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Coating Innovations for Electronics

Coatings and potting compounds for LED applications – capabilities, limitations and trouble shooting

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Content

- Some theory on conformal coatings and potting compounds
- Conformal coatings for lighting applications – determining and evaluating the right material
- Applying potting compounds and conformal coatings, avoidance of typical mistakes
- Ultra-white and thermally stable solder masks: How to determine the most suitable material when it comes to thermal cycling stress and avoidance of discolouration
- Screen defined thermally conductive heatsink and interface pastes applied on PCB manufacturing level

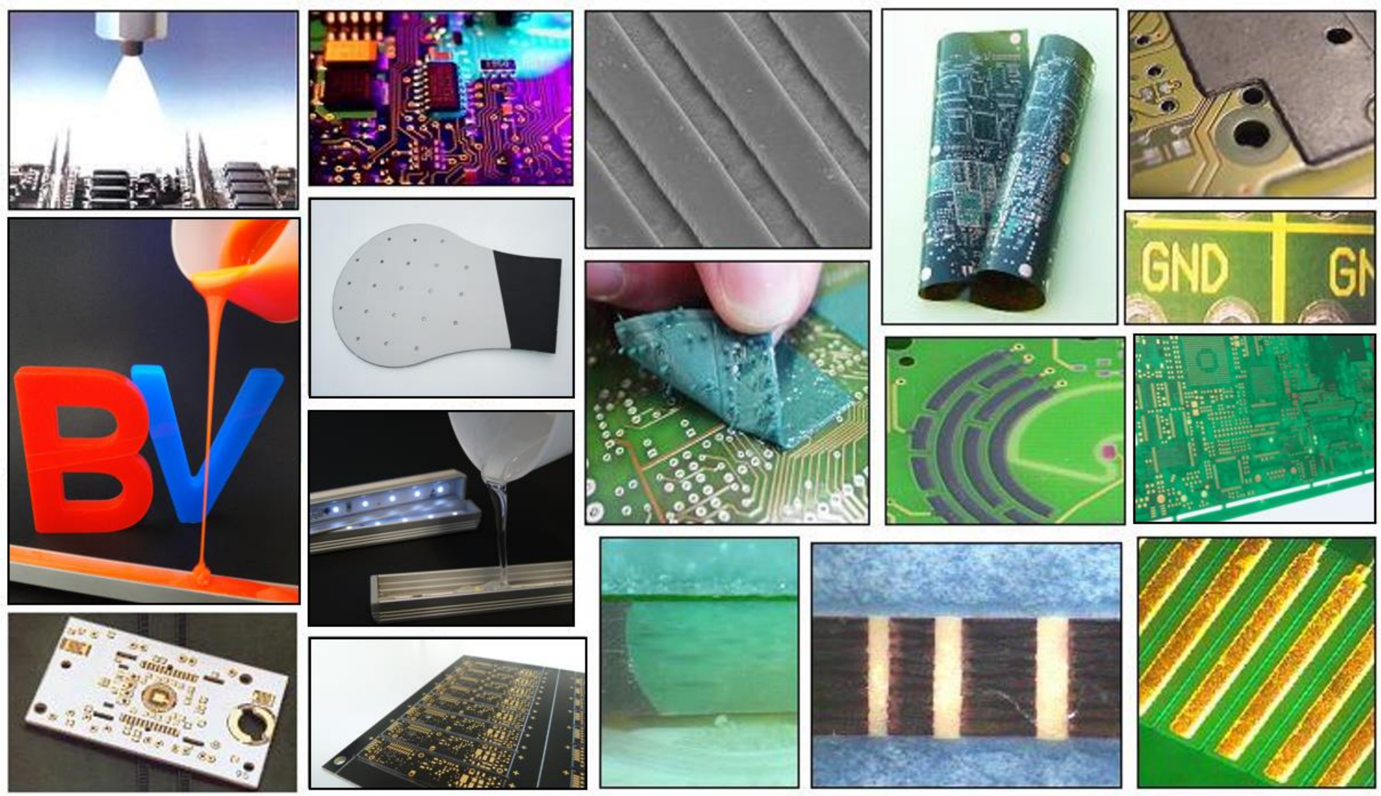
Portfolio

ELPECAST® peters

ELPEPCB® peters

ELPESPEC® peters

ELPEGUARD® peters



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Application technology laboratories and climate testing

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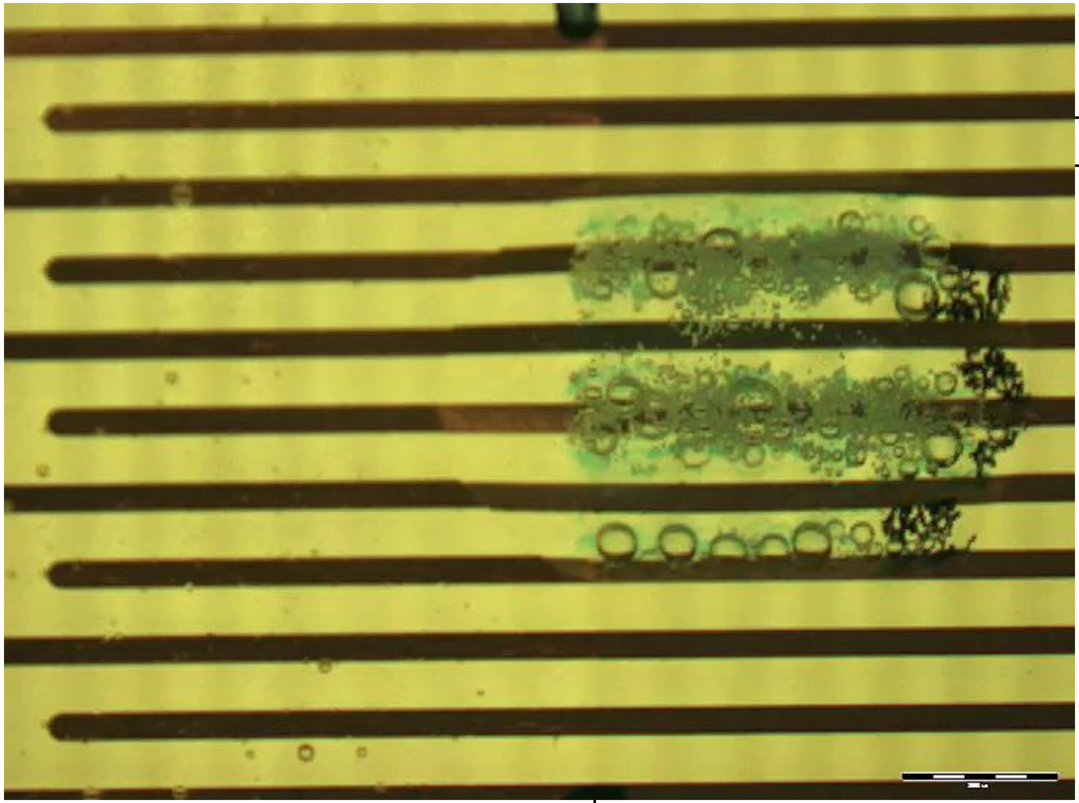
Definitions - Why use conformal coatings or potting compounds?

