CHAPTER 1 INTRODUCTION

1.1 Motivation

Demands for inexpensive and small hard disk drive (HDD) have driven by the drastic Increase in recording density. From nowadays, HDD does not use for only computer related application but also extend the capability to consumer product application i.e. game, video recording, digital camera, etc.

Diamond-like carbon (DLC) films have long been employed as head and disk overcoats due to their excellent chemical stability and mechanical hardness. Tetrahedral diamond-like carbon (ta-DLC) is deposited on recording head by a process that involves filtered cathodic vacuum arc (FCVA) for corrosion protection and to improve tribological properties at the head-disk interface including mechanical wear prevention. The challenge of DLC development is to maintain the excellent properties under the continuously reducing of thickness which is part of magnetic spacing reduction [1-2]. The thermal and mechanical stability both of process-induced and during hard disk drive operation are also important to considering. Thermally-induced changes in ta-DLC film properties can result in the head-disk interaction dynamics and/or its corrosion protection capability [3]. Previous studies on thick DLC films with thickness of few hundred nanometers up to micrometers showed that such films when exposed to heat at a temperature of higher than 400 ºC can potentially change to a more graphite-like structure with poorer mechanical properties [4-9]. However, Kamiya et al. [10] who compared various DLC films at few hundred nm thick with Raman observed that ta-DLC can be structurally stable at up to 700 ºC in N_2 atmosphere. The result obtained in their report showed that D and G peak of ta-DLC was split from each other after annealing at 750 ºC and performed as a great barrier coating after heating up to 800 ºC. In additional, the ta-DLC was also stable up to 500 ºC in air atmosphere without any change in Raman spectra. However, in present HDD application, the thickness of ta-DLC film is in the order of only a few nanometers and the operating temperature do not normally exceed 300 ºC.

The ta-DLC film of less than 2 nm can be reliably produced by filtered cathodic arc (FCA) and meet the stringent corrosion and wear resistance requirements of HDD applications [11]. FCA ta-DLC film has high sp^3 bonded structure and a very high density (>3.0 g/cm^3) thus allowing the film to be thinned down to within a few nanometer range and yet retain sufficient mechanical and corrosion protection capabilities [12]. Improvements in FCA technologies such as electrostatic filter and in-situ ellipsometric film thickness control also allowed the ta-DLC film thickness reduction by reducing the macroparticles contamination and run-to-run film control to less than 0.1 nm, respectively [13].

The thermal stability of less than 2 nm ta-DLC films was investigated in this study. The thermal oven heating in the range of temperature at 100 ºC – 300 ºC was employed to study the thermal impact on ta-DLC as-deposited. The information of this study will be used to future DLC development to match with the hard disk drive requirement.

1.2 Research Objectives

As known that Diamond-like carbon films are metalstable amorphous materials characterized by attractive mechanical, optical, electrical, chemical and tribological properties. The effect of thermal stress on the microstructure, surface chemistry, and wear resistance of the resulting film are evaluated in this study, research objectives are categorized as follow;

1. To study the ta-DLC structure , mechanical property and other films properties changes induced by heating
2. To understand the limitation of ta-DLC film and get the information for further process improvement.

1.3 Research Boundaries

1. Ta-DLC films deposition will be conducted on magnetic recording head (MR head), Si coupon and NiFe coupon by filtered cathodic arc. Seed layer, Si-Si_3N_4, have also employed to improve the film adhesion and to simulate the actual condition of head over coat film on magnetic recording head.
2. MR head and coupon after deposition will be heated in annealing chamber. Thermal annealing treatment will perform at 100, 200, 300 ºC and fixed temperature with iterated cycle.
3. Microstructure will be measured after deposition and thermal annealing treatment using Raman spectroscopy with an Ar ion laser of 35 mW power at a green wave length 514 nm. The multiwavelength Raman (additional 325 and 785 nm excitation wavelength) will be also employed to better understanding the film structure change after heating. In order to obtain more structural information, X-ray photoelectron spectroscopy (XPS) is employed to evaluate the film composition and material diffusion due to heating effect.
4. Mechanical property, wear resistance, is performed by Nanoidentor.
5. Corrosion resistance is performed to check the effect of heating on the film using HF acid dip testing.
6. Optical property of ta-DLC film is measured by Ellipsometer
7. In additional, film density and surface roughness will be verified using XRR and AFM scanning, respectively, to get more information of heating effect on the films.
8. Upon analysis and conclusion, the results from the measurements will be evaluated.

1.4 Advantages and Applications

DLC film has many excellent properties such as extremely high hardness, high density, low friction coefficient, chemical stability, relatively high thermal conductivity, and visual transparency. Table 1.1 shows the summary of DLC films application.

Table 1.1 Summary of properties and applications of diamond-like carbon thin films. Text in parenthesis indicates potential applications.

Properties	Type of use	Applications
Transparency in visible and IR; optical band = 1.0-4.0eV	Optical coatings	Antireflective coatings and wear resistant coatings for IR optics
Chemical inertness to acids, alkalis and organic solvents	Chemically passivating coatings	Corrosion protection of Magnetic recording head and media, biomedical devices
High Hardness (5-80 GPa); low friction coefficient <0.01-0.7	Tribological, wear resistant coatings	Magnetic recording head, media and hard drives, magnetic tapes, razor blades (bearings, gears)
Nano smooth	Very thin coatings < 5 nm	Magnetic media
Wide range of electrical resistivity = 10^2-10^{16} Ω/cm	Insulating coatings	Insulating films
Low dielectric constants <4	Low-k dielectrics Field emission	(Interconnect dielectrics) (Field emission flat panel displays)

For magnetic recording head and hard disk drive operation, the thermal stress from both of head fabrication and application will change the tribological properties of ta-DLC film as in this study, expecting to have several advantages and application purposes as follows;

1. Understand the microstructure and properties of ta-DLC film changes induced by thermal stress from the magnetic head fabrication process and application which will degrade the protection performance of ta-DLC film.
2. Extend knowledge of study to improve the ta-DLC film deposition process to enhance both of chemical stability and mechanical properties.
3. Resourcefulness of the results such as effects of heating on ta-DLC film properties obtained from each phase of study can be applied to suit applicative purpose of magnetic recording head overcoat.