Microelectronic Engineering 87 (2010) 1747–1750

Contents lists available at ScienceDirect

Microelectronic Engineering

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

Accelerated Publication

Preparation of silica/ceria nano composite abrasive and its CMP behavior on hard disk substrate

Hong Lei [a,*], Fengling Chu [a], Baoqi Xiao [a], Xifu Tu [b], Hua Xu [b], Haineng Qiu [b]

[a] Research Center of Nano-science and Nano-technology, Shanghai University, Shanghai 200444, China
[b] Shenzhen Kaifa Magnetic Recording Co., Ltd., Shenzhen 518035, China

ARTICLE INFO

Article history:
Received 10 October 2008
Received in revised form 14 September 2009
Accepted 2 October 2009
Available online 12 October 2009

Keywords:
Chemical mechanical polishing (CMP)
Hard disk substrate
Composite abrasive

ABSTRACT

A novel silica/ceria nano composite abrasive was synthesized by homogeneous precipitation using carbamide, ammonium ceric nitrate and silica. The abrasive was characterized by X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), time-of-flight secondary ion mass spectroscopy (TOF-SIMS) and scanning electron microscopy (SEM), respectively. Then, the chemical mechanical polishing performances of the composite abrasive on hard disk substrate with nickel–phosphorous plated were investigated. Atomic force microscopy images show that the prepared abrasive gives much lower topographical variations than before polishing. The average waviness (Wa) of the polished hard substrate surface can be reduced from 15.5 Å before polishing to 8.36 Å, and the average of roughness (Ra) can be reduced from 14 Å before polishing to 4.80 Å.

1. Introduction

With the increasing capacity of hard disk, the enhancing rotational speed and the lowering distance between the magnetic head and substrate, higher requirements are set for hard disk substrate to minimize roughness and defects of the polished surface. Chemical mechanical polishing (CMP) is one of the preferred methods that are currently in use for both planarizing and smoothing surfaces [1]. Abrasive is one of the key influencing factors on the surface quality during the CMP. At present, alumina [2–4], silica [5,6], ceria [7–13] are widely used as traditional inorganic abrasives in CMP slurries. But the traditional inorganic abrasive used in slurries often leads to undesired CMP performance. It has been proved that the nanoparticle impacts during CMP can lead to nanodeformations or damages in sub-surface layer of the silicon single crystal and Ni–P coating surfaces [14–17]. In recent years, composite particles as abrasives in slurries have been paid much attention [18]. Nobuo and Masayuki [19] presented newly designed composite particles consisting of polymer core covered with inorganic composition such as SiO_2 and Al_2O_3. Lei et al. prepared α-alumina-g-polyacrylamide composite abrasives [20], a-alumina/polymethacrylic acid composite abrasives [21] and investigated their chemical mechanical polishing behavior on glass substrate. And Lei and Zhang [17] also developed a kind of slurry with alumina/silica composite abrasives for hard disk substrates; the slurry resulted in less scratching and better planarity.

Silica and ceria are the most commonly used abrasives in CMP slurries. Silica can be prepared as monodispersed spheres with narrow size distribution [22]. Ceria possesses high polish selectivity, but the commercial ceria has large particle size. Up to date, preparation of silica/ceria nano composite abrasive and being used in CMP slurry on hard disk haven't been reported. In the present paper, silica/ceria abrasive was prepared and its chemical mechanical polishing behavior on disk substrate has been studied.

2. Experimental methods

2.1. Preparation of silica/ceria nano composition abrasive

Preparation of silica/ceria composite abrasive was carried out by homogeneous precipitation: a certain amount of 0.6 mol/l $CO(NH_2)_2$ and 0.3 mol/l$(NH_4)_2Ce(NO_3)_6$ solutions were added into the prepared 5 wt.% SiO_2 solutions respectively under continuously stirring at the reaction temperature of about 100 °C and refluxed for 2 h. The cooled mixture was washed three times with deionnize (DI) water using a centrifuge, followed by drying at 80 °C in a vacuum oven.

The purified silica/ceria composite particle was characterized by X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), time-of-flight secondary ion mass spectroscopy (TOF-SIMS) and scanning electron microscope (SEM), respectively.

2.2. Preparation of the slurry

Preparation of the slurry containing silica/ceria composite particles: 6 wt.% composite particles and 0.3 wt.% functional additives

* Corresponding author. Tel.: +86 21 66133800.
E-mail address: hong_lei2005@yahoo.com.cn (H. Lei).

0167-9317/$ - see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.mee.2009.10.006

were added into DI water in a container under continuously stirring. After adjusting pH value to be between 1 and 4 by adding nitric acid, the mixture was milled for two hours in a vibrator containing ZrO_2 balls as abrasives. Finally, the mixture was filtrated with a pore strainer to get the slurry.

2.3. Polishing tests

Polishing test was conducted with a SPEEDFAM-16B-4M CMP equipment (SPEEDFAM Co., Ltd.) using the polishing performances was measured under polishing conditions as follows: processing pressure of 70 g/cm^2, rotating speed of 25 rpm, processing duration of 3 min, and slurry supplying rate of 300 ml/min. Work pieces were NiP plated aluminum alloy disk substrates with diameter of 95 mm and thickness of 1.25 mm, the plated layer consists of about 85 wt.% nickel and 15 wt.% phosphorus elements. The polishing pad was a Rodel porous polyurethane pad. For comparison, the polishing test with traditional abrasive (commercial alumina slurry used in hard disk CMP) was conducted under the same conditions.

After polishing, the substrate was washed with ultrasonic in a cleaning solution containing 0.5 wt.% surfactant in DI water. Finally, they were dried by a multi-functional drying system.

