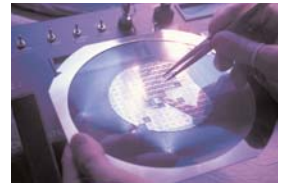


# CASE STUDY 4 SEMICONDUCTOR FACILITY



## PURAFIL REDUCES AIRBORNE MOLECULAR CONTAMINATION 4 A SEMICONDUCTOR FACILITY



### THE PROBLEM

As the size of semiconductor devices rapidly decreases, the concern over airborne molecular contamination (AMC) has become as pressing as particulate contamination. AMC can affect almost all facets of sub-micron device fabrication, from overall fab operation to final device performance.

A semiconductor facility specializing in memory products sought Purafil's help to identify and reduce the amount of AMC being introduced from nearby sources - an airport, a coal-burning power plant, a chemical plant, and a paper mill.

Under certain conditions the potential existed for elevated levels of corrosive gases, especially sulfur species, to be introduced into the facility through the makeup air handlers. Chlorine from site cooling towers and elevated levels of nitrogen dioxide and ozone were also potential AMC sources.

### PURAFIL PROVIDES THE SOLUTION

Purafil, the leading manufacturer of chemical air filtration systems, met with representatives of the semiconductor manufacturer to implement a three-step program to control AMC. This program is designed to characterize the potential of an environment for damage to materials, products, and processes.

#### ASSESSMENT:

As part of the assessment of the semiconductor facility, Purafil's Environmental Reactivity Coupons (ERCs) were used both outside and inside the fab to determine the reactivity level of the environment. The ERCs employ copper and silver sensors that react with airborne contaminants to form corrosion reaction products. Unlike direct monitoring technologies, Purafil's coupon technology makes it possible to observe and predict the synergistic effects of AMC on semiconductor processes.

Data from the ERCs allowed Purafil engineers to categorize the contamination level of the manufacturer. A classification system has been developed for correlating the film thickness to the air quality of the environment. The classification levels are the result of studies performed with a number of semiconductor manufacturers, and they reflect what are considered to be acceptable levels inside a facility.

The air outside the semiconductor showed copper and silver reactivity rates indicative of a C5/S5-Severe environmental classification. (See Table 1 at the bottom of this page for environmental classifications of semiconductor cleanrooms.) The air quality being used for ventilation and pressurization at the facility contained levels of AMC that would pose an immediate threat to materials and fabrication processes. High levels of

sulfur, sulfur oxides, and inorganic chlorine contamination were evident. This air was estimated to have concentrations in the ranges of >50 parts per billion for active sulfur compounds, 100-300 ppb for sulfur oxides, and >10 ppb for chlorine. (See Table 2 on the next page for ERC data of the outside air.)

TABLE 1

COPPER CORROSION			SILVER CORROSION		
CLASS	AIR QUALITY CLASSIFICATION	REACTIVITY RATE*	CLASS	AIR QUALITY CLASSIFICATION	REACTIVITY RATE*
C1	Pure	<90 Å/30 days	S1	Pure	<40 Å/30 days
C2	Clean	<150 Å/30 days	S2	Clean	<100 Å/30 days
C3	Moderate	<250 Å/30 days	S3	Moderate	<200 Å/30 days
C4	Harsh	<350 Å/30 days	S4	Harsh	<300 Å/30 days
C5	Severe	≥350 Å/30 days	S5	Severe	≥300 Å/30 days

\* Å = angstroms

**ADDITIONAL INFORMATION  
ON BACK**

All ERC results indicated extremely high levels of corrosion for a semiconductor environment. With these elevated levels of AMC, the facility potentially faced a multitude of problems, including corrosion on wafers, etch rate shifts, wafer and optics hazing, adhesion failure, and fab corrosion.

Inside the facility, ERCs were placed in etch bays and diffusion, film, and photolithography areas to determine the extent to which outdoor contaminants were being distributed into the cleanroom areas. Chlorine contamination was evident in every location monitored; corrosion was observed on wafers and ductwork. Even with dilution, the inside levels were still as high as 60% of the outside levels.

**CONTROL:**

To reduce the potential for AMC being introduced from outside the facility, chemical filters were installed in each of the makeup air handling units. Instead of retrofitting air handling units to accept bulk media trays or modules, the manufacturer was able to use two-inch deep, non-woven, adsorbent-loaded pleated media filters. These filters were installed in existing frames and were expected to remove chlorine, sulfur compounds, and various hydrocarbons.

**MONITORING:**

Ongoing monitoring of the controlled environment and the performance of the AMC control system is being performed with Purafil's ERC's and Environmental Reactivity Monitors (ERMs). ERMs were used outside and inside the facility to measure in real-time the overall reactivity level of the environment. A quartz crystal microbalance sensor plated with copper or silver

continuously measures in real-time the mass accumulation of the corrosion films formed. This monitor continuously transmits data to the facility monitoring system and is sensitive enough to measure AMC levels as low as 1 ppb.

Over 40 ERMs were installed in makeup and recirculation air systems, and each monitored location indicated a Class S5 environment. The ERMs were able to identify internal sources of chlorine emissions by examination of the copper and/or silver reactivity monitoring data. For AMC-related incidents for which an incident was reported and logged, the ERM data showed an increase in the incremental reactivity rate in most cases before the event had been reported. (See Figure 1 for a visual representation of the incremental peaks corresponding to the reported AMC release.) Reactivity monitoring has indicated an overall reduction in total AMC levels. Data from the ERMs monitoring the chemical filter performance showed that the air passing through the filters contained lower levels of AMC than before it was treated.

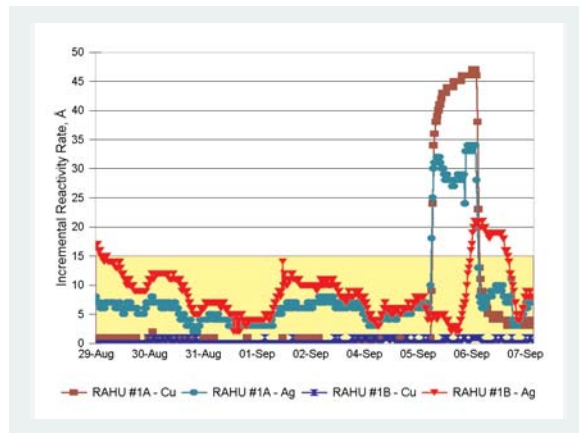


FIGURE 1: ERM NETWORK DATA

SITE SURVEY ERC DATA - OUTSIDE AIR										
ERC Location	Copper Corrosion					Silver Corrosion				
	Total	Cu <sub>2</sub> S	Cu <sub>2</sub> O	Cu-Unk	Class	Total	AgCL	Ag <sub>2</sub> S	Ag-Unk	Class
PROPERTY LINE (OUTSIDE AIR)	16,380	16,195	634	0	C5	275	192	83	0	S4
ROOFTOP AIR INTAKE	553	406	87	59	C5	163	116	46	0	S3
GROUND-LEVEL AIR INTAKE (1)	606	388	159	59	C5	416	378	38	0	S5
GROUND-LEVEL AIR INTAKE (2)	436	249	167	0	C5	442	247	66	129	S5
MUAH-INTAKE	15,698	15,348	350	0	C5	375	298	76	0	S5

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