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AGENDA



* What is Conformal Coating. 컨포멀코팅 定義 ★ Why we use Conformal Coating. ★ Where we use Conformal Coating. 適用分野 ★ What Materials are used in C-Coating 使用材料 * How are Conformal Coatings Applied 適用方法 • Bran-new Coating Technology: Non-Atomized Film Intermittent / Atomized I.P.S. Coating ★ Design Considerations for C-Coating. . . 過程/條件考察 ★ Issues & Solutions in C-Coating. 問題/對策 • Most Issues are due to Bubbles, Production Cost, Environmental.... and Whiskers ★ Curing Considerations / Bubble-free & Energy Saving.. 건조오븐 考察 * Programming / Justification Guidelines * Typical Systems Layout Appendix & Video to be referred

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- Transparent, polymeric coatings
 - conform to the contours of the printed circuit board circuitry
 - and its components create <u>a thin layer</u> which is flexible.
 - This improves its working life, ensures security and reliability
 - of the performance remarkably.
 - Virtually it protects circuitry from hazards,
 - Moisture, Droplets
 - Dust
 - Metal Corrosion
 - Mechanical Shocks & Vibrations
 - Chemicals, etc.





The conformal coatings may have several functions, depending on the type of application.

- The Most Common are :
 - Inhibit *Current Leakage & Short-Circuitry*
 - due to moisture, droplets and/or other contaminants
 - Inhibit Arcing, Corona Discharge
 - Allow Higher Power & Closer Track-Spacing in Circuitry

 - Improve The Fatigue-Life of Solder-joints
 - Provide Mechanical Supporting for Small Parts. . .
 - Prevent damages from Mechanical Shock & Vibration

* Why we use Conformal Coating (Ref. / Corona & St. Elmo's Fire)



... "Physical descriptions of St. Elmo's Fire have ranged from a ghostly dancing flame to natural fireworks. It usually is of a blue or bluish-white color attached to fixed, grounded conductors and has a lifetime of minutes. The flame is heatless and non-consuming, occasionally accompanied by a hissing sound"....."The phenomenon is scientifically known as a *corona* or *point discharge*. It occurs on objects, especially pointed ones, when the electrical field potential strength reaches about *one-thousand volts per centimeter*. (When the electrical potential field is great enough to overcome the resistance of medium across which it occurs, a current of electrons will result (Ohm's Law).) During <u>fair weather</u>, the electrical field strength of the atmosphere is about <u>1 volt per centimeter</u>. In the initial stages of thunderstorm formation, however, the field increases to 5 volts per centimeter, and *just before a lightning flash, reaches up to ten-thousand volts per centimeter*.

circumstances, to produce St. Elmo's Fire during thundery weather. When the storm is particularly heavily charged, the leaves, blades of grass and even the horns of cattle may glow at their tips. In fact, the glow of St. Elmo's Fire has often been observed on sharp objects in the vicinity of tornadoes.

www.physics.northwestern.e du/ classes/2001/Fall... st



*** Why we use Conformal Coating** (Appropriate Dry Film Thickness Estimation)





★<u>Electrical Field</u> Potential Strength ≥ 1,000(volts/cm):

/ Corona(point) Discharge
≥ 10,000(volts/cm):

/ Flashover, Arc Discharge

... due to 100(volts/mm) ... due to 25(volts/250um)



★<u>Estimation</u> of D.F.T. appropriate : T(inches) = 6.44V x 10⁻⁶
<<u>Example</u>> 12VDC: T≈2(um), 24VDC: T=3.9(um), 36VDC: T≈5.9(um)

* Why we use Conformal Coating

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(Ref. / View of real Track-Spacing in the circuitry)



***** Where we use Conformal Coating



Conformal Coatings have been mostly applied to,

- Aerospace Industry
- Military
- Automotive
- Medical

etc.

- Shipbuilding
- Appliances &
 - Telecommunications
- Industrial Applications,



1. Automotive(22%)
 2. Aerospace(15%)
 3. Medical(16%)
 4. Electronics(39%)
 5. Military/Others(8%)



***C-Coating for Automotive becomes more in active in the world market.**

* Where we use Conformal Coating (Ref. / Spec. used for Conformal Coating Process)



• 34 Listed in IPC-830-HDBK

- ASTM (7) (American Society of Testing Materials)
- FAR (1) (Federal Aviation Regulations)
- IPC (14) (Industry association for Printed Circuit...)
- JIS (2) (Joint Industry Standard)
- MIL (3) (Military Standards)
- UL (3) (Underwriters Laboratories)
- IEC (2) (International Electro-technical Commission)
- INTERNATIONAL (2)
- Mostly referenced to,

IPC-CC-830 — Qualification & Performance of Electrical Insulating Compounds for PCA's MIL-I-46058 — Insulating Compound, Electrical (Material Specification U.S. DOD) IEC 61086 — Specification for conformal coatings for loaded printed wire boards

* What Materials are Used in Conformal Coating



Major Coating Materials in Use,

- Acrylic Resin / modified Acrylic Resin AR / MAR
- Urethane Resin / modified Urethane Resin. . . UR / MUR
- Silicone Resin / modified Silicone Resin SR / MSR

- Specials, etc.