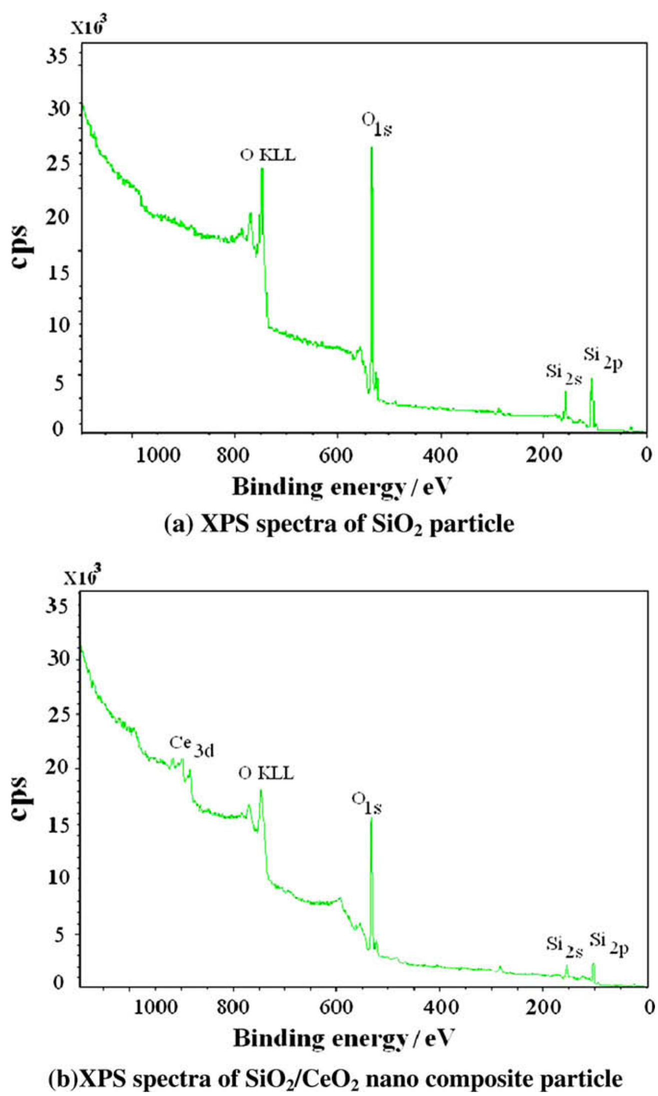

Fig. 1. XPS spectra of SiO_2 (a) and SiO_2/CeO_2 nano composite particle (b).

2.4. Examination of the polished surface

The polished disk substrate was evaluated by its surface features such as average of waviness (Wa) and average of roughness (Ra). Wa and Ra were measured by using a Chapman MP2000+ surface profiler (Chapman Instrument Inc., USA) with the resolution of 0.3 Å for Wa and 0.1 Å for Ra. The measuring wavelength was 80 μm for Ra and 400 μm for Wa. All the data were the mean values of six times of three disks.

The polished surface topography was measured by using a DID-300 atomic force microscope (Digital Instrument Corp., USA) with the resolution of 0.01 Å in vertical direction and 0.1 nm in horizontal direction, and scan area is 5 μm × 5 μm.

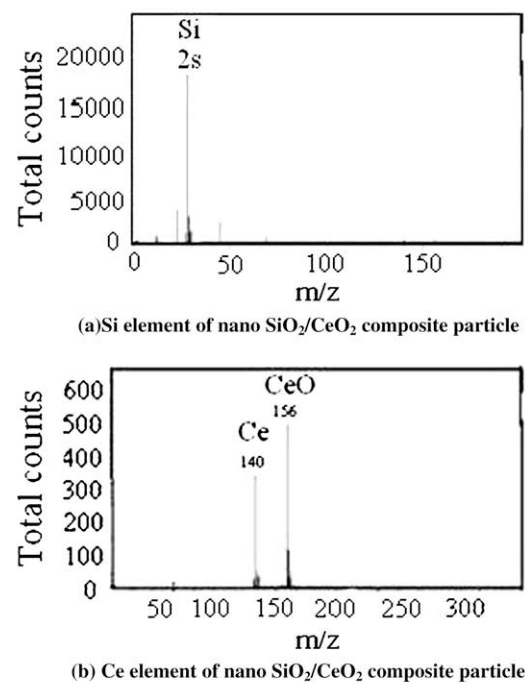

Fig. 2. TOF-SIMS spectra of SiO_2/CeO_2 composite particle. (a) Si element of nano SiO_2/CeO_2 composite particle. (b) Ce element of nano SiO_2/CeO_2 composite particle.

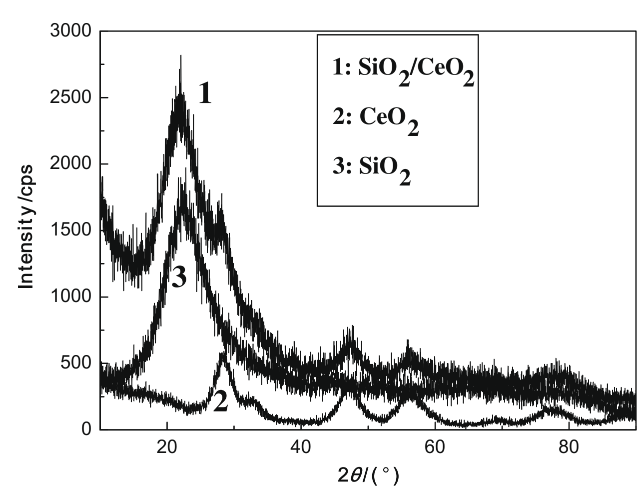

Fig. 3. XRD spectras of nano SiO_2/CeO_2 (1), CeO_2 (2), and SiO_2 particles (3).