video-clip in real-time

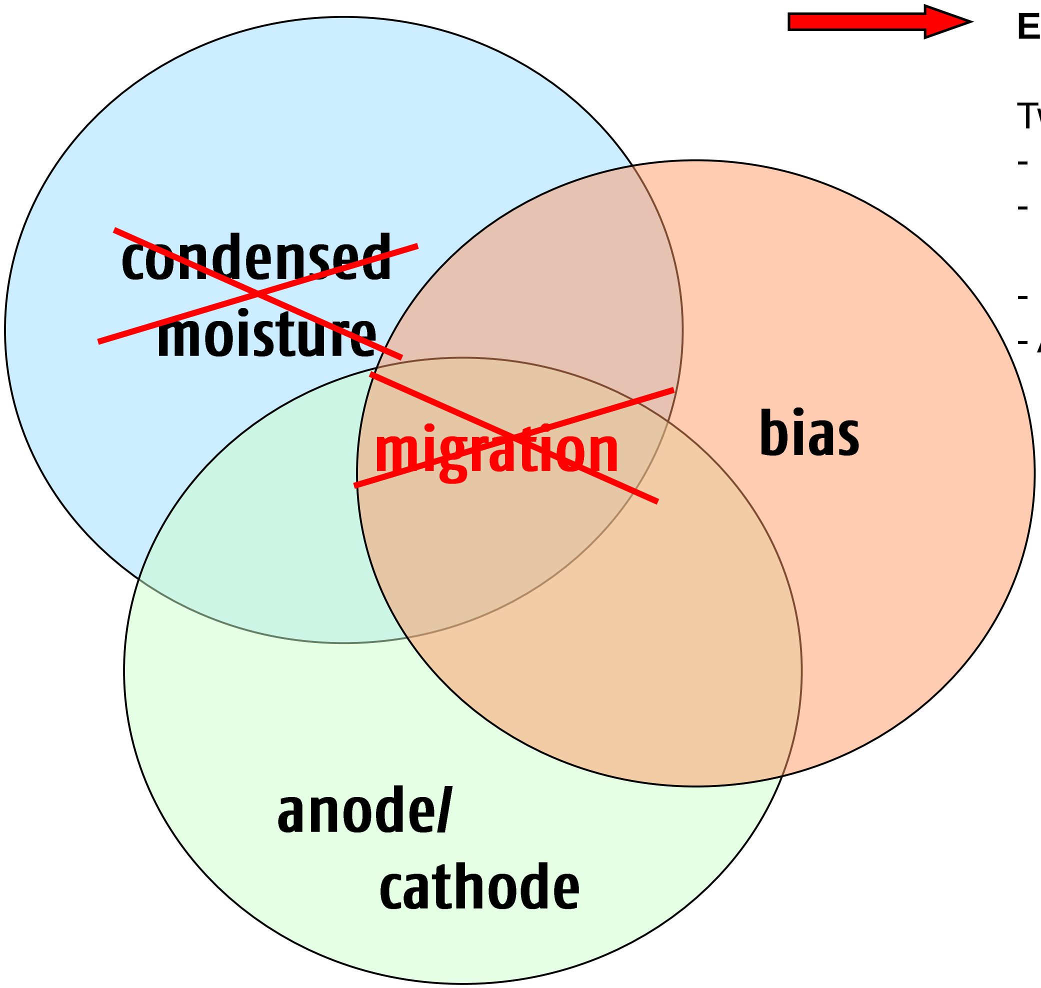


approx. 500 µm

5V

coated | uncoated

Definitions - Why use conformal coatings or potting compounds?



Electrochemical corrosion

Two basic conditions are required:
- Electron delivering metals (corrosive metal)
- Electron accepting metals / nonmetals (electronacceptor)
- Presence of an electrolyte (moisture, water)
- A difference in potential

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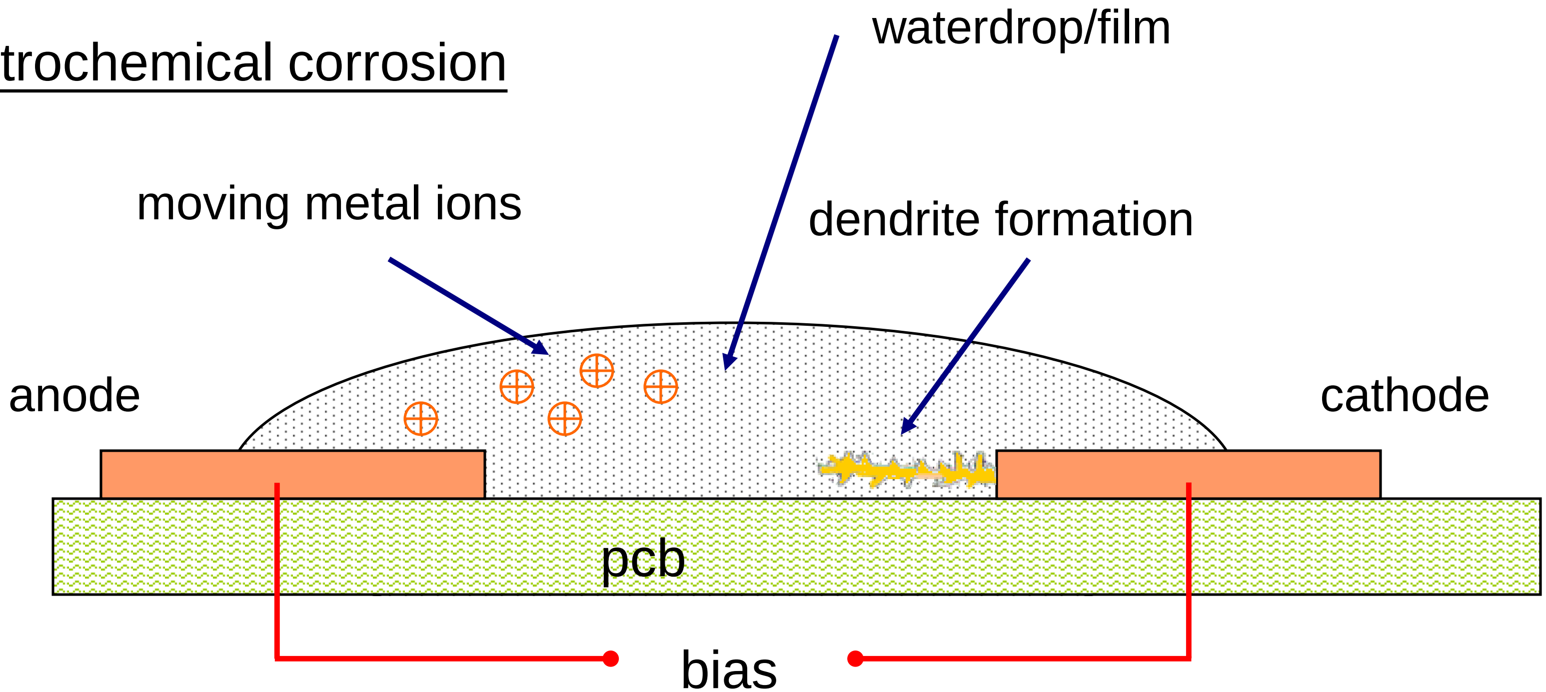
Definitions - Why use conformal coatings or potting compounds?

