Semiconductors/Photolithography

SIC Code: 3674

Number of sites: 545 sites (NIOSH, 1985)

The manufacture of semiconductor devices involves many process steps. Because PMN chemicals are frequently used as components of photoresists, this scenario describes the photolithography process.

The semiconductor base material is a high purity silicon or germanium wafer. The wafers are mechanically ground or chemically etched and polished; a silicon-dioxide coating is applied prior to the fabrication of the integrated circuit. The wafers are typically 5 to 8 inches in diameter and 0.2 inches thick.

Photolithography is the procedure used to form extremely accurate circuit patterns on the wafer. Photoresists are tyoically supplied in 1-gallon bottles. The photoresist is applied by a dispensing apparatus while the wafer is spinning at high speed in an exhausted enlosure. CEB typically assumes that 5 ml resist/wafer are dispensed and that the processing rate is 50 to 150 wafers/hr/site. These assumptions are equivalent to a useage rate of about 20 to 60 kg/week. A recent study found that an average weekly useage rate of 22 gallons equivalent to about 80 kg/week (Kennedy,1987). After the photoresist dries, the wafer is baked at a low temperature. After baking, ultraviolet light (or electron beam radiation) is shone through a mask containing the circuit pattern. The unexposed photoresist is dissolved and removed using a "stripper" containing acids and caustics.

The UV light induces a solubility change in the photoresist. Negative resists crosslink in the exposed areas and have a lower solubility in the solvent developer while the positive resists become more soluble in the exposed areas. Negative resists generally consist of a polymer (polyisoprene), sensitizer, and solvent (xylene). Positive resists consist of a resin, sensitizer (diazo-oxides or orthoquinone diazides) and solvent (xylene, cellosolve, cellosolve accetate). The need for greater accuracy in the photolithography process has caused many manufacturers to switch from negative to positive photoresists.

The manufacture of semiconductor devices occurs in "clean rooms" which are designed to minimize contamination of the semiconductors.

Releases

Releases include waste photoresist solvent and developer.

One study estimates that 18% of the photoresist remains in the bottom of the bottles for systems which depend on the operators to visually monitor and replace bottles. To avoid running the system dry, operators will change the bottles when there is one to two inches of resist in the bottom of the bottle. Automated systems which alert the operator to change the bottles reduce this amount of residual.

In addition wastes are created from the development. Negative photoresists produce a waste stream of isoprene rubber, solvent, and developer. Positive resists produce a waste stream of ortho-diazo-ketone and developer.

Generally, waste photoresist requires incineration or landfill.

Summary Sheet: Semiconductors/Photolithography

Volume (kg/yr): _____

1. Concentration of PMN in photoresist:
   Submitter's estimate: _____ %
   (Note: CEB has no default value.)

2 Volume of photoresist = 1%(PV) = soln. kg/yr

3 ~~2~~. Useage rate of photoresist:
   Default value: 80 kg/week equivalent to 4000 kg/yr/site
   Other information: _____ kg/yr/site (Source:)

~~3~~ 5. Release of PMN chemical:

   98% * ( ) kg/yr/site * ( )% (* 4000) = _____ kg/yr
   to incineration or landfill

4. Number of sites:

   ( )kg/yr
   ---------- = ----------
   ( )kg/yr/site

Depending on use, Some may be released to H_2O, if washed off

Developer soln - goes to POTW.