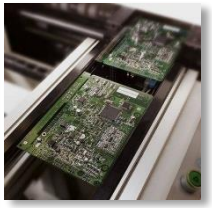
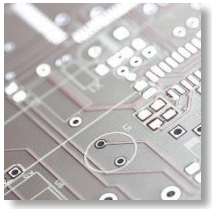
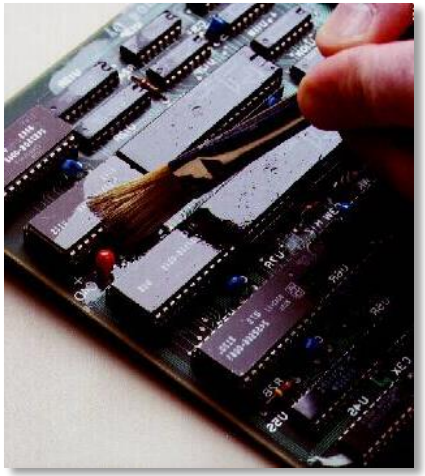
Introduction: Circuit Board Protection Materials: Conformal Coating

Hilde Goossens







Agenda

1. What is a conformal coating
2. Industry trends
3. Coating material options
4. Processing conformal coatings
    a. Cleaning
    b. Masking
    c. Application techniques
    d. Curing/drying of Conformal Coatings
    e. Reworking
5. Henkel Conformal Coating Product Line

What is a conformal coating?

- A thin transparent polymeric coating applied to PCB's to provide protection from the end-use environment

- Common Functions
  - Inhibit current leakage due to environmental contamination
  - Inhibit corrosion
  - Can improve fatigue resistance of solder joints[1]
  - Inhibit arcing and corona etc.
  - Provide mechanical support

- Demands are evermore critical with the reduction in
  - Component size
  - Pitch
  - Circuitry spacing
  - Laminate thickness

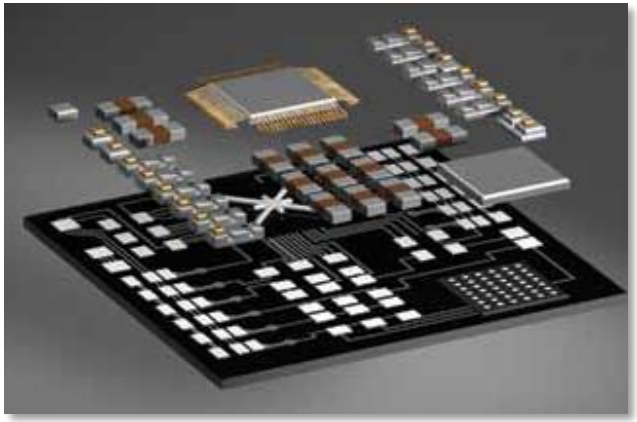
[1] Depending on the flexibility of the coating

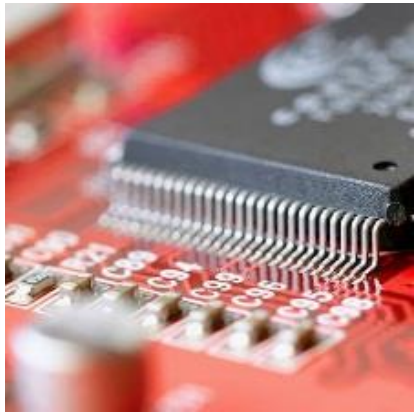
Why Conformal Coat?
Reliability

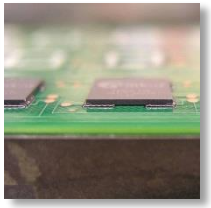
Reliability is the ability to function under specific conditions for a specified period of time without failure

IPC-HDBK-830
Guidelines for Design, Selection and Application of Conformal Coatings

Industry trends







Industry Trends (General Electronics)

- Historically circuit protection was limited to perceived high reliability applications
  - Aerospace
  - Military
- Automotive electronics has rapidly transferred into this category with life critical applications
  - Air bag sensors
  - ABS modules
  - Tyre pressure sensors
- Other areas of the electronics industry are also increasing their demand for improved reliability
  - Brand image protection
  - IP protection
  - Competitive advantages
- The general move to smaller components, finer pitch devices has required better insulation between components on the PCB
- The move from low volume/high cost PCB protection to high volume manufacturing has demanded increased performance from the CBP products (faster curing, easier dispensing etc.)

Technology Trends (Automotive)

- Fuel injection
- Ignition control
- Cruise control
- Central door lock

- Transmission control
- Climate control
- Anti Slip Control
- ABS
- Airbag
- Seat heating control

- Navigation system
- Rain sensor
- Active Cruise Control
- Park distance control
- Dynamic stability control
- Adaptive transmission control
- Xenon light
- Seat belt usage
- Traction control
- Auto mirror dimming

- 42-Volt
- Key-less
- Personalization
- Hazard Warning
- Integrated Safety System
- Brake assistant
- Steer/Brake-by-wire
- Adaptive brake light
- Tire pressure control
- SW Update
- Lane departure control
- Park tronic
- Force Feedback Pedal
- Drive dynamic seat
- Tele-aid5

1970 1980 1990 2000

source pictures BMW AG

Market Needs – Environment

- VOC Free (100% solids)
- VOC Compliant (40.CFR.51.100s)
- Low VOC
- VOC Containing (Friendly Solvents)
- VOC Containing (Aggressive Solvents)

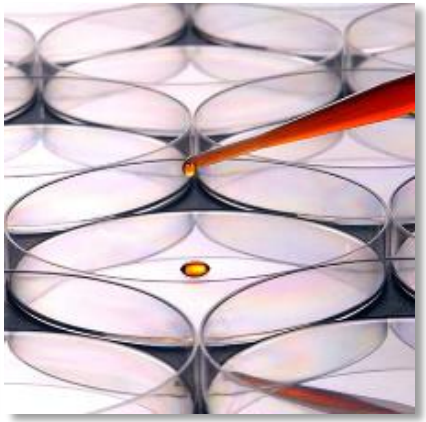
- PC40UM/UV7993
- 5293/SC3613
- PC62
- PC52/PC54

New Market Driver – Solvent Free

- Ease of Dispense
  - Need low viscosity without stringing
  - Traditionally aided by addition of solvents
  - Shorter polymer chain lengths/higher crosslink density result in more easily dispensed system but more brittle cured products
- Flexibility/Thermal Shock Performance
  - Longer chain length polymers give more flexible/durable cured systems
  - Tend to be harder to dispense; higher viscosity
- Cure Speed
  - Longer chain length polymers result in slower systems
- Cost
  - More sophisticated polymer systems can result in higher cost

