Peelable Solder Masks For Today's Challenges

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Compared with the manual application of heat-resistant masking tapes, peelable solder masks offer significant technical and economic advantages. They are a considerably less time- and cost-consuming application than adhesive tapes, for example, and there are no difficult-to-remove adhesive residues. They also offer automatable and reproducible register-true application by screen printing, and even difficult areas, such as gold-plated rotary contacts, can be covered and protected without any problems. Depending on the ink type they are also suitable for multiple soldering, reflow soldering and Lead-free soldering.

When manufacturing printed wiring boards and assemblies, it is often necessary to cover certain areas prior to soldering operations in order to avoid them being wetted with solder. Such areas may be Gold contacts, Gold-plated rotary contacts multipoint connectors, Carbon conductive touch-key contacts or even larger areas for which selective soldering and multiple soldering is necessary (e.g. mixed assembly).

This covering can either be carried out out with heat-resistant tape or by using peelable solder masks which are usually applied by screen printing to offer a very simple yet cost-competitive coverage compared to tapes. However, the field of application and requirements has grown enormously, with the latest challenge being compatibility with Lead-free soldering processes and their increased processing temperatures.

After soldering, the masks are peeled off manually.

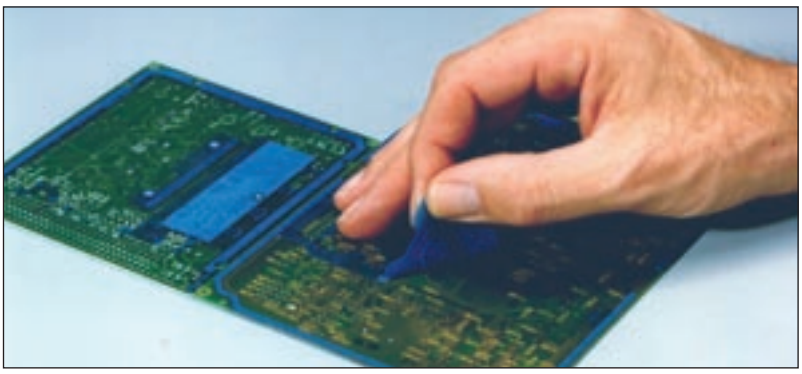


Figure 1 – Example of a typical peelable solder mask application

Screen fabric	Polyester 12 - 18 T (lines/cm) (in accordance with new nomenclature polyester 12-140 up to 18-250)
Screen tension	At least 18 N/cm
Snap-off	As low as possible
Screen coating/ stencil build-up	Particularly suitable stencil materials are presensitised, direct/indirect photopolymer films for making thick-film stencils that are available in thicknesses of approx. 200 µm and more
Squeegee	60 - 65 Shore A (if necessary with rounded blade which increases thickness)
Squeegee angle	Approx. 75°
Squeegee pressure	As low as possible
Squeegee speed	As low as possible

Table 1 - Summary of generally recommended screen printing parameters

Colour/appearance	blue-green
Solids content ISO 3251, 1 h, 125 °C [257 °F], 1 g	98 ± 1 % by weight
Viscosity at 20 °C [68 °F] ISO 3219	55,000 ± 15,000 mPas
Density at 20 °C [68 °F] ISO 2811-1	1.12 ± 0.05 g/cm_

Table 2 - Basic physical characteristics of a Lead-free soldering compatible peelable solder mask

Requirements

Economic solder masking is only possible with peelable solder masks. In practice, very high and even partly contradictory demands are made on peelable solder masks, e.g.:

- solder resistance (wave soldering, reflow soldering) Lead/ Lead-free
- resistance to plating and/or immersion processes (e.g. Gold)
- resistance to vertical Hot-Air Levelling
- very high temperature stability when used in reflow soldering/Lead-free soldering
- good peelability before and after thermal stress (also out of plated-through holes with a maximum diameter of 3mm)
- high tear resistance
- no change in the resistance of Carbon-conductive inks when covered with peelable solder masks
- thixotropic adjustment to achieve high definition and en-

able tenting of plated-through holes
• no discolouration of base material
• no corrosion of metallic Copper/storability of coated printed wiring boards.

These requirements cannot be met by one peelable solder mask alone. Therefore various ink types are available for specific fields of application.

