A New Generation System for ESD Stress and Analysis of MR Heads

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As magneto-resistive (MR) head technology matures there is a growing need to evaluate the susceptibility of these devices to electro-static discharge (ESD) stress. The trend towards increasing the areal density of disk drives has resulted in a decrease in the geometry of the MR read element. This decreased geometry makes the read element more sensitive to ESD damage due to joule heating.

Another area of growing concern is the ability to detect ESD damaged heads in a production environment. Early detection means that there is less chance of running damaged heads through any or all of the production cycle. This can provide a significant reduction in cost.

Historical Solutions

Historically the ESD characterization of MR heads has been a cumbersome process. The requirement that the MR head be first subjected to ESD stress and then analyzed has traditionally meant that ESD stress systems as well as a MR analysis system were both needed. These two components were generally utilized in one of two methods. The first configuration was to leave the two as separate systems. This meant that there were two steps required for each ESD stress point. First the MR head had to first be taken to the ESD stress system and subjected to a single ESD event. Then the head had to be returned to the MR analysis system in order to determine whether there were any electrical or magnetic changes due to the ESD stress. Significant drawbacks to this system are clear. The need to handle the head meant that there always existed the possibility of introducing uncontrolled ESD transients or other undesirable events to the head. Thus the results which were observed on the analysis system might not accurately reflect the response of the element to the controlled ESD event. Another significant disadvantage of this system was cycle time. The characterization of a single head could take many hours.

The obvious solution to this set of disadvantages is to somehow connect these two systems. The method of connecting which has most traditionally been utilized is to use a cable to stretch from the ESD stress system to the MR head mounted on the analysis system. While this method reduces the likelihood of uncontrolled ESD transients, it also introduces new problems. One problem is protecting the analysis system electronics from the ESD signal being injected into the head. In this configuration, either manually switching between ESD stress and analysis connections or the development of a custom hardware interconnect is necessary to protect the analysis system. Another problem is that the length of the interconnect cable almost certainly means that the waveform seen by the head has been significantly distorted.

Next Generation Solutions

A more recent solution to this problem has been introduced by Integral Solutions International (ISI). The addition of an ESD stress system to their currently existing quasi-static tester means that more comprehensive system integration is now possible. This provides the advantage of fully integrated controlling software resulting in the ability to characterize a single head in minutes.

As an example, Figure 1 shows the results of the ESD characterization of a MR head. The graph is plotted real-time with the results of positive stress displayed towards the right of center and the results of negative stress being posted to the left of center. In this example the ESD voltage was swept from 20 volts to 90 volts in increments of 5 volts and then from 91 volts to 120 volts in increments of 1 volts. Since at each voltage level the head was stressed at both a positive and a negative stress the total number of stress points was 88. This characterization took a total of 523 seconds or 8.7 minutes.

