CHAPTER I

INTRODUCTION

1.1 Background

Higher level of quality, throughput, and yield – and at the same time, lower cost, less waste, and less pollution – are always desired in every good and profitable manufacturing outfit. This demands a proper process optimization during the manufacturing of the product. The demand for a proper process optimization is particularly true with regards to contamination control for the Hard Disk Drive (HDD) manufacturing. Special attention is paid to the contamination control in HDD industry because of a drastic decrease in the fly-height (FH). FH is the physical separation – on the order of 10-20 nm – between the slider and the recording disk media in the HDD. (See Figure 1.1 for a description of the various key components within the HDD.) Because of such a narrow separation of the FH, any presence of contaminant will change the dynamic interactions between the read-write element and the disk media. (Figure 1.2.) The resultant changes will lead to the device not being able to function in a way that it was originally intended. This eventually will lead to a premature failure of the component itself. In effect, by not having a properly optimized process, it will negatively impact the product performance and yield – and thus demands process corrective actions and preventions.

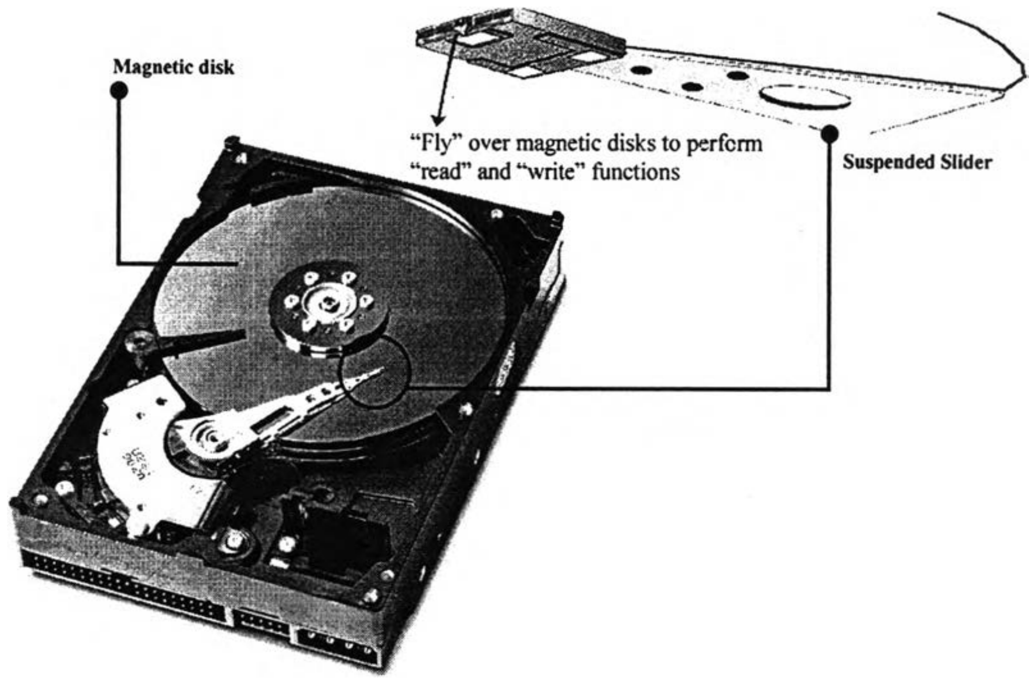

Figure 1.1. A schematic of a Hard Disk Drive main components. Note the slider is attached on a stainless steel arm – or suspension. The whole assembly of the slider onto this suspension is called Head Gimbal Assembly (HGA). The HGA is then assembled with a magnetic disk whereby the slider is allowed to "fly" over the magnetic disk at a separation distance of 10-20 nm.