Coating Material Comparison Chart

Coating Material Properties by the Resin			RUBBER-RESIN (고무수지)		ACRYLIC-RESIN (아크릴수지)		SILICONE-RESIN (실리콘수지)		S.
CONFIDENTIAL		DATE: 2011-04-25	① / N社(日本)	2 / C社(美國)	3 / P社(獨逸) - Thixotropised -	4 / C社(美國)	⑤ / E社(英國)	⑥ / D社(美國)	티티앤에스㈜
항 목	단 위	측정조건 / 방법	Synthetic Rubber, Solvent Based		Modified-Acrylic, Solvent Based	Acrylic, Solvent Based	Modified-Silicone, Solvent Based	Silicone, Solventless RTV	비고
막 투명도 (Clarity)	-	육안검자	Transparent (투명)	Transparent (투명)	Transparent (투명)	Transparent (투명)	Transparent (투명) *옅은밀짚색	Translucent (반투명)	※코팅막은 투명할수록 유리
코팅액 비중 (Specific Weight)		Undiluted (원액)	0.82	0.86	0.98	0.92	0.97	0.99	@20°C
코팅액 점도	mPa.s	Undiluted (원액)	400/Ambient	350/Ambient	220/Ambient	200/Ambient	400/Ambient	125/Ambient	※저점도/박막조건
(Viscosity)	(Cps)	Dilution in Normal (희석액)	40 ~ 60	40 ~ 60	40 ~ 80	40 ~ 80	40 ~ 80	60 ~ 125	» 버블문제에서 유리
고형분농도 (Solids Content)	%	Undiluted by Weight	25	21	30	35	50	80	
지촉건조시간 (Tack-Free Time)	minute	Drying Time to Handle	5/Ambient	10/Ambient	20/Ambient	10/Ambient	20/Ambient	7/Ambient	※도막두께 50(μm) 도포기준
추천 건조막두께 (DFT Recommendable)	um	Recommendable Coating Thickness / Dry Film	20 ~ 40	20~40	25 ~ 50	25 ~ 50	25 ~ 75	50 ~ 100	※T(inch)= 6.44Vx10 ⁻⁶ 적정 코팅맊두께산정 :
코팅막 Curing 조건		Recommended Curing Conditions	80°Cx10(min) or, 24(hr) flash in RT	75°Cx30(min) or, 24(hr) flash in RT	60°Cx15(min) or, 2(hr) flash in RT	75℃x30(min) or, 24(hr) flash in RT	2(hr) flash in RT and 90°Cx2(hr)	60°Cx5(min) and curing 24(hr) in RT	
코팅액 사용수명 (Pot-Life @Ambient)	month	액조성 後 사용가능시간 (Usable in Closed-Loop)	Pot Life ≑ 12(個月)	Pot Life ≑ 12(個月)	Pot Life ≑ 6(個月)	Pot Life ≑ 12(個月)	Pot Life ≑ 6(個月)	Pot Life ≑ 2(個月)	※코팅액 취급성 생산현장에서 중요
신축성 (Elongation)	%	인장속도: 300(mm/min)	460	•MIL-I-46058C Stated as 'Excellent'	•MIL-I-46058C TDS states as 'Excellent'	•MIL-I-46058C TDS states as 'Excellent'	Technical Data Unavailable	30	※클수록 GOOD
투습도 (Vapor Transmission)	g/m².day	40°C @RH90% 도막두께: 100(µm)기준	20	15	TDS states as 'Good' (~150)	TDS states as 'Good' (~100)	Unavailable TDS (δ ≫ 250)	-Unavailable TDS (δ ≫ 500)	•JIS-Z0208 투습도 작을수록 GOOD
도막접착력 (Film Adhesion)	-	도포後 첫터 종/횡방향 1mm 피치 각11개 칼집(관통) 내고 접착태이프부착 / 탈착 •100개 CELL 中 박리된 수량	●JIS-K5400 GlassEpoxy기판: 無박리 Cu 기판: 無박리 Polyester 기판: 無박리	•ASTM, Meth D2197 TDS states as 'Excellent'	●ISO-2409 Cu Substrate: 無박리 FR₄ Substrate: 無박리	•ASTM, Meth. D2197 TDS states as 'Excellent'	Technical Data Unavailable	Technical Data Unavailable	※박리 CELL수량 적을수록 GOOD
체적저항율 (S. Volume Resistivity)	Ω-cm	ASTM D-257	3.30E+15	2.00E+14	1.50E+15	8.00E+14	1.00E+15	5.70E+14	※체적저항율 클수록 GOOD
절연파괴강도 (Dielectric Strength)	KV/mm	●MIL-I-46058C 절연파괴전압 / 단위두께	•ASTM, Meth. D149 75	•ASTM, Meth. D149 49	•DIN EN 60243-1 60	•ASTM, Meth. D149 75	•ASTM, Meth. D149 90	●MIL-I-46058C 18	※절연파괴강도 클수록 GOOD
절연저항 / 고온.고습환경 (Insulation Resistance)	Ω	●0.3mm피치 패턴30um 도포, 85℃/85% 고온.고습환경에 노출 접연지항값 측정 印加電壓: DC25V 測定電壓: DC100V(1分후 측정)	●MIL-I-46058C 고온 고습환경 1,000시간 노출 절연저항: 5 x 10 ¹⁰	●MIL-I-46058C 고온.고습환경 1,000시간 노출 절연저항: 1 x 10 ¹⁰	●MIL-1-46058C 고온.고습환경 1,000시간 노출 절연저항: 1 x 10 ⁹	●MIL-I-46058C 고온.고습환경 1,000시간 노출 절연저항: 6 x 10 ¹⁰	•MIL-I-46058C TDS states as 'Meets Approval'	Technical Data Unavailable	※절연 저항값 클수록 GOOD

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Coating Material Comparison Chart

