure 1. From the result, it was clear that the measured total surface energy reduced upon increasing the lubricant thickness. This tendency could be interpreted in terms of lubricant coverage whereby for magnetic disks having thicker lubricant, the fraction of the high energy carbon surface covered by the low surface energy liquid increased, thus resulted a lower total surface energy [4].

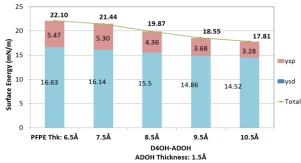


Figure 1 Total surface energy  $(\gamma)$ , dispersive  $(\gamma^d)$  and polar  $(\gamma^p)$  components of thin films of PFPE derived from water and *n*-hexadecane (unit, mN/m).

The measurement results of touchdown power for magnetic hard disk as a function of lubricant layer thickness was depicted in figure 2. In terms of the HDI flyability, the touchdown power tends to reduce when the PFPE thickness increases. A decrease of touchdown power represents a reduction or loss in the flying characteristics. The thinner lubricant showed approximately 4.7 mW improved touchdown between the slider and the disk surfaces. This result was fully expected on the basis of thinner film allows lower flying before onset of pole tip region-disk interference.

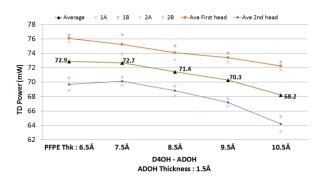


Figure 2 Different lubricant layer thicknesses towards the head flyability touchdown power performance.

Higher burnish implies that the amount of wear to the magnetic head protruding element by the magnetic disk is high. Based on figure 3, thinner D4OH thickness was prone to higher burnish rate. As the PFPE thickness increased, the burnish rate improved significantly. The magnetic disk durability in terms of altitude-drag test as a function of lube thickness was depicted in figure 4. A higher wear resistance (kPass) implied better durability of the media. It was clear from the plot that once the lubricant thickness reaches >9.5Å, the altitudes drag

increased significantly. Even though there was only 1.0Å difference, but the wear resistance increased from 32.0 to 152. kPass. The durability was greatly improved for lubricant having thickness more than 9.5Å above as faster replenishment of the lubricant by the free mobile lubricant layer could occur on the disk surface, thus enhances the wear durability of the slider head.

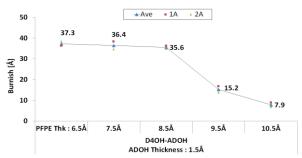


Figure 3 Relationship between lubricant layer thickness and the burnish rate.

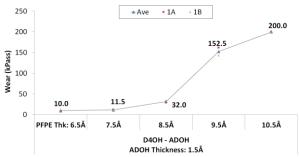


Figure 4 Altitude drag durability test according to the PFPE thickness.

# 4. CONCLUSION

Overall, the effect of D4OH main lube thickness with mixture of ADOH on the HDI performance was investigated. The results of this experiment were found to be consistent with the interpretation that high and low lube thickness possess strong relation with the HDI flyability and durability.

### 5. REFERENCES

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