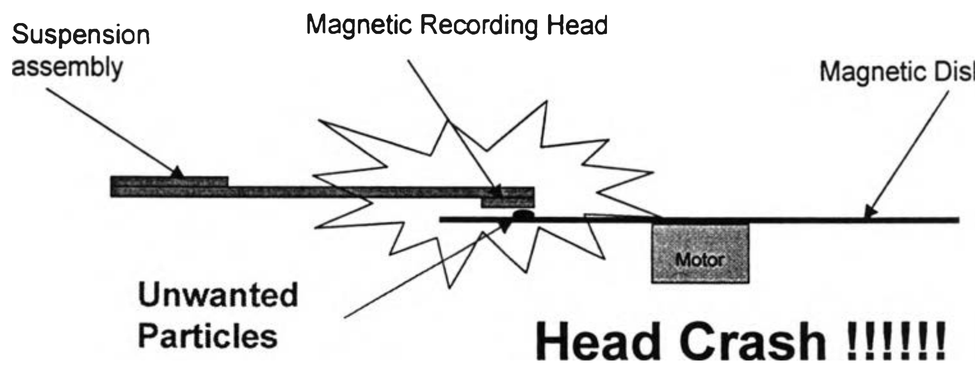

Figure 1.2. An example illustration of presence of contaminant which will change the dynamics between the slider and the disk media causing head crashes.

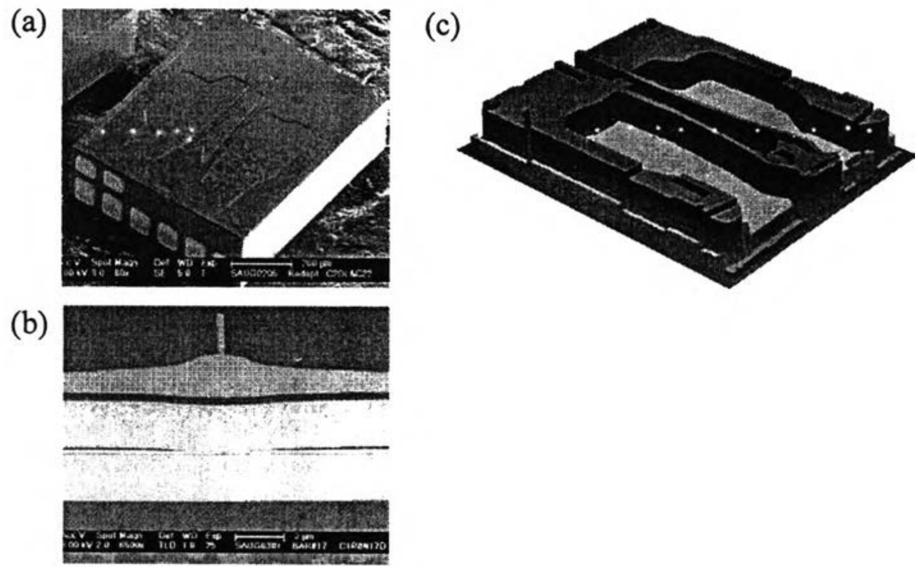

Figure 1.3. (a). An SEM image of the whole slider. Marked box indicates the location of the read-write element. (b) A magnified view of the read-write elements as seen with an SEM. (c) A topographic profile of the ABS pattern on the slider is rendered by the white light interferometer as shown.

Cleanliness control during slider fabrication is especially needed to minimize any process-induced contaminants. Slider is a component within the HDD that contains the read-write element along with the Air Bearing Surface (ABS). Figure 1.3 illustrates the read-write element and how a typical ABS looks. In slider fabrication, there are basically 7 key steps. These steps are illustrated in Figure 1.4 and each is briefly described below:

- Machining. There are approximately 30,000-50,000 read-write elements stacked along side each other on a 6-inch round wafer. The substrate material is made up of the Al_2O_3-TiC compound (AlTiC). During this machining operation, the wafer is sliced into a 2-inch long rectangular bar for each of manufacturing for the subsequent processes.

- Lapping. In this process the 2-inch long rectangular bars are lapped with a diamond slurry in order to "flatten" the read-write element and the remaining portion of the slider to the desired physical dimension.
- DLC coating. Once the slider has achieved the desired physical dimension, a thin protective coating of Diamond Like Carbon (DLC) film is sputtered onto the slider.
- Photolithography and etching. In this step, an ABS is put onto the slider by means of multiple iterations of resist application, expose, develop, plasma etch, resist strip, and cleaning.
- Quasi-Static Testing (QST). In this step, each slider is tested for electrical electrical integrity. Any slider that does not meet the specification will be identified in this step and subsequently discarded.
- Head dicing. The 2-inch bar will be diced to extract the individual slider (of approximate 1x1 mm size) during this step.
- Inspection. This is the final step whereby the slider will be visually inspected to separate out sliders with defects.