항목 단위	측정조건 / 방법	Synthetic Solven	c Rubber, t Based	Modified-Acrylic, Solvent Based	Acrylic, Solvent Based	Modified-Silicone, Solvent Based	Silicone, Solventless RTV	비고	
열팽창 계수 (C-Thermal Expansion)	Thermo Mechanical Analysis	55 ppm/°C at RT	●DMA 55 ppm/°C at RT	160 ppm/℃ at RT	●DMA 55 ppm/°C at RT	90 ppm/°C at RT	300~350 ppm/°C at RT	※열팽창계수 작을수록 GOOD	
추천 연속사용온도 (Temp. Limit advised in A Continuous Use) ℃	•자동차 室內 : ~85°C •Engine 격실 : ~125°C •Engine/Transmission : ~150°C	-45℃ ≤ T _a ≤ +135℃	-45°C ≤ T _a ≤ +125°C	●DIN EN60216: 20,000hrs -40°C ≤ T _a ≤ +125°C	-45°C ≤ T _a ≤ +125°C	-45°C ≤ T _a ≤ +150°C	-45℃ ≤ T _a ≤ +150℃	※자동차 Upper Temperature Limit	
내열성 (Thermal Resistance)	●Polyest er 기판에 도포 하고 80℃x10分 가열하여 DFT50/m 코팅막형성한다. ●기준온도구간에서 코팅막의 신축/인장강도 반감시간측정	 ※신축성, 인장강도반감 •135℃조건: 3,300以上 •180℃조건: 150~180 ※코팅막 단주기노출의 경우앤, +180℃ 고온 환경까지 허용 	•MIL-I-46058C Stated as 'Thermal- Shock: Passes' ※코팅막 단주기노출時, +180℃ 환경까지 허용	•MiL-I-48058C Stated as 'Thermal Shock: Passes' * 코팅막 단주기노출時, +150°C 환경까지 허용	•MIL-I-46058C Stated as 'Thermal Shock: Passes' 후코팅막 단주기노출時, +150℃ 환경까지 허용	●MIL-I-48058C Stated as 'Thermal- Cycling meet Approval' ※코팅막 단주기보출時, +200℃ 환경까지 허용	•MIL-I-46058C Stated as 'Thermal- Shock:Passes' 후고팅막 단주기노출時, +205℃ 환경까지 허용	※고온사용환경에서 신축성/인장강도의 특성 반감시간이 길수록 GOOD	
염수분무시험 & 절연저항치 (Salt Spray Exposure)	 ●JIS Z2371-1976(염주분무시험) ※규정시험시간 각 100 / 300 / 500hr 규정시간염수분무 後, 각단계별 85℃/RH85% 항은항습로에투임 6시간 청과 時, 절연저항값 측정 測定電壓 DC100V (1分후 측정) 	 코팅막 DFT30(um) 조건 下에서, *초기저항치: 약 1.0 x 10¹⁰ * 500시간 시험 後 저항치: 약 1.5 x 10⁹ 	NO DATASHEET	NO DATASHEET	NO DATASHEET	NO DATASHEET	NO DATASHEET	※절연저항값 클수록 GOOD	
강점 (STRONG-POINTS)	《RUBBER RESIN • Easy to Handle & Rework : 코 • Excellent Film-Lifetime due to : 제료의 높은신축율, 낮은투습 • Fast Drying, Reaching Optimu : 지촉건조 및 수시간 內 최적구 • High Dielectric Strength, Low I & RF Circuitry : 제료의 우수한 RF회로기관 노 • Excellent Adhesion & Notably : 도막접착력이 우수하고, 현저	 ✓ <u>RUBBER</u> RESIN Easy to Handle & Rework : 코팅액취급 및 수정작업용이 Excellent Film-Lifetime due to Higher Elasticity, Lower Permeability & CTE · 재효의 높은신축율, 낮은투습도 및 작은열팽장으로 도막보혼수명 우수 · Fast Drying, Reaching Optimum Physical Properties in Hours 			 ✓ACRYLIC RESIN Easy to Handle & Rework : 코팅액취급, 수정작업용이 Most widely used Chemical : 전세계, 가장 널리사용 Good Film-Lifetime due to Low Permeability & CTE : 제료의 비교적 낮은투습도, 열행장으로 도막보존수명양호 Fast Drying, Reaching Optimum Physical Properties in Hours : 지촉건조 및 수시간 더 최적수준의 물성제공 Little shrink and No heat-radiation in curing process Protect Electric Components : 큐어링 iffs 도막수축이 미미하고, 열복사 없어 부품보호에 유리 Good Adhesion & Notably Longer Pot-Life : 도막접확력이 양호하고, 현처히 긴 POT수명 		 ✓ <u>SILICONE</u> RESIN Stable over Wide Temperature Range of PCA operation, and upper limit in a continuous run allows up to +150°C ^{PLUS} : 넓은 온도폭에서 기관운원조건충족, 연속운원 時 +150°C ^{PLUS} 대응 Solventless RTV secures Remarkably Less VOC : 무용쾌 상운경화형으로 철죄한 VOC 배출억계 Thick and Flexible Film helps Dampening and Impact Protection : 유연한 후도막으로 기계적충격흡수 및 완충기능제용 Low Dissipation Factor is favorable for High Impedance of Circuitry : 낮은 전자기력소실율로 RF 회로기관보호에 유리 Lower Material Surface-Energy provides Better Flow, Penetration : 낮은 제료표면장력으로 흐름성, 침투성 우수 		
약 점 (WEAK-POINTS) (WEAK-POINTS) 약 점 : 아망 Solids Content(20-25%) ma : 20-25% 지고형분으로 후도막 • Harder Curing Conditions than R : 상윤경화형 Silicone수지에 바 • PCA continuous running in High : 회로기관 연속운전 時, 135~14		vent Based ay be unfavorable for Thick Film build-up 형성에 불리 ▶ 박막형성에는 유리 RTV Silicone Resin 비해 어려운 큐어링조건 1 Temperature limits to T _a ≤ +135~140°C 40℃ 以下로 제한				✓ SILICONE RESIN • Uneasy to Handle & Rework, Need A Caution in Store : 코팅액취급 및 수정작업에 어려움, 보관에 각별한 주의요망 • Moisture(RH≥20%) is Essential to Cure, Short Pot-Life : 큐어링공정에 적정습도유지가 필수, 짧은 POT수명 • Low Abrasion Resistance : 코팅막의 마모저항 취약 • Extra Care for improving Film Adhesion and Lifetime may be needed since High Permeability & CTE : 재료의 높은투습성, 열팽창으로 도막부착력 및 보존수명에 대한 고찰요망 • Need Extra Caution against Low-Molecular Siloxane : 저불자실록산 문제에 대한 특별한 주의요망			
기타, 참고정보 (MISCELLANEOUS)	• LSS-520MH 재료가격 / Retail Price Ref. S) : ₩68,000/Liter (VA[7별도)			● 1B31 재료가격 / Retai : ₩55,000/Liter (VAT	'}격 / Retail Price Ref. 'Liter (VAT별도) • 3-1965 재료가격 / Retail Price Ref. : ₩58,000/Liter (VAT별도)				