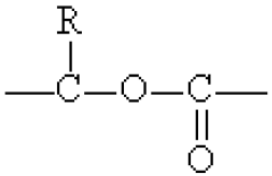
Coating Material Options





Conformal Coatings types

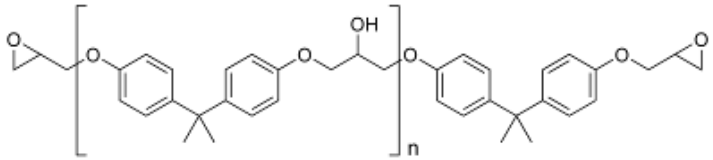
Acrylics (AR)



Strengths	Weaknesses
• Simple Drying Process	• Solvent VOC's an issue
• Easy to use and rework	• Flammability
• Good Moisture Resistance	• Poor solvent resistance
• Easy to adjust viscosity	• Soften readily at high temps

Very common in market place

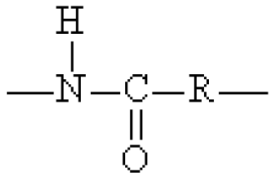
Conformal Coatings
Epoxies (ER)



Strengths	Weaknesses
• Useful to ~150°C	• Two Part systems
• Good Abrasion Resistance	• Difficult to Rework
• Good Humidity Resistance	• Potential for High Stress
• Good Chemical Resistance	• High Shrinkage
• Good Dielectric properties	

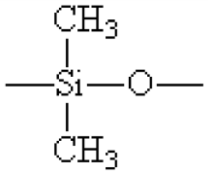
Very robust systems

Conformal Coatings
Urethanes (PUR)



Strengths	Weaknesses
• Good humidity resistance • Good dielectric properties • Good solvent resistance • Abrasion resistance	• Difficult to rework • Potential H&S concerns (isocyanates) • Moisture can effect cure rate • Many systems are solvent based

Conformal Coatings
Silicone (SR)

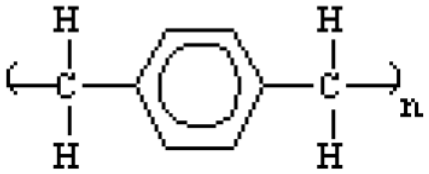


Strengths	Weaknesses
• Good for -40 to 200°C • Flexible • Moisture/Humidity Resistant • High Dielectric Strength • Excellent wetting capabilities	• Low Abrasion Resistance • High CTE • Can suffer swelling with solvents • Pt cured systems can be inhibited

Excellent for temperature extremes and cycling

Conformal Coatings

Poly-para-xylylene (Parylene) (XY)



Strengths	Weaknesses
• Excellent Uniformity	• Batch process under vacuum
• Low Environmental Impact	• Masking required
• Excellent Chemical Inertness	• Limited to ~120°C
• Biocompatible	• Rework is difficult

Common for very demanding applications

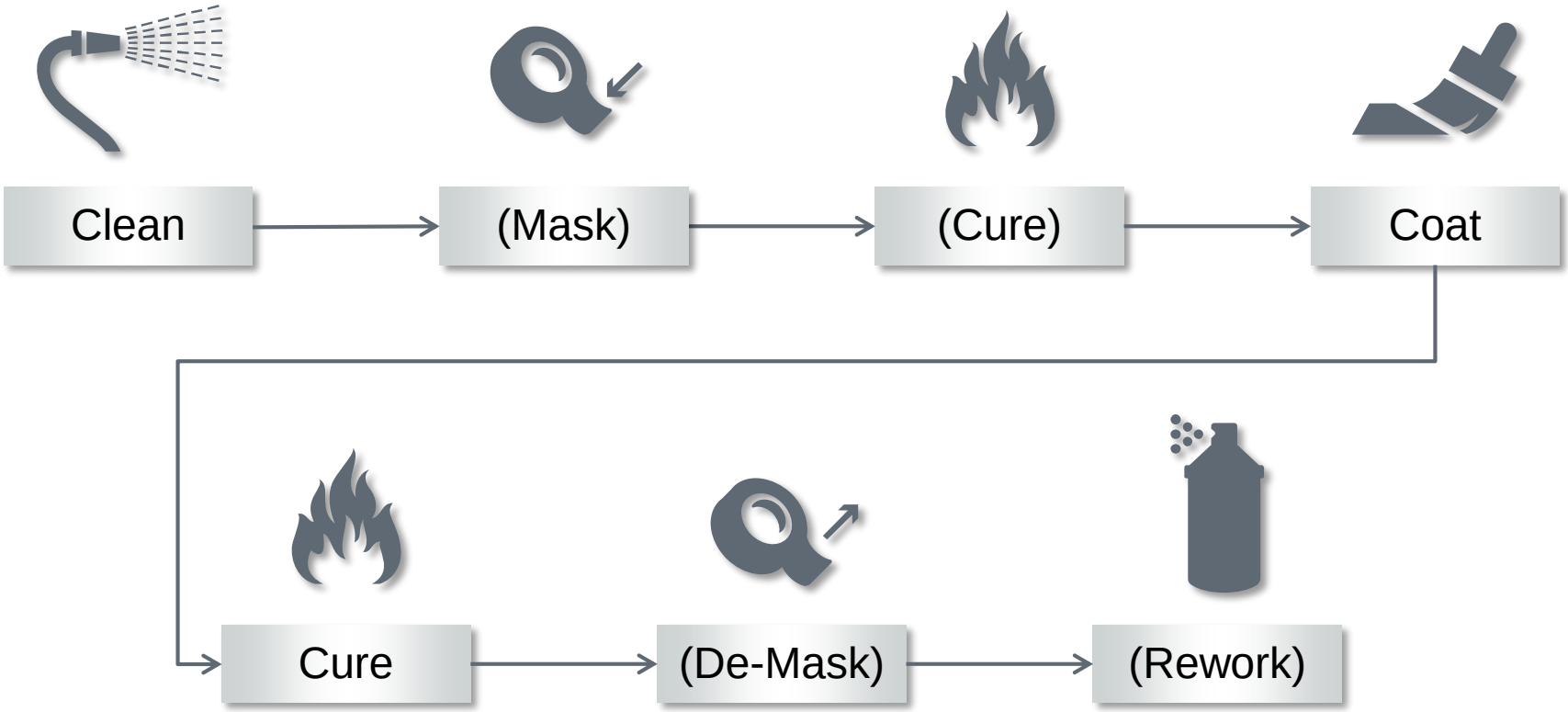
Chemistry Summary

Property	Urethane	Epoxy	Silicone	Acrylic
Strengths	Tough and Flexible	Chemical Resistance	Temperature Resistance	Impact Resistance
Limitations	Temperature Resistance	Rigid	Low Strength	Brittle
Solvent Resistance • **Polar** • **Non Polar**	Good Good	V. Good Excellent	Good Poor	Poor Good
Flexibility	High	Low	Very High	Medium
Operating Temperature (C)	-65 to 130	-65 to 125	-65 to 200	-65 to 125
Thermal Shock Resistance	Very Good	Good	Very Good	OK
Exotherm	Low (<50C)	Varies, can be high	Low	N/A
Moisture Sensitivity	Very Sensitive	Insensitive	Some systems can be sensitive	Insensitive
Electrical Properties	Good	Good	Lower, but Good	Good
Tg (C)	Low	High	Very Low	Medium
Cure Mechanism	Heat, RT	UV, Heat, RT	UV, Heat, RT	Heat

