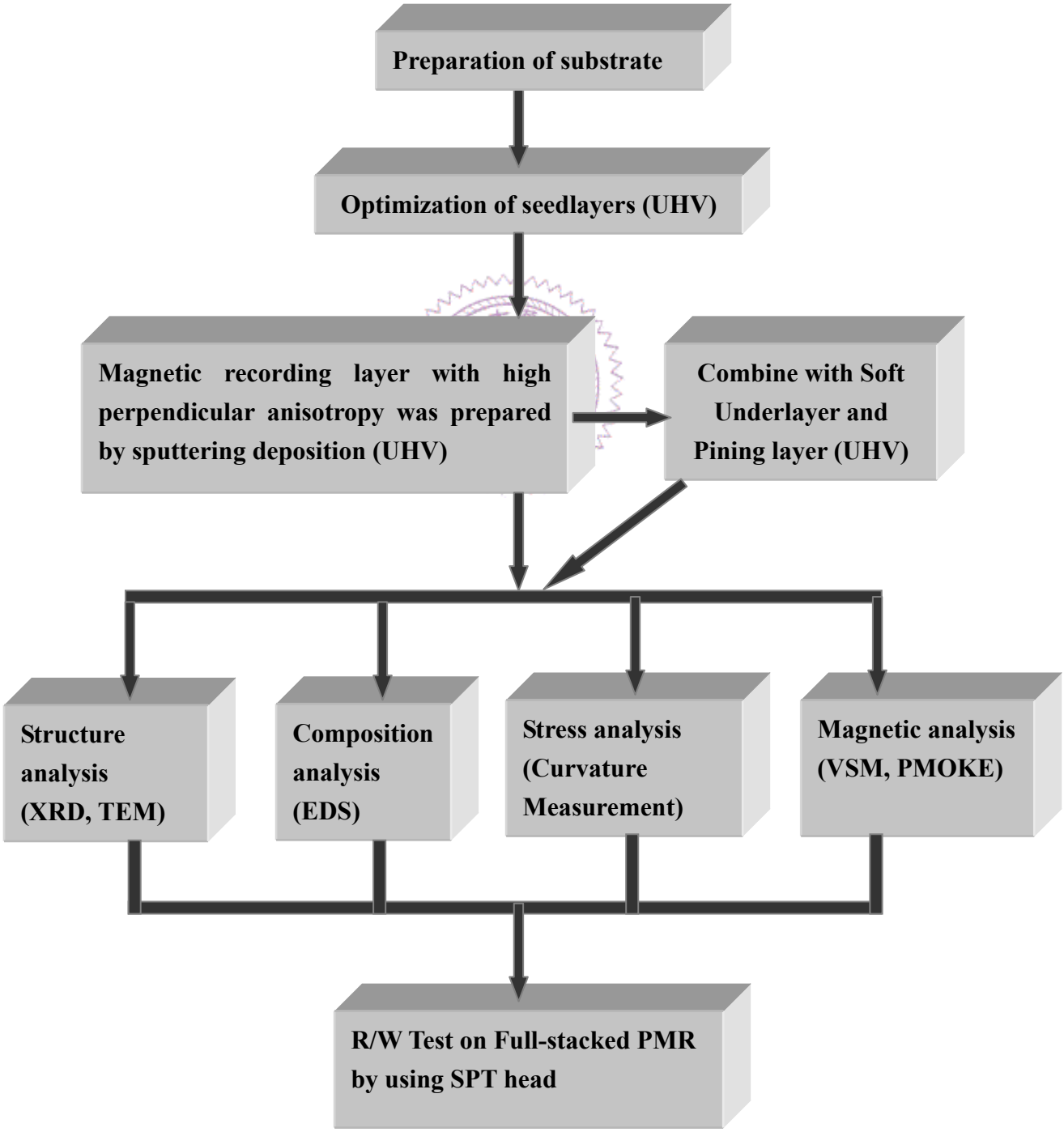
Chapter 3 Experimental and Analysis Technique

This chapter describes experimental techniques and analysis equipments used in the later chapters of this thesis.

