Chapter I

Introduction

Information technology plays an important role in today's world. In the era of computerization for 'paper-less' practice, information is processed, retrieved and stored in computers. The data storage device of the personal computer is a massive storage device that uses magnetic recording technology. This device is called the hard drive (HDD) or sometimes called as 'disk drive' or 'hard disk'. HDD plays an important role in the data storage industry as it has relatively huge storage capacity compared to the other devices like a compact disc, floppy disk and pen drive. For example, a 200 gigabyte HDD has a capacity of at least 200 times more than any of the other devices. In a laboratory, most of the analytical instruments are automated and interfaced with a computer. Data such as chromatograms, spectrums, and digital images with capacity ranging from hundreds of kilobytes to few megabytes are stored in the HDD, allowing the users to retrieve and analyse or process the results at any time in the future.

In recent years, the HDD industry face many challenges in producing HDD with high storage capacity, fast read-write speed and most importantly high reliability. The performance and reliability of a drive are the key factors that ensure its dominance in the market place. To many, HDD is known as an electronic device that has little or no relation to chemistry. Chemical contaminants can cause data lost or functionality failure on the HDD and hence the need of chemical analysis and knowledge to identify and control these contaminants are critical.

The subsequent sections describe in detail the general relation between the HDD and contamination, before defining the objectives of the project.

1.1 Introduction to Hard Disk Drive (HDD)

HDDs are assembled in [1]Class 100 (and below) cleanroom, an enclosed area with control over airborne particles and factors such as air velocity and direction, temperature, humidity, pressure and molecular contamination. This specific designed room is vital for the assembly of HDD to minimize contamination through out the whole manufacturing process.

The HDD is assembled from various mechanical components and electronic devices with the main components being the magnetic head called headstack assembly (HSA) and media or disk (substrate with magnetic layer). As shown in Figure 1, the HDD components are contained in the base. The disk clamp clamps the disk/s onto the motor. When there is more than one disk, the disk spacers are used to separate them. The HSA is the actuator assembly that hold the magnetic heads on the surface of the disks. The voice coil magnet (VCM) is an electro-magnetic positioning magnet. The HDD is covered and sealed by the cover with gasket on it. Carbon filter is used to adsorb the organic compounds as well as moisture present in the HDD.

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[1] Class: the number of particles found per volume of air. Class 100: <100 particles per feet^3 for 0.5 μm

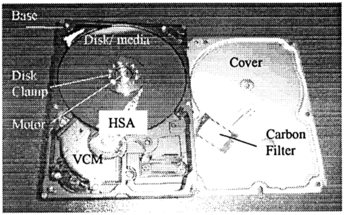

Figure 1. A HDD

Before the assembly, the components are washed through an aqueous cleaning line. A common aqueous cleaning line consists of three washing steps: that is, the Wash, Rinse and Dry. The wash tank contains surfactant in deionized (DI) water and ultrasonic agitation is applied to the components to ensure a thorough removal of loose particles or dirt from the components. The Rinse tank contains clean DI water to rinse off the detergent residue. More than one Rinse tank is applied to ensure thorough rinsing. Finally, components are blown dried with hot air. Aqueous washing line is applied in all HDD manufacturing plants.

Recently, solvent cleaning has become more popular as it is more effective in removing the organic contaminants and reducing adhesive forces that facilitate particulate attachment to the surface of a component. There are two types of solvent cleaning process: cold cleaning and vapour degreasing. The former uses liquid aliphatic petroleum, chlorinated or fluorinated hydrocarbons or a mixture of solvents at room temperature or slightly elevated temperatures while the latter uses chlorinated or fluorinated hydrocarbon solvent vapour.

1.2 Micro Contamination & Analysis

Since the emergence of HDD manufacturing, many contaminants have been identified and proven to have caused HDD failures. These contaminants, in the form of ionic, particulate, organic and metallic, originate from various sources and were transferred to the HDD by different mechanisms, for example corrosion of components, stiction, head-disk interface (HDI), attenuated fly height and thermal asperities. Four major contaminant groups classified by the IDEMA[1] standards are the ionics, particulates, organics and gases.

Various types of analytical instruments are used for detection of these contaminants. Gas chromatography (flame ionization detector or mass spectrometer detector) is used for the organic contaminants whilst Ion Chromatography is used for the ionic contaminants. For surface compositional analysis, the Fourier Transform Infra Red Spectrometer (FT-IR), Electron Spectroscopy for Chemical Analysis (ESCA), Time of Flight-Secondary Ion Mass Spectrometry (TOF-SIMS) and Scanning Electron Microscope/Energy Dispersive X-Ray Spectrometer (SEM-EDS) are used. Thermal analysis tools are also applied for characteristics analysis of resins, adhesives, gaskets and polymeric materials. Liquid Particle Counter (LPC) is a very specific instrument used to measure loose particles on the surface of a component.

