EFFECTS OF CHEMICAL MECHANICAL POLISHING (CMP) PARAMETERS ON NIP/AL SUBSTRATE SURFACE CHARACTERISTICS

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DEDICATION

Alhamdulillah, praise to Allah S.W.T for blessing me and giving me the strength to complete this project in time without facing any difficulty.

To my beloved parents, family and friends.
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ABSTRACT

Chemical Mechanical Polishing (CMP) process is widely used for global planarization of substrate and wafer technology. The purpose of the CMP is to ensure wide planarization, uniformity, precise surface finish and non-defective surface. CMP has been used in the Hard Disk Drive industry as a final process at the substrate level to provide super fine finish of the substrate surface. With the tremendous demand for increased substrate storage capacity over the years, the Head Media Spacing (HMS) between substrate and slider become more stringent. It is desirable to achieve lower HMS in order to enable good writeablity and strong read back signal integrity and thus will improve the reliability of the slider inside the HDD. The reduction on HMS will lead to more stringent substrate surface finish requirement.

Since there is no defined mathematical model of current in heritage process for Johor Bahru Substrate Plant A, this study will investigate effects of the CMP parameters on the NiP/Al substrate by using Design of Experiment (DOE) approach. A better understanding of the interaction behavior between various parameters and the effect on the material removal rate, substrate roughness and waviness is achieved by using statistical analysis technique. Mathematical model were derived and optimal solution is proposed to further improve the process.

ABSTRAK

Proses Penggilapan Kimia Mekanikal (Chemical Mechanical Polishing-CMP) digunakan secara meluas bagi menghasilkan keadaan permukaan rata untuk teknologi wafer dan substrat. Tujuan utama proses CMP adalah untuk memastikan permukaan rata terhasil, seragam, persis dan bebas dari segala kecacatan permukaan. Proses CMP digunakan di dalam industry Pemacu Cakera Keras (Hard Disk Drive-HDD) sebagai proses terakhir pada tahap substrat untuk menyediakan keadaan permukaan yang sangat licin. Dengan permintaan yang mendadak terhadap kapasiti storan substrat yang tinggi, jarak kelegaan di antara *slider* dan substrat menjadi semakin kritikal. Amat penting untuk mencapai jarak kelegaan yang minimum di antara *slider* dan substrat kerana ia membolehkan proses kemasukan data yang mantap dan menyebabkan isyarat baca semula yang bagus terhasil dan akhirnya akan memperbaiki keboleharapan *slider* yang terdapat dalam HDD. Untuk mencapai nilai minimum terhadap jarak kelegaan *slider* dan substrat, proses CMP harus memenuhi spesifikasi kemasan permukaan substrat yang lebih ketat.

Pada masa kini masih belum wujud matematik model untuk CMP proses di kilang Substrat A yang terletak di Johor Bahru. Oleh itu penyelidikan ini bertujuan untuk menyelidik kesan parameter penting di dalam prosess CMP terhadap substrat Aluminium Nikel Posphorus melalui kaedah eksperimen. Penyelidikan dilihat mampu mengkaji kesan parameter tersebut terhadap respons seperti akdar pembuangan logam dan kualiti permukaan substrat. Statistikal analisis digunakan bagi menghasilkan model matematik yang seterusnya boleh digunakan untuk menigkatkan prestasi proses.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

A Hard Disk Drive (HDD) is the most data storage medium in a computer. The HDD is used by a computer to store Operating System (OS) and the user's data is stored onto the disk in the form of files named in collection of bytes. HDD been introduced in 1957 by IBM consisted of 50 magnetic disks of 24-inch in diameter and rotating at 1200 rpm, holding just a few megabytes. Through evolution and capacity demand of data storage, HDD become the most cost effective for mass storage platform. Increasing requirement of HDD capacity can be obtained by improvement of rotational speed of substrate and Areal Density (AD) [2-4].Current storage areal density on disk surface is tremendously approaching one terabit per square inch mark and become stringent and stringent. Further narrowing Head Media Spacing (HMS) will lead to good writability and gain in term of good read back signal and finally enable better reliability and higher storage capacity of the hard disk [2-5]. Better HMS required a ultra-smooth substrate surface and require a very minimum surface defects [3-5].

Basic component of HDD consists of substrate (platters), head (slider), spindle, and other mechanical components. Head will fly with certain clearance to the substrate during read write process. Based on researches, in order to improve AD of 1 Tbit/inch2, the fly height of the head need averagely 10nm [5].

Figure 1.1 shows the HMS of typical HDD with assumption the surface to be perfectly smooth which not include factors such as surface topography and variability of fly height. Figure 1.2 depicts the terminology of fly height that denotes spacing between surface centerline of head and disk. The clearance denotes spacing between the close points of the surfaces. Based on this, it is essential to meet stringent surface finish of substrate in order to reduce variability of fly height clearance [5].

