DuPont *i*Technologies

Printed Circuit Materials

Handling and Safety Considerations for the Vacrel® Solder Mask Curing Process

VACREL® Photopolymer Film Solder Mask

Technical Bulletin TB-0054

Introduction

This bulletin discusses safe handling methods and the equipment operation for curing VACREL® dry film solder mask products. The bulletin covers the following topics:

- VACREL Solder Mask Safe Handling Procedures
- Oven Design and Operation
- Calculation of Oven Air Dilution Requirements
- Thermal Curing Operating and Safety Procedures
- UV Curing Operating and Safety Procedures

VACREL® Solder Mask Safe Handling Procedures

Handling precautions for VACREL film are similar to those employed with RISTON® photopolymer film resists. The procedures described in the technical information bulletin, "Handling Procedures for RISTON/VACREL Photopolymer Films" (copy attached) are fully applicable. Since VACREL solder mask remains on the printed wiring board, VACREL films require one or two curing steps not required with standard RISTON dry film resists (used as an intermediate product for plating/etching).

One curing step is a thermal cycle. (Refer to the process section in each film data sheet for exact conditions.) Both RISTON and VACREL films show measurable vapor evolution when heated above 65°C (150°F). Vapors generated during VACREL film curing may be harmful if inhaled. Consequently, local exhaust must be provided to assure a safe working area.

Oven Design and Operation

Oven design and operation are not unique to VACREL film thermal curing; they can be used in any process for batch heating flat sheets where vapors are evolved. In fact, tray ovens of the type designed for thermally-curing screened printed circuit panels are generally satisfactory for VACREL film thermal curing.

To assure safe, trouble-free operation, the oven should have:

- a recirculating fan to provide air movement flowing parallel to the panel's surface
- a fresh air purge system, including inlet and outlet ports
- a device to measure air purge rate
- a dedicated blower in the exhaust duct, terminating outside the building
- tight fitting oven doors
- a maximum temperature control during the process cycle

Forced Air Ovens

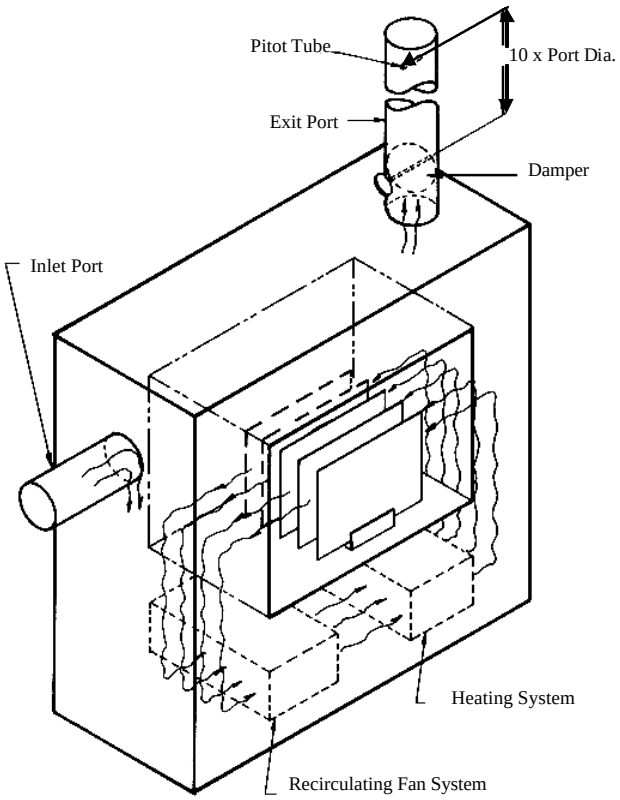
Forced-air tray ovens are the most common type used for VACREL film curing. The forced-air oven has a built-in blower that circulates air across steam, electric or gas fired burners within the oven. In standard designs, the air enters the chamber from one wall and exits from the opposite wall. Place panels so that the air currents flow parallel to board racking direction, to allow uniform heating and assure that vapors evolved are swept away along the air channels between panels. The minimum air velocity across the oven (parallel to the panel surface) should be 100 feet per minute (fpm). We recommend velocities of 300 fpm. If the oven has 3 ft. x 3 ft. side panels (area = 9 ft.') then the minimum recirculating air flow should be 900 cubic feet per minute (cfm); air flows of 2500-3000 cfm are more usual.

Fresh-Air Purge Systems

In addition to the recirculating air, the oven must be purged with fresh air to dilute and remove the film vapors. Forced air ovens for VACREL film curing must be equipped with an air inlet to supply fresh, dilution air and an exhaust duct for removing vapor laden air. While the recirculating air fan will create some air turnover, it cannot be depended upon to assure a guaranteed purge rate. A dedicated blower selected for static pressure and flow should be installed in the exhaust side ductwork regardless of whether it is a dedicated exhaust line or feeds to a central exhaust system.