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* What Materials are Used in Conformal Coating

HUMISEAL

click here

 $\mathbf{\Delta}$

VITTO SHINKO

click here

OW CORNEN

click here



Most widely referenced, conformal

c-coating materials...

(for reference. . .)



*TDS_Representative C. Coating Material: NITTO SHINKO

*TDS_Representative C. Coating Material: DOW CORNING





click here

 $\mathbf{\Delta}$

ELECTROLUBI

click here



***TDS_**Representative C. Coating Material: *HENKEL*

***TDS** Representative

C. Coating Material: DYMAX



click here



• click here

FILM Optimization per Coating Parameters



i-Tronik WORKSHOP 2015 in Venice, Italy



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		-	Confo	rmal Coating References,		기술정보 by TTnS Inc.		
	ENTIAL	F	Presently Au	Itomotive PCAs in Japan (日 Z	朱國)	As of June 2, 2010		
NO.	PC ASSEMBLY PRIMARY MAKER	COATING MATERIAL	FILM THICK (DFT in um)	PC ASSEMBLY, REFERENCED SEGMENT	CAR MAKER (END-USER)	NOTE		
1	DENSO	1B66	10~30(um)	ECU, AIR-BAG, 각종 자동차제어기판	TOYOTA, HONDA, NISSAN, MITSUBISHI, MAZDA, DAIHATSU, SUZUKI 等 全-日本車	Humiseal1B66 ※Humiseal1B31과 同- Acrylic계열로 속건성. 도막강도, 친환경요소강화		
2	AISIN	1B51	10~30(um)	POWER-SEAT 제어기판 外	ΤΟΥΟΤΑ	Humiseal1B51		
3	TOYOTA HIROSE	1B51	25~40(um)	ECU, AIR-BAG, 각종 자동차제어기판	ΤΟΥΟΤΑ	※속건성고무수지		
4	ZEXEL	1B51	30~50(um)	상용트럭 ECU, 기타	ISUZU	코팅액. 방습, 절연 저항, 내열성 및 친		
5	ASCO	1B51	20~40(um)	AIR-BAG	NISSAN	완경묘소강와		
6	YAZAKI	TF1141	10~40(um)	자동차 각종제어센서	ΤΟΥΟΤΑ			
7	FUJITSU TEN	TF1141	25~50(um)	ECU, 각종 자동차제어기판	ΤΟΥΟΤΑ	Acrylic계열 코팅액		
8	ALPINE	LSS-520MH	30~50(um)	각종제어기판	ΤΟΥΟΤΑ	LSS-520MH		
9	HONDA ELESYS	LSS-520MH	20~40(um)	ECU, 각종제어기판 (ECU 30um 以上 코팅)	TOYOTA, HONDA	수지코팅액. 내열성, 도막강도, 방습 및 친환경요소강화		
10	HONDA KEIHIN	TF1141	20~40(um)	ECU, 각종제어기판	HONDA	~※一部 ShinEtsu社		
11	MITSUBA	TF1141	20~30(um)	각종제어기판	HONDA	···· 무용제 병행사용		
12	KANSEI 1B51		25~45(um)	AIR-BAG, 자동차 내부제어기판	NISSAN			
13	HITACHI AUTOMOTIVE	1B66 &	10~40(um)	ECU, 각종 자동차제어기판	NISSAN			
14	MITSUBISHI ELECTRIC.	1B51	10~30(um)	ECU, 각종 자동차제어기판	MITSUBISHI			
15	NALTEC	ShinEtsu/SR	40~80(um)	ECU, 각종 자동차제어기판	MAZDA, FORD			
]]		(Solventless)						

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* What Materials are used in C-Coating (Ref. / How to measure Permeability of the film)



How to measure 'Vapor Transmission' according to JIS Z 0208



DEMO with Rubber Film



•The calcium chloride is put in the cup which is made of aluminum, the lid is done in the seat of 100(µm), and surroundings are sealed with the row wax. Turns it on during the fixed time in the tank set with 40°C×RH90%.

 The weight change is measured, and the amount of steam transmission through the film is calculated from the weight increase.

 The moisture absorbent is entered into the cup wherein the surroundings 40°C×RH90%.

 Steam penetrates the film(Lid) according to the difference in vapor pressure generates inside and outside of the cup.