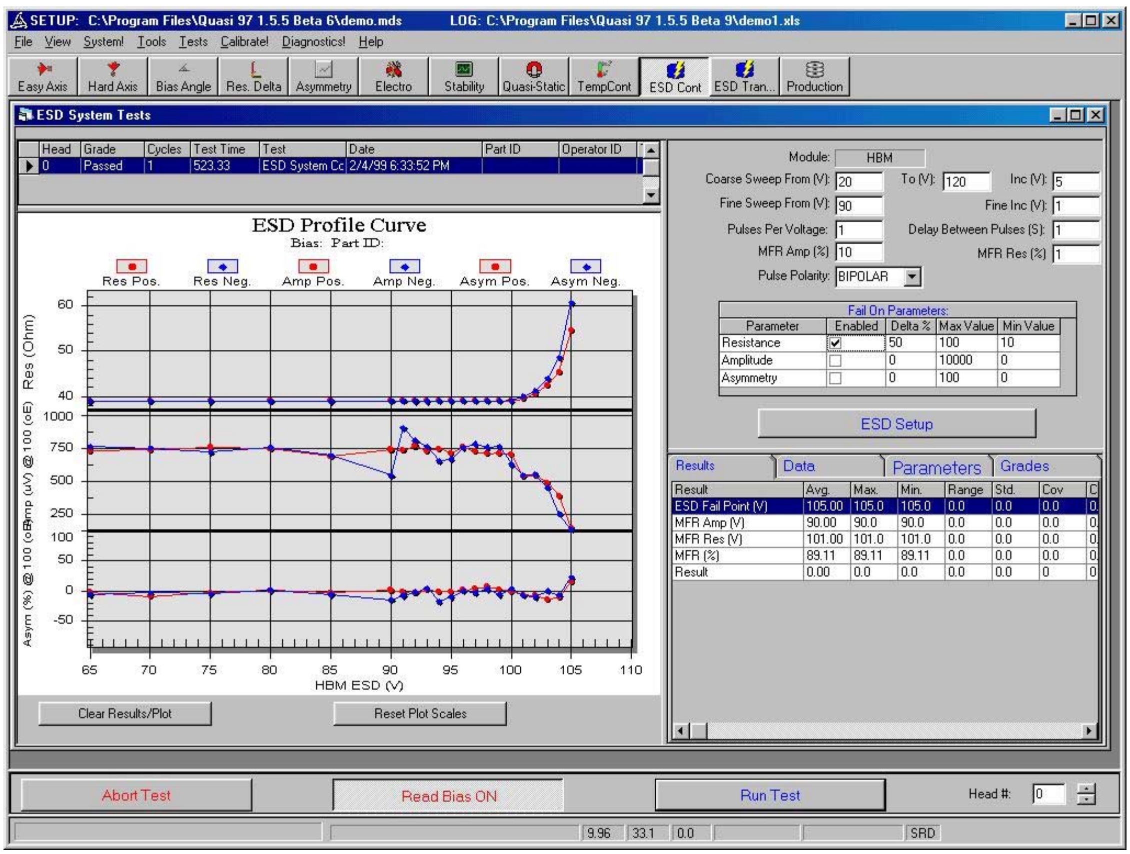

Figure 1. Sample ESD Results

In figure 2 we notice an interesting phenomenon. At about 45 volts there is a sudden reversal in both peak-to-peak amplitude and asymmetry. What is interesting to note is that there is no change in measured resistance until approximately 80 volts. On the transfer curve plot the reversal in these values corresponds to a reversal of the slope of the transfer curve. The relationship between the magnetic failure voltage and the electrical failure voltage is described by Dr. Al Wallash of Quantum Corporation using the term "Magnetic Failure Ratio" (MFR). The MFR is described as the ratio of the magnetic failure voltage to the electrical failure voltage and is included as a standard measurement in the ESD Sweep Test.