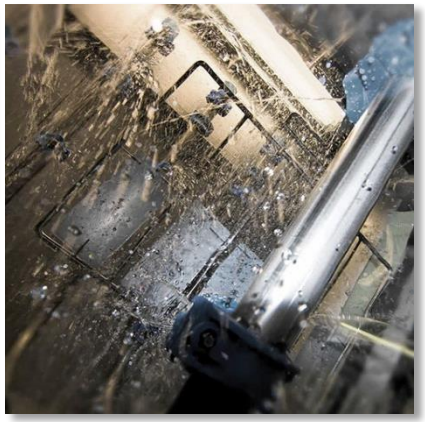
Processing Conformal Coatings

Henkel

Processing Conformal Coatings



Cleaning



Effects of Contamination & Defects

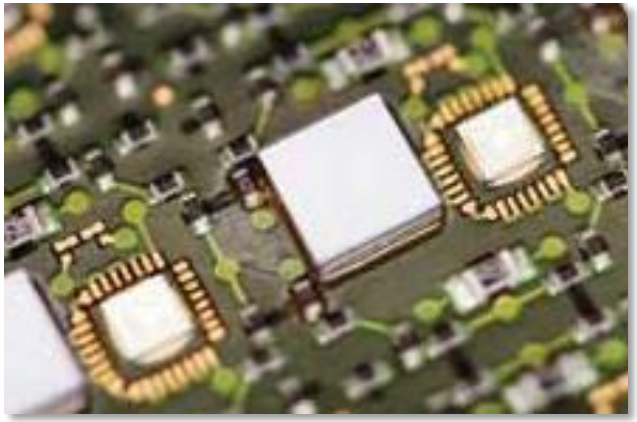
- Poor adhesion of the coating to the substrate gives
  - Air pockets where water can condensate

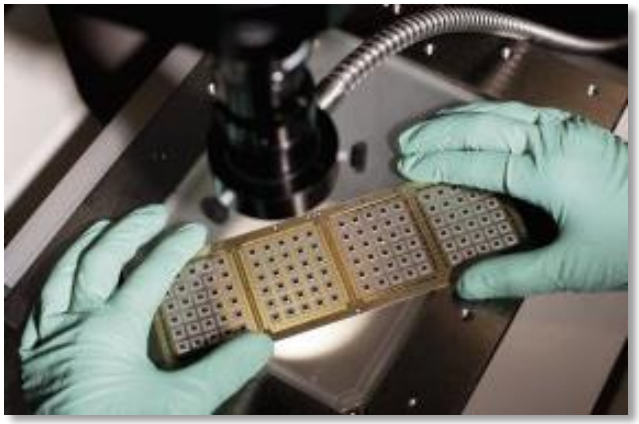
- This leads to
  - Corrosion
  - Discolouration of the exposed metallisation
  - Bubbling, blistering and lifting of the coating

Board Contamination

- Contamination **under** the conformal coating after application
  - Flux related Contamination Issues
  - Contamination from Poor Handling
  - Chemicals in PCBs and Components
  - Other Contaminants

Masking





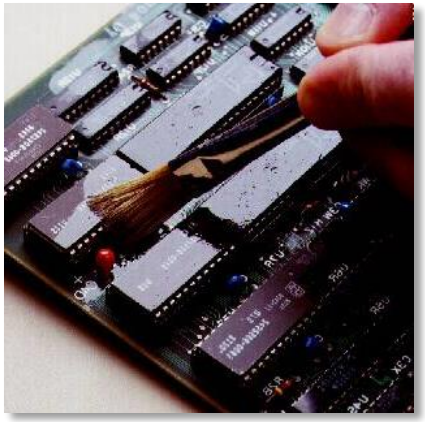
Board Masking

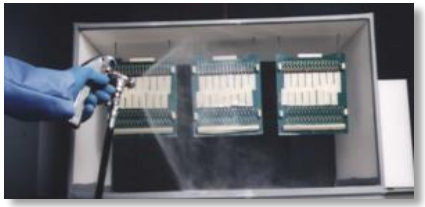
- Masking is required for non-selective coating processes
- Masking material must be compatible with coating system
- Many different systems are available

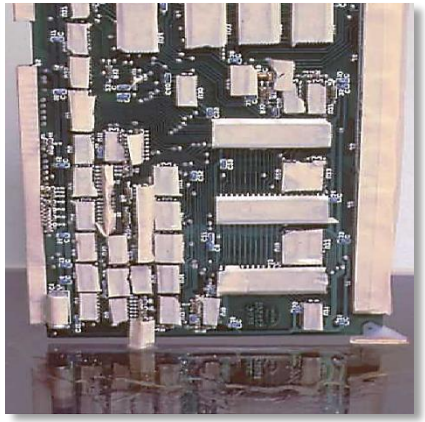
Board Masking

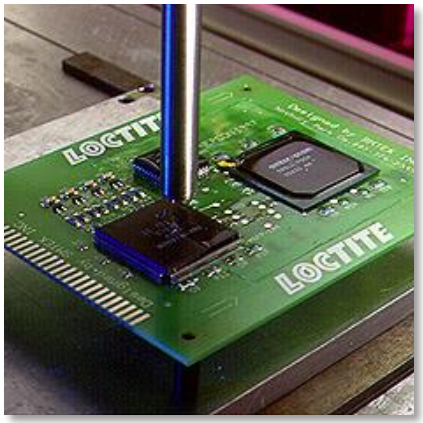
	Advantages	Disadvantages
Tape	• No cure required	• Labour intensive
Liquid Masks (Latex)	• Inexpensive • Fairly consistent	• Labour Intensive • Slow curing • Difficult to Automate • Odour
Boots	• No Cure Required • Reusable	• Manual – labour intensive
UV Mask	• Fast cure • Can be automated	• Equipment (UV) investment • Removal can be critical

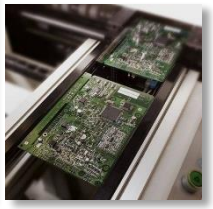
Coating Application techniques











Principal Application Methods

- Brush
- Dip
- Selective Flood Coating
- Needle Dispensed
- Manual Spray (atomized)
- Automated Selective Coating

