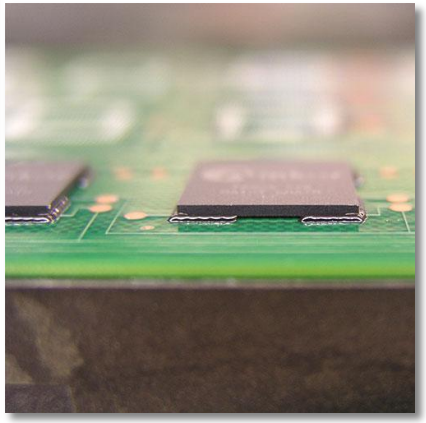
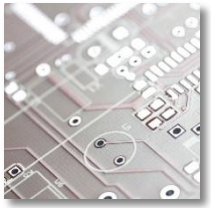
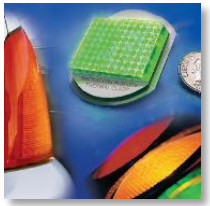
Reliability of Interconnects in LED Lighting Assemblies Utilizing Metal Clad Printed Circuit Boards

Stefano Sciolè
BDM I.M.S.
Henkel Electronic Materials



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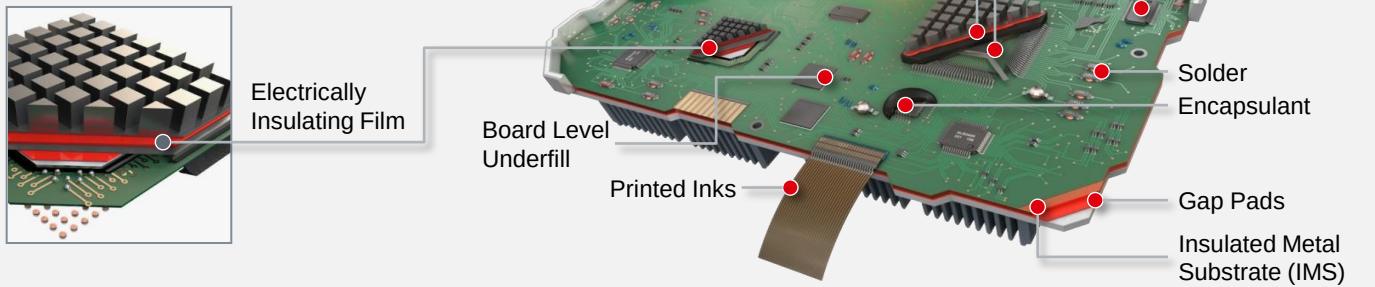
Agenda

1. Introduction
2. Motivation
3. Interconnect Reliability
4. Solder Joint Testing
5. Test Results
6. Conclusions

Introduction
Henkel at a glance

- 140 years old, German based, family owned company
- Close to 50,000 employees, over €18B in sales
- 3 divisions: Laundry & Home Care, Beauty Care and Adhesive Technologies
  - Specific division focused on solutions for Electronics applications

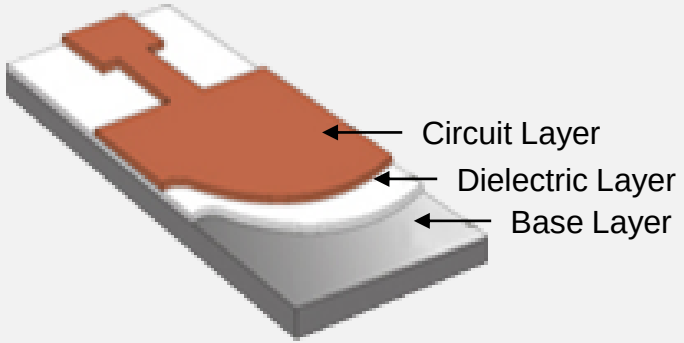


Motivation

Why using MCPCB in a LED assembly?