Processing

Peelable solder masks are typically processed while observing the following (see Table 1):

Ink film thickness
Basically, all peelable solder masks need to be applied very thickly in order to meet all the different kinds of requirements. Due to their paste-like flow behaviour and thixotropic adjustment this is achieved fairly easy. When coating plain surfaces, i.e. areas of the printed circuit board without plated-through holes, one should aim for a minimum coating thickness of between 250 µm and 300 µm. For the tenting plated-through holes and HAL applications a minimum coating thickness of between 300 µm and 400 µm is required. The general rule is: the higher the coating thickness, the higher the reliability.

The vast majority of peelable solder mask applications are carried out by screen printing. Some printed wiring board manufacturers (or their customers) prefer to apply peelable solder masks with selective dispensing devices, which allow very high accuracy with regard to register-true application in the case of extremely tight printing tolerances or clearances.

Screens

Choice of screen fabric depends on the size of the areas on the printed circuit board to be covered. For small areas, e. g. contact fingers, tip-contact areas and others, 17 T and 18 T (in accordance with new nomenclature 12-140 up to 18-250) polyester fabrics have proven best. In order to obtain a thick ink film these fabrics require an additional thick screen emulsion. For large areas, or if the coating nearly covers the entire board, it is advisable to use coarse-meshed 12 T polyester fabrics, in which case an extremely high stencil build-up can be dispensed with. A sufficient screen tension of at least 18 Newton should be observed.

Screen coating

The thickness of the screen coating also has a major influence on the film thickness and definition that can be achieved. A stencil build-up of approx. 200 - 400 µm is required. Since only coarse-meshed screens are suitable for printing peelable solder masks, it is obvious that only highly viscous screen emulsions/thick film stencils can be used. Coating with standard screen emulsions is usually very time-consuming and cost-intensive and thus this procedure is increasingly on the decline. However, with new and highly thixotropic copy layers/emulsions thicknesses of up to 600 µm can be achieved very easy and fast.

Squeegee

Practical experience has shown that rubber squeegee blades with a shore-A hardness of 60 - 65 are ideal. If the definition allows, the blades can be slightly rounded, enabling a thicker ink film to be achieved. The squeegee angle should be set to approx. 75 degrees and as low a printing speed as possible observed. To achieve a satisfactory coating thickness in one print, if possible the screen fabric must be very well filled before commencing printing. If this is not achievable with standard metal pre-squeegees, the use of a rubber squeegee is recommended.

Printing machines

Peelable solder masks can be processed manually or in semi- or fully automatic screen printing machines. In order to achieve a thick ink coating, the squeegee pressure should be as low as possible. When tenting plated-through holes the squeegee pressure of the printing machine should be adjusted just enough to avoid pressing the ink through the holes, thus causing soiling of the back of the printed circuit board and/or of the screen printing table.

Figure 2 – 500 µm layer of a highly thixotropic screen emulsion / copy layer

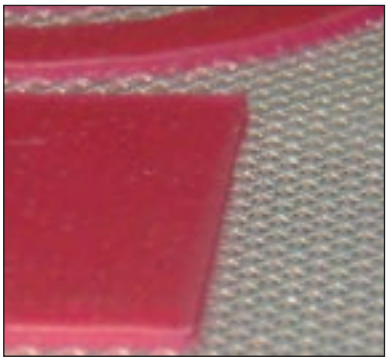


Table 3 – Typical drying conditions for a peelable solder mask with high thermal resistance (Lead-free compatible) considering various applications

Required Properties / Drying conditions	• peelable before and after soldering • resistant to wave soldering • resistant to reflow soldering	• peelable after soldering only • resistant to wave soldering, following reflow soldering • resistant to reflow soldering	• resistant to vertical Hot-Air Levelling
Ink curing oven/ Convection dryer: Temperature: Time:	150 °C 30 min	130 °C 10 min	130 °C/150 °C 60 min/30 min
Infrared conveyorised dryer: Temperature: Time:	160 °C - 180 °C 3 - 5 min	160 °C - 180 °C 2 - 3 min	160 °C - 180 °C 5 - 8 min

Figure 3 - Example of a test panel coated with peelable solder mask after exposure to horizontal hot-air-levelling

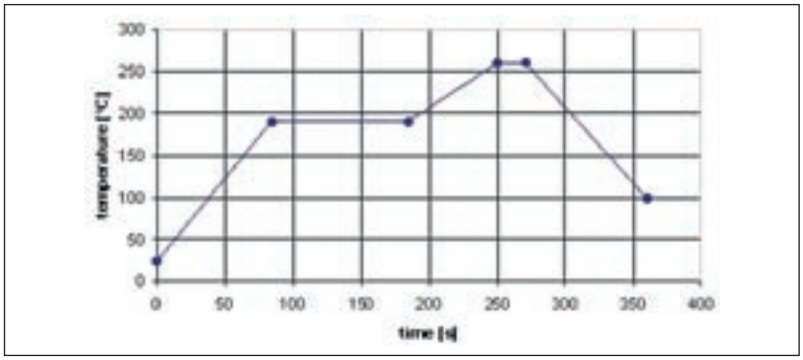


Figure 4 - Model temperature profile for Lead-free reflow soldering (ZVEI)