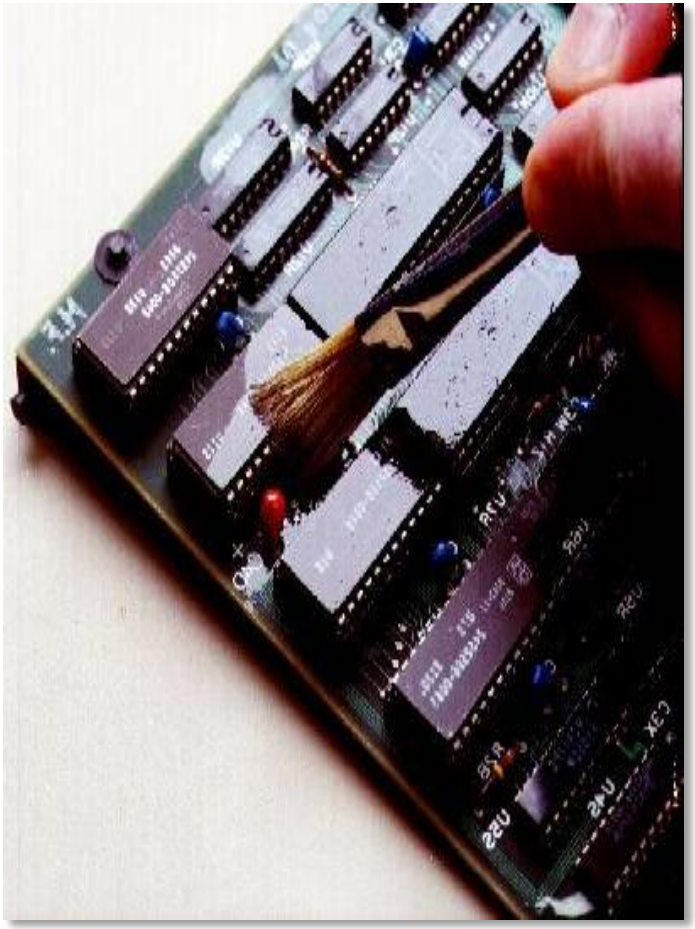
Brush

Pros

- Low investment
- Skill needs vary low to high
- No masking
- Good for repair

Cons

- Exposure
- Inconsistency of thickness
- Contamination
- Mechanical contact



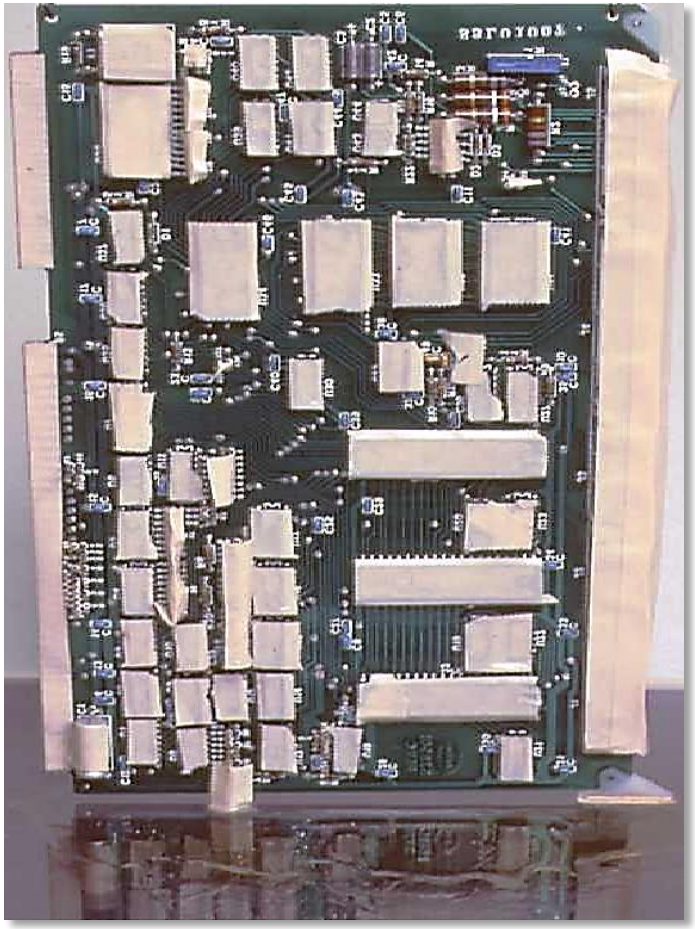
Dipping

Pros

- Low capital investment
- Simple process
- High throughput

Cons

- Poor consistency of thickness
- Contamination into tank
- Masking required



Selective Flood Coating

Pros

- No manual masking required
- Low material wastage
- High throughput

Cons

- New Stencil-plate required for each board design
- Requires plate for front & rear
- Contamination into tank

Needle Dispensing

Pros
- Low cost
- No masking
- No emission

Cons
- Semi-manual system
- Inconsistencies in coatweight
- High film build
- Low throughput

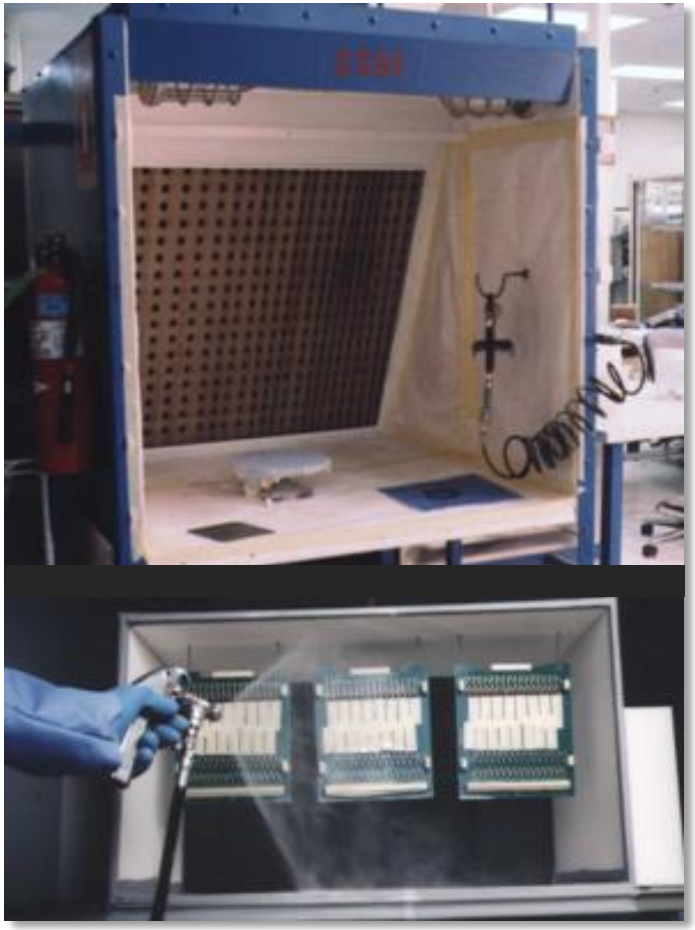
Manual Spray (Atomized)

