CHAPTER 1 INTRODUCTION

1.1 ELECTRONIC INDUSTRY – AN OVERVIEW

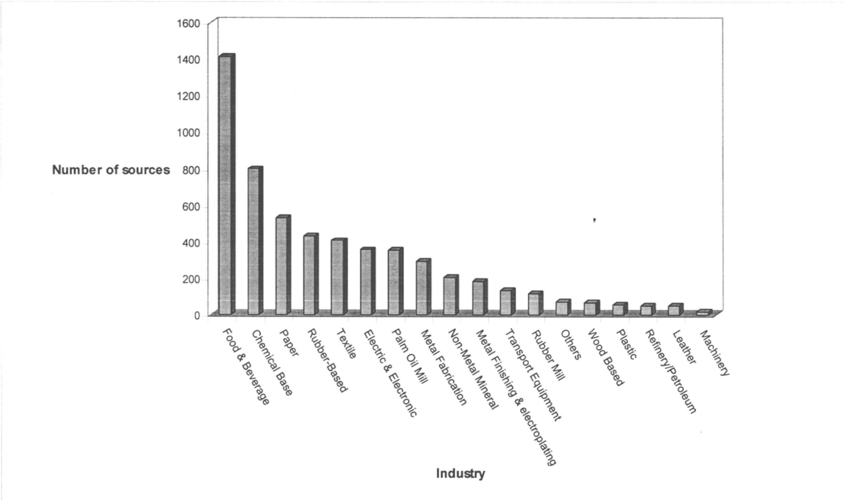
The electronics industry is one of the fastest growing manufacturing sectors, exhibiting rapid changes in production technology and output. Electronic component manufacturing produces the hardware for electronic systems. The manufacturing process includes production of various semiconductor components, manufacture of passive components such as resistors etc., production of printed circuit boards incorporating these components, and finally board-level assembly (Weitz, 2000).

The early image of the electronics industry as a clean, environmentally friendly industry was somewhat dented by the realization that untoward environmental and health impacts could result. The process of manufacture and cleaning of components can produce large quantities of waste in the form of effluents, air emissions and solid waste. Direct disposal of these may cause local environmental pollution, especially of surface and groundwater (Chang, *et al.*, 2002).

1.2 POLLUTION SOURCES INVENTORY

1.2.1 Water Pollution Sources

The estimated number of effluent-related sources for the year 2002 was 13,160 comprising mainly of agro-based industries, manufacturing industries, pig farms and sewage treatment plants. Based on the DOE report 2002, Figure 1.1 shows the source of water pollution sources based on industry.



Source : Malaysian Environmental Quality Report, 2002

Figure 1.1
Malaysia : Industrial Water Pollution Sources (Agro-Based and Manufacturing Industries)

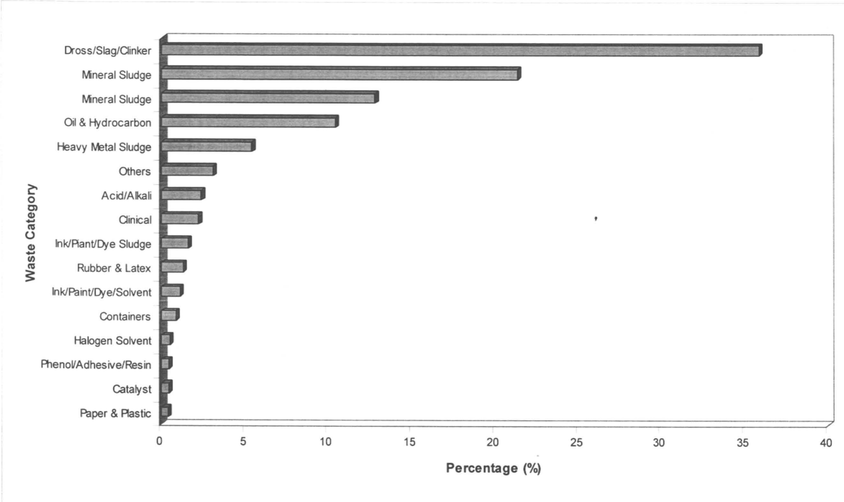
Electric and electronic industry is one of the major contributor to the water pollution. Based on DOE inventory compilation in 2002, 358 sources constituting 6.4% were identified.

1.2.2 Scheduled Waste Inventory

In the year 2002, 420,198 tonnes of scheduled wastes generated were notified to DOE by 3,741 waste generators comprising mainly industries. The breakdown according to waste category and type of industry is given in Figure 1.2 and Figure 1.3 respectively.