3.1 Experimental Flow Chart



3.2 Ultra-High Vacuum Sputtering System (UHV)

The sputtering system is fabricated by ULVAC Corporation Taiwan. This system is composed of two vacuum systems; one is growth chamber and the other is loading chamber.

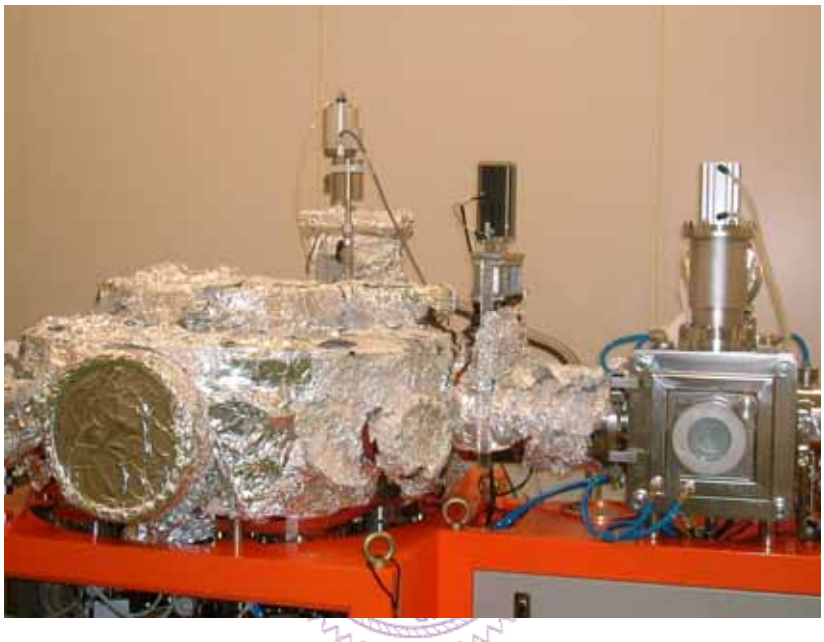


Figure 3.1 Main growth chamber and loading chamber of UHV system.

3.2.1 Specification of UHV System

Main Chamber

- 8 sputter cathodes: 4 non-magnetic guns 4 magnetic guns
- View port-with sputter
- Vacuum: Ultimate background pressure of $5*10^{-9}$ Torr within 24 hrs

Load Lock System

- Transfer manipulator: Single-axis gimbals and Transfer valve
- O_2 plasma oxidation function
- Vacuum: Ultimate pressure: 10^{-7} Torr

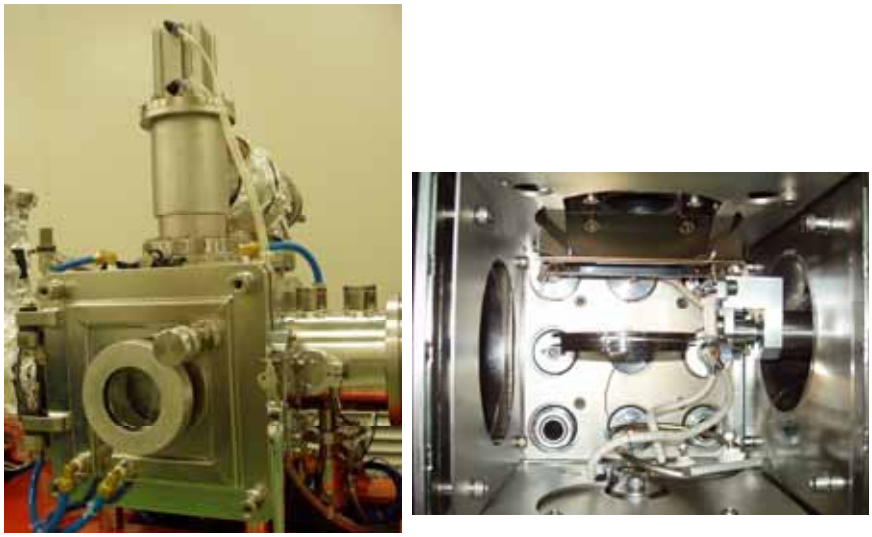


Figure 3.2 Load lock system of UHV system.

