CARAPACE®

TECHNICAL DATASHEET CARAPACE® EMP110

Aqueous Developable PHOTOIMAGEABLE SOLDERMASK

PRODUCT DESCRIPTION

Carapace® EMP110 has been used in the high volume production of PCBs since 1987. The **Carapace®** family has been formulated to exceed the increasing demands of PCB processes, combined with a large process window.

- **High resistance to low solids fluxes.**
- **Electroless Nickel / immersion gold compatibility.**
- **Fine solder dam resolution (50-75µm, 2-3 mil).**
- **Fast processing times allowing High throughput and productivity.**
- **Low ionic contamination.**
- **Solderball elimination.**
- **Optimised rheological and coating properties for each method of application.**
- **High moisture and insulation resistance**
- **Excellent adhesion to flexible substrates.**
- **Contains no halogenated flame retardants.**

Carapace® EMP110 is a contact exposure, aqueous developing, liquid photoimageable soldermask, using two-component epoxy technology to give high levels of chemical resistance over copper, copper oxide, tin-lead or gold plated circuits. Due to their resolution capability, high dielectric strength and physical resistance properties **Carapace®** soldermasks are used as solder resists and insulation coverings on all types of printed circuits, particularly high-reliability, double-sided and multilayer, fine line, surface mount boards.

CARAPACE® EMP110 PRODUCT RANGE

PASTES:

All **Carapace**® pastes are coded as EMP110 followed by a 4-figure number and letters. The 4-figure number and letters denote the colour, finish and application method.

E.g. **EMP110/1972 DGM AS**

Product Family:	**EMP110**
Product reference:	**1972**
Colour & Finish:	**D**ark **G**reen **M**att
Application Method:	**A**ir-**S**pray

Carapace® **EMP110** pastes are available as standard in the following colours, finishes and application methods:

Light Green Matt	SP, CC, AS, ES
Light Green Gloss	SP, CC, AS, ES
Light Green Extra Matt	SP, CC, AS, ES
Dark Green Matt	SP, AS
Dark Green Gloss	SP, AS
Blue Gloss	SP
Blue Matt	SP
Red Gloss	SP
Red Matt	SP
Black	SP
White	SP
Yellow Matt	SP, AS
Yellow/Green Matt	SP, CC , AS
Yellow/Green Gloss	SP
Transparent	SP

Products for application methods that are not listed may be available upon request.

HARDENERS:

1) H1123 - Standard (not suitable for electroless Ni – immersion Au (ENIG).
2) H-1348 - High chemical resistance specifically formulated for ENIG.
3) H-2010 - Hard drying (suitable for ENIG see pg.7).
4) EMP110 PtB - The following hardeners are grouped into the EMP110 PtB class:

    a) H-1613 Hard drying, wide tack-dry window, TGIC-free.
    b) H-1833 Hard drying, reduced Cu tarnish, TGIC-free (can be used with ENIG see pg.7).
    c) H-1400 Fast drying reduced copper tarnish hardener (not suitable for ENIG).
    d) H-1550 Fast drying hardener (not suitable for ENIG).

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Board surface preparation:

Copper surfaces should be mechanically or chemically cleaned to give a 60s waterbreak-free surface. Recommended mechanical methods are pumice, aluminium oxide or 320 grit brush.

Tin/lead boards should be thoroughly degreased using detergent/water rinse or solvent cleaning methods. Adhesion over tin/lead will be enhanced by lightly brushing the surface prior to coating.

All boards **must** be completely dry before coating.

Mixing:

Carapace® is supplied pre-weighed in 1kg, 3kg or 10kg packs.

The resist should be mixed in the ratio 100 parts paste (pt A) to 19 parts hardener by weight. Stir well to ensure complete mixing.

Incomplete mixing can cause poor developing, stickiness during exposure and impaired final properties.

Viscosity reduction:

SP formulations:

SP versions of EMP110 are supplied screen ready. If viscosity adjustment is required prior to, or during printing, then this may be achieved using **Electrareducer ER1.** No more than 5% reducer should be added or deterioration of the printing and drying properties may occur, resulting in thin deposits on track edges and/or prolonged drying times.

CC, ES and AS formulations:

It is advisable to use a slow speed mechanical mixer when mixing in solvent for CC, AS, ES. Care should be taken to avoid incorporating air into the resist during mixing. Resist should be allowed to stand for 2 hours after mixing to allow air to escape. Excessive air in resist can cause microbubbles/voids in the finished film and/or poor curtain stability when curtain-coating.

