Journal of Magnetism and Magnetic Materials 421 (2017) 453–456

Contents lists available at ScienceDirect

Journal of Magnetism and Magnetic Materials

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

Investigation of electromagnetic interference effects by ESD simulator on test parameters of tunneling magnetic recording heads

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ARTICLE INFO

Article history:
Received 24 April 2015
Received in revised form
8 August 2016
Accepted 15 August 2016
Available online 16 August 2016

Keywords:
Electrostatic discharge (ESD)
Electromagnetic interference (EMI)
Magnetic recording head

ABSTRACT

Electrostatic discharge (ESD) has been an important issue in the manufacturing processes of hard disk drive. It can also generate electromagnetic interference (EMI) which could possibly damage magnetic recording heads. The aims of this work are to measure the EMI from ESD events and to examine the effects of EMI on the heads. The discharge current and the EMI generated by an ESD simulator were experimentally measured. Also, the EMI was applied to the heads to determine if this can cause changes of head parameters. Our results show that the discharge current waveform is consistent with the theoretical waveform of the IEC ESD standard. Additionally, we found that the EMI applied due to ESD at distances greater than 2 cm does not have any significant effect on the head parameters. Hence, further detailed experiments are proposed to evaluate the EMI effects on recording head parameters in order to improve the measurement methodologies to prevent the degradation of the heads performance and to increase the robustness of the heads.

1. Introduction

Electrostatic discharge (ESD) is a main issue in the hard disk drive (HDD) manufacturing processes. It can cause soft, hard and latent failures in the HDD components during the assembly processes [1,2]. The soft and hard failures can be detected by commercial equipment however, the latent failure is very hard to detect by commercial tool and methodology. It must be detected by complex methodology [3,4]. Generally, an ESD event can generate and radiate electromagnetic fields that disturb an electronic circuit, called electromagnetic interference (EMI) [5]. Many studies found that magnetic recording heads, especially the read sensor, can be damaged by applying the EMI to the heads which can reduce the read performance and stabilities [6,7] nevertheless, the effects of EMI on the writer of the head have not been studied yet. The performance of the magnetic recording head can be examined by monitoring the test parameters of the read/write head such as, the normalized noise (NORM_NSE) and baseline noise (BL_NSE) for the read head meanwhile the writer resistance (WR_RES), writer width (WR_WDT) and overwrite (OVW) for the write head performance [8–11]. For the reader sensor parameters, the NORM_NSE indicates the noise generated in the read head whereas the BL_NSE refers to the signal to noise ratio of the output signal scanned from the media track [8,9]. For the parameters of writer head, the WR_RES is normally the resistance of the write head, the WR_WDT is the width of the write field generated by the writer and the OVW indicates the ability of a write head to write over the prior data bits [10,11].

Research aimed at improving the performance of the read heads are typically focused on further developments of the read heads which are tunneling magnetoresistive (TMR) sensors, since it offers many outstanding advantages such as, high magnetoresistance ratio, thin insulator, and small sense current [12,13]. However, TMR sensors are very sensitive to ESD and EMI events as well [1]. Some of the TMR read head parameters affected by the EMI were experimentally investigated by Khunkitti et al. [14].

The IEC 61000-4-2 ESD standard is a standard for testing the performance of electronic systems when dominated by ESD including a contact or an air discharge mode [15]. This standard can provide a higher current than other models of ESD at the same charged voltage which also generates a higher radiated EMI.

In this work we measure the effects of EMI on the magnetic recording head by evaluating the changes of test parameters including WR_RES, WR_WDT, OVW, NORM_NSE and BL_NSE after the EMI was applied to the head by using the IEC 61000-4-2 ESD test standard. The areal density of the magnetic recording head used in this evaluation is 150 GB/in^2.

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http://dx.doi.org/10.1016/j.jmmm.2016.08.047
0304-8853/

2. Experimental setup

2.1. Measurement of the discharge current and radiated EMI field from ESD events

In order to measure the discharge current and the EMI amplitude generated by the ESD, the experimental setup shown in Fig. 1 based on the IEC 61000-4-2 standard was used, a detailed description can be found in Ref. [15]. The EMI was measured at distances, d, between 2 and 30 cm from the discharge point. The H-field was reconstructed following the methodology explained by Fotis et al. [16]. Also, the magnetic recording heads were placed at the same distance as the H-field probe while measuring the H-field in order to evaluate the EMI effects on the head, described in section B.

