CHAPTER 1 INTRODUCTION

1.1 Motivation

The diamond-like carbon (DLC) film and amorphous silicon (a-Si) seed layer thicknesses control of deposition in desirable range are highly important for DLC coating of read/write head manufacturing; currently the areal density of recording magnetic disk drive is rapidly increasing at a compound annual growth rate of 40%. Higher areal density requires less magnetic spacing between read/write head and media disk in operating hard disk drive (HDD). One obvious way to reduce the magnetic spacing is to reduce the thickness of the protective carbon overcoat film; meanwhile it tradeoff read/write head protective performance compare with thicker film. The carbon overcoats are require for wear, scratch and corrosion resistant for HDD in operating environment [1-6], therefore the films must be dense, hard, and pinhole-free. Traditionally, DLC which tetrahedral-bonded amorphous carbon (ta-C) is widely used for magnetic recording overcoats.

The DLC films can be deposited by various methods, i.e. ion beam assisted deposition [7], sputtering [8], filtered cathodic vacuum arc [9], plasma-assisted chemical vapor deposition [10], and pulsed laser deposition [11]. Research over the last years has identified filtered cathodic arc (FCA) deposition as one of the promising techniques for hard carbon films thinner than 5 nm [12-13]. The latest version of FCA call pulse filter cathodic arc (PFCA) using high voltage pulse which produces highly ta-C films that exhibit highest dense to 2.9–3.05 g/cm^3, hardness and pinhole-free. As well known DLC coating is generating high compressive stress in films; therefore, a-Si seed layer deposition between substrate and DLC layer has been introduced for enhancement adhesion and relaxation stresses; moreover, these thicknesses affect mechanical, chemical, electrical and optical properties of film.

The aim of this study is to deposit and characterize DLC/a-Si thin film stack ratio on germanium wafer substrate. The thickness of DLC films was varied from 2 to 9 nm. Before coating of DLC, amorphous silicon (a-Si) with various thicknesses in the range from 2 to 6 nm was coated as a seed layer. Different wafer substrate types have been deposited by DLC/a-Si thin film stack ratio. A significant feature of the study is using a PFCA deposition technique and varies a-Si seed and DLC layer thickness combination in the same times.

1.2 Research Objective

This work addresses the DLC overcoat process using PFCA deposition technique including a-Si seed layer coating prior to the deposit ion of DLC for adhesion enhancement and relaxation of compressive stresses in DLC films. This work includes the following:

(1) To understand the thin films deposition process by varying thickness of DLC/a-Si thin film stack using PFCA technique on germanium substrate.
(2) To study DLC/a-Si thin film stack growth rate on various substrates, including germanium, tantalum and silicon respectively.

(3) To study surface morphology of, chemical bonding structure, chemical composition, thickness, optical property and mechanical property of the DLC/a-Si thin films stack.
(4) To study chemical composition and thickness of interfacial layer between DLC and a-Si.

1.3 Research Boundarie

DLC overcoat process of a magnetic recording heads consists of three steps following; 1) pre-cleaning of wafer substrate with low power Ar ion beam etching, 2) sputtering of a-Si seed layer for depositing an adhesive layer and 3) the DLC deposition. The conditions of pre-clean etch parameter, etch time, condition of a-Si deposition and condition of DLC deposition were fixed according to optimization coated recipe done at Western Digital. Thus, this work only concentrated on the study of DLC overcoat process using PFCA deposition technique. This study of DLC overcoat process used commercial PFCA machine available in Western Digital (Thailand) company (from Veeco Instrument Inc., model Nexus DLC-X)

(1) Several deposition parameters will be pre-determined. Selected parameters, i.e., Ar etching gas and reactive gas flow rates, sputtering power, pulse frequency and arc voltage, will be conditionally manipulated in the study. In these boundaries, the DLC/a-Si thickness stack ratio arc varied on Germanium substrate.
(2) Films deposition will be conducted on the tantalum wafer, silicon wafer and germanium wafer substrate by PFCA.
(3) Various physical measurements for surface morphology, chemical bonding structure, chemical composition, thickness, optical property and mechanical property of the DLC/a-Si thin film stack will be investigated and analyzed.
(4) Upon analysis and conclusion, the results from the measurements will be evaluated.

