1. INTRODUCTION

The air pollution problems, including acid rain, global warming, smog and the depletion of the ozone layer, which is long-term affected on whole environment. In contrast to the long-term problems, the short-term effects of air pollutant can normally become hazardous to human health. Many researches emphasize the correlation between air pollution and public health problems. The air pollutants generally cover: aerosols, sulfur oxides, nitrogen oxides, volatile organic compounds, particulate matter and heavy metals, etc. Among all, some metals, such as Arsenic, Cadmium, Nickel and Lead already were listed in principal control material from the developed countries. Therefore, the investigation of metal pollution may reveal the important and possible ways to protect the living environment. In the past, several studies were attempted to investigate the metal distribution and identify the possible emission sources. Additionally, related researches also provided some information for regulatory purpose, which can also be used to control the pollution problems. However, both human health and air quality are the major concerns for the sustainable development of the Earth.

Recently, the rapid industrialized and urbanized countries show an ascending trend of trace metals contamination, which are confirmed to have various diverse effects on human health (Borbély-Kiss *et al*., 1999, Clarke and Chen, 1996, Vadjic and Fugas, 1997). Many epidemiology studies also support the correlation between metal dose and health risk (Dockery and Pope, 1994). Espinosa *et al*. (2001) found high levels of metal concentration in suspended particulate were generated by anthropogenic emission sources and may exceed the environmental background levels. High metal level in the environment may cause serious health problems on human being. Long-term exposure to particulate deposition has been confirmed to adversely affect human health, such as cancer and chronic respiratory diseases

(Pedersen *et al.*, 1999). Some evidences also directly indicate that exposure to metal in respirable particulates can increase a notable toxicity effect for lung or cardiopulmonary injuries (Costa and Dreher, 1997, Espinosa *et al.*, 2001, Espinosa *et al.*, 2002 and Trijonis, 1983). Therefore, the United State Environmental Protection Agency (U.S. EPA) has published a fact sheets of health effect notebook for hazardous air pollutants on the website, which describing the effect on human health of substances (U.S. EPA Air Toxic website, 2006). From the U.S. EPA website, it covers hazardous substances of metal element, which includes arsenic (As), calcium (Ca), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn) etc. According to the U.S. EPA fact sheets of health effect, which indicated the acute exposure of high concentration metal dusts will cause the injuries of respiratory system, gastrointestinal effects, central and peripheral nervous system disorders. The long-term exposure to metal dusts will cause the human syndrome strongly associated with skin, liver and lung cancers. Among all, the high toxicity metal of lead is specially labeled as target compound of Air Quality Index in both Taiwan and USA. The possible reason of controlling lead is due to its possibly affects on children and infants. The Pb can be found at high levels in both urban and industrial areas, with the type of deposited in soil or dissolved in water and harms animal and fish (U.S. EPA Six Common Air Pollutants website, 2006). European Union (EU) enforced most metal emissions, due to the metal toxicity and industrial type, which include As, Cd and Ni are listed in the Air Quality Target (European Community, 1992). Englyst *et al.* (2001) discussed the lung cancer risks among lead smelter workers also exposed to arsenic. Gidhagen *et al.* (2002) indicated inorganic arsenic in total suspended particle had several characteristics: (1) extremely toxic material (2) long time exposure may cause serious health effects, such as skin disorders (3) development of different cancers and

(4) enters to the body through ingestion, inhalation and skin absorption.

USEPA used a mathematical model, applying data from an occupational study of arsenic-exposed copper smelter workers, to estimate the probability of a person developing cancer from continuously breathing air containing a specified concentration of inorganic arsenic (U.S. EPA Arsenic compounds websites, 2000). It calculated an inhalation unit risk estimate of 4.3 ng/m^3. EPA estimates that, if an individual continuously breathe air containing inorganic arsenic at an average of 0.2 ng/m^3 over his or her entire lifetime, that person would theoretically have no more than a one-in-a-million increased chance of developing cancer as a direct result of breathing air containing this chemical. Similarly, EPA estimates that continuously breathing air containing 2 ng/m^3 would result in not greater than a one-in-a-hundred thousand increased chance of developing cancer, and air containing 20 ng/m^3 would result in not greater than a one-in-ten thousand increased chance of developing cancer (U.S. EPA Arsenic compounds websites, 2000). European Union also provides the ambient arsenic value must be lower than 6 ng/m^3 after December 31, 2012 (European Union commission websites, 2004).