2.2. The evaluations of magnetic recording head by using test parameters of the head

To investigate the EMI effects on the recording heads, the EMI radiated from ESD with a charging voltage of 2, 6 and 8 kV were applied to the recording heads placed at various distances. The direction of the applied EMI is similar to the experiment shown in Ref. [15]. The head gimbal assembly (HGA) attached with the slider at the tip is placed on an insulator in order to isolate the slider from the ground. The slider comprises the writer and reader of magnetic heads and the heater which is used to protrude the head to reduce the head/media spacing. The TMR read head consists of various magnetic and non magnetic layers. The sensing layers used to detect the data bits are the focus of this work. This is because it can be affected by the external H-field. The sensing layers of the TMR read head consist of two ferromagnetic layers separated by an insulator which are the pinned/spacer/free layers. In this experiment, both the pinned and free layers of the head have the magnetization in the in-plane direction. The magnetization of the free layer is biased by a pair of permanent magnets and will be tilted following the magnetic stray field from the media meanwhile, the magnetization of the pinned layer is biased by an anti-ferromagnetic layer. The magnetization of the pinned layer and free layer are aligned in the perpendicular and parallel direction to the ABS. Also, the H-field was applied to the air bearing surface of the slider in the direction perpendicular to the magnetization of the pinned layer because it was expected to affect the read head by disturbing the magnetization orientation of the pinned layer, which could be a cause of the noise generated in the recording head. The spin stand tester is used to measure the heads parameters which are WR_RES, WR_WDT, OVW, NORM_NSE and BL_NSE to compare the parameters during pre- and post-EMI exposure.

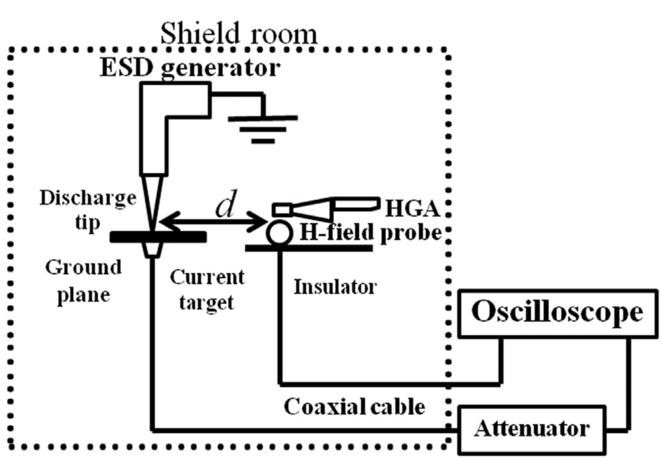

Fig. 1. Experimental setup [15].

3. Results and discussions

The agreement of discharge current of the test system based on the IEC 61000-4-2 standard with the standard was verified by measuring its waveform, as shown in Ref. [15]. In addition, the amplitudes of H-field at various distances with different charged voltages were obtained. It was shown that the magnitude of H-field decreases slowly with increasing distances above approximately 10 cm whereas a rapid increase of H-field is found when decreasing distances below 10 cm [15]. In principle, the magnitude of the H-field depends on the distance between the source and the measurement point. In the near-field region, the H-field is decreases like $1/d^2$ with increasing distance whereas decreases like $1/d$ with increasing distance in the far-field region [17].

To evaluate the EMI effects on the heads, the percent changes of WR_RES, WR_WDT, OVW, NORM_NSE and BL_NSE measured pre- and post- the applied EMI are shown in Figs. 2–6, respectively. The changes of the test parameters measured from three heads were averaged at each data point. No systematic change of the test parameters was found with increasing charging voltages up to 8 kV or as a function of distance above 2 cm. In order to quantify random changes of the head test parameters, they were additionally measured twice without applying an EMI. The results indicate that the fluctuations of the test parameters without an applied EMI to the magnetic recording head are similar to the variations observed in Figs. 2–6. Therefore, the observed variations of test parameters measured in this work are the results of tester variation. Then, there are no permanent effects from the EMI applied to the magnetic heads in the perpendicular direction to the pinned layer magnetization. The reason is that the magnitude of the EMI is too small to cause any permanent change of the magnetization of the pinned layer held by the exchange bias field from anti-ferromagnetic layer. Another reason why no systematic changes of the test parameters were detected is that the test parameters were measured only after the heads subject to the EMI. Thus, the current experimental procedure cannot be used to detect the temporary effects while the EMI is applied to the head.

Therefore, for future work it is suggested to measure the changes of test parameters while the EMI is applied to the recording head and/or the head is placed at distances closer than

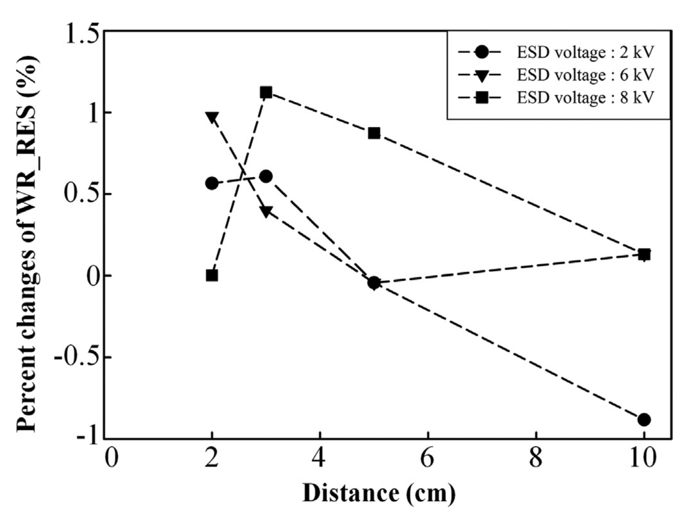

Fig. 2. The percent changes of the WR_RES of write heads at various distances for 2, 6 and 8 kV charging voltage.