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[2] IDEMA: International Disk Drive Equipment and Material Association

1.2.1 Ionic Contaminants

High level of ionic contaminants for examples fluoride, chloride, sulphate and phosphate will corrode the pole[3]. Sulphate can originate from the ionic surfactant, which is left on the components due to insufficient water rinse whilst fluoride and phosphate usually originate from electroplating solution. Ion chromatography is a very useful tool used for the detection of anion and cation contaminants. In fact, it plays an important role in the electroplating industry to monitor the plating solution chemical content. In nickel/ copper electroless plating solution, it is used for the determination of hypophosphite, phosphite and Ni^{2+}/Co^{2+} ratio. In copper sulphate electrolytical plating solution, it is used for determination of chloride/sulphate ratio [1].

1.2.2 Particulate Contaminants

Loose particles can cause detrimental failure to HDD. Particles with sufficient hardness can induce physical defect to the disk when they are trapped between the head and disk during HDD operations. Examples of these particles are stainless steel, Aluminium oxide and silica particles. Most of the HDD components are made of metal, especially Aluminium alloy with surface treatment such as electopolishing or electroless nickel plating to ensure smooth surface finishing to minimize their particle count. The LPC test provides quantitative particles counts of HDD components. Elemental analysis of particles is carried out with a SEM/EDX.

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[3] Read and write component on a magnetic head

1.2.3 Organic Contaminants

Organic contaminants are commonly transferred by gas phase (outgas) from adhesives, gaskets, packaging bags and polymeric components. Among all organic contaminants, silicone is the most frequently occuring contaminant due to its vast applications, as polymeric material such as silicone rubber sealant, gasket, roller used in chambers, as mold release agent and pressure sensitive adhesive release liner, with a primary back bone polymer polydimethyl siloxane (PDMS). The presence of PDMS on the disk will lead to serious stiction problem. A study conducted by Kasai and Eng [2] postulated a plausible mechanism for the formation of silicone oxide debris in the disk environment. It was reported that the volatile siloxane oligomers released from PDMS components, are repolymerized back into PDMS at the HDI area catalyzed by the acidic component of degraded lubricant.

GCMS analysis of silicone materials shows a series of siloxane oligomers peaks with common mass peaks at 73, 147, 221, 281 and 355 m/z (Figure 2).

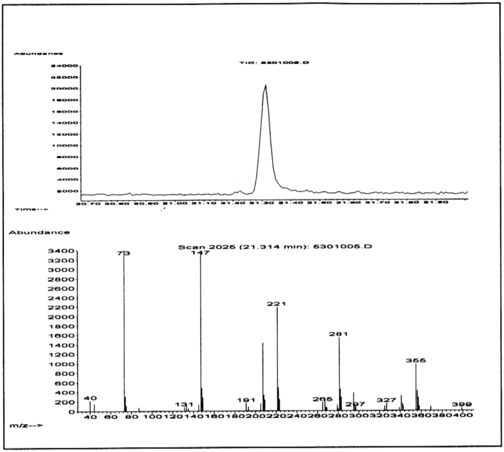

Figure 2. Siloxane Peak and Its Mass Spectrum

The presence of PDMS can also be identified by FTIR where a sharp peak at wavelength 800 cm^{-1} corresponds to Si-C stretching and CH_3 rocking; the very prominent Si-O-Si stretching vibrations occurs at wavelength 1020 and 1100 cm^{-1} and the CH_3 symmetric deformation of Si-CH_3 is observed at 1260 cm^{-1} [3].

The presence of Dioctyl Phthalate (DOP) and erucamides on the head/ disk can also lead to stiction problem. DOP is a common plasticizer and erucamides is used as anti-slip agent in packaging bags. These compounds can be detected via FTIR. Organo metallic tin compounds used as the anti-microbial compounds in coatings or foam gasket is also proven to have caused stiction and it was speculated that these compounds may also degrade the lube additives and induce HDI failure mode. The detection of tri-butylchlorotin, for example is performed via GCMS. Figure 3 shows the standard mass spectrum for the compound.

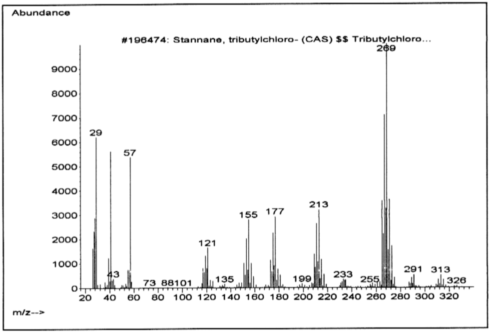

Figure 3. Mass Spectrum of Tributylchlorotin

The control and analysis of cleanroom air is an important area as airborne molecular contaminants present in the cleanroom can deposit and condense onto the HDD components. Thus, for cleanroom used materials, low outgas behavior is an important criteria. P.H. Schnabel et.al [4] carried out characterization of the airborne molecular contaminants that outgas from cleanroom materials such as construction materials, cleanroom furniture, garments and utensils by using TOF-SIMS, GCMS and FTIR. By using these analysis techniques, it was revealed that tri-phenyl phosphate was the main compound outgassed from a cleanroom chair seat cover.