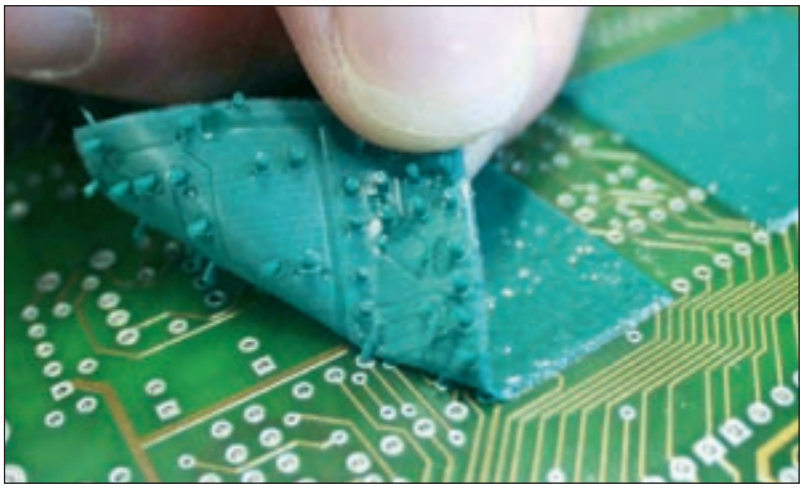


Figure 5 – Peelability testing of a peelable solder mask after reflow soldering according to ZVEI profile (thickness 400 µm, curing 10 min, 130°C [266°F])

In practice, push-stroke flooding with a right-angled, sharp-edged elastomeric squeegee has proven helpful in achieving thick, bubble-free ink coatings with good definition in only one print. This leads to an optimum filling of the screen mesh. Subsequent printing should be effected with as low a squeegee pressure as possible, as the peelable mask should only be gently dislodged from the screen fabric; if the process conditions allow, push-stroke flooding should also be used for printing.

To make it easier to subsequently peel off the solder mask, printing a "pull tab" is also recommended. Where possible, neighbouring masked areas should be linked by strips of peelable. This additional and elementary support does not require much effort and is a welcome and cost-saving service for the user of the printed circuit boards.

Thermal curing

Peelable solder masks dry solely through the application of heat. In principle, the higher the temperature chosen within the indicated limits, the more complete the degree of cross-linking and the associated tear resistance; i.e. brief yet high curing temperatures give the best results when it comes to the later peeling of the solder masks, particularly when they are peeled out of plated-through holes.

When determining the curing temperature and/or during process control, care should be taken to make sure that the inks are not cured too much, since over-curing leads to embrittlement of the ink coating and subsequently to a loss of peelability on account of the poor elasticity.

In addition, it should be considered to which thermal stresses the peelable solder mask is to be subjected after thermal curing, such as chip adhesive curing, reflow soldering or tempering processes.

Influences of stress applied on peelable solder masks

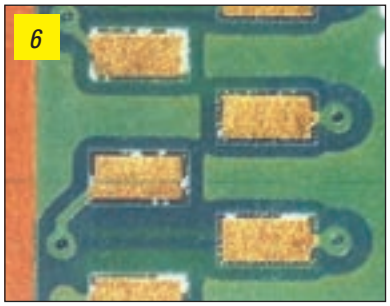
Hot-air levelling

Generally, hot-air levelling is a critical application for any peelable solder mask, due to the fact that both thermal and mechanical (i.e. impact of air knives) stress are applied. This requires both a very good adhesion (to withstand the air pressure) as well as high temperature stability.

An acceptable level of process safety can only be achieved with vertical hot-air levelling equipment. Generally, horizontal operating hot-air levelling units cannot be used, because the mechanical stress applied by the rollers at the in- and outlet of the machines is too high. In case of processes using leaded solder there are a few exceptions which surprisingly do work, however, in case of Lead-free solder the stress applied is definitely too high.

