International Labour Organization

Your health and safety at work

CHEMICALS IN THE WORKPLACE

Appendix X: Chemical groups

Health hazards in the electronics industry, International Metalworkers' Federation, Asia Monitor Resource Centre, Hong Kong, 1985.

Chemicals used or occurring in electronics manufacturing are listed here under general groups. This chemical groups list can be used (1) to identify specific names of chemicals, and (2) to group chemicals generally according to use and type of hazard. For example, you are using certain acids, but are not sure what specific kinds. The group list for acids provides specific names which may help you to identify the acids you are using.

Acids

Acids are corrosive substances widely used throughout the industry for cleaning, etching, plating and stripping. They are usually in liquid or powder form. Most are acutely hazardous, especially when concentrated. Acids can penetrate clothing rapidly causing serious burns and damage to tissues beneath the skin. Protective gear is essential, especially for the hands, face, eyes and lungs. All corrosives should be labeled clearly with warning placards.

Organic acids	**Inorganic Acids**
acetic acid	aqua regia
adipic acid	buffered oxide etch
citric acid	boric acid
formic acid	chromic acid
lactic acid	hydrobromic acid
oxalic acid	hydrochioric acid
	hydrocyanic acid
	hydrofluoric acid
	hydrofluoric acid
	nitric acid
	phosphoric acid
	sulfonic acid

sulfuric acid

Alkalis (Bases)

Alkaline or base substances are used primarily for cleaning and scouring. Like acids, they are acutely hazardous, especially in concentrated form. Most have strong caustic or corrosive action, and as such should be clearly labeled with warning placards. Be sure to use protective gear especially for the face, eyes, hands and lungs.

ammonia

ammonia persulfate

ammonium fluoride

ammonium hydroxide

calcium hydroxide

potassium hydroxide

sodium hydroxide

Cryogenic gases

Cryogenic means ultra-cold. These gases are usually stored in liquid form under high pressure and are used to heat and cool ovens in the process of seminconductor wafer fabrication. Some are used as 'carrier' gases, carrying dopants into the oven chamber. Hydrogen and oxygen are extremely flammable (they ignite and burn very easily). These gases have a potential to explode and thus require special storage and handling precautions. A major leak of liquefied gas can rapidly fill the workroom displacing oxygen and causing sudden death by asphyxiation.

argon

carbon dioxide

carbon monoxide

deuterium

helium

hydrogen

nitrogen

oxygen

ozone

Cyanides

Cyanides are a group of highly irritating and rapidly acting poisons. They are used for cleaning, plating and metallizing. Notice that most cyanide compounds (salts) contain a metal or mineral molecule. The biggest risk is exposure to cyanide in gas form, although they are often stored in solid or liquid form. Cyanide is quickly absorbed through the skin and lungs. It prevents the body tissues from taking up oxygen causing sudden death by asphyxiation. Repeated low-level exposure can cause severe dermatitis, thyroid disease, and muscle incoordination. Another highly reactive and poisonous group related to the cyanides are the isocyanates. Be extremely careful with any cyanide compound, and always wear a proper respirator if the process is not completely enclosed. Be sure cyanides are labeled clearly with warning placards.

calcium cyanide

copper cyanide

hydrocyanic acid

potassium cyanide

potassium ferrocyanide

sodium syanide

nickel cyanide zinc cyanide

Dopants

Dopants are metal compounds in solid, liquid or gas form and are used to make chips. Dopants are sometimes called impurities. They are usually injected as a gas or vapour into ovens which are heated to extreme temperatures. When heated, the metal of the dopant is deposited in the semiconductor wafer, penetrating its surface and giving it the ability to conduct electricity. The metals more commonly used in doping include aluminum, antimony and arsenic. Boron and phosphorous are also commonly used. Dopants are considered to be potentially the most hazardous group of chemicals used in electronics. Most are highly toxic. If a leak or rupture occurs with a substance like phosphine, arsine, or the boranes, the whole factory and surrounding community can be affected with many cases of serious harm and sudden death. Argon and deuterium are sometimes used as carrier gases.

Gases

arsenic pentafluoride

arsine

boron trichloride

boron trifluoride

diborane

diethyl telluride

dimethyl telluride

hydrogen arsenide

hydrogen phosphide

pentaborane

phosphine

phosphorus petafluoride

selenium hexafluoride

trichlorosilane

Liquids

antimony trichloride

antimony trioxide

arsenic trichloride

arsenic trioxide

boron tribromide

Solids

aluminum

antimony

antimony trioxide

arsenic

arsenic trioxide

beryllium

boron

boron nitride

boron trioxide

cadmium

chromium

gallium

germanium

phosphorus

phosphorus pentoxide

selenium

tellurium

tin

zinc arsenide

boron trichloride

boron trioxide*

phosphorus oxychloride

phosphorus pentoxide*

phosphorus tribromide

phosphorus trichloride

silicon tetrabromide

**with a solvent*

Fillers

Fillers are powders or tiny fibres added to resins (plastics, epoxies, glues, paints) to give bulk, strength and form. They are durable and some resist heat, fire and electricity. Asbestos and chromates cause cancer, and fibreglass can cause serious lung problems if breathed in over a period of time. These substances can also be highly irritating to the skin and eyes. Fillers are used to make printed circuit boards and plastics. They are easily released as harmful dusts when resin products are shaped, sawn, or drilled. Avoid breathing and direct contact.

antimony trioxide

asbestos

chromate pigments

fiberglass

quartz

silica

titanium

Metals (and their compounds)