Purge Rate

The purge rate of dilution air is controlled by dampers located on the fresh air inlet and/or the exhaust duct. If two dampers are used, the inlet damper should be fully open and the purge rate controlled with the exhaust damper. The air purge rate must be measured with an anemometer or Pitot tube. We strongly recommend installing a permanent measuring device in the oven exit ductwork for routinely checking flow rate vs. the posted minimum flow rate. (Inexpensive Pitot tubes with an inclined manometer, Magnehelic gauge, etc., or a swinging vane anemometer are all satisfactory.) In addition, a sensor device such as a sail switch or static pressure transducer can be installed to activate an alarm and/or shut down the oven, when the flow drops below the established minimum. If no permanent measuring device is installed, the proper damper settings must be



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clearly marked and flow rates checked periodically (semiannually or when any changes are made to the exhaust system).

Ovens not designed with air purge should not be used for VACREL or RISTON film curing since the vapors have no escape path except into the work area. Also, when no dilution air is added, it is possible that vapor concentrations in the oven could build up to the potentially explosible range. This applies to any heating process where combustible vapors are evolved. Contact the oven manufacturer before modifying any oven.

Exhaust Ducting

The exhaust ducts should be fabricated of rigid duct piping of a minimum diameter equal to the oven exhaust fitting and that will withstand the operating temperature. The ductwork should be tight fitting and free of holes. Exhaust systems carrying vapors from the VACREL film curing oven must terminate outside the plant. The vapors should not be vented (1) directly into the work area, (2) to a false ceiling, or (3) be incorporated into any air recirculation system.

Calculation of Oven Air Dilution Requirements

The quantity of dilution air required for safe operation is related to the quantity of VACREL film in the oven. (Oven size is not a major consideration and generally does not figure into the equation.) The quantity of volatiles is related to the mass (volume) of VACREL film and not the surface area. Volume is expressed in mil square feet, i.e., the number of square feet of film-covered surface area multiplied by the film thickness in mils. For each 100 Mil ft.^{2} of VACREL film, a minimum of 2.5 cfm (at 25°C) of dilution air is required. See the following sample calculation.

Sample Calculation

1) *Define Oven Batch*

A Number of panels	= 120
B Panel size	= 12" x 16" = 1.33 ft.2
C Percent of resist coverage	= 80%
D Single or double-sided coverage	= 2 sides
E VACREL film thickness	= 4 mils
F Batch size	= AxBxCxDxE

2) *Calculate Mil ft.^{2} of VACREL film in each oven batch*

F		A		B		C		D		E
Batch Size =		# of panels	x	ft.^{2}/panel	x	surface coverage	x	# of sides	x	film thickness
Batch Size =		120		1.33		0.80		2		4

Batch Size = 1024 mil ft.^{2}

3) *Calculate dilution air flow rate required:*

(2.5 cfm [at 25°C] required for each 100 mil ft.^{2})

Dilution air flow rate required = Batch Size x Dilution Air Factor

Dilution air flow rate required = 1024 mil ft.^{2} x 2.5 cfm/ 1 00 mil ft.^{2}

Dilution air flow rate required = 25.6 cfm (at 25°C)

Thermal Curing Operating and Safety Procedures

After turning on the oven and setting the correct temperature, check the damper for proper adjustment. Turn on the exhaust fan, leave it running and confirm proper flow rate/damper setting. (See section on Purge Rate.) When the oven reaches the set temperature, place the VACREL film-covered panels inside, close the door and turn on the heater and recirculating blower.

There is considerable air turbulence within the oven. If the door is opened while the recirculating fan is on, the air will be blown into the work area and in the face of the operator if he is standing in front of the equipment. The rate of vapor evolution is highest early in the cure cycle, and decreases steadily, but does not stop after the one-hour cure period. Therefore, follow this sequence any time the oven door is opened, either during or at the end of the one hour period:

(1) Turn off the heater and recirculating blower.
(2) After the blower has stopped, crack the oven door slightly.
(3) Wait, with the oven door ajar, for 5-10 minutes so the panels cool slightly and vapors in the oven are drawn out by the exhaust blower.
(4) Wearing heat resistant gloves, open the door and remove the racks of panels.
(5) Vapor evolution will continue until the panels cool below 65°C (150°F). Place racks of warm panels where the vapors can be exhausted until the panels are sufficiently cooled.

If the oven doors are loose fitting or not properly gasketed, some of the vapors will blow out into the work area. If this occurs, terminate the process and repair the doors.

UV Curing Operating and Safety Procedures

High intensity ultra violet (UV) curing is another curing method used for VACREL films. Commercial conveyorized UV curing equipment has very high exhaust requirements to cool the lamps. By meeting the manufacturer's exhaust requirements, any vapor generated from the VACREL film by the heating accompanying UV curing will be safely removed by the equipment's own exhaust system. To check for good exhaust, run a smoke tube along the inlet and exit sides of the UV cure chamber about 1" from the chamber and 1" above the conveyor. The smoke should be drawn into the curing chamber.

Personnel should not look directly at the UV lamps or at a specular reflection. Direct exposure to UV light can cause serious eye injury to occur if the eyes are not suitably protected. Note: Some UV curing equipment emits a narrow ray of UV light parallel to and just above the conveyor toward both the operator feed and exit stations.

For specific operating and safety instructions consult the manufacturer's instruction manual.

Note: Make sure all covers and protective shields are in place.

Handling Hot Panels

Following thermal and UV curing, panels are hot! Wear heat resistant gloves when handling them.

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