- LED performance is highly influenced by junction temperature
  - LED lifetime depends on junction temperature of the die
  - LED brightness depends on junction temperature of the die
  - LED Color shift depends on junction temperature of the die

- Various ways to achieve this:
  - FR4 with filled vias
  - FR4 with Cu-inlays
  - Ceramic boards
  - MCPCB



Proper thermal management is a must

Motivation

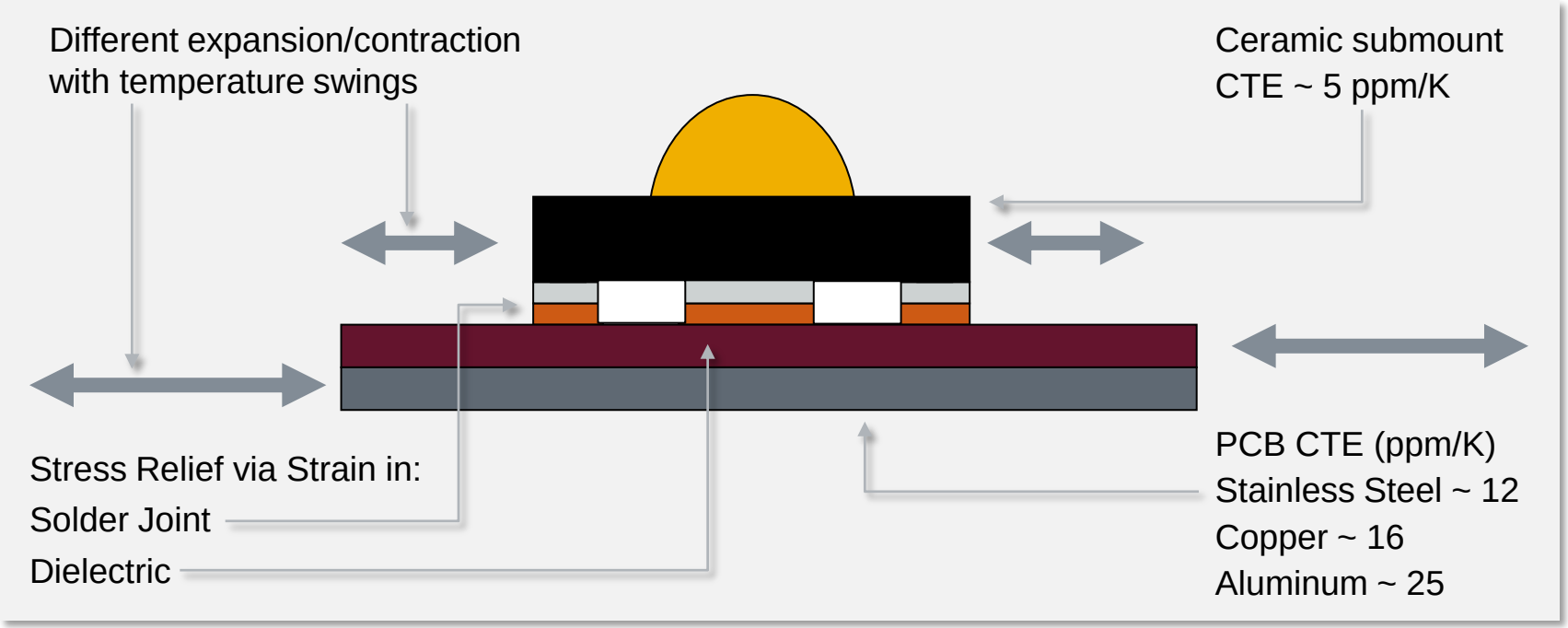
Interconnect Reliability

- Interconnect failure is an open circuit, not a short
- This causes all of the lights in series with the failed interconnect to go out.
- More significant than a single point source due to a short

- Warranties of 5 year or more are common in high reliability applications like street lighting, so the interconnect is crucial.