Wave soldering

During wave soldering a comparatively short temperature stress is applied. Therefore it is usually not necessary to use peelable solder masks with the highest possible thermal resistance. Due to other critical factors, however (e.g. mechanical stability using turbulent solder waves or a very high definition required), various products can be suitable.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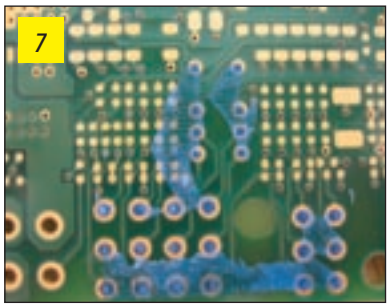
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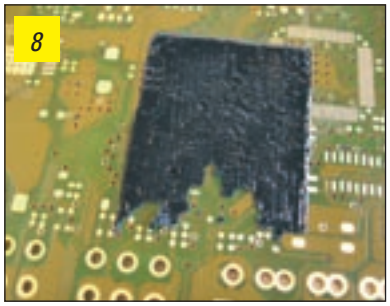
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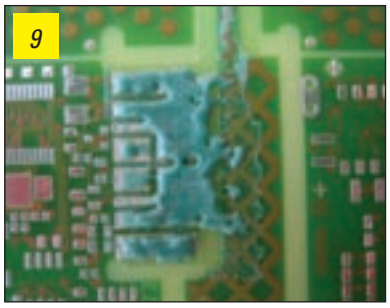
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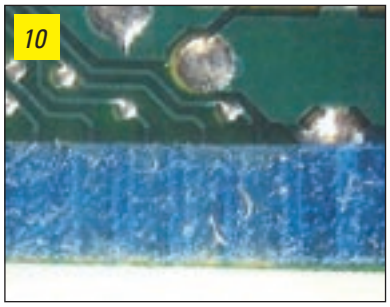
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Reflow soldering

In terms of thermal stress applied to a peelable solder mask, reflow soldering is certainly the most demanding soldering process, especially in case of Lead-free processes. It is not so much the applied temperature but the total duration of thermal stress applied to the material. The model reflow soldering temperature profile in Figure 4 (ZVEI "Lead-substitution task force", Germany) was applied to test the thermal resistance of various peelable solder masks. Independent of curing conditions or thickness, applied standard materials formulated for leaded solder generally showed insufficient peelablity. Only materials especially formulated for Lead-free applications were able to withstand this process.

Combinations of soldering processes

When several soldering processes or thermal steps are combined (e.g. chip adhesive curing plus additional (double) reflow soldering plus additional wave soldering) the total amount of thermal stress needs to be considered. Generally, types with

Table 4 – Peel strength of a peelable solder mask on various substrates

	Peel strength [N/cm] 300 µm, **130°C / 30 min** cure	Peel strength [N/cm] 300 µm, **150°C / 45 min** cure
Before soldering(on solder mask)	0.25	0.80
Base material (etched)	0.90	2.10
Brushed Copper	2.00	3.50

Table 5 – Potential problems related to peelable solder mask processing

Problem	Cause	Solution
Ink film can only be peeled in bits; it is not tear resistant; ink residues on PCB (see Figure 6)	1. printed too thin 2. cured at too low a temperature and for an insufficient length of time 3. squeegee pressure too high	1. use coarser meshed screens and higher stencil build-up 2. check temperature guidance and increase temperature and/or time, if required 3. reduce squeegee pressure
Ink film is not peelable out of plated-through holes (see Figure 7)	1. printed too thin 2. cured at too low a temperature and for an insufficient length of time 3. hole side walls are too rough 4. unsuitable ink type	1. see above 2. see above 3. check roughness of hole side walls and, if necessary, reinforce plated-through holes 4. use suitable ink type
Ink film is not peelable (see Figure 8)	1. curing temperature is too high 2. cured for too long 3. unsuitable ink type; thermal resistance too low for given soldering conditions (e.g. Lead-free soldering)	1. and 2. mostly recognisable by the over-dark colour; check drying time and temperature and reduce accordingly 3. use suitable ink type
Melting during wave soldering (see Figure 9)	1. coating exposed to high humidity for too long 2. unsuitable soldering conditions 3. unsuitable ink type	1. ensure proper climatic conditions (i.e. 20 – 25 °C, 50 – 70% RH) 2. optimise soldering conditions (e.g. reduction of preheating) 3. use suitable ink type
"Solder webbing" / solder ball adhesion during wave soldering (see Figure 10)	1. cured at too low a temperature and for an insufficient length of time 2. coating exposed to high humidity for too long 3. insufficient flux agent applied 4. flux agent not sufficiently dried	1. check temperature guidance and increase temperature and/or time, if required 2. ensure proper climatic conditions (i.e. 20 – 25 °C, 50 –70 % RH) 3. increase amount of flux agent 4. optimise drying/preheating
Leaching in plating and immersion processes	1. unsuitable ink type 2. curing conditions not sufficent	1. use suitable ink type (typically a material containg insoluble pigments instead of materials containing dyes) 2. check temperature guidance and increase temperature and/or time, if required

the highest level of thermal resistance should be chosen and curing should be carried out as quickly as possible (and at the lowest possible temperature) to ensure complete peelablity.