1.4 Advantage and Application

DLC thin film overcoats have been widely used in many of engineering applications to control wear and friction due to their exceptional mechanical and tribological properties. Coating of DLC thin films for protective magnetic storage disks and magnetic recording heads is one of the most important application. DLC/a-Si thin films stack ratio as used in this study, expecting to have several advantages and application purposes for magnetic recording heads as follow:

(1) Understand the thin films deposition process by varying thickness of DLC/a-Si thin film stack ratio
(2) Know the growth rate on various substrate types.
(3) Known the characteristic of DLC/a-Si thin film stack ratio.
(4) Understood and mechanical and tribological behaviors of coated film as thin as a few nanometers.
(5) Applying the optimum DLC/a-Si thin film stacks ratio combination to mass production.
(6) Novel research development in the field of optical, protective, chemical bonding and thickness of thin films can be applied to manufacturing industries

1.5 Slider Fabrication Process

The most important component of hard disk drive is magnetic recording heads which read/write signals on media disk. The manufacturing of magnetic recording heads (slider) calls slider fabrication is shown in Figure 1.1.

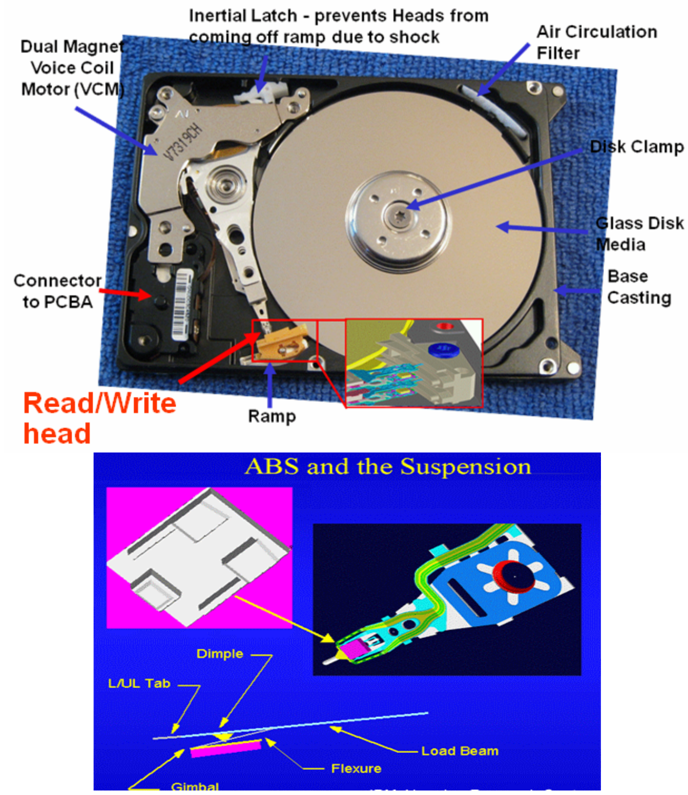
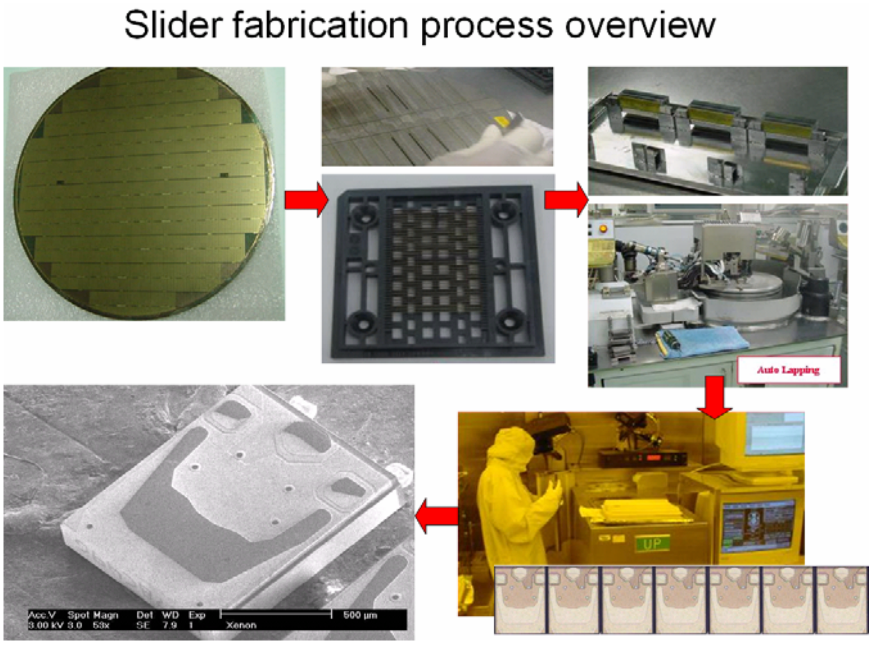


Figure 1.1 Hard disk drive component and magnetic recording heads.