Electrochemical corrosion



anode: $Me \rightarrow Me^{n+}\ n\ e^-$

$2\ H_2O \rightarrow O_2 + 4\ H^+ + 4\ e^-$

cathode: $Me^{n+} + n\ e^- \rightarrow Me\downarrow$

$2\ H_2O + O_2 + 4\ e^- \rightarrow +\ 4\ OH^-$

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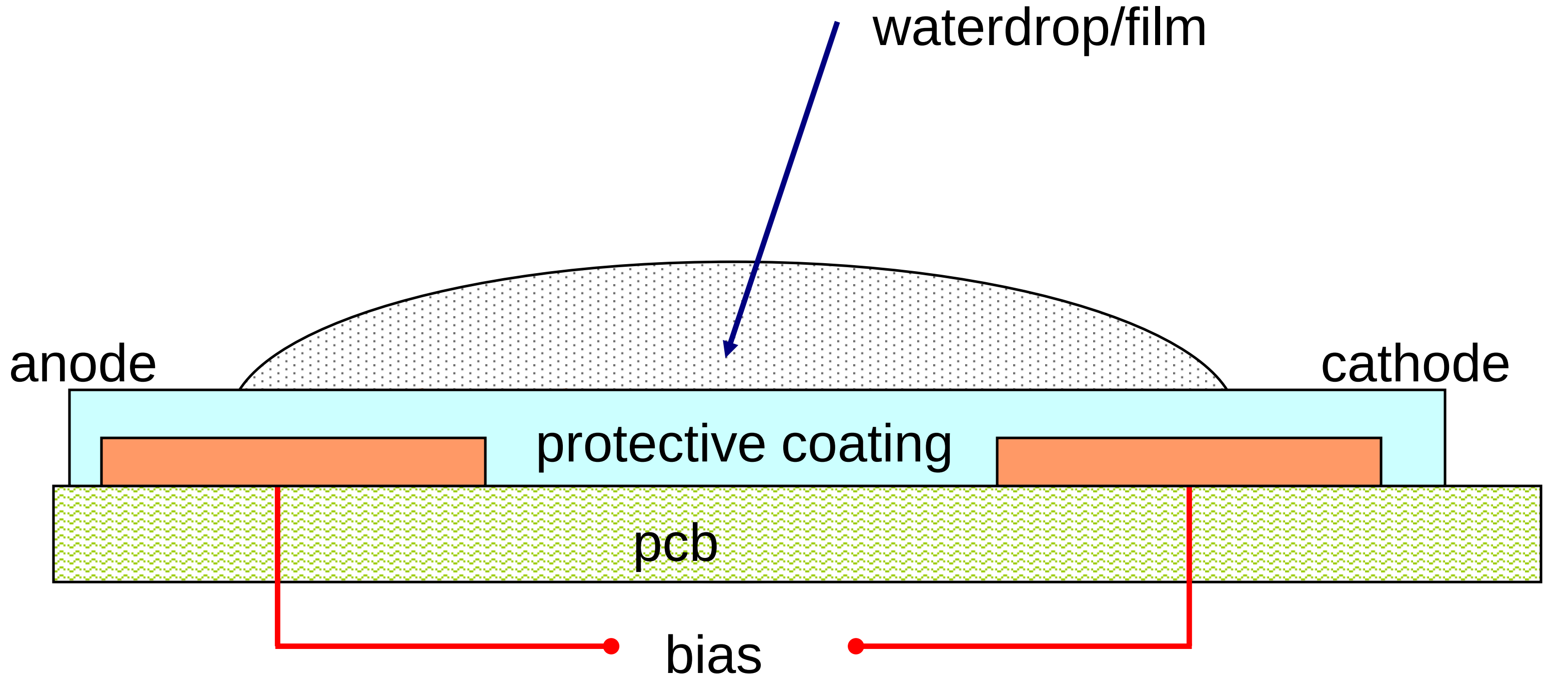
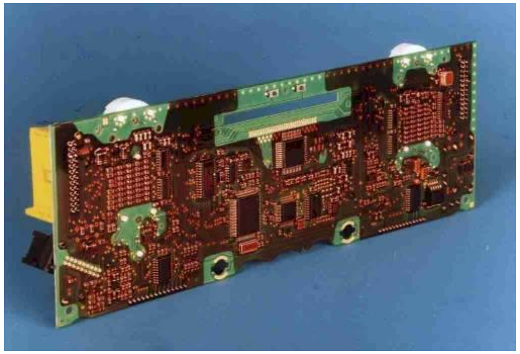
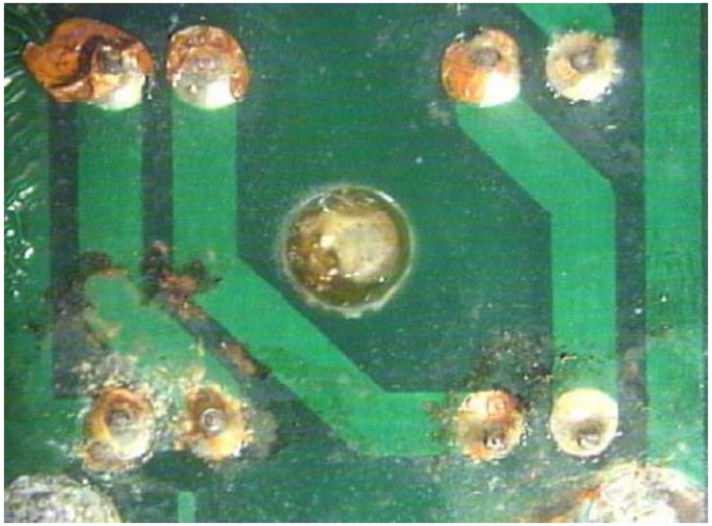
Definitions - Why use conformal coatings or potting compounds?



Definitions - Why use conformal coatings or potting compounds?

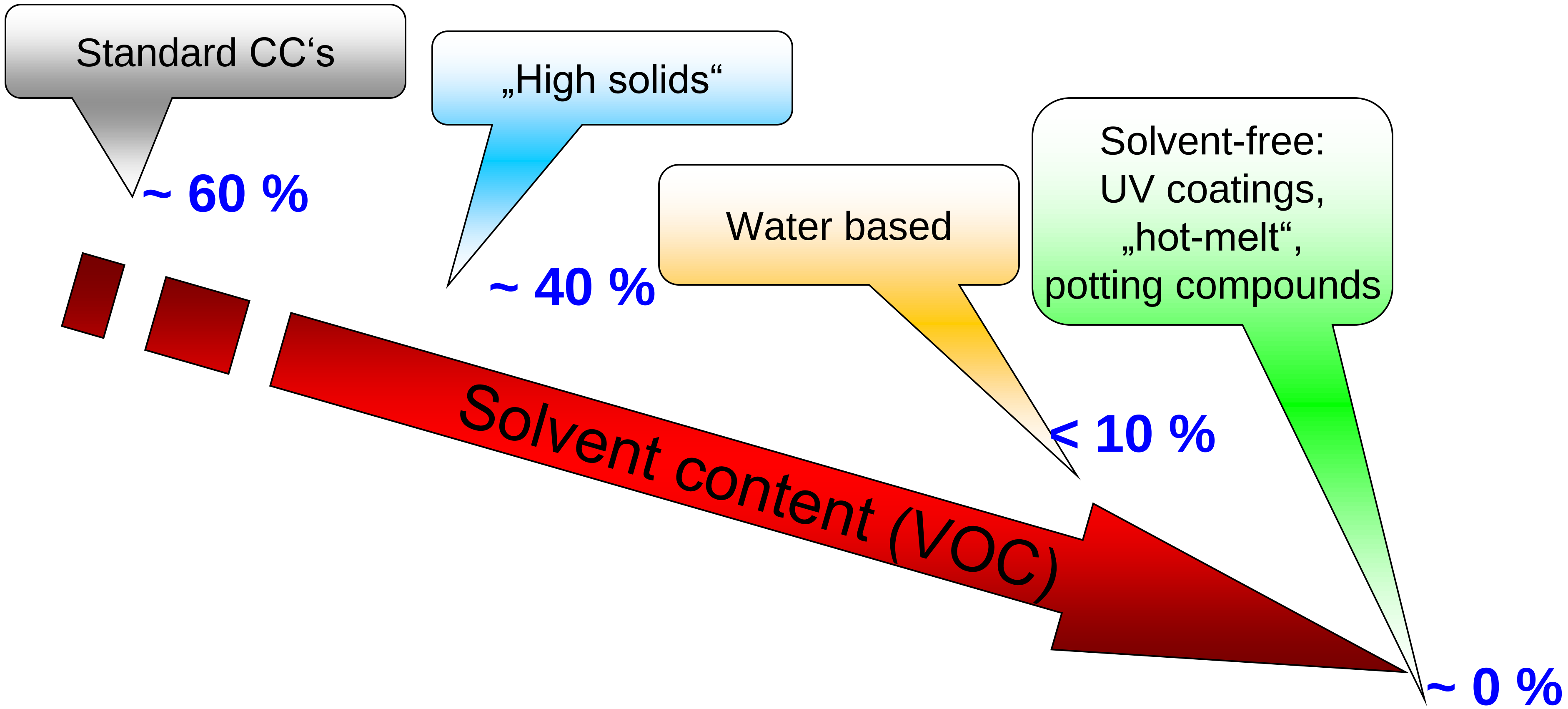




- Typically 50 - 100 µm (300 µm) vs. virtually unlimited thicknesses
- Primarily humidity protection vs. „heavy duty“ protection (e.g. under water)
- Typically 1-pack system vs. 2-pack system

→ Basically the application determines the choice!

Types of conformal coatings – solids content



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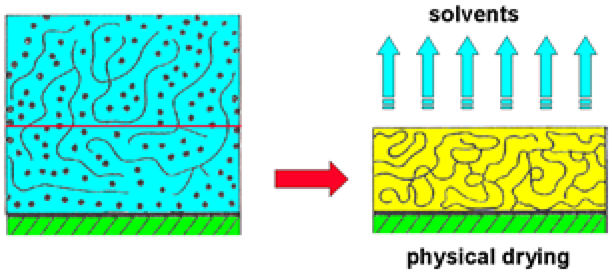
Types of conformal coatings – curing mechanism

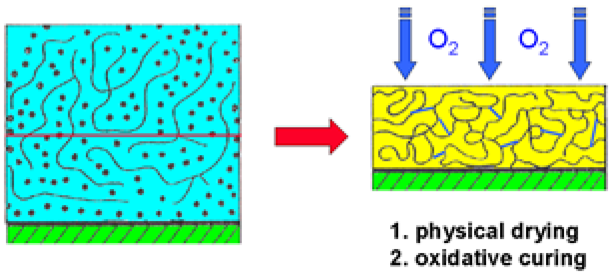
Film formation of physical drying coatings

ELPEGUARD® SL 1307/2 FLZ series



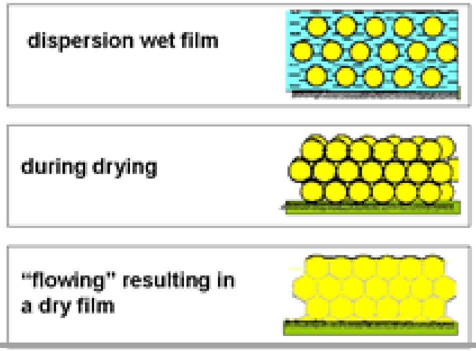
Film formation of oxidative curing coatings