Chemical processes

When utilising peelable solder masks in plating or immersion finishes, much longer curing times and curing temperature are required compared to soldering operations in order to achieve a sufficient level of adhesion and thereby exclude the risk of subsurface migration. Very important in view of adhesion is also the used substrate. The example of a peelable solder mask in Table 4, typically used for chemical processes, shows the different levels of adhesion achieved by various substrates dependent on the curing conditions.

When considering the use of peelable solder masks for the protection of certain areas of a printed wiring board during plating or immersion finishes, the potential leaching of the mask also has to be considered. The leaching of ink constituents into the process is of course also potentially critical. Factors to be observed in this respect are:

- chemistry of the used baths
- process parameters (e.g. pH, temperatures, dwell times)
- level of acceptable leaching (e.g. potential influence on bonding, metal turnover).

A higher level of curing leads to an improved embedding of lower molecular weight ink constituents and therefore reduces the risk of leaching. Furthermore, peelable solder masks should be used that contain insoluble pigments as colour-giving substances rather than products containing dyes, which could leach.

Troubleshooting

The application and processing of peelable solder masks are generally very reliable. If, despite this, mistakes are made, the resultant costs can of course be unpleasantly high, since errors are usually only noticeable on the final printed circuit board. Whenever a peelable solder mask shows insufficient peelability, it is often because one of the following mistakes has been made:

- the ink coating was applied too thinly
- the curing temperature was too high and/or curing time was too long or
- an unsuitable ink type was used.

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The low elastic modulus of the ePTFE matrix imparts softness, conformability and excellent compressibility to the composite, while the high thermal conductivity of the BN particles gives the composite its good thermal transport characteristics. The reinforcing nature of the ePTFE matrix results in a composite that is physically robust, easy to handle and does not require additional reinforcement.

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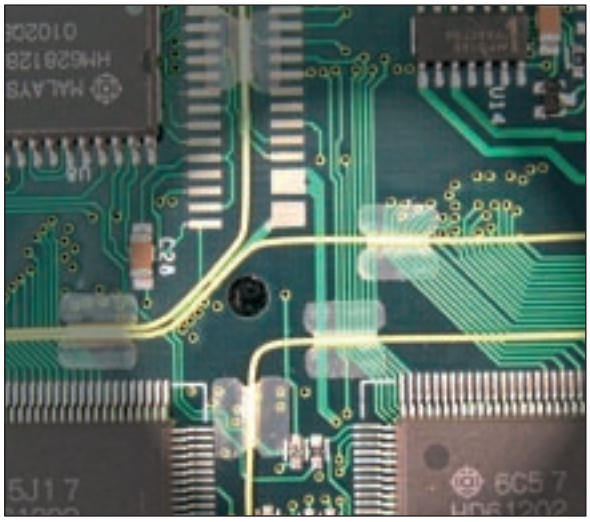
Wire Tacking System Fastens Jumpers Without Gluey Mess

Jumper wires or ECOs and surface conductor repair are a fact of life in PCB modification and repair. In the past, technicians used messy quickset glues for attachment. In answer to this CircuitMedic now offers Flextac Wire Dots, a wire tacking system consisting of pre-cut shapes of a thin, flexible polymer film membrane coated on one side with a high performance, electronics grade permanent pressure sensitive adhesive. It is simply a case of peeling off the sheet and pressing into place. They form a highly conformable, high strength bond, and can be repositioned during and immediately after initial bonding without causing adhesive transfer or loss of bond strength.



Unlike hot melt glues, epoxies, or quick-set cyanoacrylate 'super' glues, Flextac Wire Dots apply instantly to a clean PCB surface with no mess, no curing time, no bonding to skin or clothes or difficult cleanup. They also maintain their hold across a wide range of process and operating temperatures, and will hold securely after exposure to numerous chemicals including most flux cleaning solutions/sprays, saponifiers, "Freon" TF, mild acids and alkalis. Wires attached with Flextac Wire Dots will hold securely through a typical PCB hot water wash.

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