Applied Surface Science 360 (2016) 59–68

Contents lists available at ScienceDirect

Applied Surface Science

journal homepage: www.elsevier.com/locate/apsusc

Effects of non-spherical colloidal silica slurry on Al-NiP hard disk substrate CMP application

Sideq Salleh [a,*], Izman Sudin [b], Arobi Awang [a]

[a] *Polish Engineering Development Laboratory, Seagate International Sdn. Bhd, Johor, Malaysia*
[b] *Department of Mechanical Engineering, Universiti Teknologi Malaysia, Malaysia*

ARTICLE INFO

Article history:
Received 18 June 2015
Received in revised form 12 October 2015
Accepted 23 October 2015
Available online 26 October 2015

Keywords:
Chemical mechanical polishing (CMP)
Non-spherical colloidal silica
Hard disk drive substrate
Surface roughness
Surface defects

ABSTRACT

Spherical and non-spherical colloidal silica size and shape were characterized and its effects on aluminum alloy nickel plated (Al-NiP) hard disk substrate during chemical mechanical polishing (CMP) was investigated. Non-spherical colloidal silica slurry shows significantly higher material removal rate (MRR) with higher coefficient of friction (CoF) when compared to spherical colloidal silica of similar size. CMP evaluations on non-spherical colloidal silica slurry particle size distribution (PSD) reveal that MRR can be further increased by using wider PSD. Conventional slurry for Al-NiP hard disk substrates which use alumina–silica composite slurry induces embedded alumina thermal asperities (TA) defects which can cause reliability failure at product level. CMP comparison between conventional alumina–silica slurry and non-spherical colloidal silica slurry shows substrates polished by using non-spherical colloidal silica slurry have no embedded TA defects, lower surface roughness and lower surface defects.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Hard disk drive (HDD) storage capacity has increased dramatically over the years. As the storage capacity increased, the magnetic head flying height has been reduced. At present, magnetic head flying height is around 2 nm height [1]. Protruding type of defects known as thermal asperities (TA) can easily damage the magnetic head due to collision with the defects. This will lead to HDD reliability issues at product level [2] such that the substrate surface topography and surface defects have become critical aspects of HDD reliability. To achieve low surface topography with low surface defects, chemical mechanical polishing (CMP) is required [3–7].

CMP is a combination of chemical and mechanical effects to produce a planar and smooth surface with low defect levels. Research on CMP chemical effects has been focusing on CMP slurry components such as etchant, oxidizer and lubricant type with various parameters such as pH and concentrations. Lin et al. [8] demonstrated the effects between HNO_3 and H_2O_2 while Wang et al. [9] studied the chemical effects of oxidizer content and pH toward MRR on silicon wafer substrates. On mechanical effects, abrasive particle type, shape, size and distribution influence the mechanical effects during CMP. Lei and Luo [5] investigated the effects of abrasive particle size, concentration as well as oxidizer and lubricant concentrations and its effect on CMP MRR and surface topography.

Conventional CMP process for Al-NiP hard disk substrates uses a combination of etchant, oxidizer and alumina–silica composite abrasive particle for its CMP slurry [10]. However, this slurry creates TA alumina defects from embedment of alumina abrasive particle onto the substrate surface. Fig. 1 shows graphical illustration and AFM topographical view of HDD reliability failure due to TA alumina defects [10]. To reduce the TA alumina defects, the source of the alumina defects must be eliminated. In recent years, few researchers have shown interest in developing and testing alternative abrasive particles for Al-NiP hard disk substrate CMP slurry. Lei et al. [11–14] investigated the effects of various abrasive composite slurry such as ceria–silica, α-alumina, copper incorporated alumina, porous alumina while Li et al. [15] studied the CMP effects of FeO_2/SiO_2 abrasive composite on hard disk substrate. From literature most of the research conducted has been focused more on MRR and surface topography with very few researchers considering the performance of surface defects, especially embedded TA defects.

Non-spherical colloidal silica as abrasive particle for CMP application is not new. Various researchers have studied the CMP application with non-spherical colloidal silica and its effects on CMP performances. Morioko et al. [16] studied the effects of

* Corresponding author.
E-mail addresses: sideq.salleh@seagate.com (S. Salleh), izman@mail.fkm.utm.my (I. Sudin), mohdarobi.awang@seagate.com (A. Awang).

http://dx.doi.org/10.1016/j.apsusc.2015.10.169
0169-4332/© 2015 Elsevier B.V. All rights reserved.

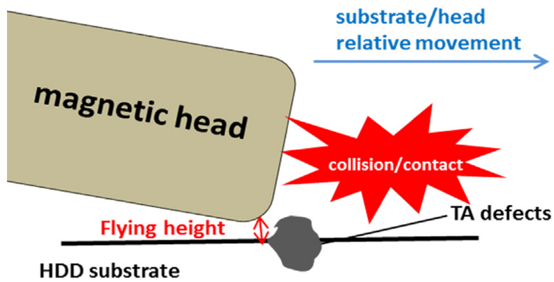

Fig. 1. HDD failure due to magnetic head collision/contact with embedded thermal asperities (TA) defects.

non-spherical colloidal silica in nodular form at various pH. Matsushita et al. [17] also had demonstrated the effects of non-spherical colloidal silica by varying the aggregated type and size during CMP of silicon wafer. Liang et al. [18] developed 'cation induced method' to produce non-spherical colloidal silica and compared the CMP performance between both non-induced and induced (non-spherical) colloidal silica abrasive particles.