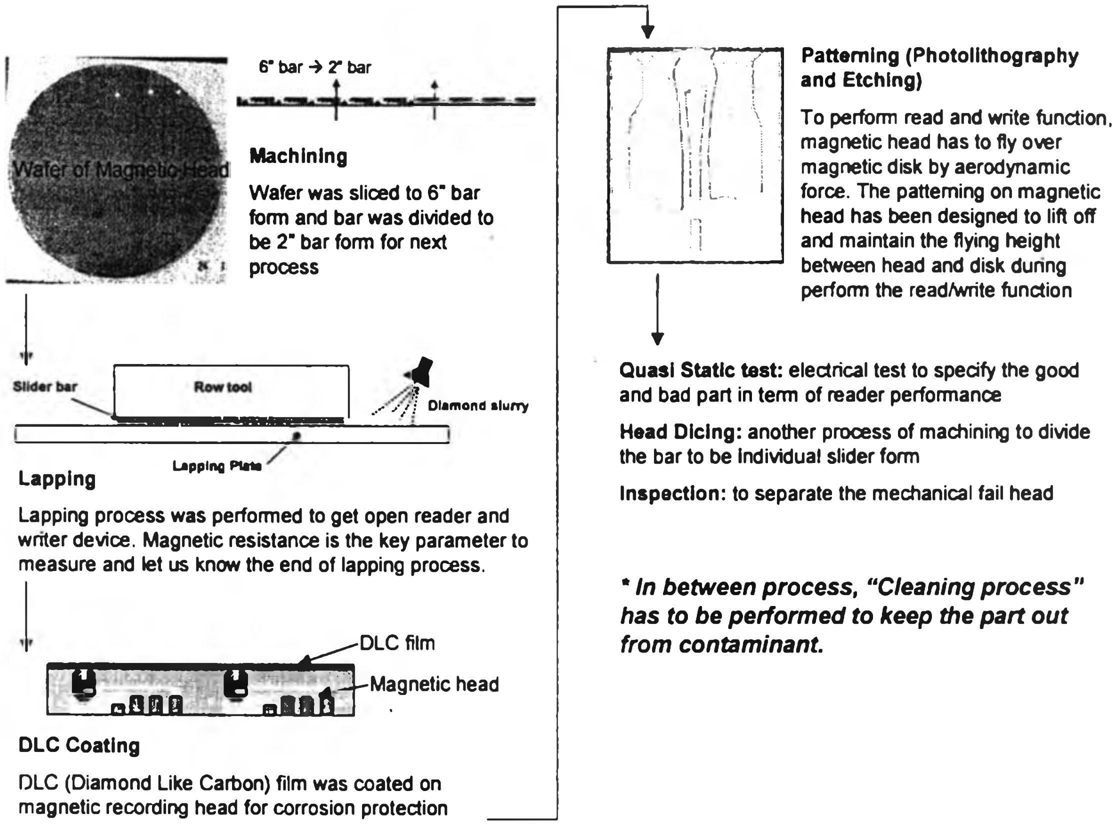

Figure 1.4. Key process steps of magnetic recording head fabrication.

In this study, focus has been given to the characterization and process optimization associated with the control of contaminants induced during the application of Reactive Ion Etching (RIE) plasma in the photolithography and etching steps (for ABS formation as briefly alluded to above). The contaminants from the etching step is commonly referred to as redeposit (from the etching process) and can always be found on the etched step sidewall of the ABS as showed in Figure 1.5. This redeposit can only be seen with the Scanning Electron Microscope (SEM) as the redeposit feature is too small to be seen optically.