ELPEGUARD® SL 1301 ECO-(BA)-FLZ series

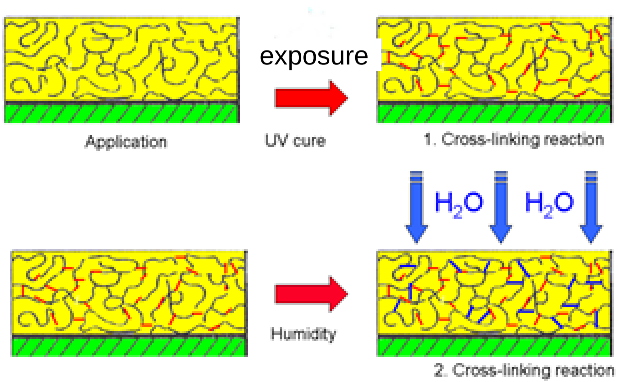


Stages of film formation polymer dispersions

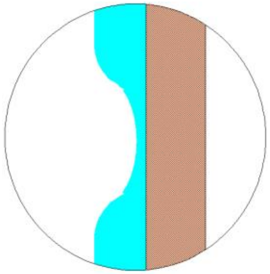
ELPEGUARD® SL 1305 AQ-ECO series



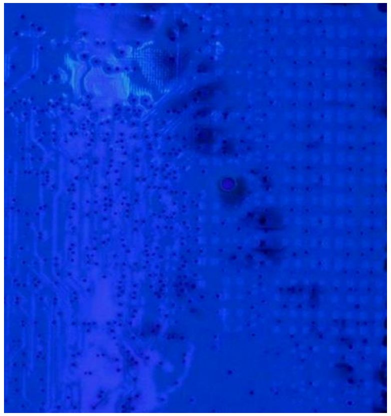
Film formation of Twin-Cure®



Surface tension and „dewettings“



„crater“
(particals)

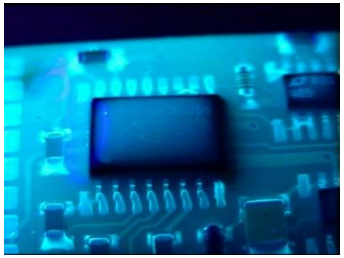
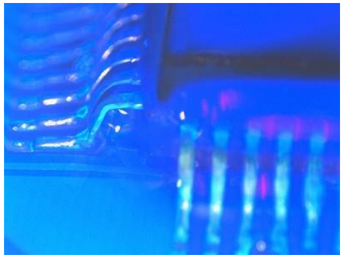
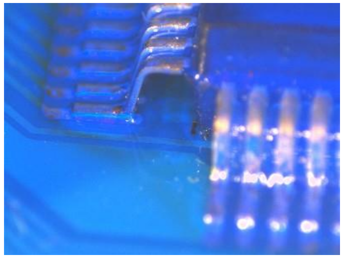


- „Dewettings“ are a surface energy / surface tension phenomenon
- Potential contaminants can be numerous; silicones, grease, fat etc., source is sometimes difficult to determine
- Substrate surface tension should be > 30 mN/m to allow proper wetting, „higher is generally better“
- Remedy for contaminated assemblies can be rinsing (organic solvents), UV-bump, tempering, plasma

Is thicker better?

Thick film coatings ⟷ Thin film coatings

Type of coating	*Thickness (dry)*
Acrylic resin based (AR) **Polyurethan resin based (UR)** **Epoxy resin based (ER)**	25 – 75 µm (IPC-CC-830) 30 – 130 µm (IPC 2221/J-STD-001)
Silicone resin based (SR)	50 – 200 µm (IPC-CC-830) 50 – 210 µm (IPC 2221/J-STD-001)
Paraxylylene coating (XY)	12,5 – 50 µm (IPC-CC-830) 10 – 50 µm (IPC 2221/J-STD-001)

- Typically thicknesses of **thin film** coatings are in the in the range of 20 - 50 µm, maximum around 100 µm
- Typically thicknesses of **thick film** coatings are in the in the range of <1 mm („micro-encapsulation“)
- Whether a coating can be used for thin or thick film applications is determined by solids content, viscosity and cure
- **Where should the thickness be measured? Where do indications usually refer to?**

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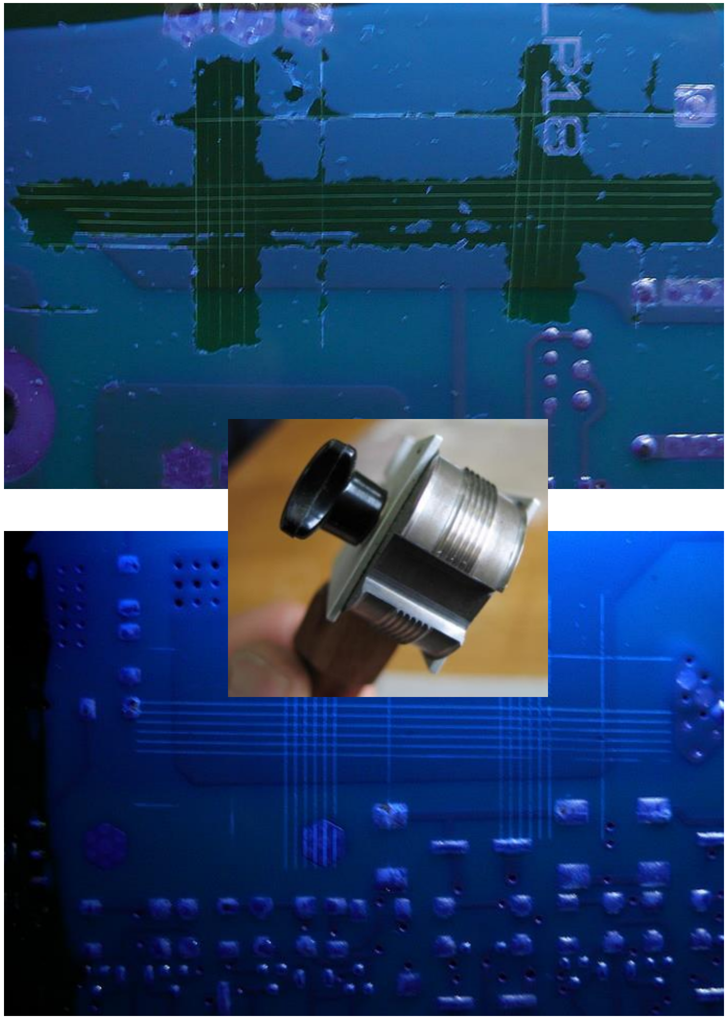
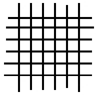
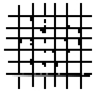
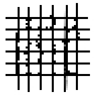
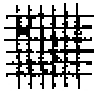
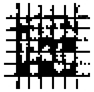
Adhesion



Cross-cut characteristic value	Description	Example of surface
Gt 0	The edges of the cuts are completely smooth, none of the squares of the lattice is detached	
Gt 1	At the intersections of the grid lines small fragments of the coating chipped off; chipped off surface about 5 % of the sections	
Gt 2	The coating chipped off along the edges of cut and/or at the intersections of the grid lines; chipped off surface about 15 % of the sections	
Gt 3	The coating is chipped off along the edges of cut partly or in broad strips and/or the coating of individual sections is totally or partly chipped off; chipped off surface about 35 % of the sections	
Gt 4	The coating is chipped off along the edges of cut in broad strips and/or the coating of individual sections is totally or partly chipped off; chipped off surface about 65 % of the sections.	
Gt 5	Chipped off surface > 65 % of the sections	—

