Proceedings of Malaysian International Tribology Conference 2015, pp. 255-256, November 2015

Diamond like carbon deposition process optimization for media disk corrosion performance

W.S. Khoo[1,2,*], R. Md. Nasir[1], M.R. Zaidi[1] , W.L. Ng[2]

[1)] Nanofabrication and Functional Material Research Group, School of Mechanical Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal Pulau Pinang, Malaysia.
[2)] Fuji Electric (Malaysia) Sdn. Bhd., Lot 5, Industrial Zone, Phase 1, Kulim Hi-Tech Park, 09000 Kulim, Kedah, Malaysia.

[*]Corresponding e-mail: khoo-weeshen@fujielectric.com.my

Keywords: Corrosion; diamond like carbon; design of experiment

ABSTRACT – Carbon thickness reduction activity is important to reduce the magnetic spacing in hard disk drive. However, thinner carbon overcoat thickness is susceptible to galvanic corrosion from the magnetic underlayer. Process optimization of the deposition chamber is important to obtain an overcoat carbon thickness with good corrosion resistance. The corrosion performance relationship between different process parameter was investigated.

1. INTRODUCTION

Hard disk drive (HDD) consists of a casing, arm actuator, motor, electrical board, magnetic head and magnetic disk. The magnetic recording process in HDDs involves relative motion between magnetic disk and magnetic head. During the process of writing and reading, the magnetic disk is always rotating close to the magnetic head. By reducing the magnetic spacing, the signal from the head to the media increases exponentially. Marchon & Olson explained that lower track width, lower bit length and lower magnetic spacing contribute to increase in areal density [1].

One of the way to reduce the head magnetic spacing is through the reduction of carbon overcoat thickness. Plasma enhanced chemical vapor deposition is widely used to deposit the carbon overcoat. Varying the process parameter: gas flow (GF), bias voltage (B), emission current (Ie) and precursor gas type (GT) will give different film properties. Those influence the magnetic disk corrosion performance. Optimizing and Understanding those parameters is important towards optimizing the media disk corrosion performance. Full factorial design experiment matrix was used to analyze the relationship deposition parameter towards corrosion performance. A verification experiment was conducted to verify the optimal deposition towards the magnetic disk corrosion performance.

2. METHODOLOGY

Glass substrate with diameter of 65mm and thickness of 0.635mm were used in this study. Magnetic underlayer was sputtered prior to the carbon overcoat deposition. The 1.8nm carbon overcoat film was measured with X-ray fluoresce machine, which was previously correlated with transmission electron microscopy cross-section. All samples were then coated with a perfluroether (PFPE) lubricant with a nominal thickness of 0.9nm. The uncoded design of experiment using the four factors with 2 levels is listed in Table 1. All cell deposition time were adjusted to have the same carbon thickness. This design of experiment cell is generated using Minitab 15.

Table 1 Full factorial uncoded design matrix.

Parameter	Level	
	High	**Low**
Gas type (GT)	C_2H_6	C_2H_4
Emission current (Ie)/A	0.3	0.5
Bias voltage (B)/V	80	160
Gas flow (GF)/sccm	30	50

Raman spectroscopy was utilized to study the structural properties of the overcoat film. The Raman spectrum is collected using a Renishaw Raman system with Ar laser at 514nm wavelength. Acid extraction method was used to study the magnetic disk corrosion performance. Nitric acid droplets were left on the surface of the disk for 1 hour. The acid droplets were then collected and tested with ICPMS. The Co ions concentration was analyzed.

3. RESULTS AND DISCUSSION

3.1 Raman Analysis

The carbon properties were investigated by Raman spectroscopy. Dh/Gh is obtained. It is the ratio between D band and G band in Raman spectra. The null hypothesis was rejected when the p value is higher with a confidence level of 95% (α=0.05). Figure 1 shows the significance of each parameter towards Dh/Gh parameters. For Dh/Gh, the parameters that shows P value lower than 0.05 is GT*B and GT*GF*B. B and combination of B*GT, B*GT*GF parameter plays a more important role to reduce the graphitic clusters in the film. Higher Dh/Gh value also means the graphitic cluster in the film is higher. This is according to a Tuinstra-Koenig relation. When grain size is smaller, the cluster area in the film is smaller [2]. D mode also represents structure ordering in the film.

The interaction plot was shown in Figure 2, C2H6 gas with higher Ie 0.5A gives higher Dh/Gh value.

When compare Ie, GF and B, both gases shows similar tendency. Higher B and Ie with lower GF tends to give higher Dh/Gh values which translate towards higher graphitic clusters in the film.

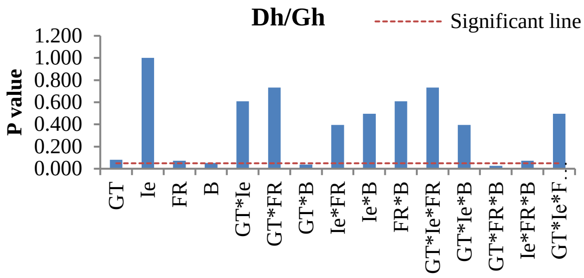

Figure 1 p value for Dh/Gh.