Special Mechanisms

- In-situ heating system:

  The heater is just upon the substrate that can maintain the substrate temperature anywhere and anytime during the deposition process.

- 4” wafer of functions of self-spin, orbital rotation, and substrate bias
- Face-up 3” magnetron sputter cathode of gas ring (Ar, O_2, and N_2)

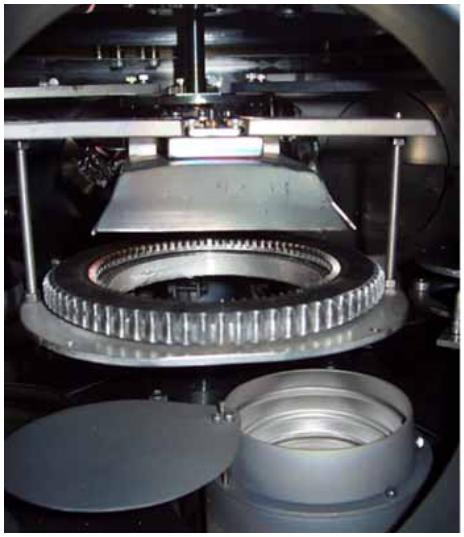


Figure 3.3 Special mechanism of UHV system.

3.3 Analysis Technique

3.3.1 Vibrating Sample Magnetometer (VSM)

Figure 3.4 The Feature of VSM.

The measurement method was proposed by Foner. The principle of VSM is vibrating the sample near the coil, which would induce the variation of magnetic flux. The sample can be in the useful shape of rod or sheet and is mounted on one end of the test rod. The other end of the test rod is connected to loudspeaker. In the beginning with measuring, the testing rod vibrates together with sample with 80Hz frequency. The direction of vibration is perpendicular to the magnetic field. An induced electromotive force would be occurred in the coils due to the variation of magnetic flux though the detection coils. With a reference sample (the saturation moment M_s is known) fixed at the testing rod vibrating together with the measured sample, there is also an induced electromotive force formed in the reference coils. Therefore, we can obtain the magnetic moment of measured sample by comparing the induced electromotive force in the detection coils with reference coils. The scheme of VSM is illustrated in Fig. 3.4 and Fig. 3.5.

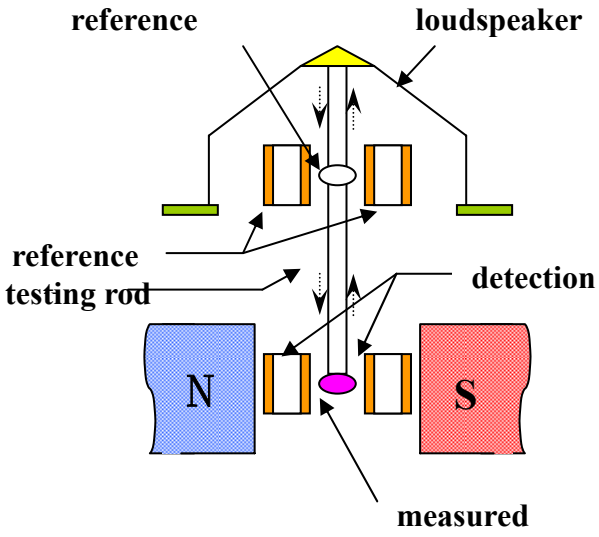


Fig. 3.5 Schematic illustration of VSM.