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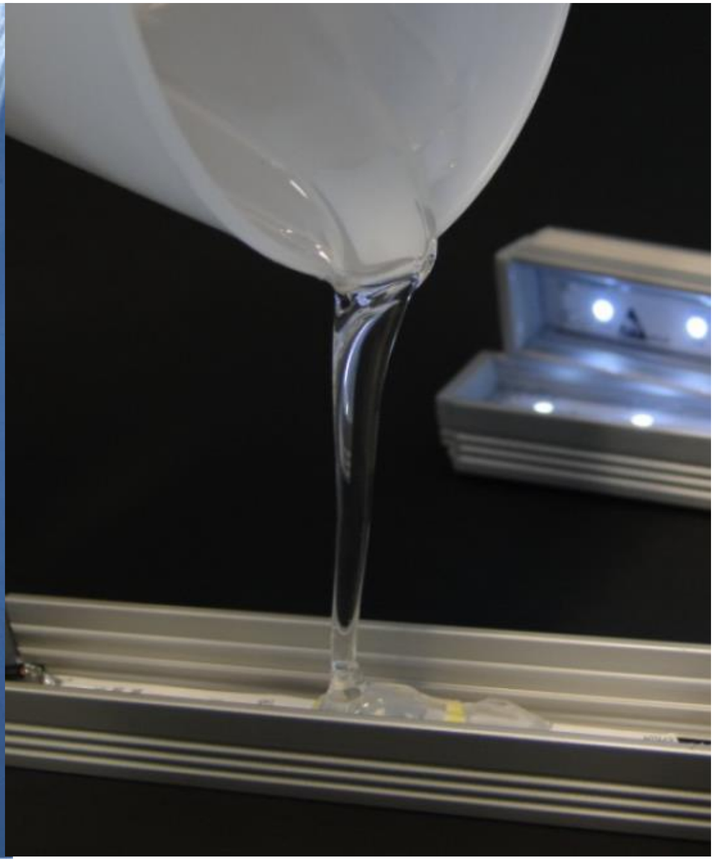
Cure of UV-curing coatings

„Cauliflower effect“

- Occurs when UV coating with secondary moisture cure has been insufficiently cured
- 3D UV crosslinking is not sufficient, reaction of moisture with isocyanate, CO_2 generated, forming greater bubbles

⇨ Complete UV reaction necessary, CO_2 cannot accumulate to larger bubbles



Working with „crystal clear“ / transparent potting compounds

			
Moisture on substrate	Ratio A : B wrong	Not evacuated	Optimum processing
30 min @ 60°C tempering	Check ratio A : B	30 mbar vacuum after mixing	

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Working with „crystal clear“ / transparent potting compounds

Climatic tests

Dewing test
(„condensation water test“)

- 72 h 40°C / 100 % RH
- 350 mA / 8,1 V

85/85 test
„climate test“

- 1 d 35 °C / 90 % RH
- 3 d 65 °C / 90 % RH
- 3 d 85 °C / 85 % RH
- 1 d 25 °C / 50 & RH
- 350 mA / 8,1 V

Thermal shock test

- 30 min cycle
- 30 min change over
- 252 cycles
- -40 / +85 °C
- 350 mA / 8,1 V

Suitability for specific applications

Selection chart

Application \ **Product name**	Conformal coating **Acrylic type**	Thick film coating **Acrylate moisture + UV**	Thick film coating **Silicone type 1**	Thick film coating **Silicone type 2**	Thick film coating **Silicone type moisture + UV**	Casting compound **PUR type transparent**	Casting compound **Silicone type transparent**
Coating of LEDs, e.g. in display panels	very good	very good	very good	very good	very good	very good	very good
Coating of high power LEDs	good	good	good	good	good	not suited	very good
Use under high humidity and high temperatures	good	good	very good	very good	good	moderate	very good
Outdoor use	moderate	good	good	good	good	very good	very good
Use under condensation	very good	very good	very good	very good	very good	very good	very good
Underwater use	not suited	not suited	moderate	moderate	moderate	very good	very good
Flame class UL 94	V-0 (very good)	V-0 (very good)	V-1 (good)	not suited	V-1 (good)	HB (very good)	not suited
Temperature and yellowing resistance under thermal load	very good	moderate	very good	very good	good	good	very good

very good (very well suited)	good (well suited)	moderate (moderately suited)	not suited

Economic efficiency evaluation

Feature	Conformal coating **Acrylic type**	Thick film coating **Acrylate moisture + UV**	Thick film coating **Silicone type 1**	Thick film coating **Silicone type 2**	Thick film coating **Silicone type moisture + UV**	Casting compound **PUR type transparent**	Casting compound **Silicone type transparent**
Processing method	Automatic selective coating unit					2-K mixing and dosing equipment or evacuation necessary	
Typical layer thickness on LED	20-50 µm	100-200 µm				2-3 mm, theoretically unlimited	
Material consumption kg/m²							
Relative cost per m²	1	3	4	5	10	43	74
VOC content							
Process time when curing	1-2 h at RT	UV and moisture curing	15 min at 110°C [230 °F]	45 min at RT (50% RH)	UV and Humidity curing	24 h at RT	24 h at RT

Very economical	economical	less economical

Comparison theoretical consumption

Consumption of **acrylic type conformal coating** per m^2 (dry layer thickness approx. 50 µm, equivalent to a wet layer thickness of approx. 200 µm):

$0{,}02\ cm * 10000\ cm^2 = 200\ cm^3$

$\rho = 1.00\ g/cm^3$

$1.00\ g/m^3 * 200\ cm^3 =$ **200 g**

Consumption of **acrylate thick film coating UV + moisture cure** per m^2 (dry layer thickness approx. 200 µm):

$0.02\ cm * 10000\ cm^2 = 200\ cm^3$

$\rho = 1.06\ g/cm^3$

$1.06\ g/m^3 * 200\ cm^3 =$ **212 g**

Consumption of **casting compound PUR type transparent** per m^2 (layer thickness of approx. 5 mm):

$0.5\ cm * 10000\ cm^2 = 5000\ cm^3$

$\rho = 1.09\ g/cm^3$

$1.09\ g/m^3 * 5000\ cm^3 =$ **5450 g**

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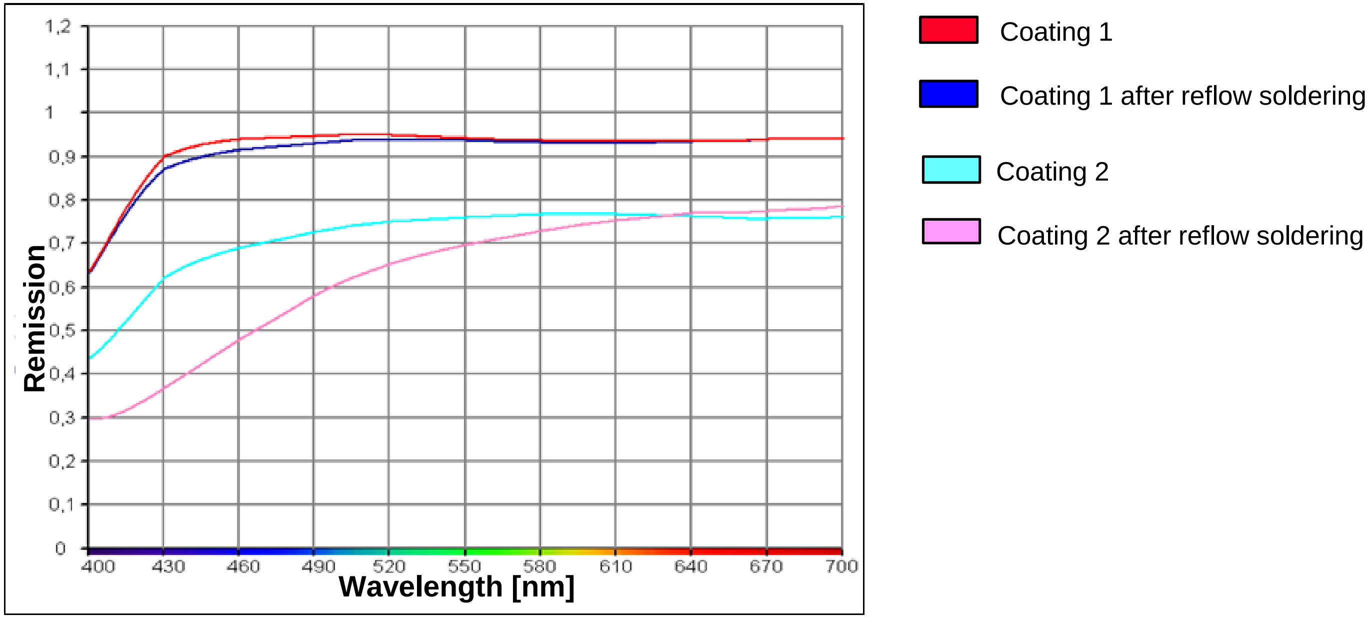
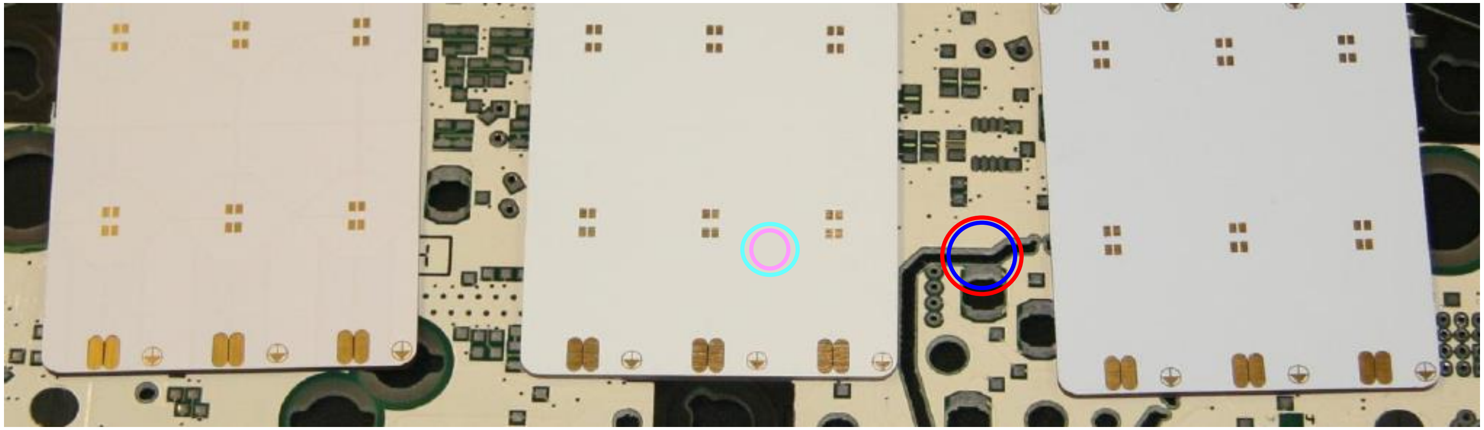
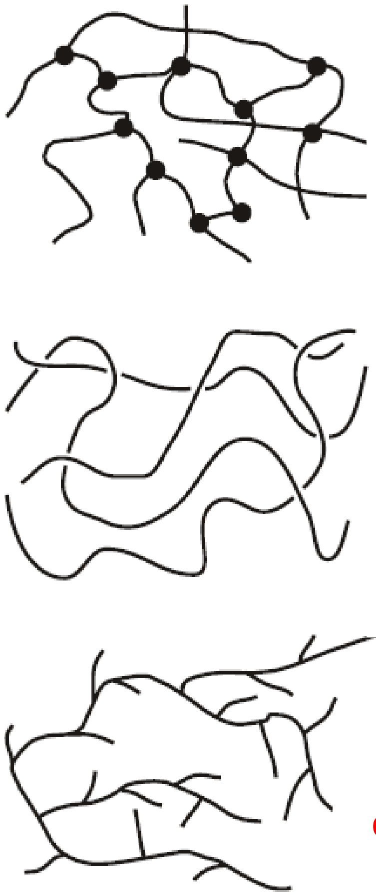
„Ultra-white“ thermally stable coatings

