Enthone

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Compatibility of Conformal Coatings and Solder Masks

A key issue for printed wiring board (PWB) material suppliers, fabricators and assemblers/OEMs is the compatibility of PWB coatings (e.g. solder mask) with assembly materials such as solder pastes, fluxes, component adhesives, underfills, glob tops and conformal coatings.

Conformal Coatings

Although historically used primarily for military electronic applications, conformal coating use has become more prolific with the increased electronic content in the automotive, industrial and portable computing/telecommunication sectors. The basic types and common description of the popular conformal coatings include:

Acrylics:	Easy to apply/remove, marginal protection
Epoxies:	Best solvent/moisture resistance, brittle
Urethanes:	Best all-around performance, difficult to repair
Silicones:	Good performance under thermal cycling, popular in automotive
Paraxylyene:	Vacuum deposit, excellent protection, expensive

Combinations of some of the above materials: Modified performance vs. 100%

Identifying compatible solder mask/conformal coating combinations and processes is complicated by the variety of conformal coating chemistries available as well as the multitude of other factors that can impact adhesion, including the OEM's definition of "acceptable" adhesion. The most critical factors for mixed technology assembly scenarios are listed below.

Materials deposited on the solder mask prior to conformal coating
- Surface finish (HASL, OSP, Ni/Au, etc.)
- Solder paste residues
- Wave solder flux residues
- Component adhesive
- Underfill
- Glob top

Wave solder flux application method
- Foam
- Spray
- Wave
- JETFLUX* (microjet) flux application method

Thermal cycles
- Reflow profiles and temperatures
- Pre-heat temperature
- Solder wave temperature

Solder mask
- Chemistry
- Surface finish (gloss, semi-matte, matte)

Conformal Coatings Properties

If all intermittent steps and materials are ignored, curing, coverage and adhesion may be most directly impacted by the solder mask. Other materials present on the solder mask surface may also chemically interfere with curing mechanisms of some conformal coatings. These materials may include the residues of no-clean solder pastes, no-clean wave solder fluxes, and non-reacted materials from the solder mask itself. A poor cure means the conformal coating's intended performance properties will never be realized. Coverage and adhesion of even properly cured conformal coatings may still be unsatisfactory if the surface tension of the as-applied liquid conformal coating is not properly matched to the surface energy of the solder mask and/or intermediate materials. A mismatch in these two properties can result in dewetting of the liquid conformal coating from the solder mask surface. Dewetting may occur immediately following conformal coating application or later during solvent loss or curing stages.

Adhesion may also be affected by surface topography. Rougher, matte-finish solder mask surfaces may be difficult to adhere to if the conformal coating as applied does not wet and penetrate the "peaks and valleys" of the solder mask surface. Conversely, the higher surface area provided by a rough solder mask surface may result in superior adhesion of a particular conformal coating. Once again, a proper match between conformal coating surface tension and solder mask surface energy is critical.

Evaluating Compatibility

It is recognized that compatibility of the conformal coating and the solder mask ensures the highest first-pass yields and the lowest unit cost at assembly.

True system compatibility of a conformal coating and solder mask is determined by subjecting a solder masked test vehicle to ***all*** chemical and thermal conditions present in the assembly process. It is especially important to evaluate conformal coating adhesion on PWBs that have experienced the particular assembly production process employed. As noted earlier, the post-solder paste reflow residues, post-wave solder flux residues, and other intermediate chemistries that remain on the PWB surface in no-clean assembly operations may interfere with conformal coating cure and adhesion.

EACH step of the assembly process may impact the adhesion between a solder mask and the subsequent conformal coating materials placed on the board. To date, the following results for ENTHONE® DSR solder masks have been reported either from specific assembly facilities or from internal testing (Note: In the case of internal testing, the conformal coating was applied to the solder mask WITHOUT intermediate processing as no standard process has been defined.) Test method code: CCU = Customer criteria unknown; TN = Internal Thumb Nail scratch test which indicates ease of conformal coating removal:

Solder Mask	Conformal Coating Type	Conformal Coating	Adhesion Results*	Test Method Code
DSR-3241	Acrylic	Humiseal 1B31	Pass	CCU
	Modified Acrylic	Start PC101	Mixed	CCU
	Urethane	Conap CE-1155	Mixed	CCU
		Humiseal 1A20	Good	TN
		Humiseal 1A27	Good	TN
		Loctite 393	Fair	TN
		Loctite 394	Fair	TN
	Silicone	Konform C414	Pass	CCU
		Dow 3-1744	Poor	TN
		Dow 3-1753	Fair	TN
		Loctite 5290	Fair	TN
		Loctite 5293	Fair	TN
		Humiseal 1C49	Fair	TN
		Humiseal 1C55	Good	TN
		Humiseal 1C57	Fair	TN
		Humiseal 1C61	Fair	TN
	Paraxylyene		Good	TN
	Epoxide	Envibar UV 1244T	Mixed	CCU
DSR-3241(CR)	Urethane	Humiseal 1A20	Good	TN
		Humiseal 1A27	Good	TN
	Silicone	Dow 3-1744	Poor	TN
		Dow 3-1753	Fair	TN
		Humiseal 1C49	Fair	TN
		Humiseal 1C55	Good	TN
		Humiseal 1C57	Fair	TN
		Humiseal 1C61	Fair	TN
DSR-3241(MD)	Urethane	Humiseal 1A20	Good	TN
		Humiseal 1A27	Good	TN
	Silicone	Dow 3-1744	Poor	TN
		Dow 3-1753	Fair	TN
		Humiseal 1C49	Fair	TN
		Humiseal 1C55	Good	TN
		Humiseal 1C57	Good	TN
		Humiseal 1C61	Fair	TN

Solder Mask	Conformal Coating Type	Conformal Coating	Adhesion Results*	Test Method Code
DSR-3242(I)	Urethane	Humiseal 1A20	Good	TN
		Humiseal 1A27	Good	TN
	Silicone	Dow 3-1744	Poor	TN
		Dow 3-1753	Fair	TN
DSR-3300	Acrylic	Humiseal 1B31	Fail	CCU
		PD George 5026	Marginal	CCU
	Urethane	Humiseal 1B55	Pass	CCU
		Humiseal 1A20	Good	TN
		Humiseal 1A27	Good	TN
		Loctite 393	Poor	TN
		Loctite 394	Poor	TN
	Silicone	Dow X1-4097	Pass	CCU
		Dow 1-2620	Pass	CCU
		Dow 3-1744	Poor	TN
		Dow 3-1753	Fair	TN
		Loctite 5290	Good	TN
		Loctite 5293	Poor	TN
	Paraxylyene		Good	TN

*Pass/Fail criteria varies with criteria of testing site. Thumb nail testing is subjective at best, and should only be considered relative within the specific combination of solder mask and conformal coating type being evaluated. Results reported are ONLY intended as a guide to readers and may differ under individual production conditions.

Conclusion

Because of the multitude of materials and assembly process variations which can be combined, it is recommended that qualification testing using all of the chosen materials and assembly processes be performed prior to committing full production quantities to the system.

Polyclad Technologies
A COOKSON ELECTRONICS COMPANY

www.polyclad.com

AMERICAS
Enthone Inc.
P.O. Box 1900
New Haven, CT 06598
Tel. 203-799-4971
Fax 203-799-1513

EUROPE
Enthone-OMI (UK) Ltd.
Woking, England, UK
Tel. 44-1483-758-400
Fax. 44-1483-728-414

ASIA
Polyclad Asia Ltd.
Wan Chai, Hong Kong
Tel. 852-2891-1920
Fax 852-2574-0187

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