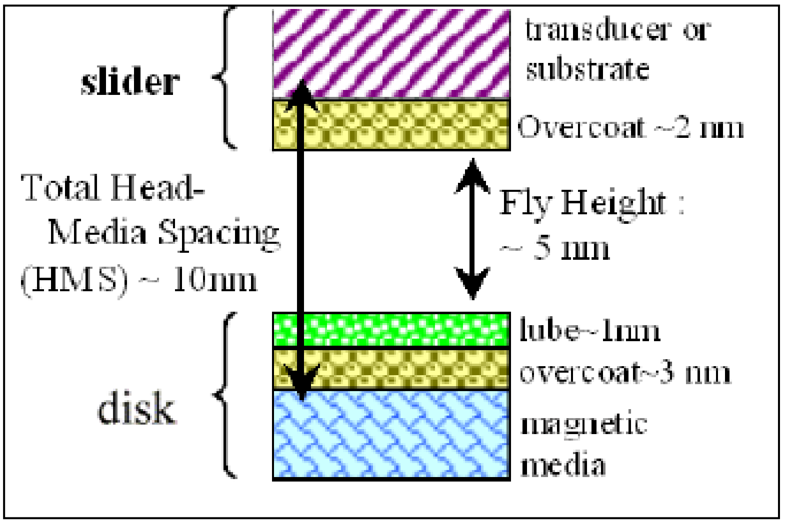

Figure 1.1 Head Media Spacing (HMS) structure

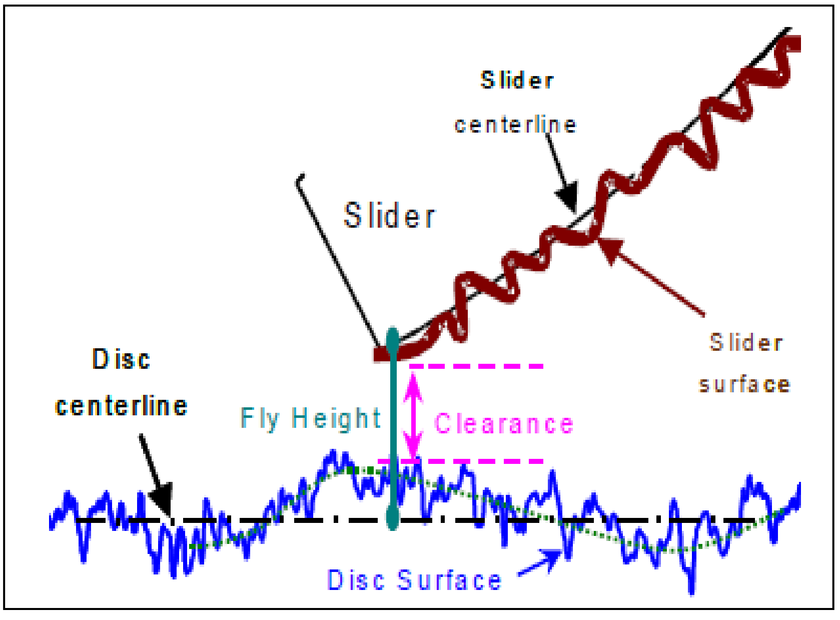

Figure 1.2 Clearance and fly height of HDD

Chemical Mechanical Polishing (CMP) process is one of the global planarization and smoothing substrate surface process that currently applied for HDD manufacturing. It consist of chemical etching effect from abrasive slurry and mechanical from synergize action of pressure and relative rotational velocity [6-10].

1.2 Problem Statement

Due to higher storage capacity requirement, product specification becomes stringent and stringent. CMP process needs to meet a new set specification for a new product to support better HMS. Company A is new HDD Company that located at JB been transferred from previous site from Limavady, Ireland. As the process is inherited from a previous site, there is no defined CMP process model on the site.

1.3 Objective

The objectives of this study are:

a) To identify the significant factors influencing CMP process
b) To come out with mathematical model of CMP process for each response
c) To propose optimal solutions based on constraints and goal set

1.4 Scope of Study

This research work will be conducted within the following scopes:

a) Focused on the CMP process parameters of pressure, rotational speed and slurry flowrate in substrate process
b) Substrate NiP/Al with dimension of 95/1.25 mm, material removal rate and surface topography will be studied
c) Experiments are conducted on a 3 axis double-sided SpeedFAM machine

1.5 Significance of Study

a) It is expected that optimized model of CMP will improved current process capability of the substrate surface finish without significantly impact material removal rate of the
b) Optimization will lead to improvement of process capability and maintained or further minimize cost of ownership
c) Study will covered pad degradation effects contribution during high manufacturing volume run for industry application

1.6 Outline of Report

This report is organized into six chapters. The 1st chapter described of the background of the study, project problem statement, the objective and scope of the project and finally the significance of this study.

The second chapter provides the introduction of CMP process and its basic terminology. Basic Preston equation of CMP mechanism also been discussed. Critical review on previous research had been summarized especially on its approach and evaluated parameters windows. It will also share some guideline on Design of Experiment (DOE)

The third chapter describes on the methodology being employed in this research. Details of the CMP model are described Experimental setup, measurement sampling and measurement tool are also covered.

The fourth chapter presents the experimental results and the analysis of the data. Design of experiment works start from full factorial, adding up axial point for curvature been covered and finally come out with mathematical model of responses.

Confirmation run for the mathematical model and optimal solution generated by software will covered towards end of chapter. Chapter six is the final chapter for conclusion from all of the experiments. Recommendation for future works also been covered towards end of chapter.

1.7 Summary

This chapter has highlighted the background of the study. This research tackled CMP parameters on Aluminium Nickel Phosphorus (NiP/Al) substrate surface topography. New requirement of surface topography of the CMP process lead to higher rejection rate and increase cost of rework. Thus this paper will studying the basic process parameters effects, design of experiment (DoE) method will employed in order to induce improvement of MRR and substrate surface characteristics of roughness and waviness.

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