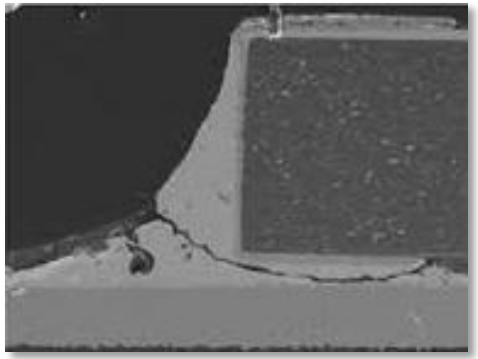
Interconnect Reliability

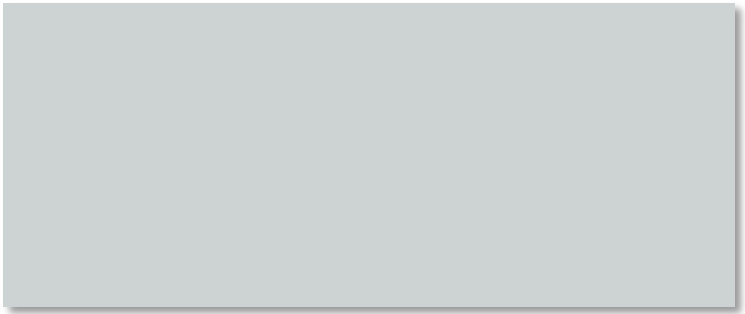
What happens

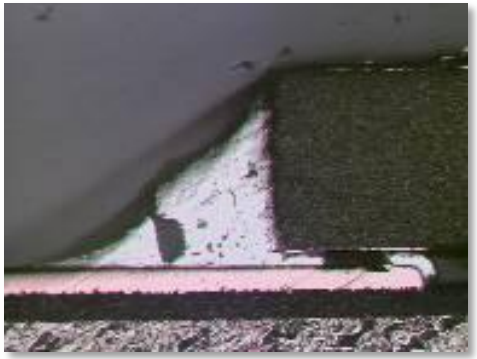


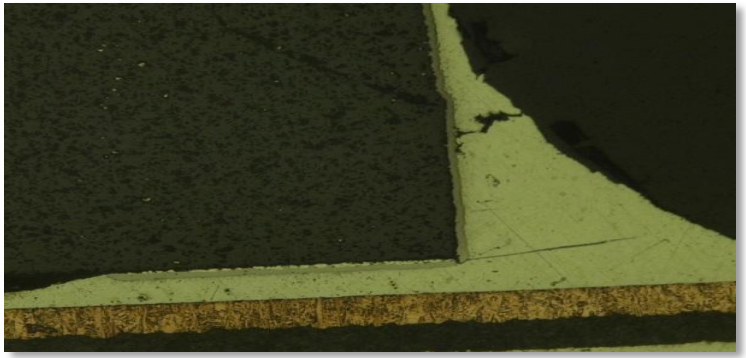
Interconnect Reliability

The Result



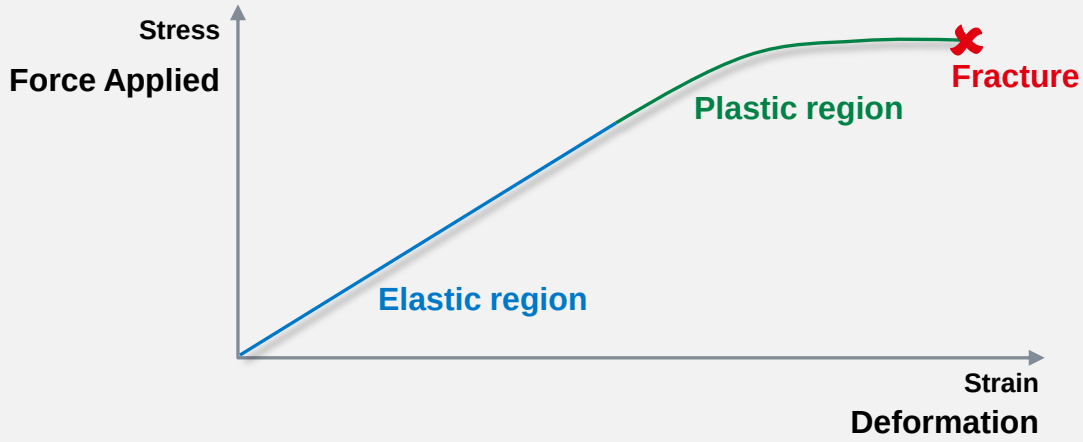






Interconnect Reliability

What Happens



- Most interconnect reliability / fatigue failures occur where there is local plastic deformation. They are initiated at a void, discontinuity, or stress concentration and grow through plastic deformation

Source: Wikipedia

Interconnect Reliability
Fatigue Relationships

- Δ D = the cyclic damage term. Generally: **the lower the better**

$$\Delta D = \frac{F\ L_D\ \Delta\alpha\ \Delta T}{h}$$

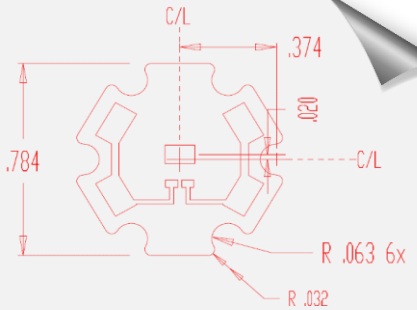
- F: correction factor 0.7>F>1.2, generally
- L_D : distance to centerline or neutral plane
- Δ α : difference in CTE between package and substrate
- Δ T : maximum and minimum temperatures in thermal cycle
- H: solder joint thickness

Source: Engelmaier, Pb-free solder creep-fatigue reliability models updated and extended; Global SMT& Packaging, 9/2009. pg 36-37