* What Materials are Used in Conformal Coating



Subsidiary Tech Papers, back-up C-Coating Materials

*TDS_Technical Issue Low-Molecule Siloxane: VOC GAS

★TDS_Technical Report ►
H.A.L.T. Test: ***TDS_Technical Report** ►

고장유발시험 결과보고서 • click here

nnical Report H.A.L.T. TEST: • click here ★TDS_Technical Issue
Coupon Sample Test (IPC-B-25A):



• <u>click here</u>

★TDS_Technical Report
High Temp/High Humidity Test:



• <u>click here</u>

یک علاقت عبا • click here

★TDS_Technical Report
High Temp/High Humidity TEST:



***** How are Conformal Coatings Applied



Conventional Methods. Masking needed in most cases

- Dip Coating
- Brush Coating
- Manual Spray Coating
- Advanced Methods. . . **Selective Coating under No-Masking*
 - Atomized Coat : Air Spray, Spiral Spray & Bead
 - ➤ Need to Sacrifice Throughput(UPH), Cleanness & Edge Definition
 - Non-Atomized Coat : Film Pattern, Needle Dispense
 High UPH thru Intermittent Coating Technology
 Less Contamination, Fine Edge-Definition due to Film Pattern
 Little Maintenance

* How are Conformal Coatings Applied / CONVENTIONAL - Dip Coating



• Pros :

- Low Capital Investment
- Simplicity
- High Throughput (UPH)

• Cons :

- Poor Film-build, Inconsistency
- Material Contamination
- Requires Masking
- Safety & Environmental Issue due to Exposure









• Pros :

- Low Capital Investment
- Low Skill
- No Masking
- Cons :
 - Poor Film-build, Inconsistency
 - Material Contamination
 - Mechanical Contacts
 - Safety & Environmental Issue due to Exposure



* How are Conformal Coatings Applied / CONVENTIONAL – Manual Spray Coating



• Pros :

- Low Capital Investment
- Simplicity
- Tooling
- Cons :
 - Inconsistency
 - Masking
 - Emissions
 - Cleanliness (Hard in Maintenance)
 - Safety & Environmental Issue due to Exposure





***** How are Conformal Coatings Applied / ADVANCED – Automated Selective Coating

• Pros :

- High Consistency
- High Throughput
- Material Savings
- No/Little Masking
- Closed Fluid Circuit No Exposure to AIR
- Cons :
 - Capital Investment













▲TCM45A **Fully Automated** Inline Con-Coating WorkCell



TCM45A Coating Applicator **Dual Heads Configuration**



NCAF-gun Film Dispensing Works in 30° Tilting mode

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***** How are Conformal Coatings Applied **/ ADVANCED – Automated Selective Coating**



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* How are Conformal Coatings Applied Automated, Selective Coating / TCM45A WorkCell



• TCM45A / Features & Benefits

- I. Precision Five(5)-axis Cartesian Robot ensures,
 - Fully-automated, Selective Coating
 - Virtually eliminates Masking & Coating Reworks
 - Maximize UPH and Repeatability
- II. Equipped with 'Easy Coating Manager' @WIN7
 - TTnS Exclusive Coating Program,
 - Compatible with Windows 7
 - Easy to handle, Even Entry Level Operator can use
 - Performing Various Coating Patterns :
 - Line-Coat, Area-Coat (beyond Area), Intermittent-Coat, Spot-Coat, Tilting-Coat all sides by 30°, Program Duplicate and Impact Pulse-Spray Coat are available

* How are Conformal Coatings Applied Automated, Selective Coating / TCM45A WorkCell



III. Backed by Intermittent Coating Technology by aids of Film NCAF-gun / millisecond Pulse-Timer



- FCN Film Nozzle / Film NCAF-gun
- IV. Backed by Impact Pulse-Spray, Dispensing NCAS-gun performs tri-mode of coatings that Bead, Spiral-Bead and Spiral-Spraying



▲ TPC999 4(Ch) millisecond Pulse-Timer



▲ Spiral Spraying Pattern NCAS-gun @S6CN/S12CN





A Bead Pattern A Spiral Pattern



▲ S6CN Spiral Nozzle / Spiral NCAS-gun

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2. This DEMO was performed with FCN50 / NCAF-gun / TCM45A for HMC-KIA. 3. Any question about the demo results will be appreciated.

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3. Actual PCBA size reads 224(W)x194(D)mm

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Case Coating with 24(unit) <u>Tail-Lamp</u> control PCAs arrayed,

ISSUES : 1. Coating without masking

- 2. Cycle-Time reduction seems so hard.
 - Currently Cycle-Time has been barely 50(sec/pca)
- 3. Bubbles forming over the film has been Issue.
- Solution : We made it in 10(sec/pca) at no masking whereas Cycle-Time specified was 50(sec/pca), moreover, the bubbles become controllable.
- Case Coating with 3(unit) <u>C346</u> PCAs arrayed, *NDEO_TTnSI.P.S. Coating TCM45A*
 ISSUES: 1. Coating without masking
 i-Tronik WORKSHOP 2015 in Venice, Italy
 - 2. Cycle-Time reduction seems so hard.
 - Currently Cycle-Time has been barely 30(sec/pca)
 - 3. Bubbles forming over the film has been Issue.
 - Solution : We made it in 12(sec/pca) at no masking by aids of "Impact Pulse-Spraying" technology which enables three guns dispensing in synchronized.



click here

*, VIDEO TTnS Film Coating TCM45A





• Case Coating with Bullet-Train IT control PCA,

★ VIDEO_TTnS Film Coating TCM45A FILM / FIN ISSUES : 1. Coating without masking EDGE, TILT i-Tronik WORKSHOP 2015 in Venice, Italy click here 2. Cycle-Time reduction possibly Currently Cycle-Time has been barely 60(sec/pca) Visual bubbles free and fine edge-definition Solution : We made it in 32(sec/pca) at no masking We made ± 0.25 mm fine edge film where the bubbles become controllable. Case Coating with LED Lighting PCA, ★ VIDEO TTnS I.P.S. Coating TCM45A LED COAT / ISSUES : 1. Coating without masking i-Tronik WORKSHOP 2015 in Venice, Italy click here 2. Electrical Insulation has to be OK against water droplets test. 3. Bubbles forming over the film has been Issue. Solution : We made electrically well insulated samples in 68(sec/pca) at no masking by aids of "Impact Pulse-Spraying" technology.