In atmosphere, the transport of toxic metals is majorly associated with the diffusion of airborne particulate matters. Natural sources of particulate matter are usually emitted from evaporated sea spray, wind-borne pollen, dust, volcanic activity and the Earth's crust activity. While the anthropogenic sources of particulate are generated by combustion and various industrial processes, which include the fossil fuel burning, heating and household cooking, agricultural burning, diesel-fuel engine combustion, cement manufacturing, mining, stone crushing and metal milling. Many other sources of particulate matter are coming from the dusts re-suspension by vehicles and large conveyances (World Bank Group, 1998). In general, particulate matters on receptor surface is by the ways of either dry (gravity) or wet (precipitation) deposition processes. The suspended particulate is a critical mechanism to carry the airborne toxic and transport from the atmosphere to receptor surface. The transmission rate of particulate depends on the physical property (particulate size, density, shape), chemical property, surface characteristic and meteorological conditions (temperature, wind speed, etc.). Theoretically, the level of total suspended particulate is significantly affected by the ambient meteorological condition and particulate physical property.

In Taiwan, the air quality problems are degrading seriously due to the mass anthropogenic development effect, such as heavy industrialization and urbanization and cause the high metal emission. For example, several studies indicated that some acute air pollutants emitted from industrial emission, traffic source and municipal incinerator were the major pollutant sources in central Taiwan (Fang *et al.*, 2004 and Hu *et al.*, 2003). Besides, the new development of the central Taiwan science park (CTSP) also may emit extensive metal pollutants and damaged the ambient quality. Su (2000) indicated the ambient metal concentrations around the Hsinchu Science-based industrial Park (HSBIP) were significantly higher than the nearby background environmental levels. Metals including As, Cd, Cr, Cu and Ni are normally released from anthropogenic high-tech industrial sources. Chein *et al.*, (2004) also indicates the semiconductor and optoelectronic manufacturing processes utilizing many chemicals which might be discharged as pollutant. Arsine (AsH_3) is used in many processes such as chemical vapor deposition, ion implantation and diffusion, epitaxy process, etc. and the source of arsenic compounds in flue gas as well as surrounding ambient air contamination. Gas phase arsenic, i.e. AsH_3 is very unstable and will furtherly oxidized to As_2O_3 (can exist in vapor phase)/ As_2O_5 under the conditions of the vent duct (Jadhav and Fan, 2001). Figures 1-1 and 1-2 show the glass producing process and the emission arsine treatment process. The glass producing process include (1) furnace (2) glass shaping (3) cutting (4) grinder (5) wash (6) inspect and (7) pack. Thus, the arsine compound is added into the glass material before furnace and may cause the discharged arsenic pollutant. While the emission arsine treatment process includes (1) local and (2) central scrubbers then discharge and the process could remove part of arsenic pollutant. According to the information from CTSP, one glass base plant spend on H_3AsO_4 more than 218 ton per year, and the theoretical emitted capacity is 63.7 kg per year (CTSP, 2007). However, the European Union expects the LCD glass base should be non-arsenic since 2007, and CTSP will carry out the non-arsenic producing process hereafter (European Union commission websites, 2007 and CTSP, 2007). Although those high levels of metal were possibly emitted by the science-based industrial operation, while related investigations are very limited. The information indicated the possible air pollution sources in Taichung area are high-tech industries, traditional industries and traffic exhaust.

The definition of the science-based industry in this paper covers the high-tech industry, primarily includes two categories: the optoelectronics and semiconductor industries, which the Taiwan Government strongly supports to develop recently. Therefore, many high-tech industrial parks were established consecutively, such as the HSBIP found in 1976, Southern Taiwan Science Park (STSP) found in 1995 and Central Taiwan Science Park (CTSP) found in 2002. The CTSP constructed in 2003 and expected to accomplish in 2012, under a three stages of expansion project with a total developing area of 413 hectares (Central Taiwan Science Park websites, 2007). During sampling period of this study, the CTSP is under first stage development project. The types of CTSP industry cover aerospace, precision machinery, optoelectronics, telecommunication, biotechnology, semiconductor and other strategic research and development industries, which are belonging to high value added and high-tech intensive industries. Since the CTSP is under construction, some of the data implies the mass pollution diffusion during the developing period. Table 1-1 shows the Taiwan semiconductor manufacture emission standard. Among all, the major targets are focusing to control organic and acid gases, there is no toxic metal limitation of the plants were covered by this standard. Therefore, a possible serious pollutions may occur due to the incomplete coverage of the regulation, especially the toxic metal contents.