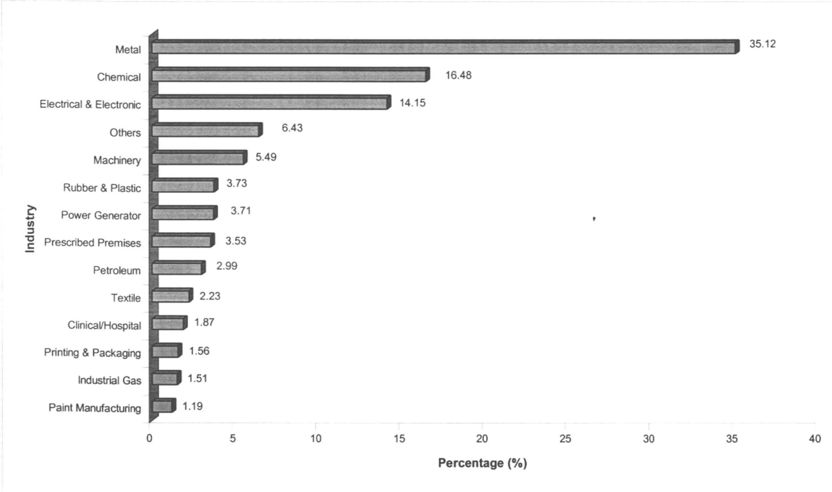
Of the total wastes produced , 76,334 tonnes (18.2%) were reacted and disposed at Kualiti Alam; 7,863 tonnes (1.9%) of clinical wastes were incinerated at licensed off-site facilities; 2,675 tonnes (0.6%) were exported for recovery purposes;123,670 tonnes (29.4%) of scheduled wastes were recovered at off-site local facilities and an estimated 209,656 tonnes (49.9%) were treated and stored on-site at waste generators' premises. Six landfarms and 34 on-site waste incinerators were licensed by the DOE to allow for on-site treatment and incineration respectively.

Based on the Figure 1.2 the possible wastes from electric and electronic industries are mineral sludge, heavy metal sludge and halogen solvent. These wastes are contributing nearly 30% of the waste in 2002 (Malaysian Environmental Quality Report, 2002). No information available on the general status of the solid waste generated in electronic industries specifically.



Source : Malaysian Environmental Quality Report, 2002

Figure 1.2
Malaysia : Quantity of Scheduled Wastes Generated by Waste Category



Source : Malaysian Environmental Quality Report 2002

Figure 1.3
Quantity of Scheduled Wastes Generated by Industry in Malaysia

1.3 ENVIRONMENTAL IMPACT FROM ELECTRONIC INDUSTRY

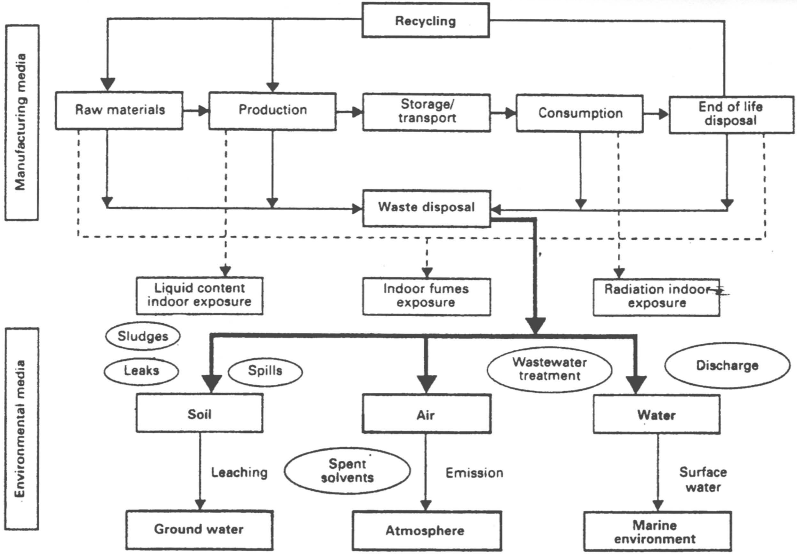
Since the electronics industry uses hazardous chemicals and substances in a variety of complex operations, it is hardly surprising that there are many potential risks involved. Figure 1.4 illustrates the possible sources of pollution from the electronics industry itself, the transport mechanisms and the final destination of the pollutants. There are three main categories of waste from this electronic industry (UNEP & UNIDO, 1994). They are:

(a) Gaseous emission,

(b) Liquid and aqueous waste and

(c) Solid and semi-solid waste.