***** How are Conformal Coatings Applied Automated, Selective Coating / TCM45A WorkCell Δ ***TDS** Pulse-Action C.Coating Application ULSE / SPR/ C.COATING i-Tronik WORKSHOP 2015 in Venice, Italy click here V. TCM45A Self-diagnosis function detects the system faults and displays real-time on the screen. - Pre/After-Purge Fail_interlock - Gun Trigger Pressure Low_interlock E3A00 - Fluid Safety - Atomizing Air Pressure Low_interlock 2009-09-30 17:05:19] Trigger Pressure Dowr - Syringe Pressure Low_interlock - Accidental Door Open_interlock Error Clear Buzzer Off Detail - X-Y-Z Robot Overrunning_interlock ※ Gun-Trigger Pressure Beyond Range << BACK 1. Check the Primary Air-Pressure (Higher than 5.5Bar) 2. Check the Set-Value of Pressure Regulator for Gun-Trigger - 30° Tilting Outrange_interlock Check the Propriety of S-V of Pressure Switch for Gun-Trigger Click [Ignore] in Sensing Option in Parameter, if None is Incorrect - VOC Vent Fail interlock - Conveyor Jamming/Time-out_interlock Close ▲ Error Message Pop-up

- Fluid Level Low_interlock (option)

/ Troubleshooting

* How are Conformal Coatings Applied Automated, Selective Coating / TCM45A WorkCell



VI. TCM45A Underbody Platform is constructed with a single-body, Robust Welding Structure.



VII. TCM45A Coating WorkCell is equipped with,

A <u>Precision</u> and <u>Multipurpose Fluids Delivery Circuit</u>, as standard, for appropriate responding to various Coating Materials & Applications.

***** How are Conformal Coatings Applied Automated, Selective Coating / TCM45A WorkCell



VIII. Utility & Safety Requirements / VOC Vent

- Necessary to maintain a safe environment inside coating and
 - curing chambers LEL(Lowest Explosion Limit) : under 0.6% vol.
- Typical Coating WorkCell
 - 15-20(CMM) thru 6" Damper @1.0" WC
- Typical Convection Curing Oven
 - 4.0 (CMM) thru 5" Damper @0.5" WC

X Inline IR Oven is not recommendable for Conformal Coating Cure due to Bubble Issue

***TDS** TTnS, C-Coating WorkCell TCM45A

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click here

(CM45A plus TDS

click here

*TDS_ITINS, C-Coating WorkCell TCM45A⁺

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Feasibility study for The Coating PCA <u>STEP #1</u>

- Target Throughput (UPH)
- Information about Coating Sides & Dimension
- PCA edge handle-able dimension with <u>minimum</u> <u>3.5(mm) edge-clearance</u> opposite sides
- Specification for The Bubbles & Edge Definition
- Propriety of the Substrates Cleaning prior to Coating
- Selective, or Broadcast Coating
- Heating temperature limits once the curing specified

***** Design Considerations for C-Coatings



Feasibility study for The Coating Materials <u>STEP #2</u>

- Trying to <u>Protect</u> against <u>Mainly What</u>? / Solvents, Humidity & Dirt, Vibration, etc.
- Planning to use What Type of Curing?
 - / Convection-Cure, IR-Cure, Humidity-Cure, UV-Cure
- Propriety of the <u>Selected Coating Material</u>
- in view of environment & regulations.... - Granting <u>Priority</u> to <u>What</u>?
- / Coating Quality, Productivity, VOC-emissions, Others

***** Design Considerations for C-Coatings



Feasibility study for The System Appropriate <u>STEP #3</u>

- <u>Working Hours & Shift</u> per day over anticipated volume per year
- <u>Decision Batch or In-line</u> production based on roughly 100(units) per shift
- Space Available for the system set-up
- What Material will be used?
 - / This may dictate the curing requirement & type
- Primary Utilities Availability including ventilation

 \times Refer to the following. . . .

*TDS_Pre-Quote Questionnaire



----- • <u>click here</u>

*** Issues & Solutions in Conformal Coating** Acceptance / Rejection Criteria for CC Application



- Acceptance Criteria : <u>Ref.</u> / NASA-STD 8739.1A / IPC-HDBK-830
 - PCAs shall be properly cleaned and dried prior to coating.
 - Conformal Coating Film is <u>uniform in color</u>, <u>thickness</u>, <u>and texture</u>, <u>tack-free</u> and <u>shows proper adhesion</u> to all coated surfaces.
 - Conformal Coating Film covers all areas and has a smooth continuous surface which follows the contours of the PCA. Minor pull back from sharp points and edges is permissible, unless otherwise specified.
 - Conformal Coating Thickness shall be determined <u>using wet film thick</u> gauge, or other tool on flat surfaces of the PCA or on the conformal <u>coating specimens</u>. ***Equivalent Thickness as Alternative !!!**
 - Conformal Coating shall be Free from Contamination.
 - Conformal Coating Material may bridge between adjacent part leads providing stress reliefs are not negated.