CC: EMP110 CC soldermasks should be reduced to a viscosity of 80 to 100s (Ford N°4 cup), 60 to 80s (Frikmar N°4) at 25°C with **Electrareducer ER6**. Where **ER6** is not available, an equivalent from an approved source may be used. The use of non-approved solvents is not recommended as they can cause contamination and other processing problems. The amount required is typically 30 to 35% by weight.

When using curtain-coating equipment that utilises short/low temperature evaporation zones it is advantageous to use a blend of viscosity reducers to ensure microbubble elimination. Recommendations will be made by the Electra Technical Service Department during pre-trial discussions.

ES: EMP110 ES soldermasks should be reduced to a viscosity of 70 to100s (Ford Nº4 cup), 60 to 80s (Frikmar Nº4) with **Electrareducer ER10**. Where **ER10** is not available, an equivalent from an approved source may be used. The use of non-approved solvents is not recommended as they can cause contamination and other processing problems. The amount required is typically 30 to 35% by weight.

AS: EMP110 AS soldermasks should be reduced with **Electrareducer ER10.** Where **ER10** is not available, an equivalent from an approved source may be used. The use of non-approved solvents is not recommended as they can cause contamination and other processing problems. Addition level required will depend on spray system used. The following levels are typical:

Machine type	% reducer (by weight)	Viscosity		
		Zahn Nº3	Frikmar Nº4	Ford Nº4
Argus horizontal spray	35 to 45%	25 to 30s	40 to 60s	50 to 75s
Teledyne vertical spray	35 to 50%	25 to 30s	40 to 60s	50 to 75s

Due to the fast viscosity readings using a Zahn$_3$ cup, air inclusion can give erratic readings. It is therefore recommended to use the Ford Nº4 or a cup giving similar values (e.g. Frikmar Nº4).

Process settings:

SP: Mesh count: 37-55T polyester.
Squeegee: 60-70 Shore.

20µm dry thickness should be aimed for; this is typically achieved using a 43T.

The board outline image may be made on the screen using conventional stencil material or masking tape and screen filler. To prevent a build up of ink on the reverse of the screen that may block holes, it is advisable to shift alternate boards along the x- or y-axis before printing. Alternatively, a rudimentary stencil, such as an expanded drill mask, can be used on the screen to prevent ink going into the holes.

Do not utilise the vacuum bed, as this will suck an exaggerated amount of ink into the holes.

CC: The exact coating parameters required to give optimum results should be determined by preliminary tests using typical board designs. Viscosity and coating speed can vary depending on the track-height, density and sidewall configuration.

Below are recommended settings for initial set-up:

Nip-gap	0.3 to 0.6mm
Coating speed	90 to 100 mmin^{-1}
Viscosity	70 to 100s Ford N^{o}4 cup
Wet-weight	80 to 110gm^{-2} depending on track-height and density
Pump rate	Set to attain desired wet film weight

Increasing or decreasing pump rate is a quick and precise way of adjusting the wet-weight. Changing coating speed will also vary the wet-weight, however it is advisable not to go below 80mmin^{-1} (causing ink to be dragged onto belt and exaggeration of tear-drops) or exceeding 120mmin^{-1} (increasing risk of skips and shadowing).

ES: Exact spray parameters will depend on track height and circuit layout.
These parameters will also depend on equipment manufacturer, please contact Electra Technical Service Department for specific recommendations.

Below are recommended settings for the initial set-up:

Conveyor: 1.0 to 2.0mmin^{-1}

Potential: 25 to 40kV

The potential required will depend on the board design. Boards with a higher track density will need a higher potential, similarly boards with large laminate areas will generally require lower potentials.

Viscosity: 70 to 100s Ford N^{o}4 cup.

Rotating bell speed: 25,000 to 35,000 rpm (where applicable).

	Increase	Decrease
Conveyor speed	Decreased film-weight	Increased film-weight
	Greater risk of laminate voiding	Increased coverage on high-tracks
Resist viscosity	Increased film-weight	Decreased film-weight
	Reduced thinning on track-edges but increased risk of orange-peel	Increased risk of resist thinning on track-edges

AS: Exact spray parameters will depend on track height and circuit layout.
These parameters will also depend on equipment manufacturer, please contact Electra Technical Service Department for specific recommendations.

Below are general recommendations and guidelines:

Wet-weight: 60 to 100µm (1.2 to 4 mils)

Tank pressure and coating speed are set to give desired wet thickness.
Atomising pressure should be set to give minimal mottling.
Shaping air is to be adjusted to give an even spray pattern.

Lower atomising pressures and higher coating speeds will lead to increased mottling.

Tack-dry:
The aim of the tack-drying stage is to solely remove the solvents. It is important for the drying chamber (static or conveyorised) to have good air circulation with air supply and extraction facilities.