Slider fabrication process can be classified into the following steps, as shown in Figure 1.2 following;

(1) Up-stream slider fabrication process call “Front End”
(2) Middle-stream slider fabrication process call “Clean room”
(3) Down-stream slider fabrication process call “Back End”



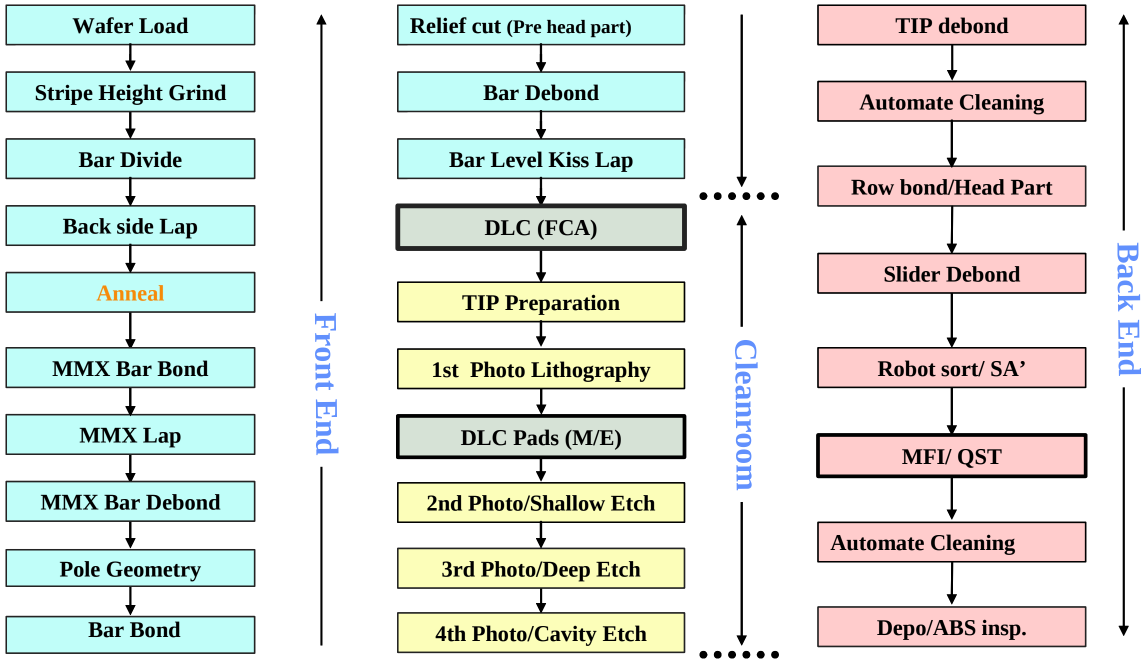


Figure 1.2 Slider fabrication process.

1.5.1 Up-Stream Slider Fabrication Process (Front End)

The operations of the up-stream slider fabrication process are as the following

(1) Wafer Load is the operation that issue document for identify, tracking and control individual magnetic recording heads after wafer loading to production line. Typical the round wafer 6 inch including magnetic recording 44, 646 heads as shown in Figure 1.3.

Figure 1.3 Wafer of 6 inches diameter.

(2) Stripe Height Grind is the operations that divide the 6 inch wafer into row bars as shown in Figure 1.4.

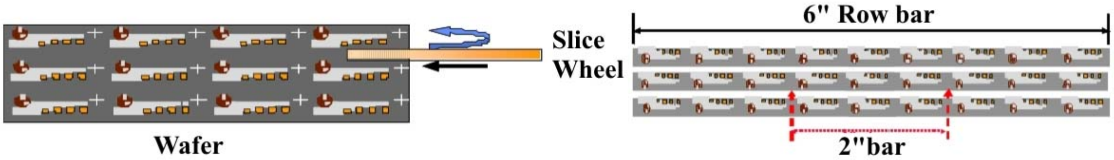


Figure 1.4 Wafer slicing.