Ordinarily, people do not consider that metals are chemicals. But they are, and many can be very harmful if swallowed or if breathed in small unnoticeable amounts day after day. Because metals are good conductors of electricity, they are widely used in electronics. Metals are used or occur in many forms - such as bulk solids, powders and liquid solutions suspended in gas form, and emitted as a fume when heated and as dust when drilled, sawn, or fiied. Exposure to the more dangerous forms of metal (gases, dusts and fumes) occurs more frequently during doping, soldering, plating, tinning and other metal work.

aluminum

antimony

arsenic

barium

beryllium

boron

lithium

manganese

mercury

molybdenum

nickel

phosphorus

calcium	platinum
chromium	rhodium
chromates	selenium
cobalt	silver
copper	tantalum
iron	tellurium
gallium	tin
germanium	titanium
gold	tungsten
indium	vanadium
lead	zinc

Oxidizers

Oxidizers are highly reactive chemicals which can be used to clean or to render a metal surface free from corrosion. During oxidation, oxygen (from the oxidizer or from the air) combines with a metal or semiconductor surface to form a protective oxide layer. Some oxidizers have strong corrosive action and care must be taken to protect the eyes, skin and lungs from exposure. Oxidizers are also highly flammable and require special handling and storage arrangements.

ammonium persulfate	nitrous oxide
cerric ammonium sulfate	oxygen
chlorine	ozone
chromic acid	potassium iodide
hydrogen peroxide	silver nitrate
iodine	sodium persulfate

Resins (epoxies, curing agents, plastics)

There are many kinds of resins: plastics, epoxies, glues, adhesives, paints, waxes, synthetic rubber, synthetic fibres, and many others. With obvious exception of rosin (colophony) flux used in soldering, most resins used in electronics are man-made organic polymers. Polymers are complex chemical substances. Most contain many poisonous ingredients, such as solvents, dyes, stabilizers, fillers, plasticizers, catalysts and monomer residue. Some of these ingredients cause allergies, birth defects and cancer. Polymers are formed from monomers. Epoxides (epoxy resins) are normally cured with a phenol compound, and polyesters are cured with a peroxide compound. Uncured epoxy resins or monomers are very toxic and penetrate the skin and lungs rapidly. After they are reacted, cured, or set they are much less harmful, though dust created by shaping, cutting and drilling can be harmful. Resins are widely used in electronics, particularly in making printed circuit boards, moulding plastics, bonding, encapsulating and packaging, and are also used as wire coatings and a variety of other electrical insulation materials. Resins can produce a wide variety of highly toxic vapours and gases when heated or burning. Fires caused by burning plastic are sometimes very difficult to control.

Epoxy resins (epoxies)

diepoxybutane

diglycidyl ethers

epichlorohydrin

triethylene glycol diglycidyl ether

Curing agents (for epoxies)

adipic acid

amines

anhydrides

3,3'-dichlorobenzidine

diethyl amine

diethylene triamine

dimethyl amine

ethylene diamine

ethylene triamine

maleic anhydride

methylene dianiline

MOCA

organic acids (see Acids above)

phthalic anhydride

piperazine

Monomers

acrylonitrile

butene oxides

Polymers

polyesters

polyethylene

polystyrene

polytetrafluoroethylene

polyurethane

polyvinylchloride

silicones

Resin ingredients / additives

chlorinated diphenyls

formaldehyde

ethyl acrylate

ethylene imine

fillers (see above)

isobutene

isocyanates

isocyanates

ketones

methyl methacrylate

phenol

styrene

toluene diisocyanate

xylene

ethylene oxide

styrene oxide

vinyl chloride

vinyl cyclohexane dioxide

Semiconductors

Semiconductors are the basic raw material or substrate for making electronic devices. They are treated with dopants and other chemicals to give them special electrical capabilities. Semiconductor substances are sometimes made by chemical companies which specialize in supplying chemicals to the electronics industry.

cadmium sulfide

gallium arsenide

germanium

indium phosphide

silicon

Solvents

Solvents are used in nearly every phase of electronics manufacturing. They are used primarily for cleaning and degreasing, and for thinning plastics, resins, glues, inks, paints and waxes. There is a wide range of organic solvents, some very toxic and others only mildly toxic. The subgroups should be considered to have a better idea of specific hazard risks and uses.The aromatic compounds and the chlorinated hydrocarbons are perhaps the most dangerous groups of solvents since many of them are known to cause cancer and other serious diseases.

acetone

amyl acetate, sec-

benzyi chloride

bis(chioromethyl)ether

butyl acetate, n-

butyi acetate, tert-

butyl cellosoive

butyl glycidyl ether, n-

carbon disulfide

carbon tetrachloride

carbon tetrafluoride

cellosoive

glycidyl ethers

heptane

hexamethyl disilazane

hexane

hexanone,3-

isopropyl alcohol

kerosene

methyl isobutyl ketone

methyl cellosolve

methyl ethyl ketone

methyl isobutyl ketone

ethyl-2-pyrrolidone

cellosoive acetate
chiorobenzene
chloroform
chlorotoluene
cresoi glycidyl ether
dichlorobenzene
dichioromethyl ether, *a,a*-
diglycidyi ether
dimethyi formamide
dioxane, 1,4-
ethyl acetate
ethyl alcohol
ethyl benzene
ethyl chioride
ethyl ether
ethyl formate
ethylene dichioride
ethylene glycol
ethylidene chloride
freons
methylene chloride
naphtha
nitrobenzene
nonane
pentane
perchloroethylene
petroleum spirits
phenol
phenol cyclohexane
phenol glycidyl ether
propyl alcohol
stoddard solvent
styrene
toluene
trichlorobenzene
trichloroethane, 1,1,1-
trichloroethylene
trimethyl benzene
turpentine
xylene