Convection dry
Recommended drying settings and hold times will vary with hardener selection, see below.

Hardener	Recommended/Max temperature (□C)	Recommended/Max time (mins)	Max hold-time after optimum tack-dry
H-1123	75/80	40/60	72 hours
H-1613	80/90	40/60	96 hours
H-1833	80/85	40/60	48 hours
H-2010	75/80	40/60	48 hours
H-1348	70/75	40/60	24 hours
H-1400	75/80	30/60	48 hours
H-1550	80/85	30/60	72 hours

IR Drying
IR drying is dependent on coating application method, IR wave-length and IR intensity.
Please contact Electra Technical Support Department for recommendations regarding specific equipment types and manufacturers.

Optimum **board temperature**: 125 to 135ºC. Peak temperature

Optimum drying time: 4 to 5 minutes

Exposure
Spectral output: 310-420 nm. Optimum wavelength is approx. 365-385nm.

Step wedge: 9-12 clear (Stouffer 21 step).
Note: exact milliJoule requirements will vary with formulation type.

Determination of the correct exposure should be carried out after setting the developing speed since this will affect the step wedge reading obtained.

Step wedge checks should be carried out on brushed copper with the step wedge under the phototool.
Energy level should be measured through the artwork and mylar/glass. It is important to recognise that the energy level should only be used as a guide for setting the correct exposure; step wedges should be used for determining the actual exposure setting.
Separate exposure tests should be carried out for each different colour, as variations in lamp emissions can cause differences in exposure speed. After determining the correct setting, energy level can be monitored as a means to check for any changes in lamp output.

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Developing

Developer:	1% soln sodium or potassium carbonate.
Spray pressure:	1.5-2.5 $kgcm^{-2}$, 20-40 psi.
Spray time:	30-90s in carbonate chamber(s) (dependent on quantity of ink in holes).
Temperature:	35 to 40°C for H-1613 and H-1833 30 to 32°C for all other hardeners

Boards should be well rinsed with fresh water and fully dried after developing.
Do not final cure boards when wet.

The optimum developing speed is set when an unexposed board develops off completely, 25- 50% of the way through the machine. This speed should be ascertained by preliminary tests prior to making exposure tests.

Developing speed and break-point settings will be determined by the amount of ink deposited in the holes during coating.

Due to the varying degree of ink deposited in holes, different application methods will require different developing speeds.

Typical developing speeds using a 2m long carbonate chamber:

Screen-print	1.3 to 2.0 $mmin^{-1}$
Curtain-coating	2.0 to 2.5 $mmin^{-1}$
Air-spray	3.0 to 4.0 $mmin^{-1}$

Final Cure Convection oven: 60 mins at 150°C **Time at board temperature**

Electroless nickel – immersion gold (ENIG)

Thin coating and/or overcuring of the soldermask can lead to adhesion loss after ENIG. Coating thickness should not fall below 10µm (0.4mils) and cure cycles must not exceed the recommended time and temperature.
If coating thickness is low due to track heights or via holes then it is recommended to carry out a two-stage cure cycle as follows:

1) Final Cure: 10-15 mins at 150°C
2) ENIG plate
3) Recure: 45-60 mins at 150°C

Note: the two-stage cure process is particularly recommended with H1833 hardener or if using a chemical clean process prior to soldermask.

UV bumping

It is not normally necessary to UV cure Carapace® EMP110 but under certain conditions it may be advantageous (see below). Under these conditions, conveyor speeds should be set to attain 1500 to 2000 $mJcm^{-2}$.

High film weight plating:
When depositing high filmweights and/or coating heavily plated tracks it is sometimes possible to see slight wrinkling of the soldermask between the tracks after final cure. UV curing before final cure may prevent this.

Flux residues/staining:
Occasionally flux residues or staining can be seen on boards, particularly after Hot Air Solder Levelling with very acidic or aggressive fluxes. Washing boards when still hot causes this and can be exaggerated by using hot water rinse. Boards must be allowed to cool after soldering before rinsing and it is recommended all rinse solutions be below 40°C (104°F).

If staining does occur it can be removed by post baking boards, after soldering, for 10-15 mins @ 120-150°C. Alternatively if it is not possible to cool boards after HASL, staining can be prevented by giving boards a UV bump cure after the final thermal cure.

Reduced ionic contamination:
Certain fluxes, in conjunction with a poor recirculated-rinse after HASL, can lead to increased levels of ionic contamination. Although Carapace® has proven to give very low contamination figures, in these extreme cases a UV bump after final cure will reduce the risk of increased levels.