* Issues & Solutions in Conformal Coating



Acceptance / Rejection Criteria for CC Application

Rejection Criteria :

- Conformal Coating Material used after shelf-life expiration
- The Bubbles or Bare-spots bridging two electrically conductive parts, And larger than <u>600~750</u>(um) in any dimension
 - %Ref. / IPC-HDBK-830 states
 - Bubbles are bigger than 50% of the Distance between Conductors and they expose to Conductor, Bridge of Lands or Adjacent Conductor Surfaces are Rejection.
- Conformal Coating Film exhibits pinholes, scratches, wrinkling, blistering
 & peeling, cracking and discoloration
- Conformal Coating Film exhibits excess runs, fish-eyes and/or de-wetting
- Conformal Coating, any signs of <u>Contamination</u> (Flux Residues, Loose Particles)
- Conformal Coating Material <u>bridges</u> stress relief areas thereby negating stress relief

*** Issues & Solutions in Conformal Coating** Acceptance / Rejection Criteria for CC Application



- Major Issues encountered in Conformal Coatings :
 - Coating Thickness : Critical, and has to be managed properly <u>XIf the film is too thin</u>, The Coverage becomes Poor, <u>Too thick</u>, the residual stresses on solder joints & specially glass-bodied components can be a problem. / cf. with ER, some UR •AR/DFT25~60(um), SR/DFT50~125(um), RR/DFT20~40(um) recommended
 - Coating Coverage : Points & Edge
 - ※Gravity, surface energy in liquid coatings prevent film build-up from sharp points and/or edges.
 ※Inadequately coated conductors can easily develop circuitry malfunctions. •Multi-Coat can be solution for such difficult-to-cover parts.
 - Bubbles : They normally originate from air trapped underneath components and at solder joints.



econdary Bubbl

***** Issues & Solutions in Conformal Coating **Bubbles Form in the Film**

How The Bubbles Form?

- Higher Viscosity of the Fluid : Disturbs bubbles burst-out
- **Dispensing Overlap**
 - : Physical reasons / unavoidable
- Radical, Heat Impact
 - : Insufficient flash-off time, prior to curing oven
- Substrate, Components' Pores and/or Recesses : entrapped air & moisture - Residual Bubbles in the Pressure Pot



AECU / Secondary-Bubbles Form

▲ AECU / Primary-Bubbles Form



* Issues & Solutions in Conformal Coating Bubbles Form in the Film

Remaining Bubbles as Time goes-by



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*** Issues & Solutions in Conformal Coating** Bubbles Form in the Film / Conclusive Summary



- Undiluted high viscous materials (∂>200Cps) for CC application is inadequate in terms of both productivity & bubble issue.
 No matter what flash intervals may be useless at very thick materials such (∂≥250Cps)
- Diluted possibly lower viscous materials (∂<100Cps) appear to be most ideal answer for CC application regardless input substrate.
 - CAS/#40 fluid system along with 200~100Cps 1B-31 LOC and substrate pre-baked at 85°Cx20(min) made fairly transparent bubbles-free film whereon most areas but but underneath tiny components
- In solvent based CC application, securing solvent flash-time appropriately appears to be more essential for bubbles-free, regardless material properties and/or dispense conditions.
 Depending on material, more or less 4~6(min) flash-time will be OK in most cases.
- What bubble forms in liquid coating is natural phenomenon inevitable and thicker material needs longer flash-time in bubbles burst process.
 Overall taken time to completely burst-out the bubbles is proportional to the viscosity of the applied coating material.

* Issues & Solutions in Conformal Coating Bubbles Form in the Film / Case Study



The Effect of the bubbles : ※Ref. / NASA-STD 8739.1A

- Bubbles bridge uncommon conductors, trapped moisture, contaminants may reduce insulation resistance or cause shorts and possible arcing.
 Drying & Curing schedule can also affect bubbles.
- Thicker Coating Applications, degassing in a vacuum chamber will remove entrapped air.



▲ MDPS / Mixed-Bubbles Form → Primary, → Secondary Bubbles

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• The Bubbles Categorization . . . Suggestion!!

(1) Super Micro-bubble; B ≤ Ø50, (2) Micro-bubble; Ø50 ≤ B ≤ Ø250
(3) Visual-bubble; Ø250 ≤ B ≤ Ø600, (4) Mega-bubble; B ≧ Ø600~750
※Mega-bubble observation to be estimated Reject

Terminologies of Long Term Reliability & Test

(1) Loss of Adhesion, (2) Film De-wetting, (3) Film Bubbles
 (4) Film Blistering, (5) Film Cracking, (6) Film Discoloration
 (7) Film Peeling, (8) Film Scratch, (9) Film Degradation

(10) Film Edge & Point Coverage, (11) Film DFT / WFT



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The Generation of whiskers in lead-free solders,

- Whiskers :
 - A pure, mono Sn-crystalloid
 - Start to generate, roughly 500hrs after soldering
 - and last until saturated, more or less 1,000hrs after
 - Number of whiskers
 - tend to be proportional to
 - the amount of moisture
 - and time exposed



▲ <u>NOTE</u>

Reported by D-company in Japan, Automotive PCA supplier



• Where the whiskers come?

Eventually caused by increased inner-stress of the metal, originate in the corrosion & volume expansion fact



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What's the solution?

- Entirely isolate the metal from the air by the appropriate, bubble-free & better adhesion of conformal coating film
- Suitable pre-cleaning is essential for better film adhesion

• Harmful-effects of Flux-residue over Whiskers?

- ※Simulation (a case study)
 - Test sample PCAs are pre-cleaned for 3(min) dipping in solvent,
 - then performed additional ultrasonic cleaning
 - Observe the generation of whiskers in each case of C-Coated PCA vs None

***Results**.... refer to the bar-graph on the following page
Substantially Big Difference in number of whiskers was confirmed
None c-coated PCA / Many whiskers with 104(um) tallest observed
C-coated PCA / No more than 5(pts) whiskers with 30(um) tallest observed



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*Conformal Coating Materials / Common use in Japan / with Film Application