Many solvents in the electronic industry are toxic and volatile. The effect would be to add on to the air pollution problem over the industrial area and also to contribute to the formation of smog, acid rain and to the destruction of the ozone layer. In the aqueous phase, although there are regulations that force the industries to treat the effluents, some small scale industries are unable to comply. The effect of this is bound to be devastating on the aquatic life and the food chain. Lastly the effect from the solid waste generated could be that if dumped into normal landfills, they could seep into the water table and pollute the ground water. Table 1.1 shows the main sources and impacts associated with the electronic industry. While Table 1.2 shows substances used in the electronics component manufacturing industry that are suspected to cause cancer (UNEP & UNIDO, 1994).



Source : UNEP & UNIDO, 1994

Figure 1.4 Pathways for Waste Streams from the Electronics Industry

Table 1.1
Main pollution sources and impacts associated with the electronic industry

Pollutants Emitted	**Process Sources**	**Representative Compounds Emitted**	**Emission Effects**	**Applicable Emission Regulation**	**Applicable Emission Control Processes**
Acid and caustic gases, vapours, and mists from wet chemical operation	Cleaning, etching, photoresist stripping	Sulphuric acid, hydrochloric acid, phosphoric acid, nitric acid, chlorine, ammonia, acetic acid	Corrosion of materials and property, visible emissions, hazard to personnel.	Local pollution control agency regulations on visible emissions and general nuisance	Scrubbing with alkaline or acidic solutions
Organic vapours (solvents)	Solvent cleaning and photoresist stripping	Isopropanol, acetone, N-butyl acetate, trichloroethylene, xylene, petroleum distillates, halocarbons	Hazard to personnel formation of photochemical smog and ozone	Federal, state and local emission regulation Uniform Fire Code (UCF)	Adsorption Catalytic incineration Thermal incineration
Toxics, reactive, and other hazardous gases, vapours, & particles from process exhaust. Gases vented during cylinder change.	Epitaxy, chemical vapour, deposition, diffusion, ion implantation, oxidation, plasma etching	Hydrogen, silane, arsine, phosphine, diborane, hydrogen chloride, phosphorus tribromide, dichlorosilane, phosphorus oxychloride, boron tribromide	Hazard to personnel, facilities and equipment	Federal and stage standards for industrial hygiene Uniform Fire Code (UFC) Uniform Mechanical Code (UMC)	Incineration, incineration plus filtration, incineration plus scrubbing, scrubbing with alkaline or oxidizing solution
Accident or emergrncy releases of hazardous gases or vapours.	Equipment failures, leaking gas cylinders, pipes or valves	Silane, phosphine, diborane, chlorine, organometallic materials,arsine	Hazard to personnel, facilities, and equipment. Hazard to general populayion in adjacent area	Iniform Fire Codes on semiconductor fabrication facilities and on use and handling of hazardous production materials	Scrubbing with alkaline or oxidizing solution plus filtration

Source : UNEP & UNIDO, 1994

Table 1.2
Suspected Carcinogenic Chemicals Used In The Electronics Industry

Chemical	H	A	Chemical	H	A
Acrylonitrile	Yes	Yes	Gold	S	S**
Antimony	S	S	Isopropyl alcohol	S	S
Aromatic amines (dyes)	Yes	Yes	Lead + compounds	S	Yes
Arsenic + compounds	Yes	S	Maleic anhydride	S	S
Arsine	Yes	S	Manganese	S	S
Asbestos	Yes	Yes	Methyl methacrylate	S	S
Benzene	Yes	S	Moca	S	Yes
Benzidine	Yes	Yes	Molybdenum trioxide	S	Yes
Benzyl chloride	S	Yes	Nickel + compounds	Yes	Yes
Beryllium + (compds)	S	Yes	Perchloroethylene	S	S
Bis(chloromethyl) ether	Yes	S	Phenol	S	S
Boric acid	S	Yes	Platinum	S	S**
Cadmium + compds	Yes	Yes	PCBs (biphenyls)	S	Yes
Carbon tetrachloride	S	S	Polymers plastics : polyethylene	S	Yes
Chlorinated diphenyl	S	S	Polystyrene	S	Yes
Chlorinated HCs	S	Yes	Polytetrafluoroethylene	S	S
Chloroform	S	Yes	Polyurethane	S	S
Chlorotoluene	S	Yes	Polyvinyl chloride (dust)	S	S
Chromates	yes	Yes	Propyl alcohol	S	Yes
Chromic acid	Yes	Yes			
Chromium = compds	Yes	Yes	Radiation :		
Cobalt	S	Yes	Microwaves	S	S
Dichlorobenzene	S	S	Radioisotopes	Yes	Yes
3,3- dichlorobenzidine (+salts)	S	Yes	UV	Yes	Yes
a,a-dichloromethyl ether	S	S	X-rays	Yes	Yes
Diepoxy butane	S	Yes	Selenium + compounds	S	S
Diethyl amine	S	Yes	Silica (quartz crystalline)		S**
Diglycidyl ethet	S	S	Siver		S**
Diglycidal ether of bisphenol A	S	Yes	Styrene	S	S
1,4-dioxane	S	Yes	Styrene oxide	S	S
Diphenyls	S	S	Tetrafluoroethylene	S	S
Epichlorohydrin	S	Yes	Titanium oxide	S	S
Ethyl acrylate	S	S	1,1,1-trichloroethane	S	S
Ethyl alcohol	S	Yes	Trichloroethylene	S	S
Ethylene dibromide	S	Yes	Triethylene glycol		
Ethylene dichloride	S	Yes	diglycidyl ether	S	Yes
Ethylene imine	S	Yes	Vinyl chloride	Yes	Yes
Ethylene oxide	S	S	Vinyl cyclohexene dioxide	S	Yes
Fibreglass	S	S	Zinc chloride	S	S
Formaldehyde	S	yes			