3.3.2 Perpendicular Magneto-Optical Kerr Effect Meter (PMOKE)

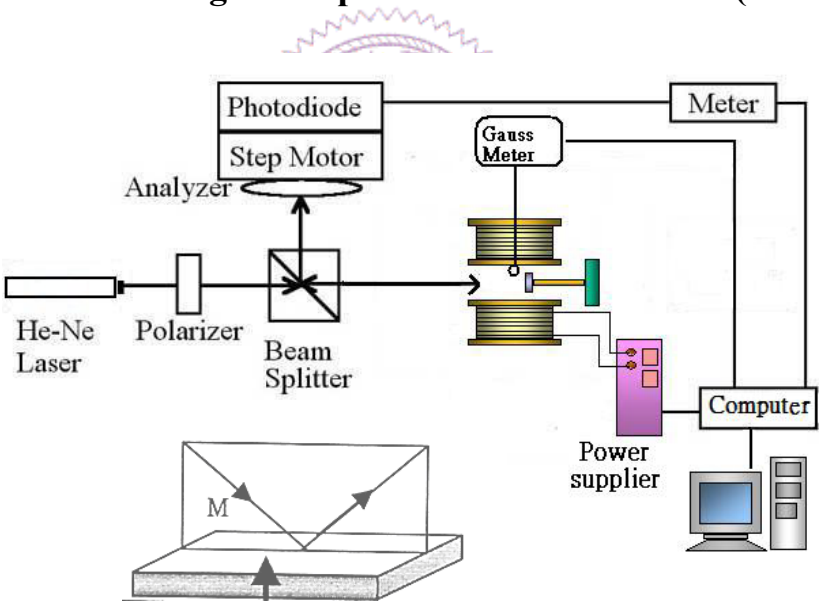


Figure 3.6 The apparatus and the theory of PMOKE.

Changing the rotation of the linear polarized light beam during reflection from a magnetized specimen is the principle of so called MOKE. The amount of rotation depends on the direction and magnitude of the magnetization relative to the plane of incidence of the light beam.

As shown in Fig. 3.6, the linear polarized He-Ne laser light by a polarizer is introduced into the sample located at the center of the electromagnet. If the sample is magnetized by the field, the induced magnetization of the sample would change the dielectric constant tensor of the sample form diagonal-only form to the non-diagonal form. This complex tensor would interact with the linear polarized light, and the reflected light from the sample thus has the elliptical polarization. One can tune the magnetization of the sample by controlling the applied field to change the ellipticity and the tilted angle of the elliptical reflected light from the sample. In our setup, the reflected light is guided into another linear polarizer called analyzer, and then into a photo-diode. Theoretically, the photo-diode voltage induced by the reflected light, called as the Kerr intensity, is proportional to the magnetization of the sample. Therefore, we can measure the hysteresis loop of the sample.

The perpendicular MOKE with perpendicular beam path to the surface of thin film is suitable to measure the perpendicular magnetization thin film as shown in Fig. 3.6.

3.3.3 X-Ray Diffraction (XRD)

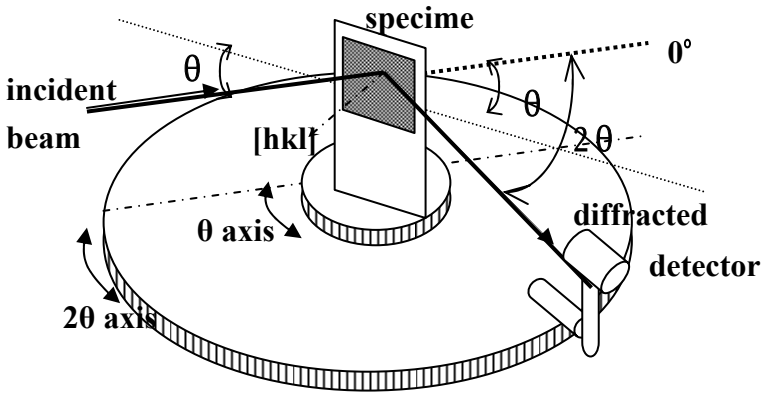


Fig. 3.7 XRD spectrometer.

The essential features of XRD instrument is shown in Fig. 3.7. The rotating axis of specimen and detector are defined as θ and 2θ axis respectively. The detector can be rotated about sample and set at any desired angular position. The crystal is usually cut or cleaved so that a particular set of reflecting planes of known spacing is parallel to its surface, as suggested by the drawing. In use, the specimen is positioned so that its reflecting planes make some angle θ with the incident beam, and the detector is set at the corresponding angle 2θ. The intensity of the diffracted beam is then measured and its wavelength is calculated from the Bragg law "$2d\sin\theta=n\lambda$." This procedure could be repeated for various angles θ.

