



Industry Guide

Semiconductor Industry

According to the World Semiconductor Trade Statistics (WSTS), the world semiconductor market is expected to reach \$356.6 billion in 2013. Semiconductor Industry Association Statistics expect industry expansion and growth to reach double digits by 2012 due to the increasing demand for consumer electronic products and automotive sector mandates. The semiconductor industry employs more than 185,000 workers in the U.S. alone and assists in providing technology for America's \$1.1 trillion high-tech industries. Workers in the wafer fabrication unit or "fab" may be exposed to hazards including:

Chemical agents

— such as acids, bases, metal particulates, organic compounds and molecular dopants based on phosphorus, arsenic, and boron compounds

Physical agents

— including soft X-rays, low-frequency electromagnetic and magnetic fields, and radiofrequency exposures⁽¹⁾

This publication is designed to assist health and safety professionals in choosing the appropriate equipment and methodology to assess the major chemical agents found in wafer fabrication units. Sources of additional information are described below.

The Semiconductor Environmental Safety and Health Association at www.semiconductorsafety.org provides publications to members on a variety of safety and health issues in the semiconductor industry.

SKC Inc. at www.skcinc.com offers equipment to sample chemical agents.

Acids

Acids are used to etch the wafers as part of the initial cleaning process. Fab workers involved with wafer cleaning at wet benches or those involved with wafer oxidation at high-temperature furnaces can be exposed to a number of acids including hydrofluoric, sulfuric, hydrochloric, nitric, or chromic. Exposures to these compounds can result in skin, eye, and respiratory irritation.

OSHA has established an eight-hour time-weighted average (TWA) of 3 ppm for hydrofluoric acid, an eight-hour TWA of 1 mg/m³ for sulfuric and phosphoric acids, and a 0.1 mg/m³ Ceiling value for chromic acid.

For information on sampling acid gases according to government methods, reference the following SKC publications:

Chemical Fact Files®

Inorganic Acids

By NIOSH Method 7903
SKC Publication 1016

Sulfuric Acid

By OSHA ID 113
SKC Publication 1465

Phosphoric Acid

By OSHA ID 111
SKC Publication 1466

Fluorides (F and HF)

By OSHA ID 110
SKC Publication 1227

Chromic Acid and Chromates

By OSHA ID 215
SKC Publication 1439

Bases

Bases that may pose a hazard to fab workers include ammonia and a variety of amines and amides. Ammonia is quite commonly used in semiconductor manufacturing and can be found within many of the fab work areas including the wafer cleaning and polishing areas. Amines including trimethylamine and triethylamine and amides including dimethyl acetamide are typically found in the photoresist coating and stripping areas.

OSHA has established an eight-hour TWA of 50 ppm for ammonia, 25 ppm for diethylamine, and 10 ppm for dimethyl acetamide and dimethylamine. Ammonia and other amines are skin, eyes, mucous membrane, and systemic irritants. In addition, dimethylacetamide can produce liver damage and central nervous system (CNS) effects and is a suspect teratogen.⁽²⁾

Ammonia

By OSHA ID 188
SKC Publication 1008

Dimethylamine

By OSHA 34
SKC Publication 1696

Diethylamine

By OSHA 41
SKC Publication 1697

Dimethylacetamide

By NIOSH 2004
SKC Publication 1695

Metal Particulates

Metals can be present in fab workplace air from several sources. Exposures can result from processes that deposit conductive metal layers onto wafers to make electrical connections. Metals can also be contained in additives such as heat stabilizers, catalysts, or in chemical vapor deposition (CVD) compounds.⁽³⁾

OSHA has established an eight-hour TWA of 15 mg/m³ for aluminum, and 1 mg/m³ for nickel and chromium metal.

For details on sampling various metals, reference the following SKC publications:

Elements

By NIOSH 7300
SKC Publication 1455

Metal and Metalloid Particulates

By OSHA ID 121
SKC Publication 1177

Metal and Metalloid Particulates

By OSHA ID 125G
SKC Publication 1371

To measure total number of particles in a cleanroom, SKC offers a handheld optical particle counter. This device monitors 5 particle sizes simultaneously. For more information, see the Product Data Bulletin at www.skcinc.com/instructions/1487.pdf.

Organic Compounds

Sources of organic compounds in a fab include outgassing from building materials and process chemicals. At the levels typically encountered in a fab, organics are more of a hazard to the product than the personnel. To test for organic compounds in air, samples can be actively pulled onto sorbent tubes using a pump or be passively collected via diffusion onto a badge-style passive sampler.

Consult the following SKC publications for method details on sampling organic compounds in air.

Various Organic Compounds Using SKC Sorbent Tubes

By OSHA 7
SKC Publication 1186 for Xylene
SKC Publication 1155 for hexachloroethane

Methyl Alcohol

By OSHA 91
SKC Publication 1328

Various Organic Compounds Using SKC 575-series Passive Samplers

SKC Product Data Bulletin for 575-series samplers and SKC Research Reports for Specific Compounds at www.skcinc.com

Various Organic Compounds Using Thermal Desorption

Following collection with SKC Thermal Desorption Tubes or with SKC ULTRA Passive Samplers
By EPA Method TO-17
SKC Publication 1689

Molecular Dopants

Dopants are chemicals that are added by diffusion or implantation to a silicon wafer to modify its conductivity. Dopants are used intentionally to define unique electrical characteristics on the wafer. Unintentionally, dopants can alter a wafer through contamination from various sources.

Molecular dopants include phosphorus, arsenic, and boron compounds. Arsine and phosphine are common dopants. Arsine is a human carcinogen and has deleterious effects on a variety of human organ systems. Phosphine is an extremely toxic gas that is a hazard to the lungs and CNS.

OSHA has established an eight-hour TWA of 0.05 ppm for arsine and 0.3 ppm for phosphine. For details on sampling molecular dopants, reference the following SKC publications:

Arsine

By NIOSH 6001
SKC Publication 1278

Phosphine

By OSHA 1003
SKC Publication 1698

References

- (1) William A. Burgess, *Recognition of Health Hazards in Industry: A Review of Materials and Process*, 2nd. Ed., John Wiley & Sons, New York, 1995, pp. 383-400
- (2) N. Irving Sax and Richard J. Lewis, Sr., *Hazardous Chemicals Desk Reference*, Van Nostrand Reinhold, New York, 1987
- (3) Balazs Analytical Services, *Cleanroom Evaluation Guidelines*, at www.balazs.com

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