Reduced soldermask outgassing:
Where important soldermask outgassing can be reduced by a post-cure UV bump (see page 10).

<u>Via hole plugging</u>
Carapace® EMP110 can be used for reliable via-hole plugging during the initial soldermask print stage. In order to achieve 100% of holes plugged it is advisable to use a double print stroke.
In order to avoid splitting or blistering of the vias please note the following:

Tack-dry: Minimum of 40mins at 80°C
Exposure: Minimum clear 12 using Stouffer 21-step wedge
Developing: Minimum speed to ensure required holes wash clean

If the board design requires prolonged developing times due to small hole development it is recommended boards are given a pre-bake **after** developing **before** final cure to allow slow release of any trapped moisture from vias.
Although it is not recommended to UV bump before final cure, it is advisable to pre-bake boards prior to passing through the UV curer if utilising a UV bump at this stage.

Pre-bake: 15 to 30 mins at 70 to 80°C

<u>Safelight</u>
It is not normally necessary to print Carapace® EMP110 under safelight conditions, although it may be advisable if there are long delays before drying. Between drying/exposing and exposing/developing, boards should be kept in yellow light. Boards should, in any case, be kept out of direct sunlight until completely processed.

<u>Notation/marking inks</u>
Both UV and thermal curing notation inks are suitable for use with Carapace® EMP110. Thermal curing inks may be applied before or after final cure. If UV curing notation inks are used they should be applied before final cure and before UV bump if this is used. In this case UV curing the notation ink will serve as the bump for the soldermask.

Stripping
After developing, any reject boards may be stripped of soldermask using a 5% NaOH solution at 40-50°C

After curing, soldermask can be stripped using a proprietary soldermask stripper such as **ES108H.**

Cleaning
Equipment should be cleaned of residual soldermask using **SW100 or Dowanol PMA.**

Shelf-life
Minimum 9 months* from date of manufacture when stored in cool, dry, recommended conditions.
Storage should be between 10 and 25°C and must be away from sources of heat and direct sunlight.

*H-1613 has a minimum shelf-life of 12 months from date of manufacture.

Final Properties

TEST	METHOD	RESULT	CLASSIFICATION
Hardness (pencil)	SM-840C	9H	Pass, class H
Adhesion	SM-840C	Copper: 0% removal Base laminate: 0% removal SnPb: <10% removal	Pass, class H
Chemical resistance Isopropanol (min.120s) Isopropanol/H_20 (75/25) D-Limonene 10% Alkaline detergent Monoethanolamine Methylene chloride Deionised water	SM-840C Room temp. 120s 46 (± 2)°C 15 min Room temp. 120s 57 (± 2)°C 120s 57 (± 2)°C 120s Room temp. 60s 60 (± 2)°C 5 min	No surface roughness No blisters No delamination No swelling No colour change No cracking	Pass, class H
Hydrolytic stability	SM-840C	No evidence of reversion	Pass, class H
Insulation resistance	SM-840C	Before solder 10^{11}-10^{12} Ω After solder 10^{11}-10^{12} Ω	Pass, class H
Moisture & insulation	SM-840C	No blistering, separation, degradation. Initial $10^{11} – 10^{12}$ Ω During $10^{9} – 10^{10}$ Ω After $10^{11} – 10^{12}$ Ω	Pass, class H
Wave-solder resistance 10 (± 1)s at 260 (± 5)°C	SM-840C	No loss of adhesion or solder pick-up.	Pass, class H

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TEST	METHOD	RESULT	CLASSIFICATION
Hot-air-solder-level	N/A	Minimum 5 cycles	Pass
Thermal shock	SM840 C	No cracks, delamination, crazing or blistering	Pass , class H
	-40°C to +150°C (30 min. each extreme) (10 sec. transfer time)	No cracks, delamination, crazing or blistering	1050 cycles
Dielectric strength	SM840 C		Pass , class H
	IEC60243-1 and IEC60464-2	134 KV/mm (3417 V / mil)	
Dielectric constant		4 (1 MHz)	

Soldermask Outgassing

	Total Mass Loss (TML)	Collected Volatile Condensable Material (CVCM)	Water Vapour Recovered (WVR)
ASTM-E-595 requirement	Max. 1.0%	Max. 0.10%	Report
EMP110 No UV bump	2.58%	0.06%	0.31%
EMP110 Plus 3200mJcm^{-2} UV bump	**0.95%**	**0.02%**	**0.31%**

Other

Bellcore TR-NWT-000078	Pass	**IPC-SM840C**	Class H
BS6096/9000	Pass	**MIL 55110D**	Pass
Siemens E-korrosion	Pass	**UL File E95722**	94 V-0

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