Most of the reported research and application of non-spherical colloidal silica are on CMP of silicon wafer with few to none available on CMP application of Al-NiP hard disk substrate. In this research, the effects of non-spherical colloidal silica on Al-NiP hard disk substrate during CMP were studied. Characterization of non-spherical colloidal silica size and shape were performed by using imaging analyzer. Non-spherical colloidal silica slurry Particle size distribution (PSD) and its effects toward MRR were also studied. The surface topography and surface defects of Al-NiP hard disk substrate polished with conventional slurry (alumina–silica abrasive composite) and non-spherical colloidal silica slurry were compared. The performances of this approach were measured via various surface topography and metrology tools such as atomic force microscope (AFM) and scanning electron microscope (SEM). To measure the performances of full surface defects, Candela optical surface analyzer (OSA) metrology tool were used [19]. CMP pad topography/cross-section and asperities were measured by using Zeta Instrument Optical Surface Profiler.

2. Experiment

2.1. CMP tool setup

CMP evaluation was conducted with a dual sided CMP tool (model: Taiyo 11.8B) with 3 axis rotation consisting of top platen, bottom platen and sun gear shown in Fig. 2. Slurry was gravity fed from top of the platen. Conventional polyurethane CMP pad for Al-NiP HDD with density of 0.38 kg/m^3, hardness of 78 (asker C) and pore size between 30 μm and 50 μm were used in this experiment. Polishing pressure was set at 120 $g\,cm^{-2}$. Platen rotation for bottom-platen, upper-platen and sun-gear were set at 15, 17 and 3.2 $rev\,min^{-1}$, respectively. Polishing time was fixed for all evaluations. To measure the coefficient of friction (CoF), platen motor torque were measured from platen driver analog output.

Table 1
Effects of particle size and shape of spherical and non-spherical colloidal silica.

Colloidal silica morphology	Particle size range (nm)	Roundness
Spherical	70–90	0.887
Non-spherical	70–90	0.756

Table 2
Effects of particle size distribution of non-spherical colloidal silica.

Colloidal silica morphology	Particle size range (nm)	Distribution
Non-spherical	100–500	Narrow
Non-spherical	100–900	Wide

Table 3
Effects of 1st step CMP slurry of non-spherical colloidal silica and conventional alumina and final CMP time.

1st Step CMP slurry	Final CMP slurry	Final CMP particle size range (nm)	Final step CMP time (s)
Conventional alumina/silica composite Non-spherical colloidal silica	Colloidal silica (spherical)	15–30	100, 200, 300

2.2. CMP slurry and substrate preparation

Spherical and non-spherical colloidal silica abrasive particles were prepared as per Tables 1 and 2. Abrasive particles at 0.5 wt% concentration were then mixed with chemical solutions consisting of deionized water and acid base etchant. 0.5 wt% concentration of hydrogen peroxide was used as oxidizer. Al-NiP hard disk substrates from similar plating batch were used to reduce error from incoming substrate plating with lot to lot variation.

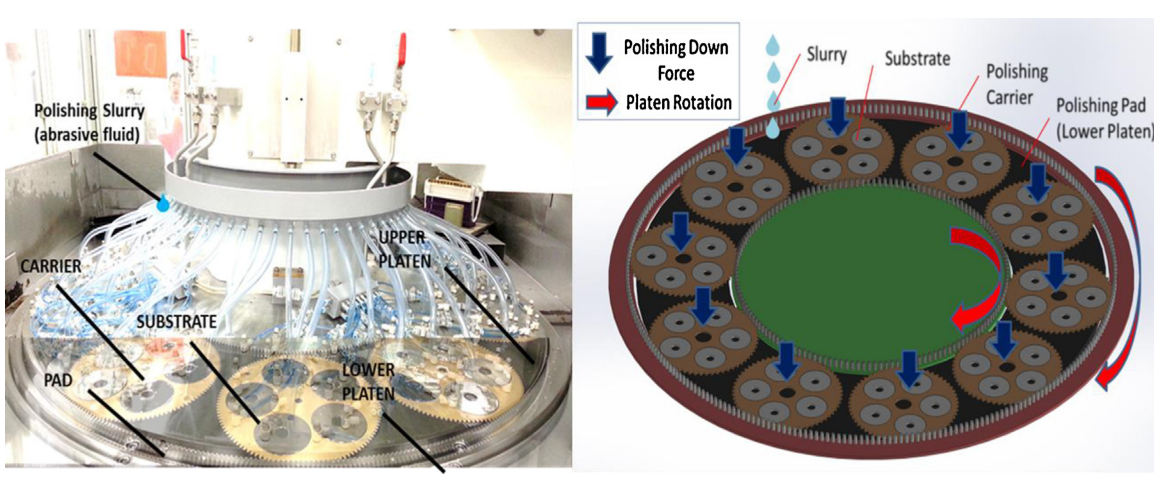

Fig. 2. Schematic of Al-NiP hard disk substrate CMP process.

Download English Version:

https://daneshyari.com/en/article/5353709

Download Persian Version:

https://daneshyari.com/article/5353709

Daneshyari.com