Pros

- Simple process
- Low capital investment

Cons

- H&S issues due to exposure
- High emissions
- Waste material from overspray
- Masking needed
- Poor coat weight consistency



Automated Selective Coating

Pros

- Uniform coating
- High throughput
- Material savings
- No/Little masking
- No custom tooling
- Range of application methods

Cons

- Capital investment
- Maintenance required
- Potentially complex system

Curing/Drying of Conformal Coatings






Principle Curing/Drying Processes

- Drying/solvent evaporation
- Heat Cure
- RT (Moisture / Two-Part) Cure
- Combined UV/X Cure
  - UV/Heat
  - UV/Moisture
  - UV/Two-Part

Solvent Evaporation

- Simple and cost effective approach
- Drying time
  - Requires drying equipment / area
  - Requires ventilation
- Material can flow before being immobilised by drying
- Safety considerations
  - Flammability
  - Health
- High coat weights must be avoided
  - Solvent entrapment

Heat Cure

- Rapid and complete cure
- Requires ovens – floor space
- Cure time
- Material can flow before crosslinking immobilises fluid
- Work in progress
- Temperature sensitive components
- Capital investment and related maintenance

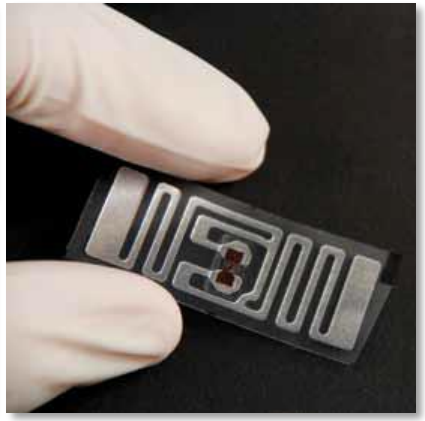
RT Moisture Cure

- Simple and cost effective approach
- Cure time
- Requires racking
- Work in-progress
- Material can flow while liquid
- Speed of cure varies with relative humidity

UV Cure

- Advantages of UV Cure, without shadowing issues
- UV light combinations
  - UV/Heat
  - UV/Moisture
  - UV/Two-Part
- Guarantees fast immobilization and 100% cure
- UV lamps can be retrofitted to production line
- Capital investment & related maintenance

Reworking



Reworking

- Frequently required due to
  - Production Problems
  - Field Failures
  - Upgrades

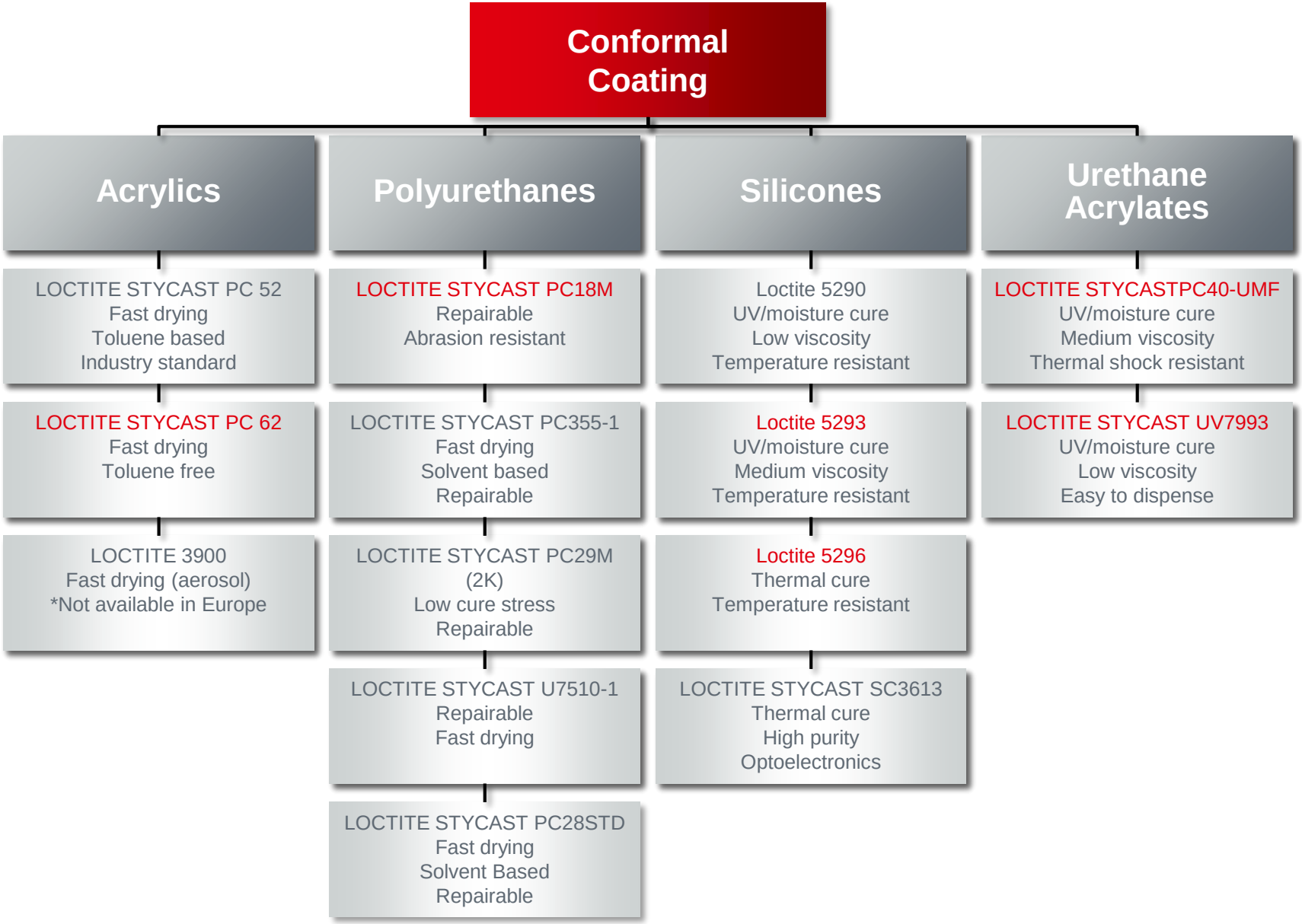
- Requires
  - Removal of coating (normally via abrasion, solvent or burn through)
  - Clean up of exposed area
  - Replacement of component
  - Clean up
  - Re-coat
  - Normally a manual process