MAT`L		PRODUCT	ACTUAL	MAT`L	MAKED	PRODUCT	ACTUAL		
Туре	WARER	NAME	DFT(µm)	Туре	WIAKER	NAME	DFT(µm)		
Acrylic Resin	Hitachi Kasei	TF1141	5~100		Seimi Chemical	STO311	10~15		
	Hitachi Kasei	TF1147	20~80	Fluorine	DAIKIN	MS171	10~20		
	Humiseal	1B66	5~80	Resili	ASAHI GLASS	EC400	20~30		
	Hitachi Kasei	TF1154	20~80	Rubber	NITTO SHINKO	LSS520	20~80		
Urethane Resin	Humiseal	1A27	20~100	Resin	Humiseal	1B51	20~40		
	ZEON	Quintone160	30~180	Vinvl	FUJI CHEMICAL	434-A	10~20		
	Sanei	SafetyCoat	10~20	Resin	Sunhayato	AY1000	10~20		
	Dow	페르간Z	50~220	Polvester	FUJI CHEMICAL	435-G	30~50		
	Dow	페르간D	15~60	Resin	SANWA	CP-1000	20~40		
	Dow	페르간C	5~20	Phenol Resin	Mitsubishi Gas	R505	10~40		
Silicon Resin	ShinEtsu	KR-114	20~60	Epoxy Resin	Ablestick	150-4	5~7		
	ShinEtsu	KE-3420(solventless)	60~100	Wax Resin	특수화학	SP-T-2	300~500		
	TORAY	SE9140	250						
	TORAY	DC-1-9420	50	If it runs car-inside, covered : DFT20-30(um), Sharp Edge \geq 2-4(um) If it runs near car-engine : DFT30-50(um), Sharp Edge \geq 3-5(um)					
	TORAY	AY42-351	20						

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* Issues & Solutions in Conformal Coating Bubbles Form in the Film / Case Study



Conclusive Summary of Issues & Solutions
 TOP5 Common Errors in PCB Conformal Coatings

*TDS_TOP5_Common Errors in PCB Conformal Coatings



(1) Dispensing <u>Pressure</u>, (2) Dispensing <u>Volume</u> Control at Real-time

*TDS_C. Coating Quality Control in Mass-Production >



click here

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TOP5 / MMON FRRC

click here

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.

Curing Considerations ECO99C / Bubble-free & Energy-saving





Curing Considerations ECO99C / Bubble-free & Energy-saving



- ECO99C / Electric-powered, Inline Convection Oven (PAT. 10-0550606)
 Provides,
 - <u>Bubble-free</u> transparent films <u>at no UPH sacrifice</u> and <u>minimal 50% of energy+space saving</u> thanks to patented, virtually extensive Flash-off time & Selective Curing Ideas - <u>Compatible with</u> Most solvent-base materials Curing, such for <u>a few minutes</u> thru <u>an hour</u> at below 100°C ~150°C/option - <u>Homogeneous</u> Temperature Profile controlled within ±3°C
 - ECO99C / Features & Benefits
 - I. Electric-powered, Inline Convection Curing Oven
 - Fully-automated, Selective Curing
 - Virtually eliminates Power Consumption & Available Space

Curing Considerations ECO99C / Bubble-free & Energy-saving



- 220(VAC)x3(Ø)x60(Hz)x10(Kwh) *Ampere Peak/Idle 30(Amp)/16(Amp)
- II. Magazine-basis Curing secures Extensive Flash-time, and it leads to Bubble-free
 - Accomplished bubble-free transparent Films
- III. Better Working Conditions provides User, Environment Friendly
 - Easy Operation & Maintenance
 - <u>Compact Design</u> for <u>Lower</u>-investments & Running-cost
 - High Performance of the system with Self-Diagnosis
- IV. Free Knocked-down Structure with

advanced Insulation-Panel

V. Safety Interlocks of the System



▲Insu-Panel Comparison



*** Curing Considerations** Typical process with TTnS curing solution





Curing Considerations ECO99C / curing oven, Typical Temp. Profile



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* Programming / Justification Guidelines Easy Coating Manager / WIN7



- ECM v2.0_WIN7 / EasyCoating Manager / TTnS exclusive
 - Graphical interface / JPEG file importing for programming
 - DWG file interface(option)
 - Internationalized software
 - Zoom In & Out
 - Position Detect
 - Capability of performing Various Coating Patterns,
 - LINE coating menu
 - AREA coating (beyond-area coat) menu
 - <u>INTERMITTENT</u> coating (mid on/off coat) menu
 - <u>SPOT</u> coating menu
 - <u>TILT</u> coating menu (all sides by 30°)
 - <u>PULSE</u>-Spray coating menu <u>*TPC999</u>, 1/1000 sec scale controlled

* Programming / Justification Guidelines Easy Coating Manager / ECM_WIN7



ECM_WIN7 Graphics Display





- What are my current material costs?
 - Coating materials
 - Solvent
- What are my current masking costs?
 - Materials (masking tape, Boots, etc.)
- What is the current time to complete masking & de-masking for all products?
- What are my current utility costs for conformal coating?
 - Ventilation
 - Electricity
 - Compressed Air, etc.
- What are my current rework costs?

* Programming / Justification Guidelines Questionnaires?



- Do I have VOC issue in the facilities?
 - Coating VOC contents
 - Solvent VOC contents
- What are my inspection costs?
 - Rework associated with inspection
 - 100% inspection necessary

Thank you so much for the time with us !!

* Typical Systems Layout. . . . Appendix WHAT DO WE OFFER?



A Total Systems Solution

- Selective Coating Module / TCM45A, TCM45A plus, TMCM16A
 - /NCAF(film), NCAS(spiral), D752V(dispenser) Applicators
- Material Handling Modules
- / Loader, Exclusive_Unloader, Inverter & TR-Conveyor
- Selective Convection Curing Module / ECO99C, ECO150C UV Curing Module
- SMEMA Interface Spec.1.2 Compatible
- A Configurable Systems Solution
 - Mix and Match of the Modules to meet various requirements of the Applications

*** Typical Systems Layout. . . . Appendix** Fully Automated C-Coating with Single WorkCell



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