Study on ESD/EMI Phenomena for Magnetic Reproducing Head

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Abstract—GMR heads, the most electrostatic discharge (ESD/EOS) sensitive device of all electron devices, are used for high density magnetic recording applications. A number of problems related to electrostatic discharge phenomenon in GMR heads have been reported, including melting and diffusion caused by the Joule heating by ESD currents, pinning rotation and demagnetization resulting from high magnetic field strength, and dielectric breakdown induced by a high voltage. In recent years, there has been a growing concern about damaging GMR heads from Electro-Magnetic Interference (EMI). In this paper, we studied a relatively easy method for comprehending the basic characteristics of EMI using the instruments that are widely used in conventional ESD evaluation.

Key words: ESD, EMI, GMR head, Damage

I. INTRODUCTION

GMR heads, the most electrostatic discharge (ESD/EOS) sensitive device of all electron devices, are used for high density magnetic recording applications. Fig.1 shows the structure of a GMR head. An anti-ferromagnetic layer (AFM), a pinned layer, and a free layer are stacked up, and domain control layers are fabricated on both sides of these three layers. The resistance of the GMR element varies according to the magnetic field from disk. A number of problems related to electrostatic discharge phenomenon in GMR heads have been reported, including melting and diffusion caused by the Joule heating by ESD currents, pinning rotation and demagnetization resulting from high magnetic field strength, and dielectric breakdown induced by a high voltage. Also, as in some previous work, we also found that ESD current leads to head amplitude degradation and instability.

The major evaluation methods use ESD waveform such as the HBM, the MM, and the CDM. Many researchers have been implementing ESD studies of GMR head, such as its destruction mechanism by ESD waveform analysis. The purpose of these studies was to better understand the signature of ESD events in order to assist in eliminating them from the manufacturing environment. Recently, as the devices become increasingly smaller, there has arisen a concern for damaging GMR heads by EMI. While the potential impact of the EMI events on GMR heads has been pointed out, a generalized method suitable to detect sources of EMI has not yet been discussed in the literature. Considering that the ESD sensitivity of the GMR head will continue to decrease with each new product generation, it is necessary to develop an easy evaluation method for EMI. In this paper, EMI waveforms are obtained using a current transformer as the detector and a digital oscilloscope to capture the waveform.

II. EXPERIMENT

A schematic of the EMI evaluation method is shown in Fig.2. In this method, firstly, the EMI wave is induced by an EMI transformer, and this wave is captured on a digital oscilloscope using CT current probe as EMI detector which has 50 ohm load impedance. Fig.3 (A) shows an example of the EMI waveform obtained in this way. Next, the EMI waveform is analyzed using FFT. Fig.3 (B) shows the result of the frequency analysis for this waveform by FFT. The analysis was performed using a software spread sheet on a PC. The frequency component analyzed by FFT is essentially same as that of the EMI wave frequency directly measured using a spectrum analyzer. The EMI that GMR head will be subjected to during the manufacturing process could be either periodical EMI or continual EMI emitted from certain equipment, or it could be a random EMI resulting from incidental factor such as the discharge of the charged body. The measurement of the latter, though, is difficult to be obtained using a spectrum analyzer, and it can be easily captured using this method which the authors of this paper employed.
III. RESULTS AND DISCUSSION

A. EMI WAVEFORM MEASUREMENT

The following EMI waveform measurements were performed under the conditions of (a) through (g).

(a) Human body is charged up to 500 V. A Metal tweezers held by the human is contacted to a metal plate.
(b) Screwdriver is charged up. The screwdriver is contacted to a metal plate.
(c) CPM (Charge Plate Monitor) is charged up to 1000 V. A Metal wire is contacted to the CPM.
(d) Using Noisy Ionizer
(e) Using Fluorescent light
(f) Switches of some equipment are pushed (for example: switch of a Power supply)
(g) Turning on a lighter with piezoelectric element

From these measurements the following results are obtained. In the case of EMI generated by metal-to-metal contact, the EMI spectrums show similar trends independent of the metal size and form, such as metal tweezers, screwdrivers, and CPM. On the contrary, different EMI spectrums were observed in each cases of a noisy ionizer, a fluorescent light, pushing some equipment switches (for example: power supply injection switch), and turning on a lighter (a cigarette lighter with piezoelectric element). Fig.4 shows the frequency ranges defined as 20% of the max peak values for each EMI waveforms, which suggests that each EMI waveforms can be characterized to the typical frequency bands.
B. Discharge Voltage Dependence of Detected EMI Power

Fig. 5 shows the result of the detected EMI power by metal-metal contact with CPM voltage increasing in incremental steps. The power of each frequency peaks (f1, f2, f3, f4, and f5) is plotted by the CPM charged voltage. From this figure, it is clear that the detected EMI peak power is dependent on the CPM voltage, which is the EMI power increase as the EMI source charged voltage increases.

C. Distance Dependence of Detected EMI Power

The distance between an EMI source and a device is one of the most critical EMI characteristics. Fig. 6 shows the distance dependence of the EMI peak power between a CPM and a CT1 current probe. The detected EMI peak power has a good fitting to the EMI source distance, indicating an inverse proportion with it.
D. EXAMPLES OF EMI IMPACT ON GMR HEAD

EMI radiation on GMR head was conducted under the following conditions:
(1) GMR head was left in front of a noisy ionizer for 10 minutes.
(2) A person holding metal tweezers was charged up to 1kV. The metal tweezers were then contacted to a metal plate.
(3) A CPM was charted up to ±4kV. The CPM then was made contact with metal wires.
(4) EMI radiation from lighter.

Irradiation from (1)–(3) was performed 10 times at a distance of 10 cm from the GMR head. The electric and magnetic characteristics of the GMR heads were compared using a QST (Quasi Static Tester) before and after the irradiations for (1)-(4). However no changes were seen on the characteristics of the GMR heads for each condition.

IV. CONCLUSION

In this study, various EMI waveforms were originated from various sources, and were captured with a new easy method using a digital oscilloscope and a CT1 current probe. Then the waveforms were analyzed with FFT on a PC. The following results were obtained.
1) The magnitude and frequency components of the EMI waveforms are dependent on their generation sources. The differences between each source are especially cleared by analyzing the each frequency components. Using FFT analysis of the frequency components for the EMI waveforms, it is possible to identify whether the EMI is due to the charged metal-metal contact, or another sources of an ionizer, and some equipments et al.
2) In the case of EMI emitted by a high voltage discharge from metal-metal contacts, the larger the charged metal voltage, the larger EMI peak power level. As the distance between the EMI source and EMI detector is getting longer the detected EMI power decays with an inverse proportion. Then, it is possible to estimate the distance of the EMI source. These methods are effective in analyzing the EMI sources and taking countermeasures against EMI phenomena.
3) Although it is difficult to detect an accidental EMI using a spectrum analyzer, the new method mentioned above in this paper can do it easily. Therefore, this method is very useful to evaluate the EMI phenomena during GMR head manufacturing.

REFERENCES