Revised: February 2005

# CYCLOTENE* Advanced Electronic Resins

## *Rework Procedures for CYCLOTENE 3000 Series and 4000 Series Resins*

### 1 Introduction

CYCLOTENE Advanced Electronic Resins, which are based on benzocyclobutene (BCB) chemistry, are used as dielectrics in a wide range of microelectronic applications. Though these films are normally intended to be permanent dielectrics, it may be necessary, on occasion, to remove a film of CYCLOTENE resin at some point in its processing. There are several reasons why removal of a film may be needed, such as defects in the coating or mis-alignment during exposure of photo-BCB. In addition, some applications of BCB, such as its use as a protective coating during silicon etching in potassium hydroxide, use the CYCLOTENE resin as a protective coating which must be removed at the end of processing. This technical processing guide describes procedures for removal and rework of CYCLOTENE films. Both photosensitive (4000 series) and non-photo-sensitive (3000 series) films will be discussed.

### 2 Safety and Handling

T1100 Rinse Solvent, DS2100 Developer, and DS3000 Developer, are organic solvents and should be handled in ventilated areas. Primary Stripper A is an organic solvent with a strong organic acid. Protective equipment is needed when handling this material. Please refer to the Material Safety Data Sheets (MSDS) for these chemicals before working with them. Note that since Primary Stripper A is an acidic organic material, it may not be compatible with either solvent waste or with water waste. Please consult with your safety engineer or with a Dow technical representative for information on safe handling techniques.

* Trademark of The Dow Chemical Company

### 3 Rework Procedures

#### 3.1 Rework after soft bake

Removal of a film of CYCLOTENE resin that has been coated and soft baked on a substrate can be accomplished using T1100 Rinse Solvent, which rapidly dissolves a film of CYCLOTENE 3022 or an unexposed film of the photosensitive CYCLOTENE 4000 series. On a wafer track, a typical procedure would be:

a) puddle T1100 on the wafer for 30 seconds
b) rinse with T1100 for 10 seconds while spinning the wafer at 500 rpm
c) spin dry, 30 seconds at 3000 rpm

An immersion (batch) process can also be used. A suggested procedure is:

a) immerse the wafers in a bath of T1100 for 1 minute
b) rinse in isopropyl alcohol (IPA) for 1 minute
c) quick dump rinse
d) spin rinse dry

If photosensitive BCB is being removed, developer (DS2100 or DS3000) can also be used to remove a film that has been soft baked but not exposed. The standard develop recipe would be used.

An adhesion promoter is always used in conjunction with CYCLOTENE resins. The removal of a soft baked BCB film with T1100, DS2100, or DS3000 does not remove the

adhesion promoter layer, so that it is not necessary to reapply adhesion promoter prior to re-coating of the BCB. However, there are no adverse consequences to re-application of the adhesion promoter.

## 3.2 Rework after exposure (4000 series)

Once a film of photosensitive BCB has been exposed, T1100 and developers will not dissolve it. Options include wet stripping with Primary Stripper A, either at room temperature or at elevated temperature, plasma etching, or delamination of the film with T1100.

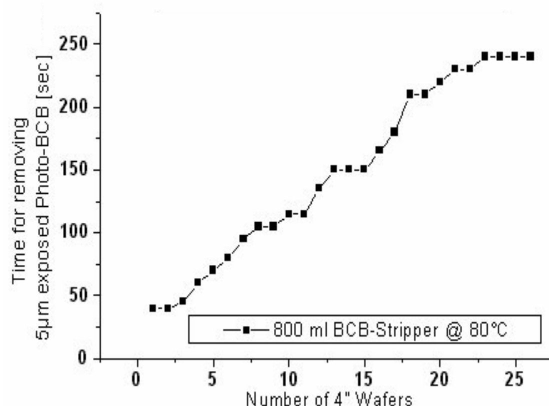
### 3.2.1 Primary Stripper A at elevated temperature

A bath of Primary Stripper A is heated to 80-85°C and maintained at this temperature, and the wafers are immersed in this bath for 5 minutes. The wafers are then rinsed in IPA for 5 minutes, rinsed with DI water in a quick dump rinse, and dried in a spin-rinse dryer. A plasma descum in $O_2/CF_4$ or $O_2/SF_6$ after rework is recommended.