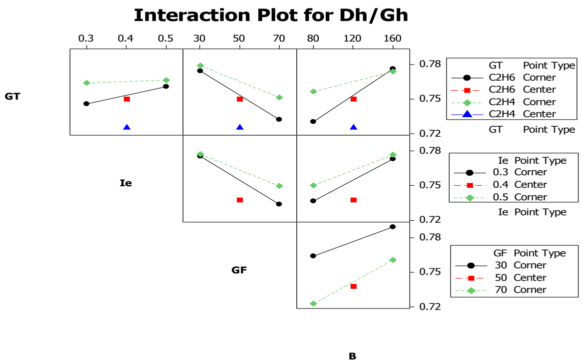

Figure 2 Interaction plot for Dh/Gh.

3.2 *Corrosion Analysis*

The p value for magnetic disk corrosion performance was evaluated in Figure 3. All individual parameter and combination of GT*B, Ie*B, and GT*Ie*B had significant relationship with magnetic disk corrosion performance. The main effect affecting corrosion is GT followed by Ie, B and GF. This means that gas type radical formation and deposition energetic is the key parameter influencing corrosion performance.

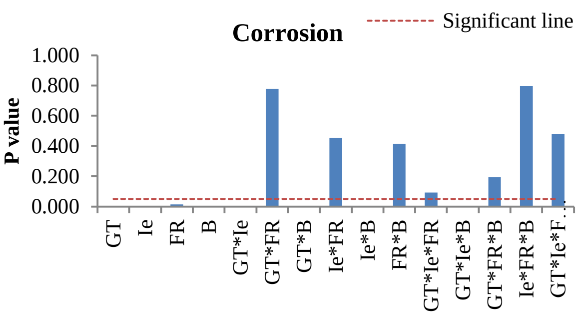

Figure 3 p value for corrosion.

In the interaction plot, different GT contributes towards better corrosion performance. Different GT will give different plasma species. This directly affects the carbon growth in the film. C2H6 gas still shows the better corrosion performance even changing the Ie, B and GF. The best corrosion performance combination is C2H6 gas with 30sccm GF, 0.3A Ie and 80V B. Lower energetics deposition is good for corrosion performance.

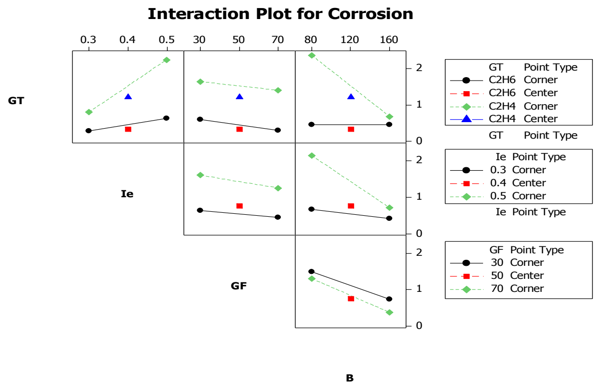

Figure 4 Interaction plot for corrosion.

3.3 *Verification Analysis*

In section 3.2, lower Ie, GT and B were useful to obtain better corrosion performance. Verification experiment was done to check the reliability of this experiment optimization. The result was described in Figure 5. Better corrosion performance was observed when C_2H_6 gas was used. The verification experiment shows that full factorial design is useful for corrosion process optimization.

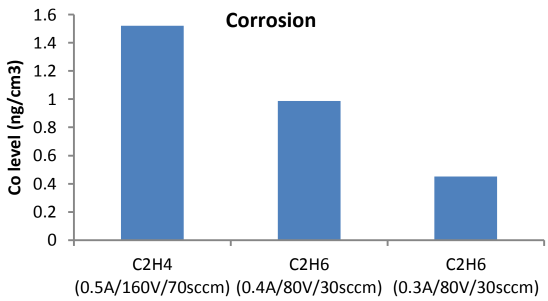

Figure 5 Corrosion verification experiment.

4. CONCLUSION

This study shows that corrosion performance is dependent on the carbon overcoat properties. Lower energetics deposition is important to grow a good corrosion resistant carbon overcoat.

5. ACKNOWLEDGEMENT

The author would like to acknowledge Fuji Electric Malaysia for financial assistance and providing a platform to conduct this research.

6. REFERENCES

[1] A. Ferrari, J. Robertson, "Resonant Raman spectroscopy of disordered, amorphous, and diamondlike carbon," *Physical Review B*, vol. 64, no. 7, pp. 1–14, 2001.

[2] B. Marchon, T. Olson, "Magnetic Spacing Trends: From LMR to PMR and Beyond," *IEEE Transactions on Magnetics*, vol. 45, no. 10, pp. 3608–3611, 2009.