(3) Bar Divide is the operation that divide the 6 inch bar to 2 inch bars which is standard length in western digital company.

(4) Back Side Lap is the operation that improve surface roughness of bar after bar dividing via lapping.

(5) Anneal is the operation that reduce stress in bar due to dividing and lapping.

(6) MMX Bar Bond is the operation that connect electrical circuit with bar before lapping front side surface (read/write element side), these bar and circuit are holding by fixture call row tool as shown in Figure 1.5.

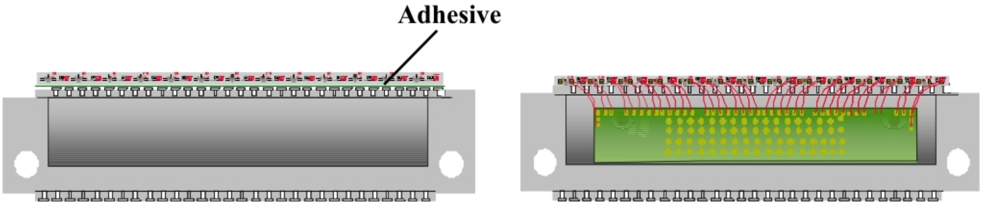


Figure 1.5 Fixture for holding bar and connecting bar with printed circuit board.

(7) MMX Lap is the operation that lapping on the front side surface (read/write element side) using diamond slurry. The key parameter is resistance on read/write element target with close loop lapping system control as shown in Figure 1.6.

Figure 1.6 Lapping process for open read/write element.

(8) MMX Bar De-bond is the operation that unassembled the circuit and bar on row tool then cleaning bar by ultra sonic machine.

(9) Pole Geometry is the operation that inspect and measure the dimension of read/ write element as shown in Figure 1.7.

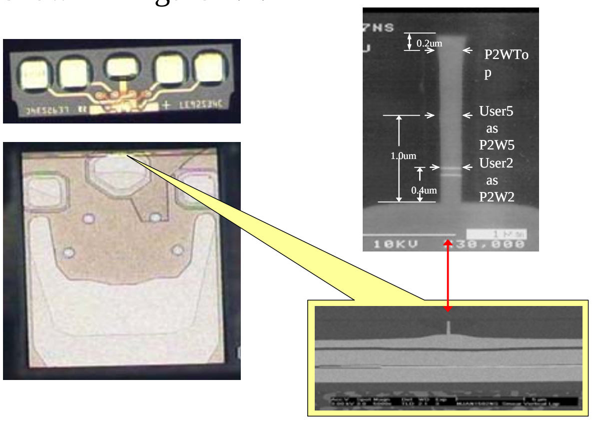


Figure 1.7 Pole geometry measurement.

(10) Bar Bond is the operation that bond the bars the on fixture using wax for next operation.

(11) Relief Cut (Pre head part) is the operation that scribe on the bar to locate sliders and improve curvature of individual slider as shown in Figure 1.8.

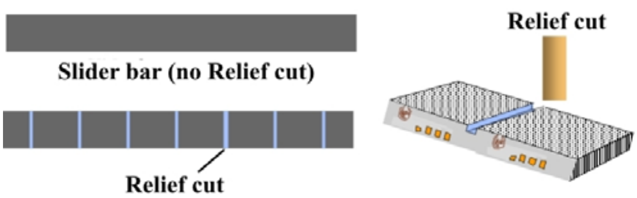


Figure 1.8 Relief cut on bars.

(12) Bar De-bond is the operation that de-bonds from fixture then cleaning.
(13) Bar Level Kiss Lap (BLKL) is the final operation of Up-stream slider fabrication process which fine lapping for adjusted resistant of read/write element and curvature of sliders to target, thereafter the parts will be clean by acetone as shown in Figure 1.9.