Source : UNEP & UNIDO, 1994

Key : H=humans; A=animals: Yes=sufficient proof of causing cancer; S= suspected of causing cancer (NOTE : suspected means either that there is some evidence but not enough for conclusive proof or that since there is some evidence of cancer in animals we must suspect there is also a cancer risk for humans)
** by implant only

Waste minimization

Among the motives for minimizing waste and environmental impact, a major incentive is money. Waste minimization option can be divided into: source reduction options, that is, any activity that reduces the amount of waste generated in the process; and recycling options, where waste streams can be re-used in the same process or other processes or some components of the waste stream can be reclaimed, thus reducing final waste load (Ashbrook & Houts, 2000) .

The electronics industries in USA have participated in many pollution prevention projects and have been the focus in many case studies. Pollution prevention techniques and processes used by these industries can be grouped into 4 general categories :

(a) Process or equipment modification

This techniques is used to reduce the amount of waste generated. For example, manufacturers can change equipment or processes to: enhance water conservation by installation of countercurrent rinsing systems, reduce alkaline and acid concentration in tanks by installing a pH controller, and reduce drag-out by decreasing the withdrawal rate of parts from plating tanks.

(b) Raw material substitution or elimination

This is the replacement of existing raw materials with other materials that produce less waste, or a non-toxic waste. Examples include substituting non-cyanide solution for a sodium cyanide solution in copper plating baths and replacing hexavalent chromium with trivalent chrome plating system.

(c) Waste segregation/separation/preparation

It involves waste separation according to the different type, hazardous wastes with non-hazardous wastes. This makes the recovery of hazardous wastes easier by minimizing the number of different hazardous constituents in a given waste stream. Also, it prevents the contamination of non-hazardous wastes. A specific example is segregation of waste water sludge by metal contaminants.

(d) Recycling

This technique is the use or re-use of a waste an ingredients or feedstock in the production process on-site. Examples of recycling include : recovering copper during the etching processes, recovering lead and tin from printed wiring boards, installing a closed-loop recycling system to reuse freon (which is being phased-out) and reduce/reuse water consumption

1.4 PROJECT SUMMARY

This project involves the analysis of two types of waste, solid and liquid waste. Both waste were obtained from Fairchild Semiconductor (M) Sdn. Bhd. In this thesis, experimental studies were carried out to investigate the reduction potential and/or treatability of the electronic solid waste. The main ingredient in this waste is titanium oxide. Solidification/stabilization method is used to evaluate the optimum amount, types of binder and additive to be applied. Ordinary Portland Cement (OPC) and white cement, with and without activated carbon were utilized in this study.

Research has been done on different type of electronic waste. But no researchWaste auditing was carried out in Fairchild facility for four weeks. Waste auditing will help to identify the possibilities of reusing or recycling all the waste in that facility. The wastewater which was obtained from Fairchild was treated for the high pH. The water was analysed for heavy metals.

1.5 OBJECTIVES

The objectives of this research are :

(i) to carry out a waste audit at Fairchild Semiconductor (M) Sdn. Bhd. to determine the quality and quantity of waste generated,

(ii) to characterize the waste generated to establish the physical and chemical characteristic of the waste,

(iii) to investigate the content of the waste water

(iv) to solidify the electronic waste using two types of cement (OPC and white cement), with and without activated carbon,

(v) to determine the leachability characteristics of the treated/solidified waste by using 2 leaching procedures : TCLP and ANS 16.1,

(vi) to investigate the hardening time and compressive strength of the monolithic waste form,

(vii) to investigate potential treatment/use of the solidified matrix