Solder Joint Testing

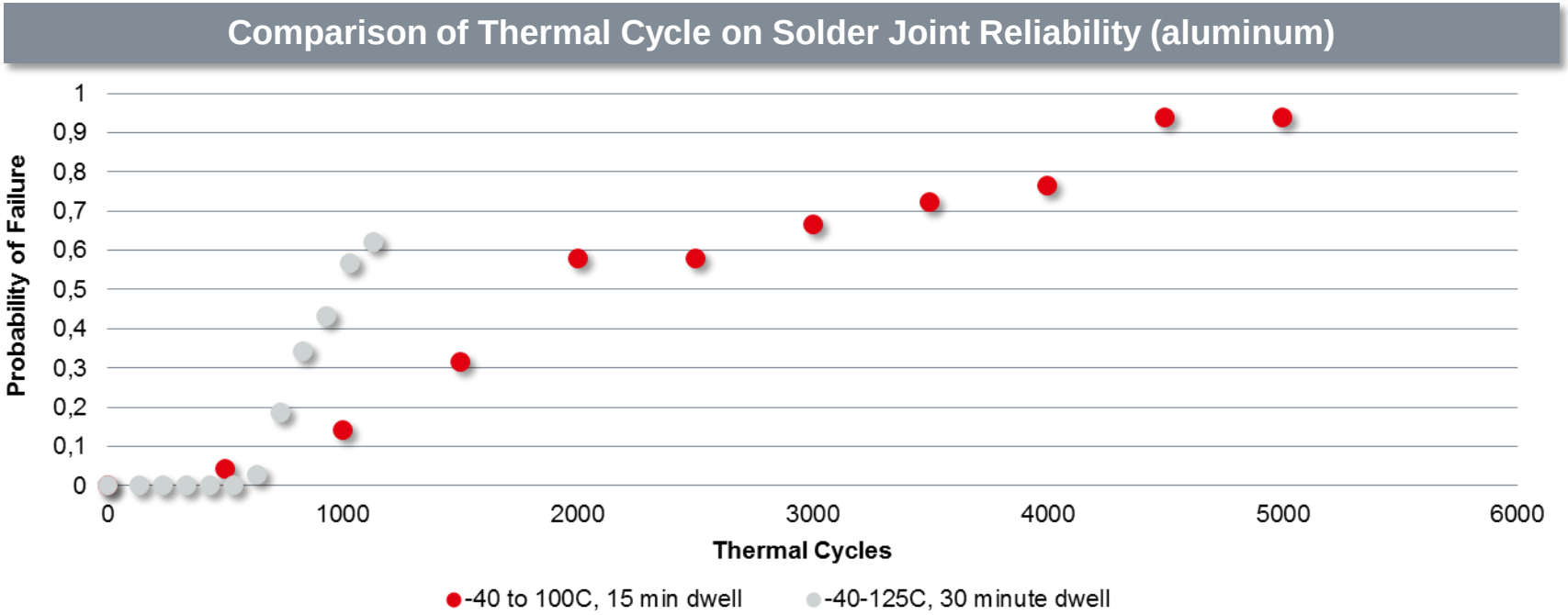
Test parameters

- Copper and Aluminum based boards with different dielectric materials
- Circuit pattern as shown
- Finished with Electroless Nickel Immersion Gold
- 3 solders evaluated
  - Low Creep (Henkels 90iSC)
  - Standard (SAC 305)
  - Low melt (140C)
- Solder was stenciled using a 125 micron laser cut stencil with a 10% reduction in aperture size
- Populated with Luxeon Rebel
- Solder was reflowed as shown in air with standard reflow cycle
- Thermal Cycle the assembly
- Apply 3 V at the pads and look for light at cycling intervals