Coating Removal

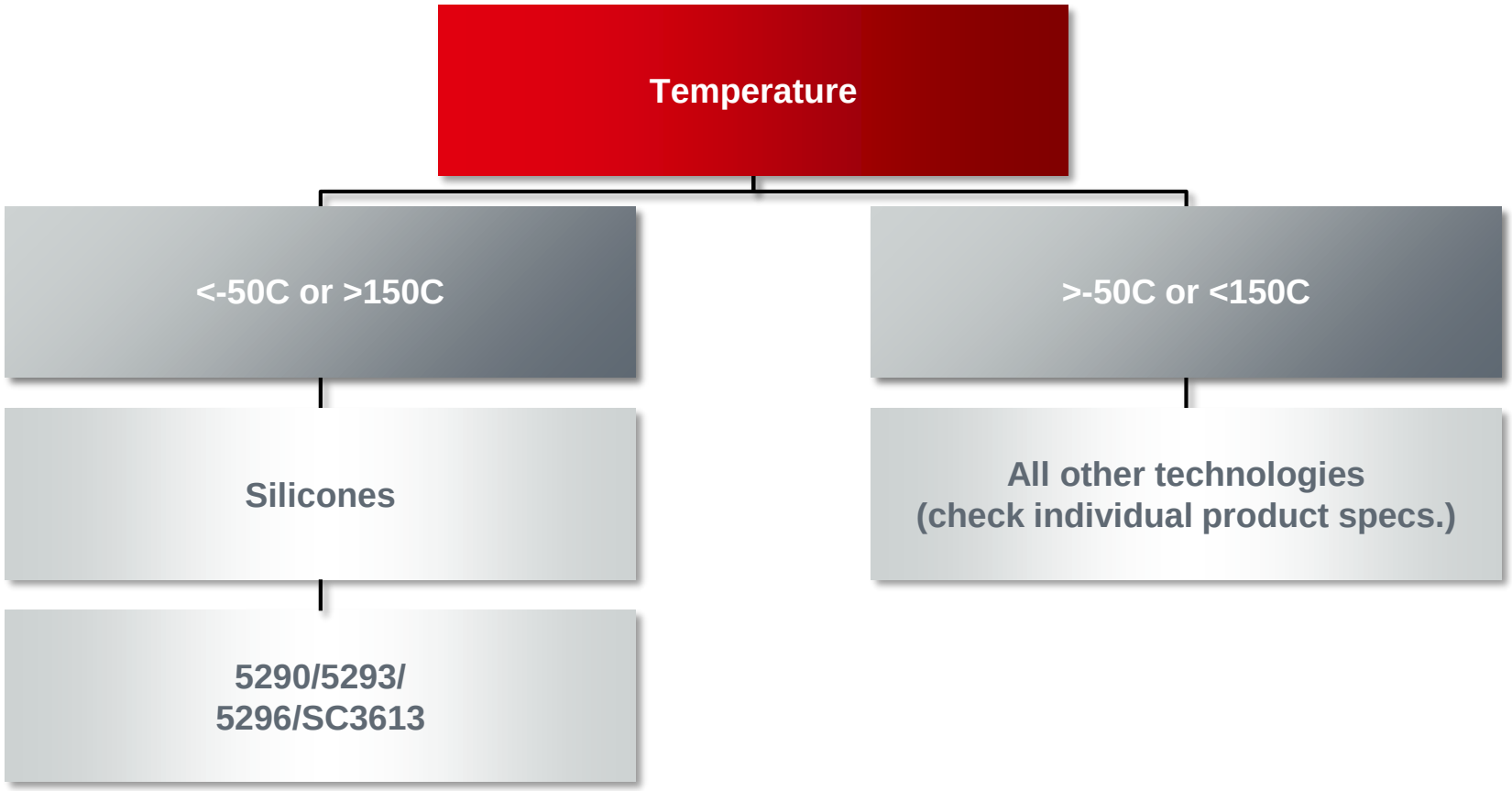
- Acrylics
  - Soak in solvent (MEK) or by burn through
- Urethanes
  - Soak in Methanol (H&S) or by burn through
- Epoxies
  - Soak in m-Pyrol, strong acid or base (H&S)
- Silicones
  - Abrasion / mechanical action or soaking in ‘Silicone Strippers’

Henkel Conformal Coating Product Line

Selection guide by end use application


Conformal Coating
Acrylics
LOCTITE STYCAST PC 52
Fast drying
Toluene based
Industry standard
LOCTITE STYCAST PC 62
Fast drying
Toluene free
LOCTITE 3900
Fast drying (aerosol)
*Not available in Europe
Polyurethanes
LOCTITE STYCAST PC18M
Repairable
Abrasion resistant
LOCTITE STYCAST PC355-1
Fast drying
Solvent based
Repairable
LOCTITE STYCAST PC29M
(2K)
Low cure stress
Repairable
LOCTITE STYCAST U7510-1
Repairable
Fast drying
LOCTITE STYCAST PC28STD
Fast drying
Solvent Based
Repairable
Silicones
Loctite 5290
UV/moisture cure
Low viscosity
Temperature resistant
Loctite 5293
UV/moisture cure
Medium viscosity
Temperature resistant
Loctite 5296
Thermal cure
Temperature resistant
LOCTITE STYCAST SC3613
Thermal cure
High purity
Optoelectronics
Urethane Acrylates
LOCTITE STYCASTPC40-UMF
UV/moisture cure
Medium viscosity
Thermal shock resistant
LOCTITE STYCAST UV7993
UV/moisture cure
Low viscosity
Easy to dispense