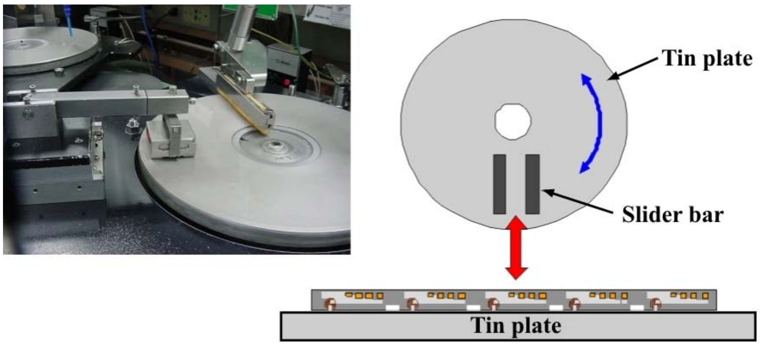


Figure 1.9 Fine lapping process.

1.5.2 Middle-Stream Slider Fabrication Process Clean Room

The middle-stream slider fabrication process was operated in a clean room under the control of contamination, temperature and humidity, illumination and air flow. The key for this operation is coating of slider surfaces by diamond-like carbon films and patterning all mask on sliders for optimizes dynamics system control when slider operate in hard disk drive. The clean room operation processes are the following:

(1) Diamond-liked carbon (DLC) coating is most the important process. The coating of diamond-liked carbon film on top of sliders with a thickness of around 17 angstrom for to protective against wear and corrosion. Prior coating of DLC, the sliders were cleaned to make sure that no contaminants on sliders surface, because DLC films can be delaminate due to contaminations as shown in Figure 1.10.

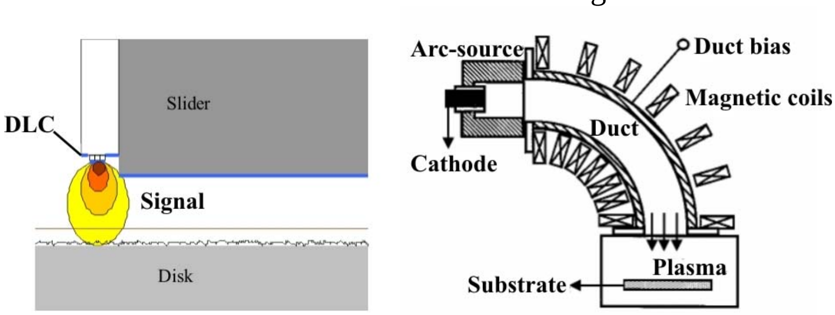


Figure 1.10 Coating of DLC film on slider.

(2) Tip Preparation is the operation that arrange the parts in bar form into 3 inch pallet by accurate automation machine, then fill with special glue. The parts obtained from this process are many bars on 3 inch pallet, called “Tip” as shown in Figure 1.11.

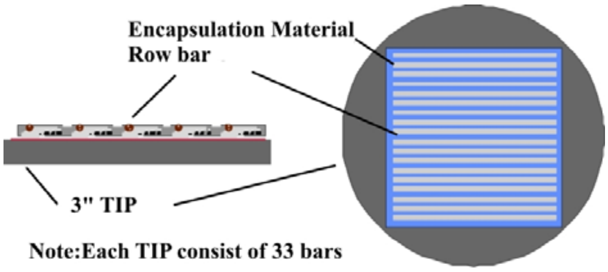


Figure 1.11 Three-inch pallet (Tip) preparation.

(3) Wet Photo Lithography is the operation that make ABS patterning on slider via wet film by dropping on Tip using spin coating process. Then expose the light for making desired patterns. Next, wash by alkaline solvent. The area which exposed to the light has been removed. So that the open area can be make it higher by coating film, or can be make it lower by etching as shown in Figure 1.12.