Thermal stress - discolouration





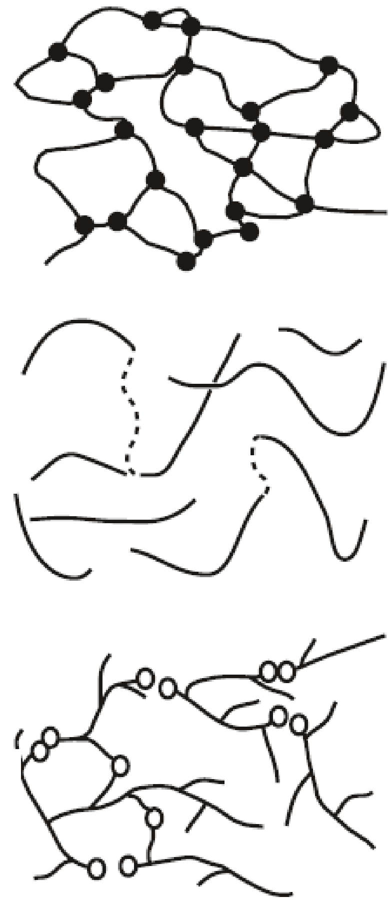
Ageing process of polymers



Thermally induced continuing cross-linking of thermoset polymers

Thermally induced decomposition

Oxidation activated by oxygen, hydrolysis caused by moisture and heat



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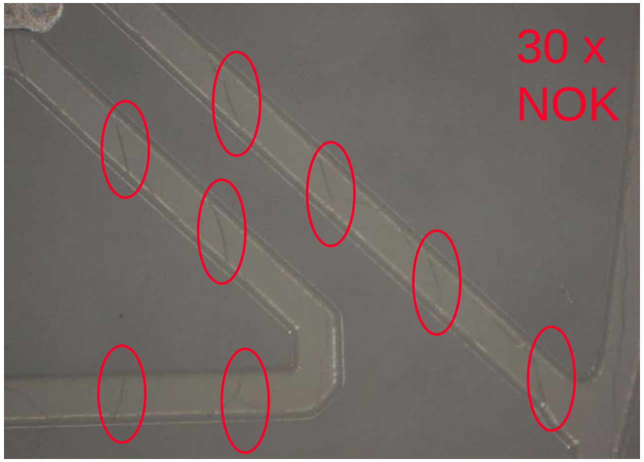
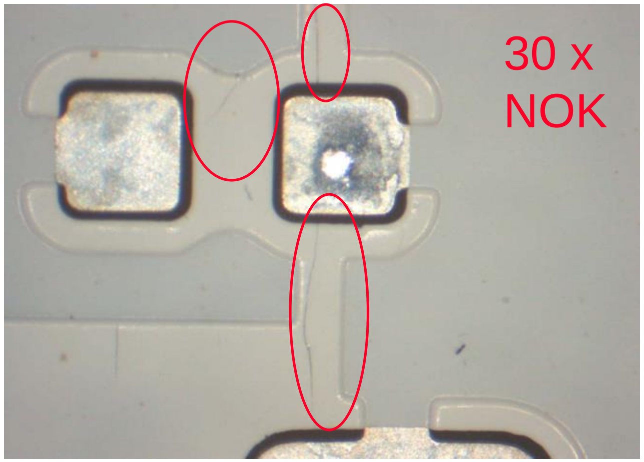
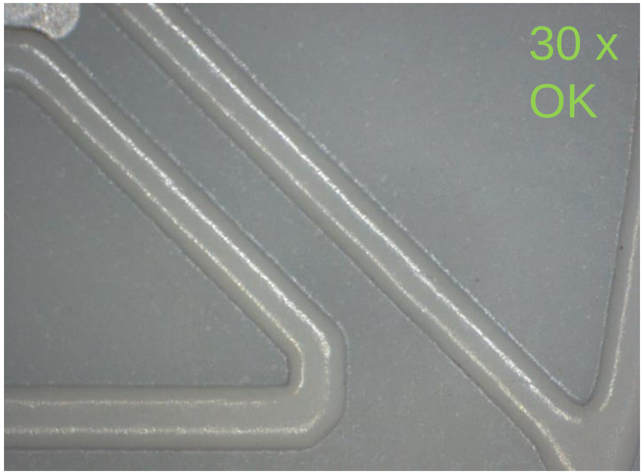
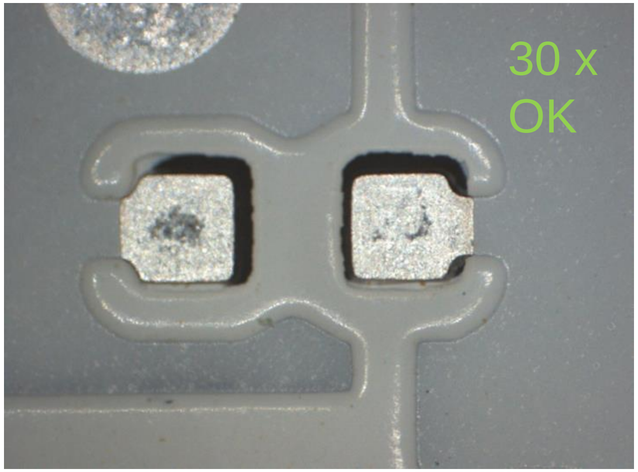
Thermo mechanical fatique