The directions in which a beam of given wavelength is diffracted by a given set of lattice planes are dependent on the crystal system to which the crystal belongs and its lattice parameters. It means significantly that it is possibly to determine about an unknown crystal by measurements of the directions of diffracted beams are the shape and size of the unit cell. In addition, the intensities of diffracted beams are determined by the positions of atoms within the unit cell.

3.3.4 Transmission Electron Microscope (TEM) and Energy Dispersive X-ray Spectroscopy (EDS)

This analysis owes much to the great support of the Center for Nano-Science and Technology of NTHU. The detail information comes from the diffraction of electrons from the crystallographic planes of the object being investigated. The source is an electron gun and the magnetic lenses are energized by direct current, being composed normally of a

current-carrying coil surrounded by a soft iron case. The HRTEM is also equipped with EDX and EELS to analysis the stoichiometry of grains and grain boundary. Moreover, grain size, segregation state and whole film structure could be observed by the plane view and cross-sectional images.

3.3.5 Atomic Force Microscopy (AFM)

The atomic force microscope (AFM) is a relatively new tool for measuring intermolecular forces between nanometer-scale objects. The type of this apparatus is DI3100. Tapping Mode is generally used in this research to simulate the roughness and film thickness.

An atomically sharp tip is scanned over a surface with feedback mechanisms that enable the piezo-electric scanners to maintain the tip at a constant force to obtain height information above the sample surface. Tips are typically made from Si_3N_4 or Silicon, and extended down from the end of a cantilever. The nanoscope AFM head employs an optical detection system in which the tip is attached to the underside of a reflective cantilever. A diode laser is focused onto the back of a reflective cantilever. As the tip scans the surface of the sample, moving up and down with the contour of the surface, the laser beam is deflected off the attached cantilever into a dual element photodiode. The photo-detector measures the difference in light intensities between the upper and lower photo-detectors, and then converts to voltage. Feedback from the photodiode different signal, through software control from the computer, enables the tip to maintain either a constant force or constant height above the sample.

3.3.6 Curvature measurement

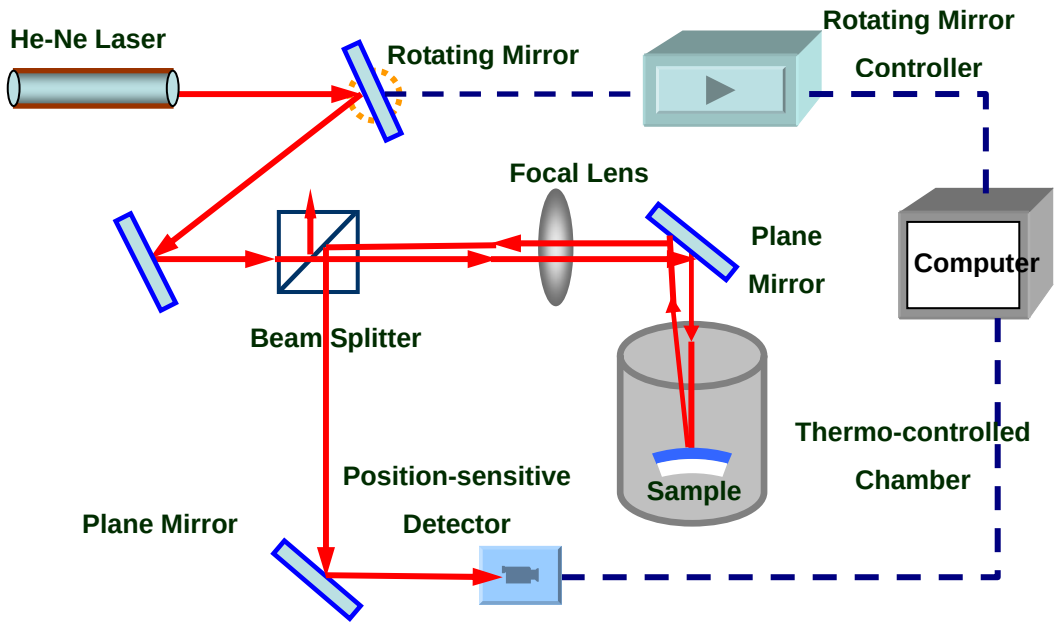


Fig. 3.8 Curvature measurement.