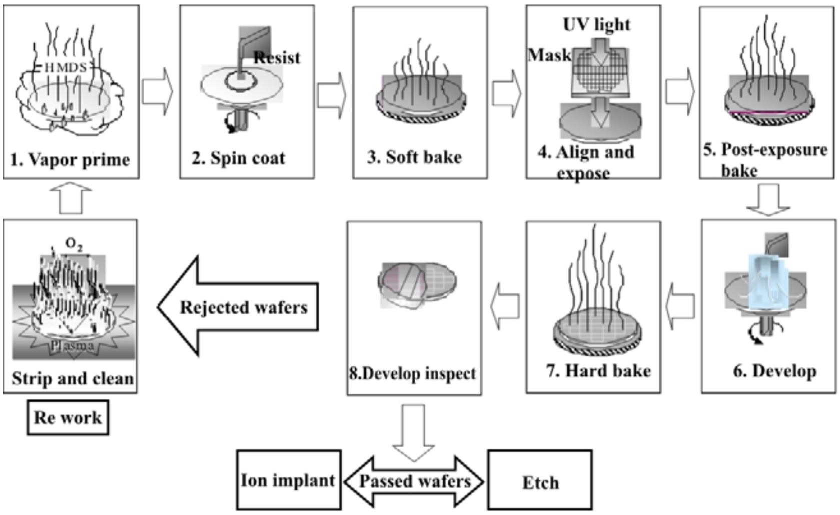


Figure 1.12 Patterning on surface.

(4) DLC Pad Coating is the operation that construct DLC pad after ABS patterning. DLC pad synthesized via methane and ethylene gas then coated on sliders. The pad height is 350 angstrom. The objective of DLC pad is to reduce the friction between slider and media disk during the operation as shown in Figure 1.13.

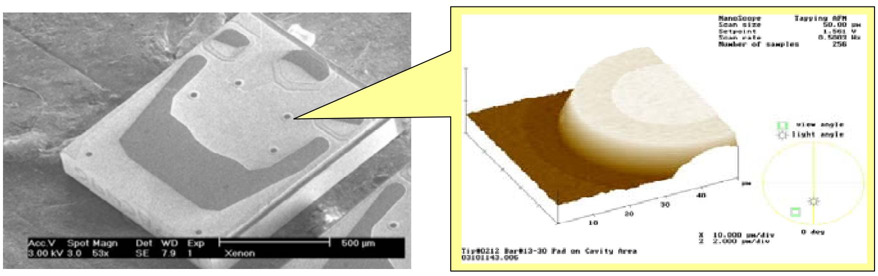


Figure 1.13 Coating of DLC pas on slider.

(5) Dry Photo Lithography is the operation that make ABS patterning on the slider, the same as wet film but use dry film cover on Tip. The dry film mechanism is contrary with wet film namely the area which has been exposed will construct polymer chain with holding sliders surface while unexposed area will be easy to remove by alkaline solvent.

(6) Etching is the operation that make step depth of sliders via etching process using reactive ion etching (RIE) machine with CF_4 gas. The step depth including 3 steps, the lowest depth using wet film process while the rest using dry film process. Due to the etching process cannot make multiple depths at the same time that are why photolithographies which make patterning on sliders has been introduce as shown in Figure 1.14.

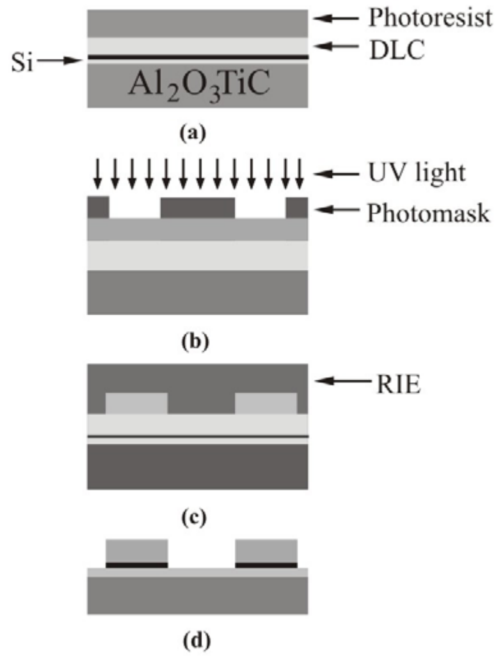


Figure 1.14 Slider's etching.

1.5.3 Down-Stream Slider Fabrication Process (Back End)

Down-stream slider fabrication process is operated in a control room. The objective is dicing parts into bar form and individual slider, also electrical quasi static test and inspection sliders.

(1) Tip De-bond is the operation that make parts on Tip into individual bar form by ultra sonic machine with methyl-2-pyrrolidone to dissolve glue that hold bars as shown in Figure 1.15.