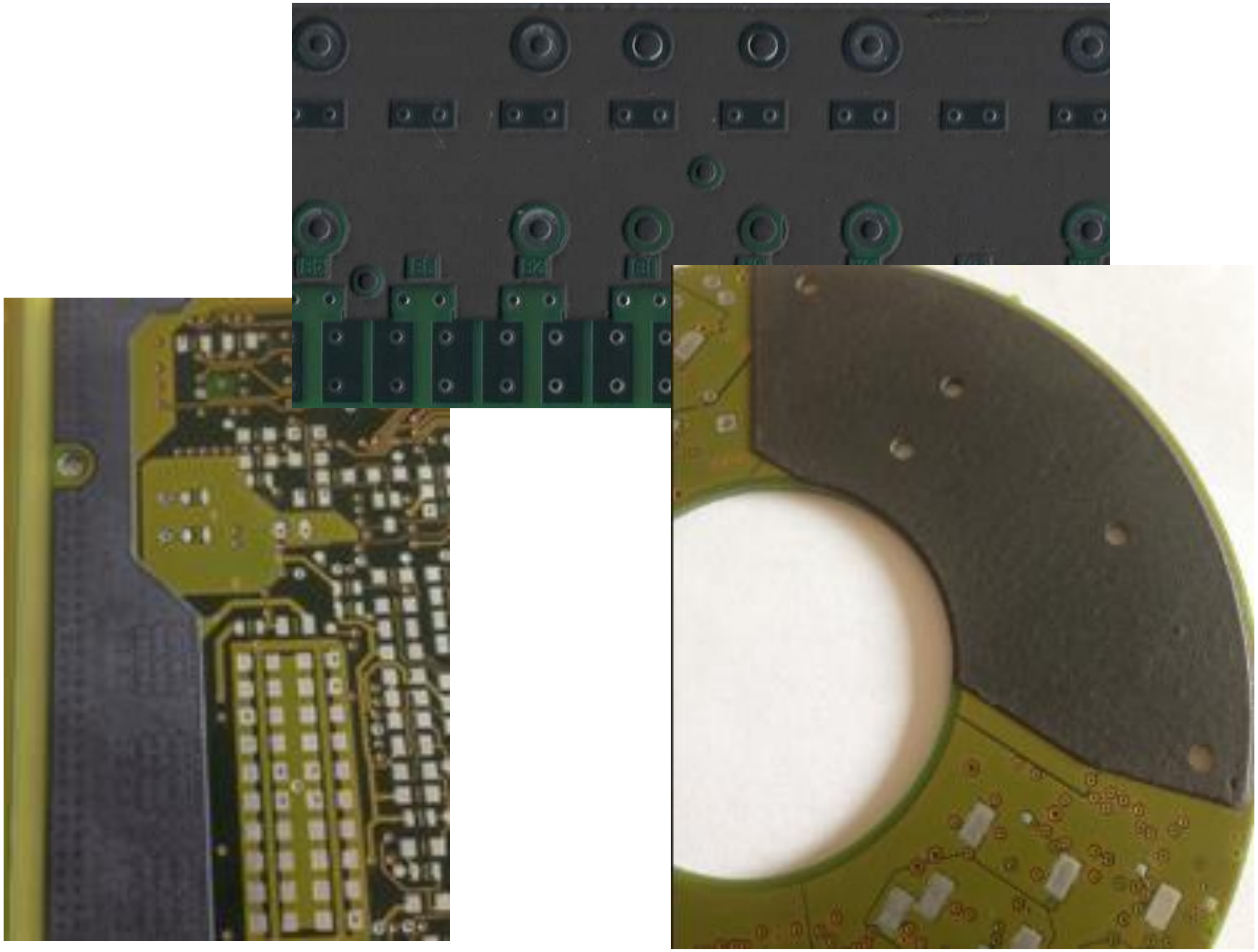






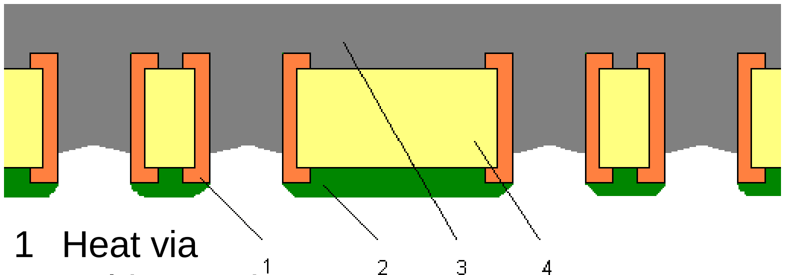
<u>HN 67036 (TK C2)</u>

- Finish IMT / HAL
- Conditioning 3 x Reflow
- 500 cycles -40 / +125°C
- Assessment 10 – 30 x

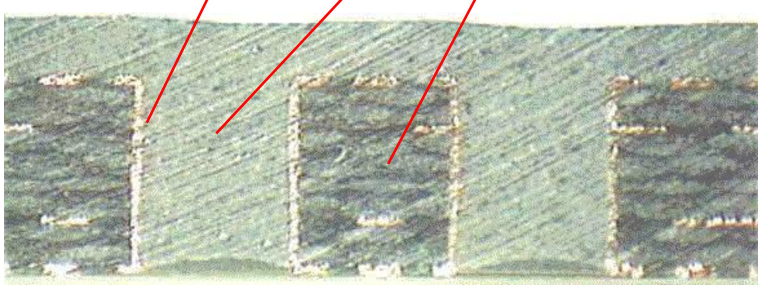


PCBs with heatsink paste technology (HSP)