Primary Stripper A has a pronounced odor, particularly when heated, so this operation should be carried out in a well ventilated chemical wet bench.

Stripping experiments with 4-inch wafers in 800 ml of Primary Stripper A at 80°C have shown that increased bath loading causes an increase in the stripping time (see Figure 1). If a 5 minute strip time is used, then at least 25 4-inch wafers can be stripped per liter of Primary Stripper A.

Figure 1. Time to remove a film of BCB vs number of wafers processed.




### 3.2.2 Primary Stripper A at room temperature

The wafers are immersed in a bath of Primary Stripper A at room temperature for 30 minutes. The wafers are then rinsed for 5 minutes in IPA, rinsed with DI water in a quick dump rinse, and spin-rinse dried. A plasma descum in $O_2/CF_4$ or $O_2/SF_6$ after rework is recommended.

Note that the removal rate is faster when the stripper is heated, which improves throughput. More important, the stripper will absorb atmospheric moisture at room temperature. The presence of water in the stripper renders it inactive, and also makes it corrosive to some metals. For these reasons use of Primary Stripper A at 80°C is preferred. If stripping is to be carried out at room temperature, it is recommended that only a freshly poured bath be used. The chemical should be used only once, and should be disposed of after use.

### 3.2.3 Plasma

A film of photosensitive CYCLOTENE resin that has been exposed can also be removed in a plasma etcher. Note that some fluorinated etch gas component must be present; BCB cannot be ashed in pure oxygen. Typical gas mixtures are 80:20 $O_2$:$CF_4$ and 90:10 $O_2$:$SF_6$, though other gas mixtures, such as $O_2/NF_3$, have also been used successfully. Parallel plate etchers are recommended for etching BCB. Barrel etchers give poor uniformity and are not recommended.

The principal advantage of using plasma to remove BCB films is that the same procedure can be used on all BCB films regardless of cure state. This is not the case with wet stripping. The disadvantages of the plasma process, relative to wet stripping, are:

(a) it is a single wafer operation, not a batch process, so throughput may be slow;
(b) materials such as silicon nitride or silicon oxide, if present under the BCB, will slowly etch due to the fluorine in the plasma and may not be acceptable etch stops;
(c) if multilayer processing is being carried out, it is not possible to use a plasma to

selectively remove an exposed BCB film if it is on top of a cured layer of BCB.

3.2.4 T1100 Rework

Photo-BCB resins are negative acting, and once exposed, the films are crosslinked and therefore insoluble in most solvents. While T1100 does not dissolve the film, it is aggressive and will severely swell it, making film removal possible. In this procedure the wafer is soaked in T1100, followed by a pressurized rinse spray. The spray rinse must provide sufficient impingement to remove all fragments of the swollen film.

### 3.3 Rework after soft (partial) cure

Once the BCB is partially cured, Primary Stripper A at room temperature will not remove it. Rework options include Primary Stripper A at higher temperature, and plasma etching.

3.3.1 Primary Stripper A at higher temperature

A partially cured BCB film (approximately 80% cure) will etch very slowly or not at all in Primary Stripper A at 80°C. However, films can be removed by raising the bath temperature to 95°C. About 1 hour at 95°C is sufficient to remove a film that is 5µm thick. The wafers are then rinsed in IPA for 5 minutes, rinsed with DI water in a quick dump rinse, and dried in a spin rinse dryer. A plasma descum in $O_2/CF_4$ or $O_2/SF_6$ after rework is recommended.

3.3.2 Plasma

See section 3.2.3 for details on plasma stripping of BCB films.

### 3.4 Rework after full cure

Fully cured BCB films are highly resistant to most chemicals, which makes them difficult to remove. Once the film has been completely cured, plasma etching is usually the only viable means of removing it. A piranha bath ($H_2O_2/H_2SO_4$) or fuming nitric acid bath will remove fully cured BCB, but metals and underlying device structures will generally not tolerate this aggressive cleaning agent, so this is only useful for test wafers.

## 4 Availability

T1100 Rinse Solvent and Primary Stripper A are available in 4-liter glass bottles.

## 5 Additional Information

Additional information on CYCLOTENE Advanced Electronic Resin properties, processing, and contact information can be found on our web site, www.cyclotene.com.