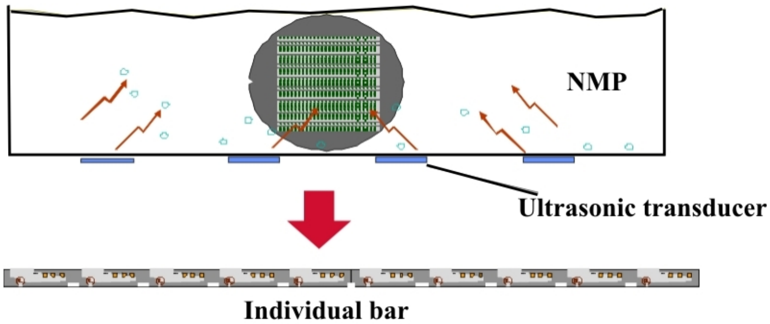


Figure 1.15 Tip de-bond to bars.

(2) Automate Cleaning is the operation that clean parts to remove glue and contaminants.

(3) Row Bond/Head Part is the operation that dice bar into individual slider form. Prior dicing the bars have to be arranged on fixture by wax then dicing by automation machine as shown in Figure 1.16.

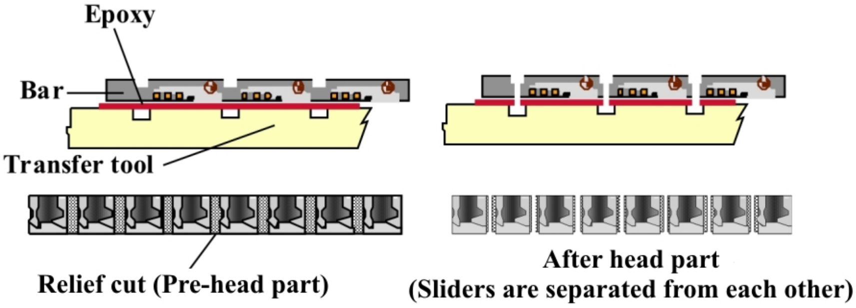


Figure 1.16 Dicing bars into individual slider.

(4) Slider De-bond is the operation that dissolve wax which hold the sliders and fixture using ultra sonic machine with N-methyl-2-pyrrolidone so that we can get individual slider as shown in Figure 1.17.

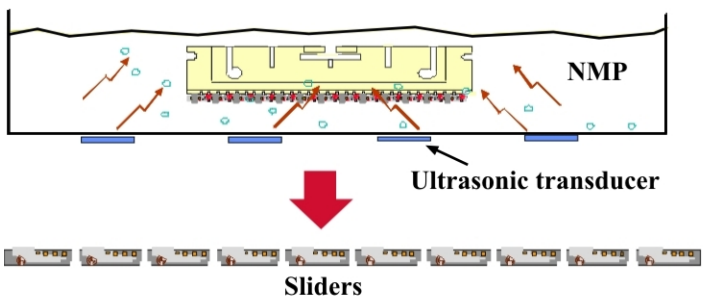


Figure 1.17 Slider de-bond.

(5) Robot Sort is the operation that sort the individual slider to slider tray with the same production lots. Moreover, this operation pick the reject sliders from previous process as shown in Figure 1.18.

Figure 1.18 Robot sort.

(6) Quasi Static Test (QST) is the operation that test magnetic signals of reader element of individual slider for separate group of slider by test performance specification as shown in Figure 1.19.

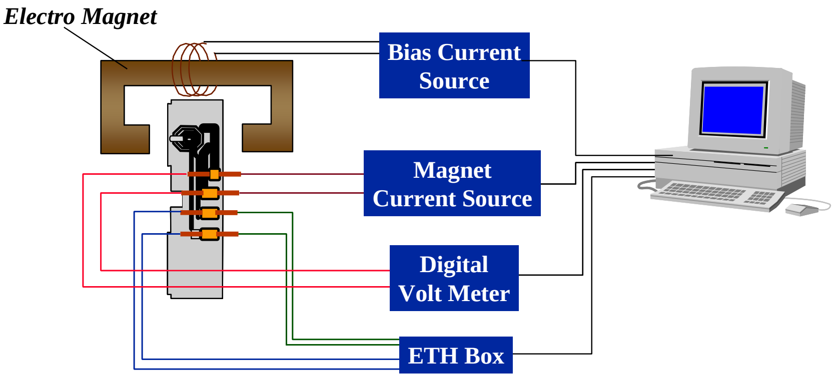


Figure 1.19 Quasi static tests.