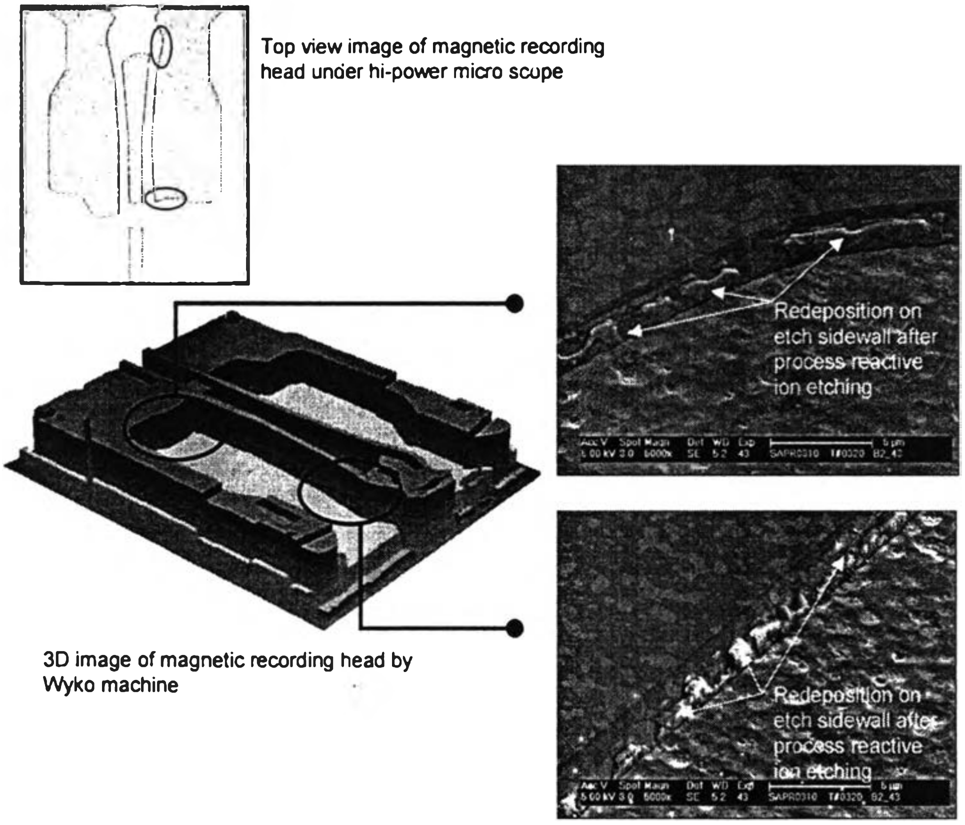

Figure 1.5. The schematic of magnetic recording head, etch sidewall and redepositions from reactive ion etching process on etch sidewall without cleaning process.

To remove this redeposit material, Western Digital Slider Fabrication facility has been scrubbing the parts with Ammonium Fluoride (NH_4F) as a post-etch cleaning solution. However, the effectiveness of this solution has been limited, and it is commonly observed that many redeposit still remains on the etched sidewall. Therefore, there is a growing interest to optimize the redeposit cleaning process to improve its effectiveness. This led to the identification of alternative chemistry namely the use of NaOH (plus de-ionized water) solution which has shown to be potentially more effective than the NH_4F. Nevertheless, as true to every manufacturing process, this redeposit cleaning process improvement has to developed and optimized in such a way that it will improve redeposit removal efficiency; while retaining the overall magnetic and electrical property of the read-write element itself. Therefore, this investigation has been initiated to undertake such task with the objective and method as defined in the following sections.

1.2 Objectives

1. Verify the cleaning effectiveness of redeposit that was generated from etching the AlTiC substrate with the RIE plasma.
2. Develop and optimize redeposit cleaning process to improve cleanliness while maintaining a good electrical and magnetic integrity of the read-write elements.

1.3 Scope of Work

1. Define the optimum condition to get cleaner etched sidewall with minimal mechanical damage and no electrical/magnetic performance degradation by conducting a Design of Experiment (DOE) using the following process factors:
   a. Factor 1: NaOH, concentration at 0.02%, 0.05%, 0.10%, 0.30%, 0.50% and 1% for response screening.
   b. Factor 2: Scrubbing time at 4, 8, 12, 16, and 20 min intervals for response screening.
2. Characterize the redeposit using SEM and AFM.

3. Quantitative data analysis based on statistical tools.

1.4 Expected Benefits

1. Understand the redeposit cleaning mechanism from etched sidewall produced by the RIE plasma.
2. Identify the optimal cleaning process condition for redeposit removal without negative side-effects to electrical, magnetic, and mechanical performances.
3. Reduce failure rate during read-write head operation