Product Selection Criteria



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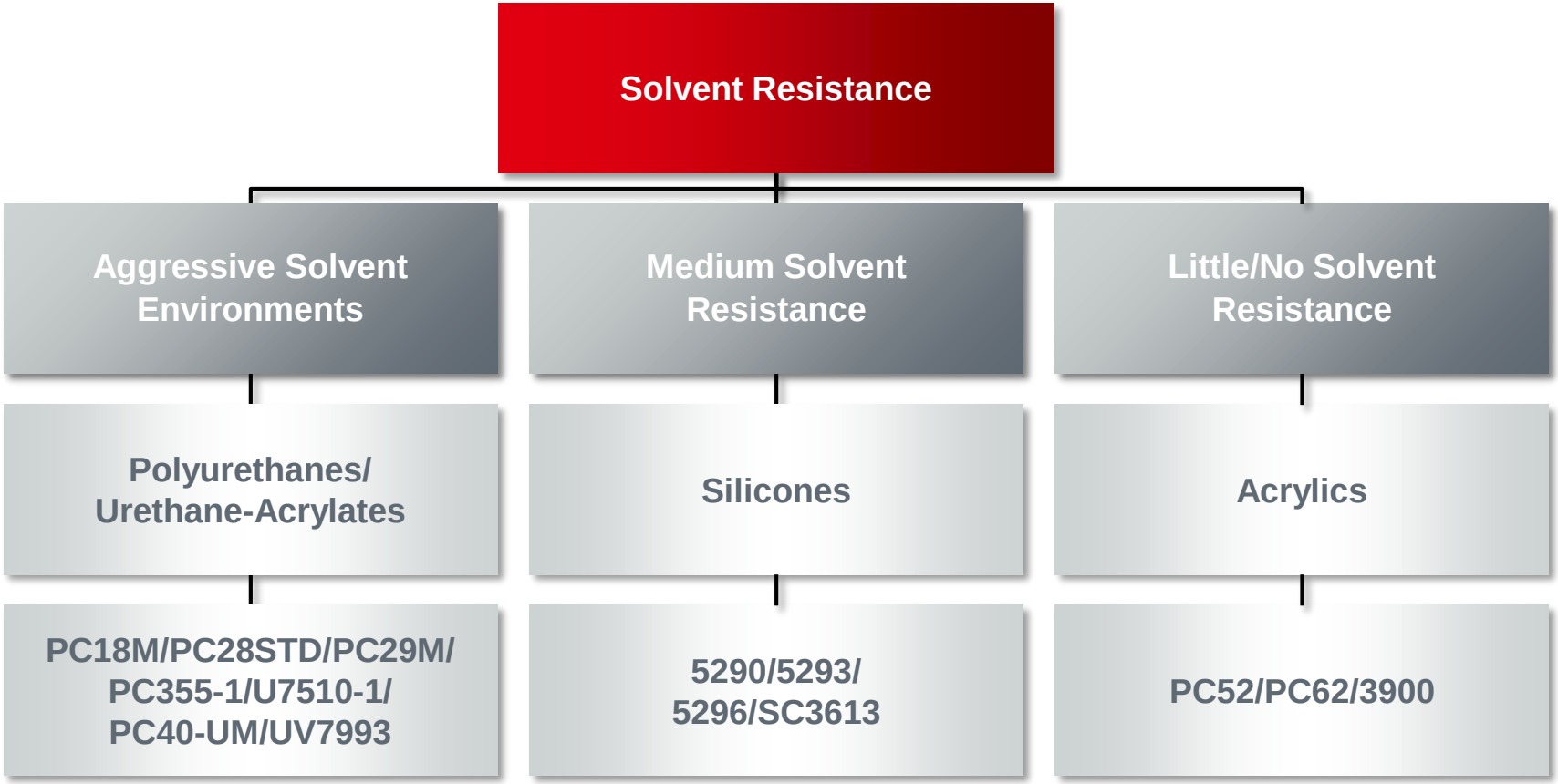

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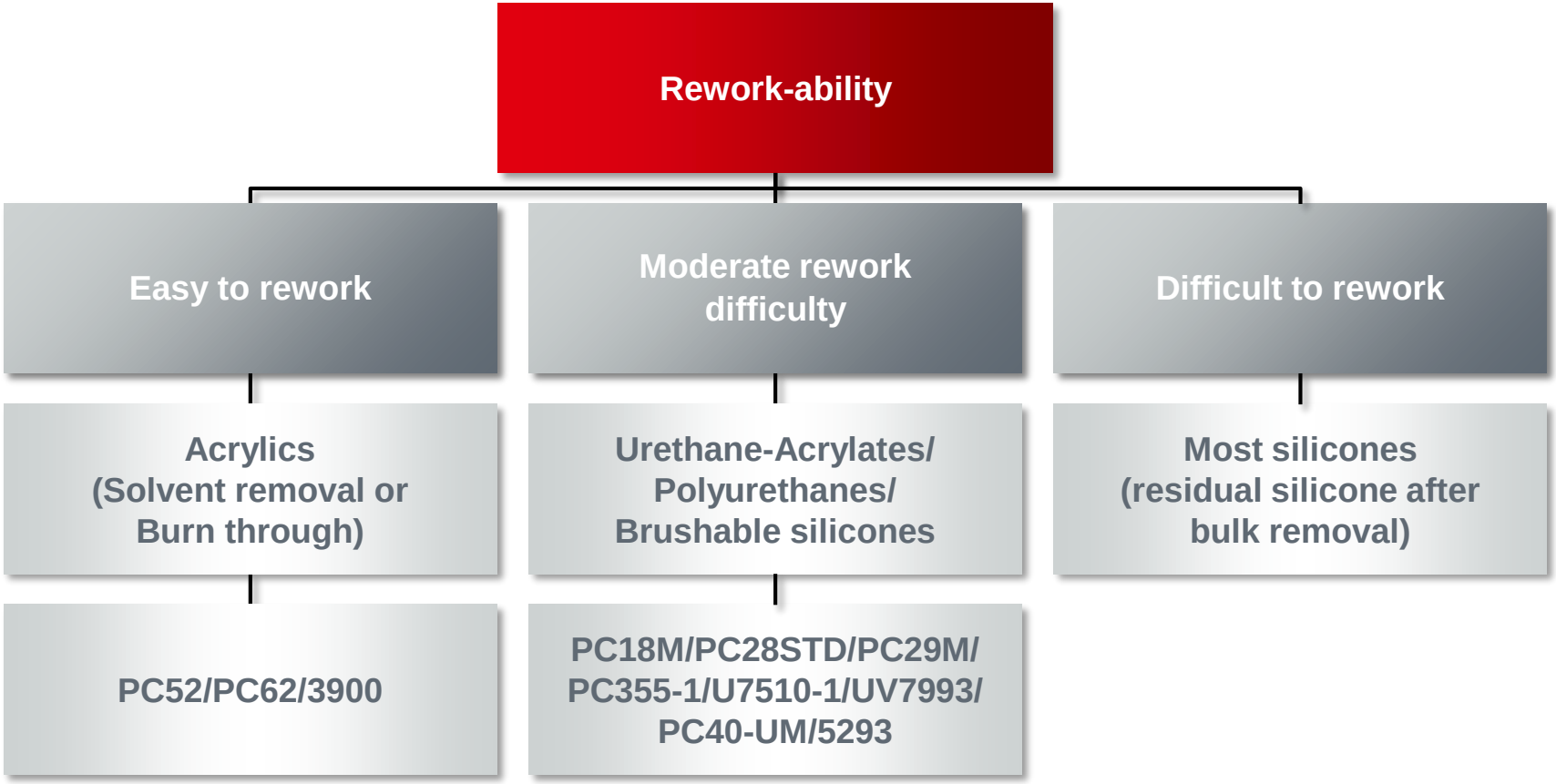