(7) Depot/ABS Inspection is the operation that inspect the defect on sliders by high magnification microscope for examination of contamination, photo/etch defect, chip and crack to make sure that no bad slider come out as shown in Figure 1.20.

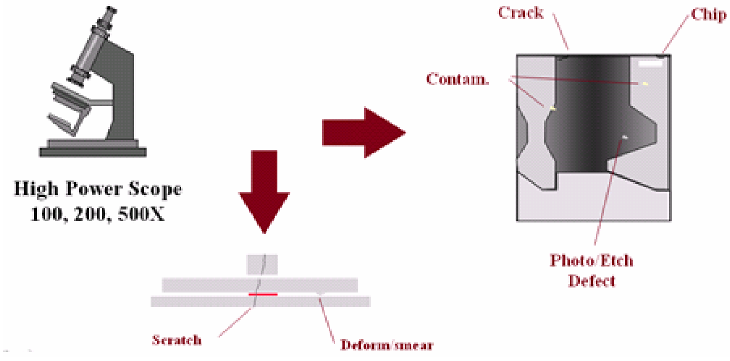


Figure 1.20 Slider inspections using microscope.

1.6 Problem Statement

The thickness control of diamond-like carbon (DLC) and amorphous silicon (a-Si) seed layer deposition in desirable range are highly important for DLC coating of read/write heads manufacturing. Currently the areal density of recording magnetic disk drive is rapidly increasing with the reducing of the slider flying height. The slider flying height in modern disk drives is typically 10 nm and continues to reduce which result in an increasing of the read/write signals. Higher areal density requires less magnetic spacing between read/write heads and media disk in operating hard disk drive (HDD). One obvious way to reduce the magnetic spacing is to reduce the thickness of the protective carbon overcoat film; meanwhile it tradeoff read/write heads protective performance such as wear, scratch and corrosion resistant compare with thicker film as shown in Figure 1.21.

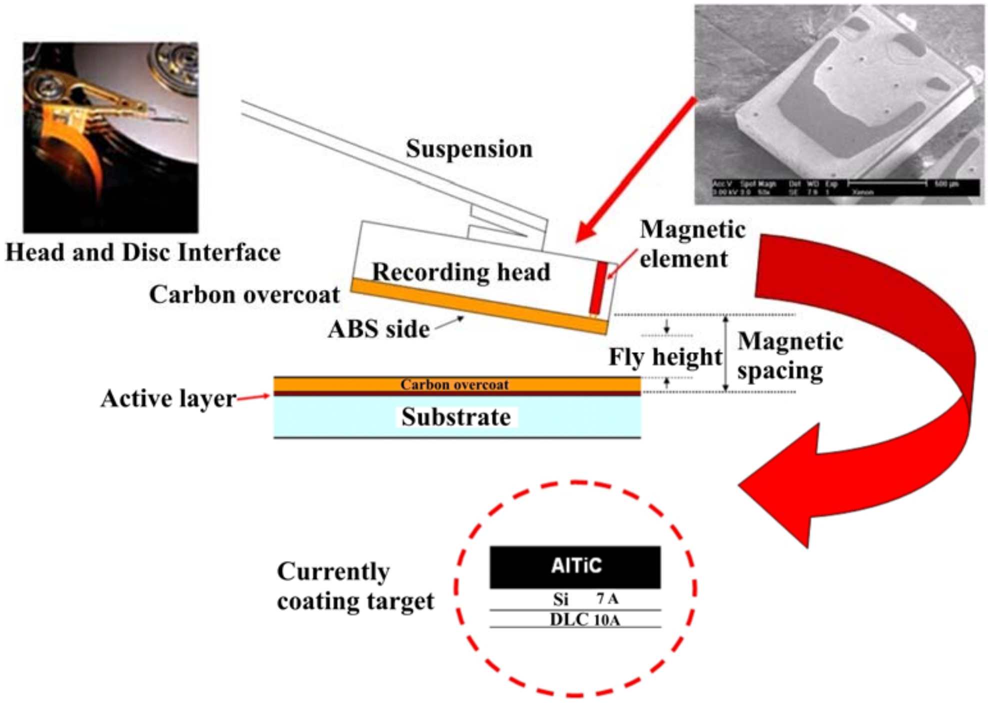


Figure 1.21 Schematic of read/write head, magnetic spacing and flying height.