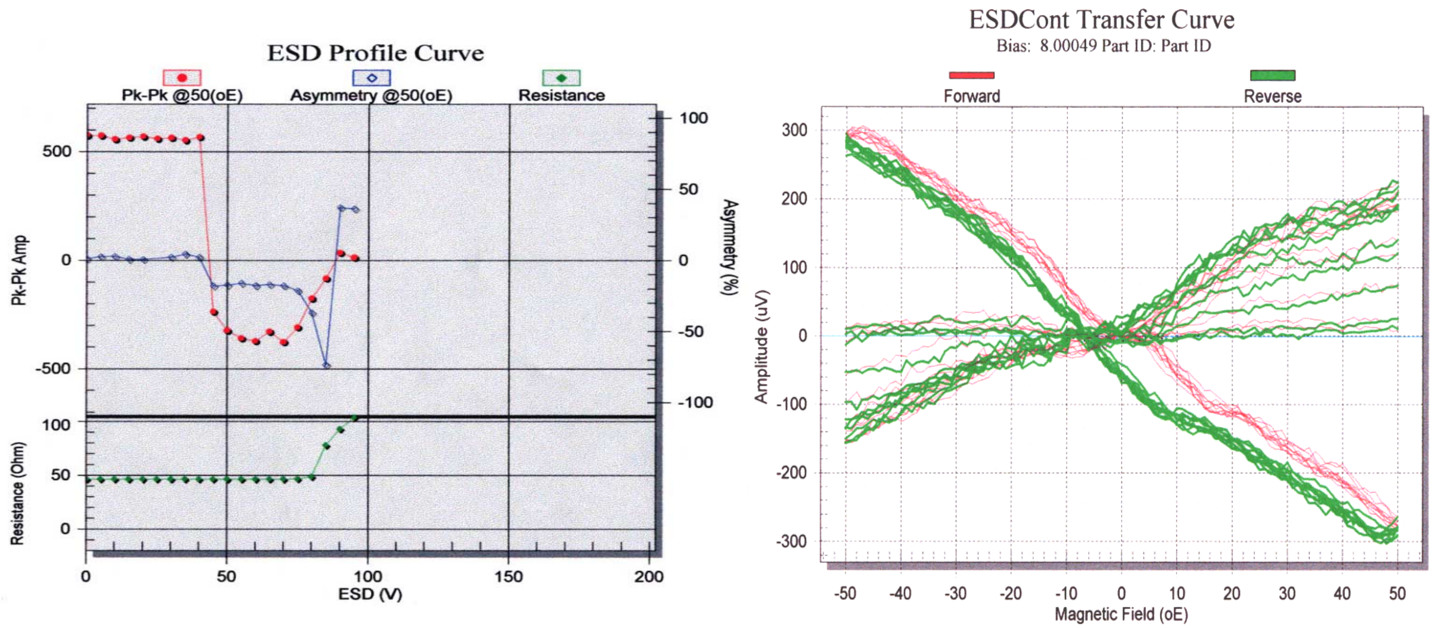

Figure 2. Example of Amplitude and Asymmetry reversal due to ESD Stress and the associated transfer curves

Below are some typical values of the MFR for various types of heads.

AMR Heads: 95%
PlMn (Platinum Manganese): 95%
FeMn (Iron Manganese): 35%

These values help to underscore the importance of ESD characterization of the MR element. Electrical resistance is insufficient as a means of determining whether the head has sustained magnetic degradation as a result of an ESD transient.

Enhanced System Capabilities

Greater system capability is now available since the ESD stress system is part of a larger quasi-static test environment. ESD analysis is performed at the HGA level. However, the system also has the ability to perform quasi-static measurements at the HSA level. With a gap size of 1.31 inches and a field uniformity of 1% across the entire gap height, the magnet is capable of testing most of the headstacks being produced in today's market. This capability is currently being utilized in a study being performed by Dr. Al Wallash entitled "*ESD Testing of Head Stack Assemblies Used in Magnetic Recording Hard Disk Drives*". In this study Dr. Wallash is injecting ESD transients into the HSA connector pins and then performing quasi-static measurement on the individual heads of the head stack to monitor electrical and magnetic changes.

Also integrated into the ISI system is a closed-loop temperature control module or "Hot Finger". This provides the ability to heat from 1 to 8 heads up to 250C while performing quasi-static measurements. A study currently under way by Chris Moore and Dr. Al Wallash is "*ESD Testing of MR Heads at Elevated Temperatures*". This is a study of the ESD failure points of PlMn MR Heads at various temperatures.

An additional study being performed by Dr. Wallash is "*Thermal Stability Testing of GMR Recording Heads*". Which is a discussion of the use of the Integral Solutions QST-2001 and "Hot Finger" to investigate the magnetic behavior of GMR Sensors at temperature

The ISI 8x option allows the testing of up to 8 MR heads at temperature. This system was developed in conjunction with Dr. Chung Lam of Read-Rite Corporation. The goal was the development of a system that could replace oven testing of heads with a more sophisticated analysis system capable of providing long-term characterization of heads.

New Concepts in Production

Some additional capabilities provided by the ISI system are appropriate for both the engineering and production environments. The ability to test at the HDA level provides the opportunity to track the individual performance of a head from the starting at the HGA level and ending with the head in a completed HDA. Changes in the head performance can be noted and studied.

Additional production support is provided by a complete set of static tests. These tests are designed to verify the integrity of the HSA flex cable, preamp chip, and voice coil. Software support for production is available at the HSA, HGA, and HDA levels as well. Correlation studies have been performed between the ISI QST system and the Guzik dynamic testers. At the HGA level with a sample of only 12 heads the peak-to-peak amplitude correlated with an $R^2 = 0.8$ and asymmetry correlated with an $R^2 = 0.6$. It is felt that a larger population would produce even higher correlation results. A more significant study was done at the HSA level with 6 headstacks each containing 6 heads. For the population size of 36 heads the peak-to-peak amplitude correlated with an $R^2 = 0.93$.

Finally, a new use for the ESD Stress system in a production environment has been suggested. It has been noted that the HBM waveform is very similar in nature to the "reset pulse" function currently being included in many preamp chips. The idea is to use the ESD Stress system as a "reset pulse" generator at the HGA level in manufacturing.

The ISI QST-2001 Quasi-static Tester introduces a new set of opportunities for the study of ESD in both the engineering and production environments. As a tool for the ESD characterization of MR heads the system provides a completely integrated solution for stress and analysis. In the production setting the QST-2001 can be used as a tool for monitoring ESD damage, identifying trouble processes, and as a true production platform for MR heads from the HGA through the HDA level.