The curvature measurement system, as described in Fig. 3.8, combines He-Ne laser with rotating mirror, and can measure the curvature with raising temperature process in short time instead of moving samples. The wavelength and power of He-Ne laser are 632.8 nm and 7 mW, respectively.

Laser beam would be reflected by rotating mirror which is dominated by rotating mirror controller (General Scanning Inc. CX-600) and able to alter scan rate and region. Subsequently, the laser beam would forward to and reflected by plane mirror, and then passes through the beam splitter as well as divided into two directions of beams. One is reflected into air while the other is lead to focal lens and reflected onto the sample in thermo-controlled chamber. According to various curvatures, the reflected beam from sample would get back along same trace to beam splitter and be introduced into position-sensitive detector. The result of curvature would be obtained from this system by linking to the computer.

3.4 Read and Write Test

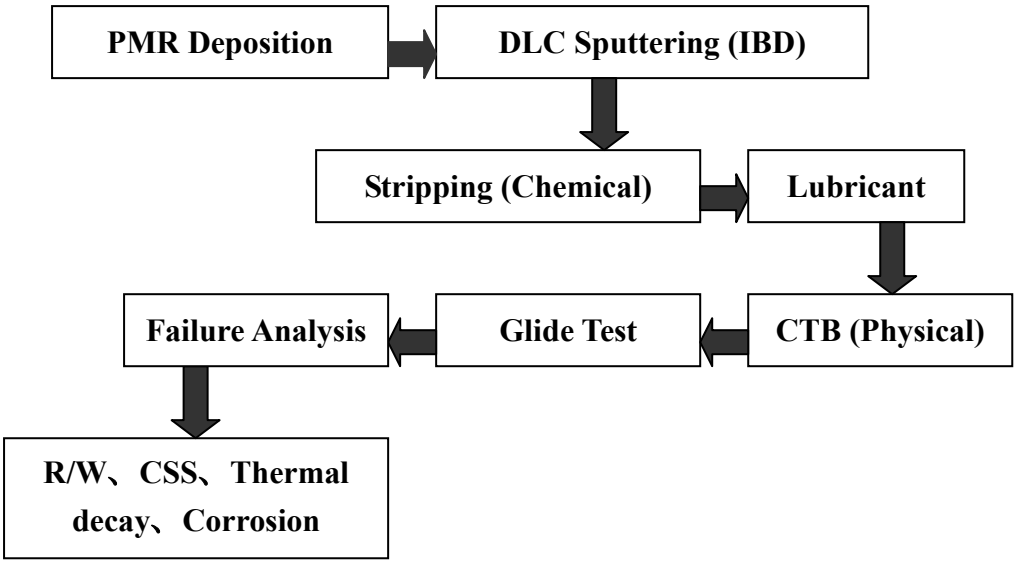


Fig. 3.8 Standard post-processing of commercial disks.

All the post-processing of the disks is performed by Showa-Denko HD Trace Company Taiwan. Firstly of the procedure, a very thin DLC (Diamond Like Carbon) film about 40-50Å is deposited under the recording layer for oxidation free and tribology concerned. Stripping with chemical solution and spin-coating a lubricant layer are the following process in order to remove the contaminants upon the disk and prevent the disk direct contact with MR head, respectively. In addition, the physical polishing process named CTB is used for removal the rest contaminants and the Glide Test is used for prominence examination. Only after all the processes are performed, it is appropriate to carry out the Read and Write Test. Subsequently, the areal recording density and signal-to-noise ratio of our films could be confirmed by the post-processing.