Product Safety Assessment

SiLK™ Semiconductor Dielectric Resins

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Names
- SiLK™ semiconductor dielectric resins
- SiLK™ semiconductor dielectrics
- SiLK™ D resin
- SiLK™ J resin
- CAS No. 96-48-0, gamma-Butyrolactone
- Porous SiLK™ Y semiconductor dielectrics
- Proprietary B-staged polymer

Product Overview
- Unless otherwise noted in this document, the information cited is for formulated SiLK™ semiconductor dielectric resins that contain solvent, rather than the cured resins or films, which are inert solids that have had the solvents removed during the curing and fabrication process.
- SiLK resin formulations are specialty polymer solutions manufactured by Dow for the microelectronics industry. SiLK formulations are mixtures of materials that have been designed specifically for use in microelectronics production processes. SiLK resin formulations are purple liquids with a sweet odor. When cured, these polymer films have low dielectric constants (low-k), meaning they will “insulate” against electrical current loss and electrical field interference. Lower dielectric constants indicate better “insulation.” For further details, see Product Description.
- SiLK™ semiconductor dielectrics provide new levels of microchip/nanochip performance allowing for the production of faster, smaller electronics devices with reduced crosstalk and lower power consumption. For further details, see Product Uses.
- Occupational exposure to SiLK formulations is possible at resin manufacturing facilities, and also at facilities using these formulations for microelectronics production. Because microchip technology is widespread, consumers may use products containing these resins. Prior to reaching the consumer, the resins are cured (polymerized) and encased within the electronic device. Consumer exposure to uncured resins is not expected. For further details, see Exposure Potential.
- Health information about SiLK resin formulations is included on the relevant Safety Data Sheets. It is important to note that the health risks associated with individual SiLK™ resin formulations may vary due to the formulation composition and use of the material. In general,
exposure to SiLK™ resin formulations causes skin burns and eye irritation. These formulations are harmful if absorbed through skin. They cause respiratory tract irritation and may be harmful if inhaled. They may cause central nervous system effects and anesthetic effects. SiLK™ formulations are harmful or fatal if swallowed; they can enter the lungs by aspiration and cause damage. For further details, see the relevant Safety Data Sheet and the Health Information section of this document.

- SiLK formulations are combustible both in liquid and vapor form. Solvent vapor presents an explosion hazard. Avoid static discharge. Formulations are stable at recommended storage conditions. SiLK formulations are incompatible with oxidizing materials as well as acids and bases. For further details, see Physical Hazard Information.

Manufacture of Product
- **Location** – Dow manufactures SiLK™ Semiconductor dielectric resins at facilities in Midland, Michigan.
- **Process** – SiLK formulations are manufactured using proprietary Dow technology.

Product Description
SiLK™ semiconductor dielectric resins, manufactured by Dow, are derived from proprietary SiLK Semiconductor dielectric chemistry. They are formulated as high-solids, low-viscosity solutions. When cured, these resins have low dielectric constants (low-$k$), meaning they function as insulators. Cured SiLK films are thermally stable up to 450ºC. They also have excellent chemical resistance. Other key properties include rapid thermal curing, low water absorption, and compatibility with copper.

SiLK resin formulations are purple liquids with a sweet odor. Cured SiLK films range in thickness from about 50 nanometers to greater than 1 µm. Cured SiLK™ films can be porous or nonporous depending on the application and the desired properties.

Product Uses
SiLK™ semiconductor dielectric resins are used as dielectric layers in back end of the line (BEOL) applications in high-end integrated circuits (ICs) where performance is critical. As the size of the chip decreases, the line spacing (between copper lines) on a chip is reduced, possibly resulting in “crosstalk”. The circuits themselves are increasingly complicated, as more and more layers of wire interconnect are added. Because of its unique polymer chemistry, cured SiLK films reduce crosstalk and propagation delays associated with multilayer interconnects and reduced line spacing. Cured SiLK films have a dielectric constant of 2.6 and can be extended to even lower dielectric constants using porous SiLK resins ($k=2.0-2.3$).

Exposure Potential
SiLK™ semiconductor dielectric resins are used in the production of industrial and consumer products. Based on these uses, the following exposures are possible:
- **Workplace exposure** – SiLK B-staged polymer and formulations are manufactured in closed systems using engineering controls which prevent the escape of liquid or vapors and minimize release to the environment. Chance of exposure is further reduced through the use of appropriate personal protective equipment.
(108x711)of personal protective equipment. Occupational exposure is possible at microelectronics production facilities. Facilities that manufacture or use SiLK formulations should have a thorough training program for employees, appropriate work processes, and safety equipment in place to limit unnecessary exposure. See Health Information.

- **Consumer exposure to SiLK™ resins** – Liquid SiLK formulations are sold for industrial use only, so consumer exposure to uncured resins is unlikely. When present in consumer electronics, SiLK resins are cured (fully polymerized as a result of the materials thermally reacting during the production process). The curing process creates a polymer solid which is encased within the electronic device. See Health Information.