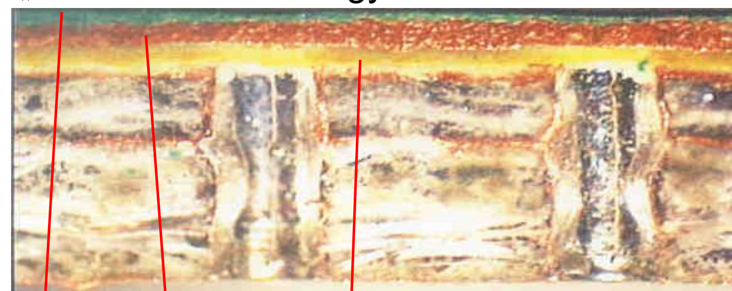
HSP technology



1 Heat via
2 Solder mask
3 HSP
4 PCB core

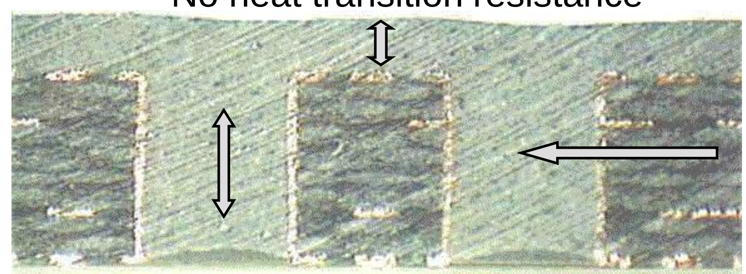


„Classical“ technology



Solder mask Cu-heatsink adhesive

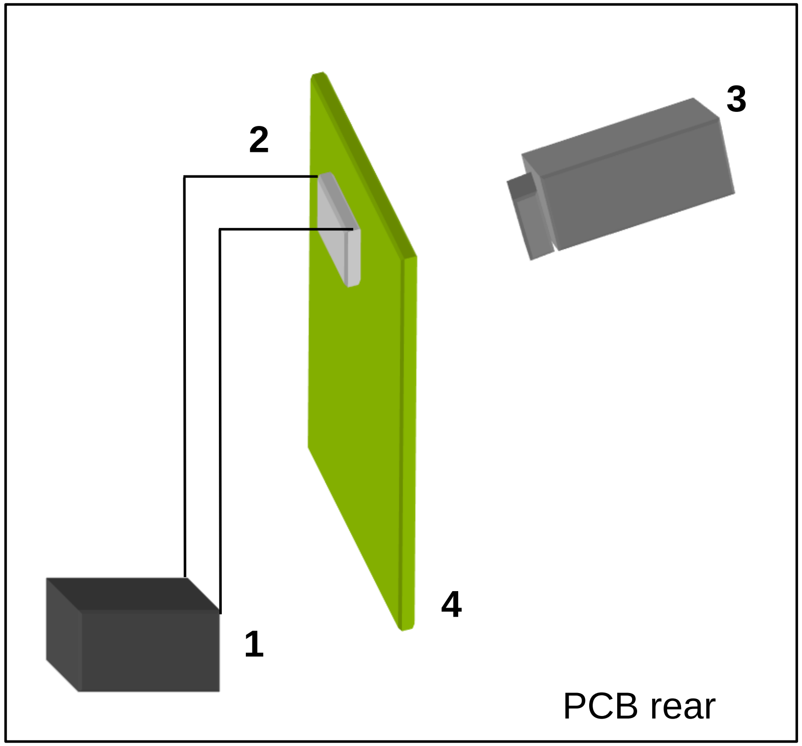
No heat transition resistance

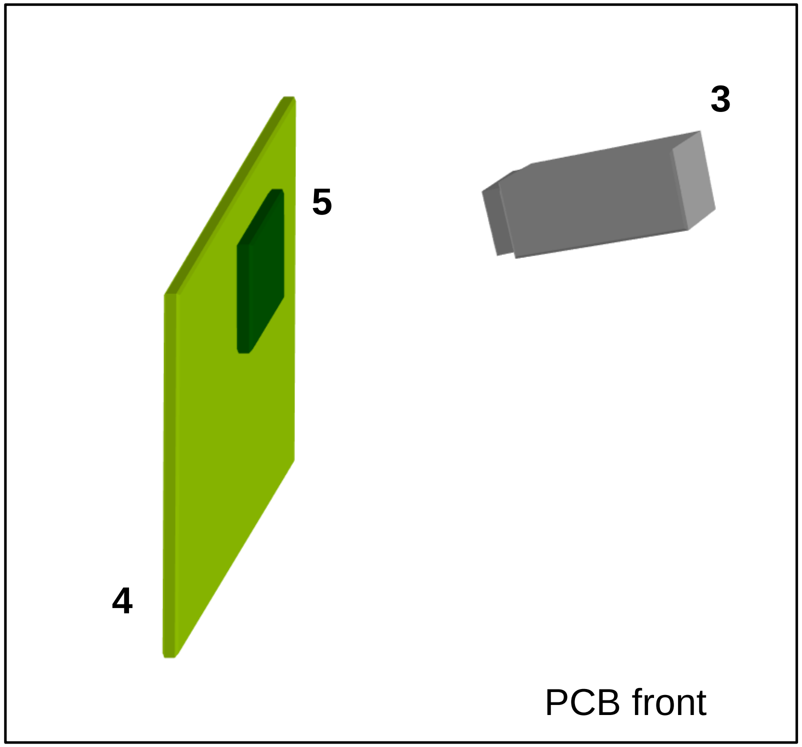


Heat via completely plugged

No air inclusions

Thermography: Experiement set-up





1 Voltage source **3** IR-camera **5** Heatsink
2 Resistor (70°C) **4** PCB

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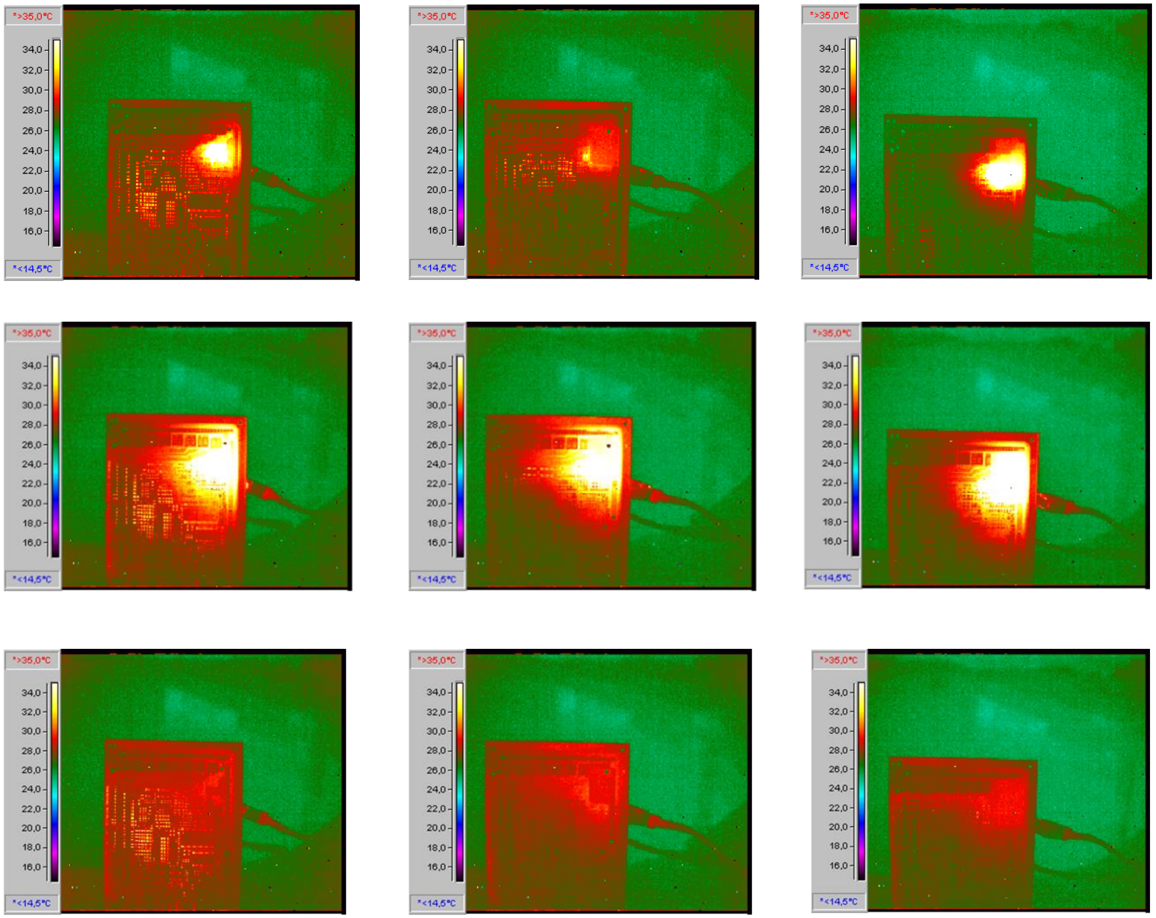
Thermography – comparative measurements

PCB without heatsink | PCB with Cu-heatsink | PCB with HSP 2741



- **Heat-up phase**

  Measurement PCB surface after 1 min thermal load

- **Heating phase**

  Measurement PCB surface after 4 min thermal load

- **Cool down phase**

  Measurement PCB surface after 4 min heating and subsequent 4 min cooling down

PCBs with Thermal interface paste technology (TIP)

infineon

4.3 Thermal management of PCB by means of HSP (Heat Sink Paste) and TIP (Thermal Interface Paste)

The need to dissipate the heat generated from the component can be satisfied in different ways. For those applications where the amount of heat does not require a mechanical heat sink (with its additional costs and space requirements), but the FR4 substrate is not sufficiently dissipative in itself, the application of a specific thermo-dissipative paste is a viable solution. The dissipative paste distributes and transfers the heat to the surrounding environment. The paste is applied by screen printing during the construction of the bare PCB, and will partially fill the thermal vias, thus improving their performances.

Thermo-dissipative paste is also resistant to reflow and wave soldering, allowing a considerable time and cost saving for the assembly process when compared to thermo-dissipative preformed interface solutions applied after soldering.

As well as its thermal properties (thermal conductivity equal to 2 W / m* K) the paste also has good electrical insulation (30 kV / mm) properties

Figure 22 Daughter PCB with heat sink paste (pcb made in Italy by Serigroup Srl www.serigroup.it)

For applications where the amount of heat requires a mechanical heat sink, the thermal coupling can be improved by the use of a thermal interface paste as shown in Figure 23.

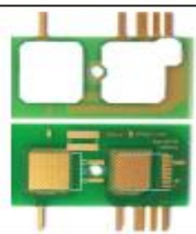
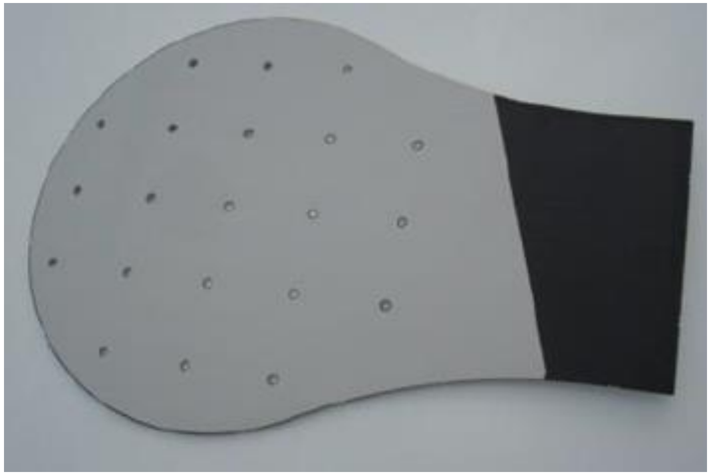


Figure 23 Daugther PCB with thermal interface paste (pcb made in Italy by Serigroup Srl www.serigroup.it)

The conductive thermal interface paste is electrically insulating and reflow / wave soldering resistant.



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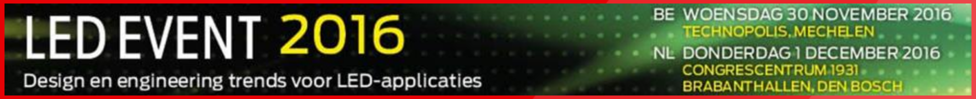
for Electronics



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