In Taichung area, there are several existing potential pollutant sources which include the Taichung Industrial Park (TIP), Taichung City Refuse Incinerator (TCRI) and a heavy traffic zone. There are many emission sources which resulted in serious air pollution problems around the nearby area for years. In the future, due to the lack of metal control regulation, the operation of CTSP might increase the metal emission concentration much more than ever. Thus, this study attempts to investigate the ambient metal content information before and after the construction of CTSP. Meanwhile, by using the statistical method and models, this study also will find out the possible metal emission sources in this area.

Table 1-1. The emission standard for the semiconductor manufacture in Taiwan*.

Pollutant	Standard	
VOCs	Reduction Percentage	> 90 %
	Emission Rate	< 0.6 kg/hr
TCE	Reduction Percentage	> 90 %
	Emission Rate	< 0.02 kg/hr
HNO_3, HCl, HF, H_3PO_4	Reduction Percentage	> 95 %
	Emission Rate	< 0.6 kg/hr
H_2SO_4	Reduction Percentage	> 95 %
	Emission Rate	< 0.1 kg/hr

VOCs: Volatile Organic Compounds.

TCE: Trichloroethylene.

*Note: the standard is collected from the website of EPA Environment Laws and Regulations, Taiwan, ROC (2006).

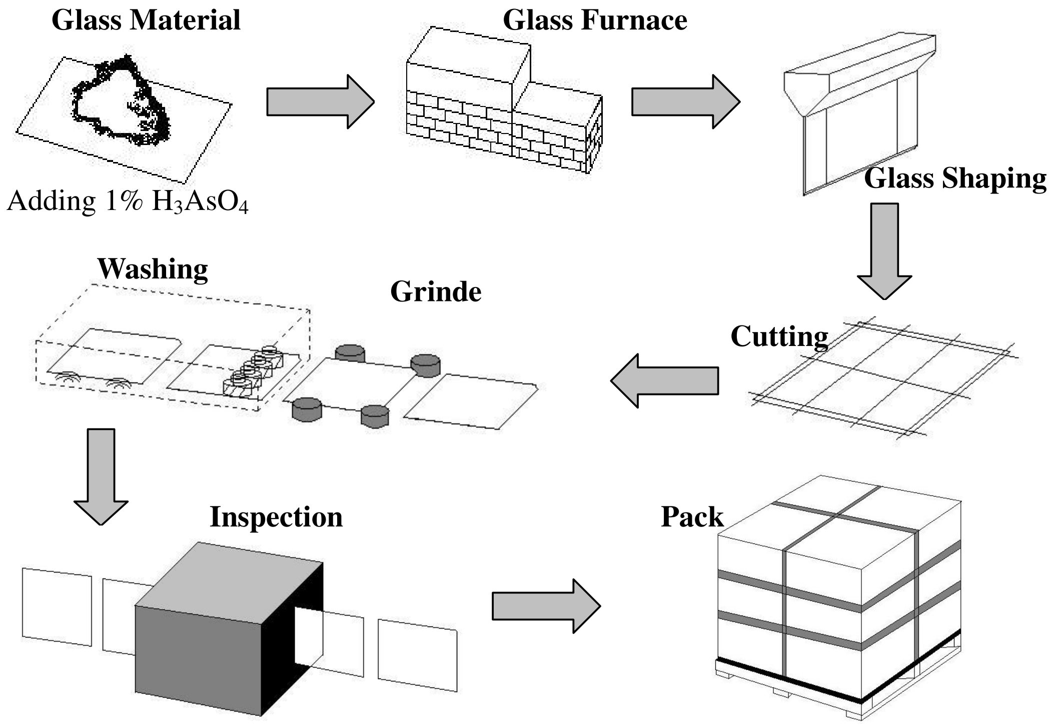

Fig. 1-1. The glass producing process (obtained from Corning, 2007).

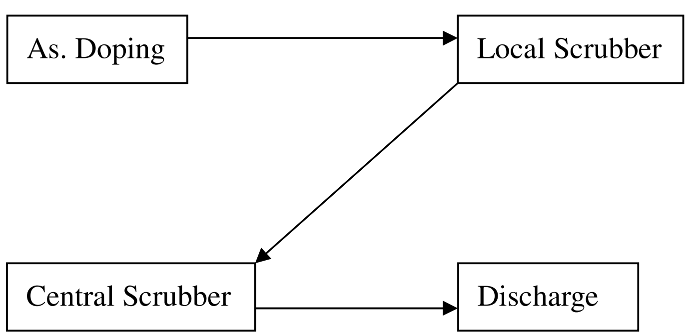

Fig 1-2. The arsine emission and treatment process of an IC plant (obtained from Winbond, 2007).