Surface Preparation for Sensing the Kerr-effect on NiFe81/19 Layers

A. Belski, M.C. Wurz, S. Cvetkovic, L. Rissing
Institute for Micro Production Technology, Center for Production Technology, Leibniz University Hannover, Germany

belski@impt.uni-hannover.de

Abstract

Gentelligent™ (GI) components are capable of storing production data information in their own surface. This can be either information about the physical values of the component, its history or other data that is created while in use. The data readout method is based on the Kerr-effect which requires special surface preparation steps of the GI material for the enhancement of the Kerr contrast. This paper presents the influence of the chemical mechanical polishing on the Kerr contrast. The results are analyzed by the difference image technique.

1 Introduction

The gentelligent™ approach allows the marking of components in an industrial environment without the usage of bar codes and Radio Frequency Identification (RFID) systems [1]. The static and dynamic data storage on the surface of the GI component is accomplished by a magnetic write head [2]. For the readout process from a distance the magneto-optical Kerr effect (MOKE) is used [3]. A data storage process requires components with magnetic characteristics. In the case of non-magnetic materials such as magnesium, the magnetic properties can be achieved by the integration of magnetic micro particles. Such a material is developed for the GI approach and is called magnetic Mg, where the magnesium matrix is filled with hard magnetic γ-Fe_2O_3 particles [4]. For the magneto-optical readout from the particle-based storage medium using magneto-optical Kerr effect (MOKE), a soft magnetic 25 nm thin film layer of NiFe81/19 is deposited on the top of the storage material by means of sputtering [5]. NiFe81/19 serves as a "keeper layer" on the magnetic Mg and mirrors the magnetization states inside the storage medium.

2 Magneto-optical Readout

For the readout process, a magneto-optical Kerr microscope, equipped with image processing, was applied. The Kerr contrast enhancement was achieved by the difference image technique which requires the application of magnetic fields to the sample. For the application of magnetic fields a rotatable electromagnet was used. This system can create DC and AC magnetic fields separately or superimpose them if required.

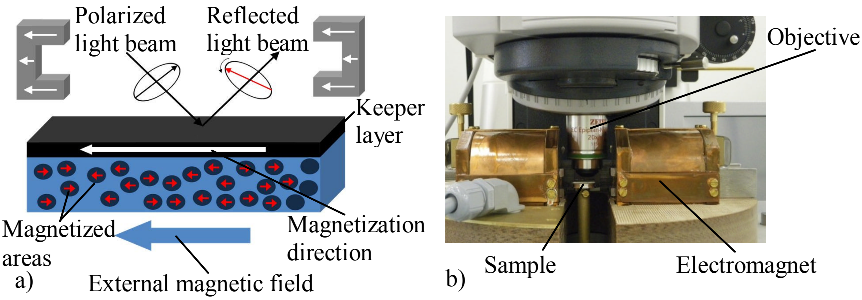

Figure 1: MOKE a) readout principle, b) Kerr microscope

3 Experimental

The magnetic Mg properties were simulated in this work by the integration of hard magnetic γ-Fe_2O_3 micro particles in an epoxy matrix at a ratio of 42% of particles to 58% of epoxy. The surface of the storage material was prepared for the magneto-optical readout as follows. In the first step the surface was grinded with sandpaper. In the second step a mechanical polishing process of the sample surface with a rotating polishing bristle was applied. As a last step, chemical mechanical polishing (CMP) was used. All CMP tests were executed on a dual-axis polishing machine with a 400 mm diameter plate equipped with a hard polyurethane pad. A commercially available MSW1500-slurry for CMP was used. After the preparation of the surface, a keeper layer was deposited on the surfaces by sputtering (PVD, physical vapour deposition) using a NiFe81/19 target. For the deposition of 25 nm thick layers, a process time of 4 min and a power density for the PVD of 0.93 W/cm^2 was used. Afterwards, all samples were magnetized by the magnetic write head. For the readout technique here the DC magnetic field was generated. With the electromagnet a field of 9 kA/m was applied, which was strong enough to saturate the permalloy layer, but weaker than the coercivity $\boldsymbol{H_C}$ of the recording medium. The contrast enhancement by the difference image technique is demonstrated here for the epoxy samples with Fe_2O_3 particles. The noise in the difference image was reduced averaging 32 frames.

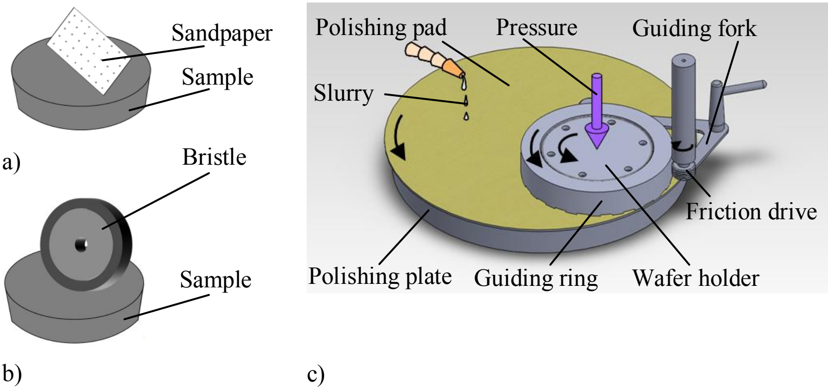

Figure 2: Surface preparation (schematic) by a) sandpaper, b) bristle, c) CMP

At first, the sample after the first preparation step of the surface – grinding – was observed by the difference image technique. For this sample no difference image of the magnetic track could be detected. In the second step, the sample after just two preparation steps of the surface – grinding and mechanical polishing – with the same 25 nm thick keeper layer was investigated. Figure 3a depicts the difference image of this sample. Afterwards, the sample after three preparation steps of the surface – grinding, mechanical polishing, and CMP – was investigated (Fig. 3b).

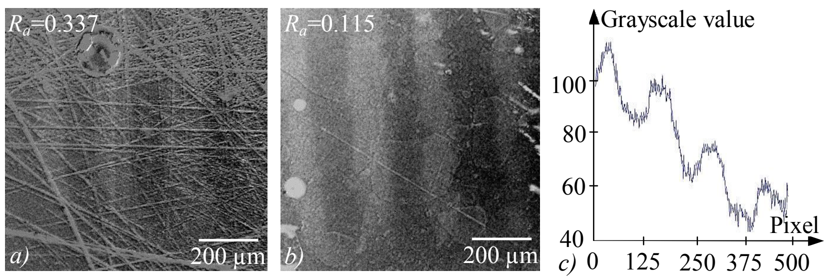

Figure 3: Difference image of the magnetization track of the sample a) prepared by grinding and mechanical polishing, b) prepared by grinding, mechanical polishing and CMP with c) grayscale average value of the pixels along the horizontal-axis

For each sample, the average roughness R_a was determined for a profile of 700 µm length. Contrast values for the magnetization track are depicted in figure 3c.

4 Conclusion and Outlook

This paper shows the strong dependence of the magneto-optical Kerr-effect and the mechanical surface preparation method by the particle-based samples. This behavior was demonstrated on different samples. The surface of the storage medium, which has been submitted to an additional CMP process, shows particularly good results. The fairly high values for R_a can be attributed to surface elevations of the more solid Fe_2O_3 particles in the flexible epoxy matrix after CMP processing. A further development of the CMP process also for the keeper layer will significantly improve the representation of the magnetization tracks by MOKE.

Acknowledgment

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