- **Environmental releases** – In the event of a spill, the focus is on containing the spill to prevent contamination of soil, ditches, sewers, waterways, and groundwater. See Environmental, Health, and Physical Hazard Information.

- **Large release** – Industrial spills or releases are infrequent and generally contained. Large releases are only possible in Dow’s manufacturing facility where bulk equipment is in use. SiLK formulations are packaged in containers under 10-liters; therefore, only small spills are possible for our industrial users. If a large spill does occur, isolate area. Dike area to contain and prevent from entering sewers. Spilled resin formulation may create a vapor explosion hazard. Evacuate personnel to a location upwind and out of low-lying areas where vapor can accumulate. Only trained and properly protected personnel must be involved in clean-up operations. Ventilate area of spill. Eliminate all sources of ignition. Pump with explosion-proof equipment. If available, use foam to smother or suppress. Pump into suitable and properly labeled containers. Use appropriate safety equipment.

- **In case of fire** – Isolate fire and deny unnecessary entry. Wear positive-pressure self-contained breathing apparatus and protective fire fighting clothing, or fight fire from a safe distance upwind. Use water fog or fine spray, dry chemical or carbon dioxide fire extinguishers, or foam. Alcohol-resistant foams (ATC type) are preferred if available. Do not use a direct water stream; it may spread the fire. See Environmental, Health, and Physical Hazard Information.

For more information, see the relevant Safety Data Sheet.

**Health Information**

Health information about SiLK™ formulations is summarized on the relevant Safety Data Sheet. It is important to note that the health risks associated with individual SiLK formulations may vary due to the specific formulation and use of the materials. The Safety Data Sheet is the preferred source for specific health information. An overview appears below:

**Eye and Skin Contact** – Eye contact with liquid SiLK formulations or vapors of the formulations may cause severe irritation with severe corneal injury. SiLK resin formulations contain volatile components, and their vapor may cause lacrimation (tears) as well as eye irritation after only minutes of exposure at concentrations of 50 ppm and above. Brief skin contact may cause irritation with pain and local redness, and may burn the skin. Symptoms may include pain, severe local redness, and tissue damage. Prolonged, widespread, or repeated skin contact may result in absorption of harmful amounts.

**Inhalation** – Vapor concentrations are attainable which could be hazardous on single exposure. Excessive inhalation may cause severe irritation to the nose, throat, and lungs, and also affect the central nervous system. Symptoms of excessive exposure may be anesthetic or narcotic effects including dizziness and drowsiness.
Ingestion – Low toxicity if swallowed. Small amounts swallowed incidentally as a result of normal handling operations are not likely to cause injury; however, swallowing larger amounts may cause injury. Swallowing may result in gastrointestinal irritation or ulceration. Aspiration into the lungs may occur during ingestion or vomiting, causing lung damage, or even death due to chemical pneumonia.

Repeated exposure – In animal studies, repeated excessive exposure to this material has caused effects on the central nervous system, kidneys, liver, and adrenal glands.

For more information, see the relevant Safety Data Sheet.

Environmental Information

SiLK™ semiconductor dielectric formulations are made from a blend of compounds.

Cyclohexanone – The bioconcentration potential (tendency to accumulate in the food chain) is low and potential for mobility in soil is very high. Cyclohexanone is readily biodegradable and practically non-toxic to fish and other aquatic organisms on an acute basis (single exposure to a large amount).

Gamma-butyrolactone – The bioconcentration potential for this material is low, and potential for mobility in soil is very high. Gamma-butyrolactone is biodegradable in laboratory testing. This material is slightly toxic to aquatic organisms on an acute basis.

For specific information, see the relevant Safety Data Sheet.

Physical Hazard Information

SiLK™ formulations are combustible both in liquid and vapor form. Solvent vapor presents an explosion hazard. Avoid static discharge. Vapors are heavier than air and may travel long distances and accumulate in low-lying areas. Ignition or flash back may occur. Electronically ground and bond all handling equipment. Formulations are stable at recommended storage conditions. Store formulations away from heat, sparks, or flame. Exposure to higher temperatures can cause these resins to decompose. SiLK resins are incompatible with oxidizing materials as well as acids and bases.

For more information, see the relevant Safety Data Sheet.

Regulatory Information

Regulations may exist that govern the manufacture, sale, transportation, use, and/or disposal of SiLK™ resin formulations. These regulations may vary by city, state, country, or geographic region. Information may be found by consulting the relevant Safety Data Sheet, or Contact Us.

Additional Information

- Safety Data Sheet (http://www.dow.com/webapps/msds/msdssearch.asp)
- Contact Us: (http://www.dow.com/silk/contact/)

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- Product Literature for SiLK™ Semiconductor Dielectric Resins [http://www.dow.com/silk/lit/]

For more business information about SiLK semiconductor dielectric resins, visit [http://www.dow.com/silk/].

References

4. Dow’s SiLK semiconductor dielectric resins website – Product Literature [http://www.dow.com/silk/lit/].

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