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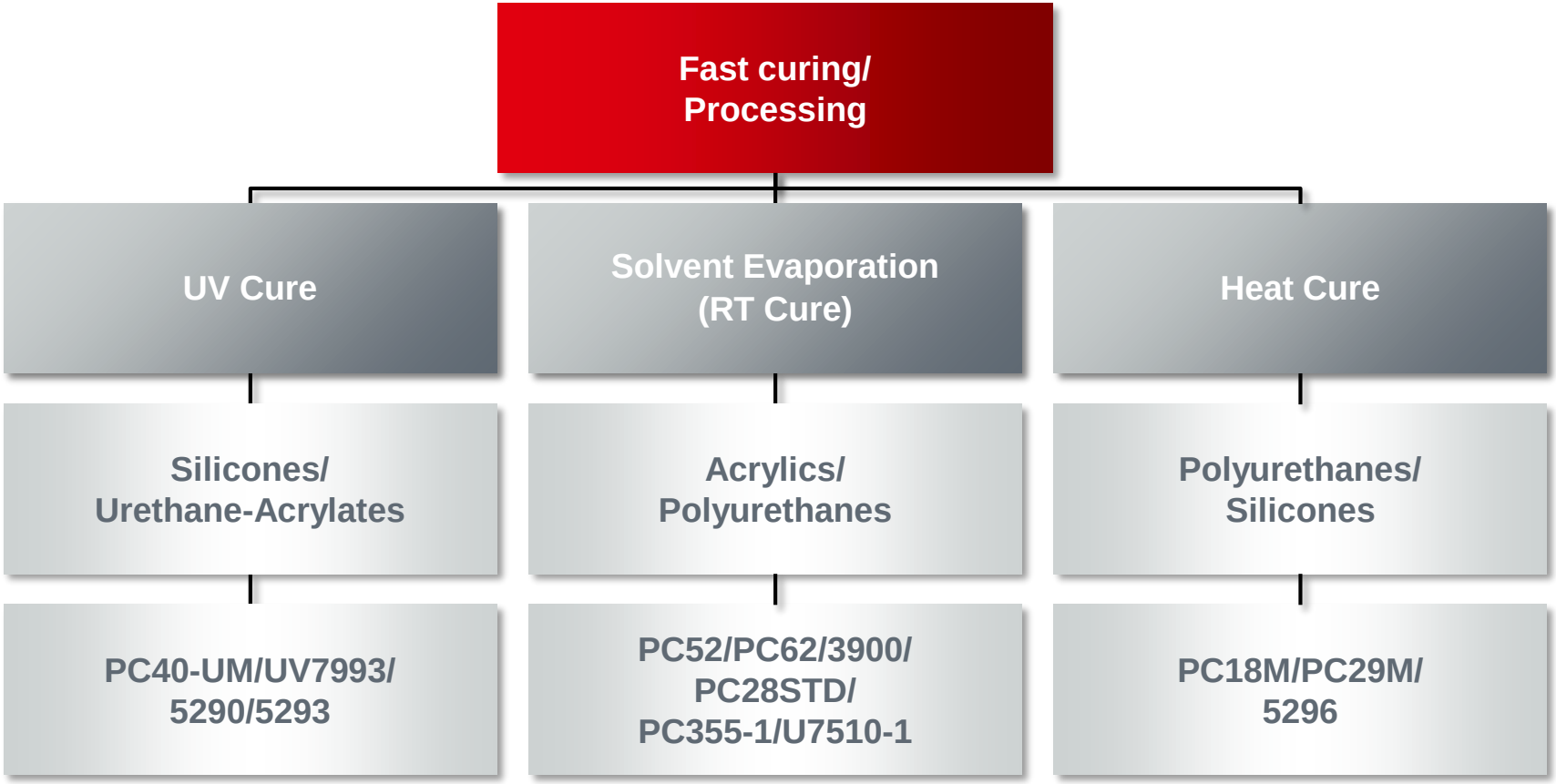


Product Selection Criteria

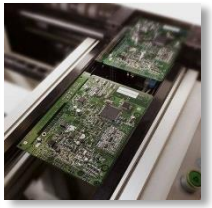
Other factors can influence the selection of a coating for an application

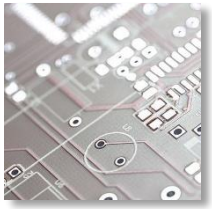
- Health and Safety/Environmental Conditions
  - Solvents
  - Isocyanates
- Approvals
  - UL94
  - MIL-I-46058C
  - IPC-CC-830B
  - BMW (and other automotive approvals)
- Perceived barriers
  - Silicone contamination

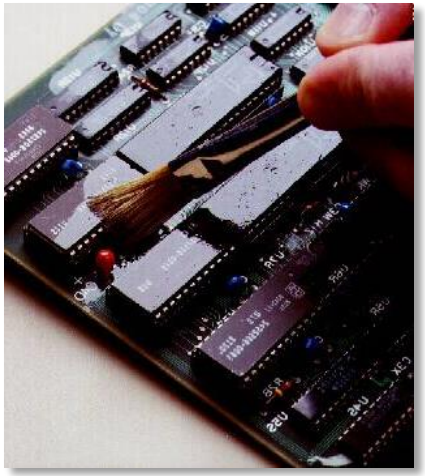
Conformal Coating

Application status	New	Existing	Product Design Request
General information			
Henkel sales person			
Customer name			
Ship-to Address			
Customer contact name			
Customer contact phone number			
Market segment			
Potential Value			
Potential Volume			
Sample quantity			
Process information			**Indicate must criteria with X**
Is the flux residue cleaned?			
Soldering process (no-clean or water soluble):			
Cleaning prior to coating (water - saponifier - solvent):			
Drying process after cleaning:			
Application Method: Spray - Dip - Brush - Selective Coating			
Solder mask type and vendor			
Desired coating thickness			
Material requirements			
UL required?			
Required pot life			
Repair or reworkability required?			
If rework is required, which method is used?			
Are solvent based systems permitted?			
If yes, are toluene free solvent based systems permitted?			
Are silicones permitted?			
IPC-CC-830B Required?			
Compliance with BMW GS 95011-5 required?			
UV trace required for inspection if not UV cured?			
Must coating be VOC free?			
Cure options			
Cure Method (UV/Moisture - UV/Heat - Heat - RTV, 2 part):			
Reliability requirements			
Product Environment - Min / max operating temp.			
Product Environment - Thermal cycling			
Product Environment - Max. operating temp			
Chemicals to be resistant to			
Other environmental requirements			
Other information			
Current Supplier and product description			
Current Material			
Is it possible to have a Henkel rep present during testing?			

Thank you for your attention!







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