Solder Joint Testing

Test results



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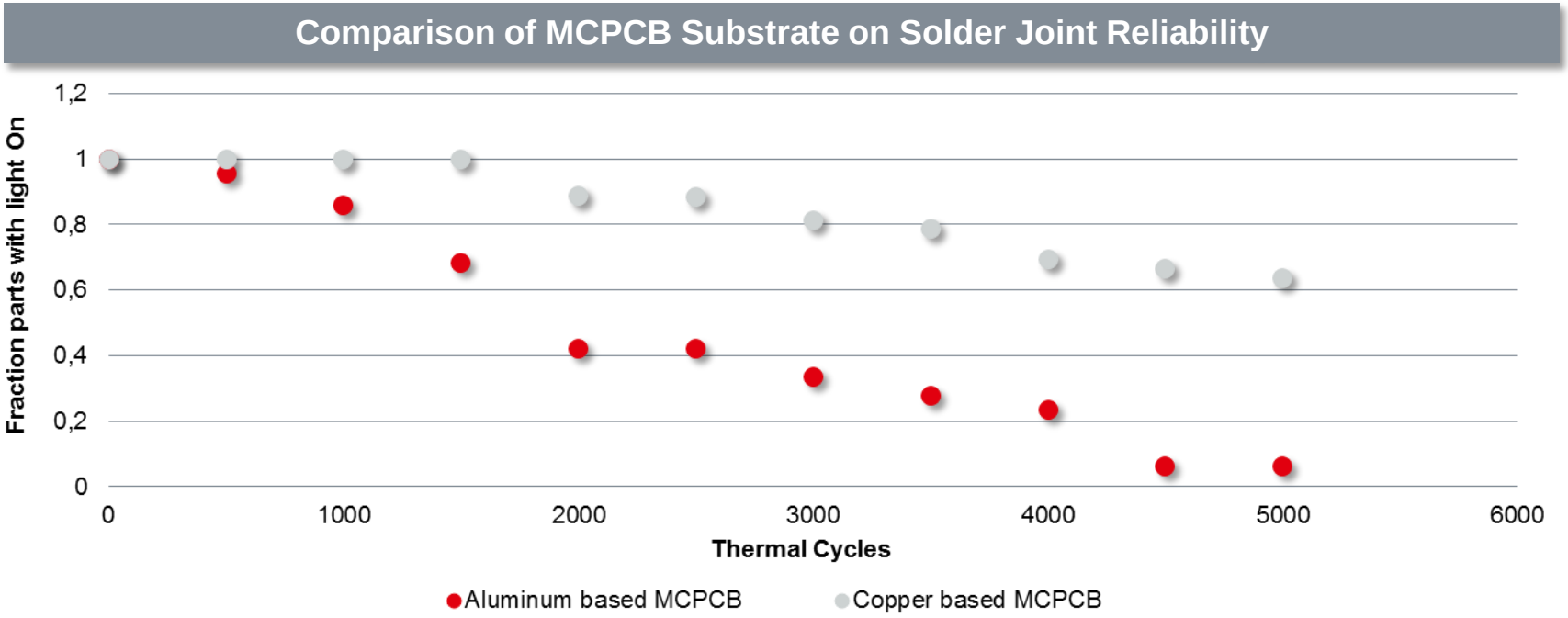
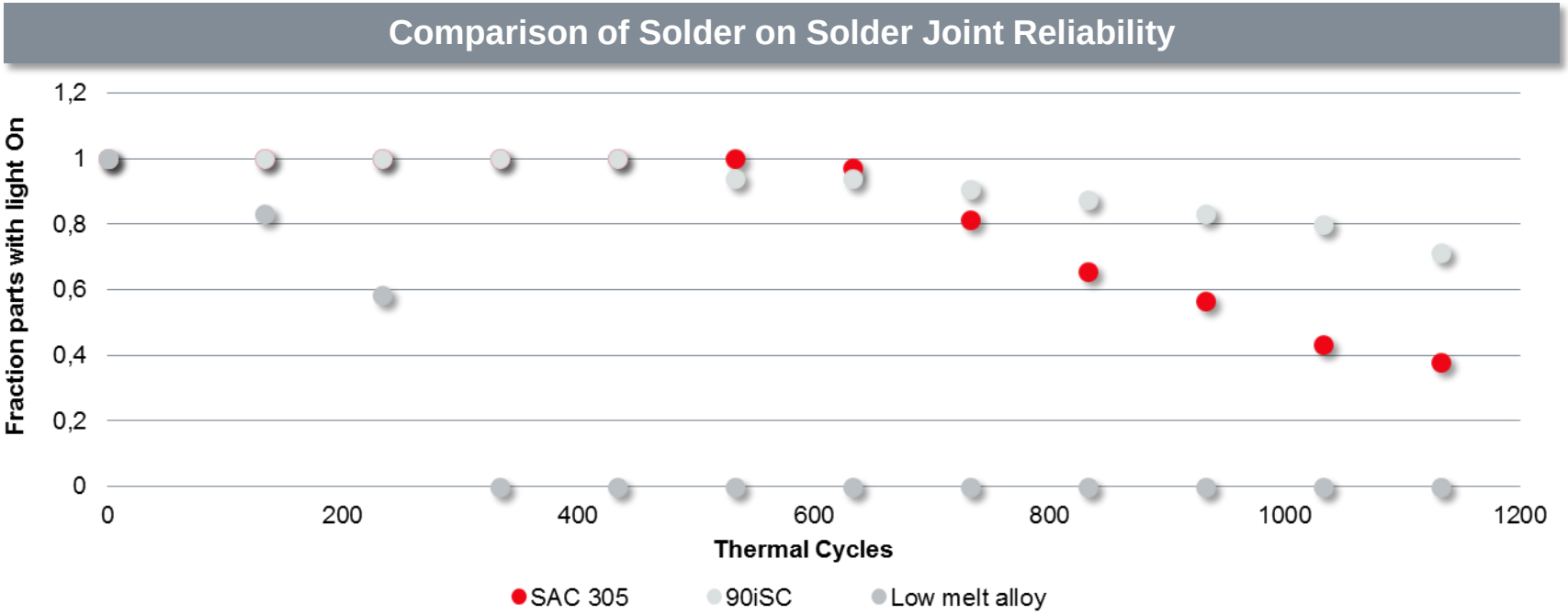


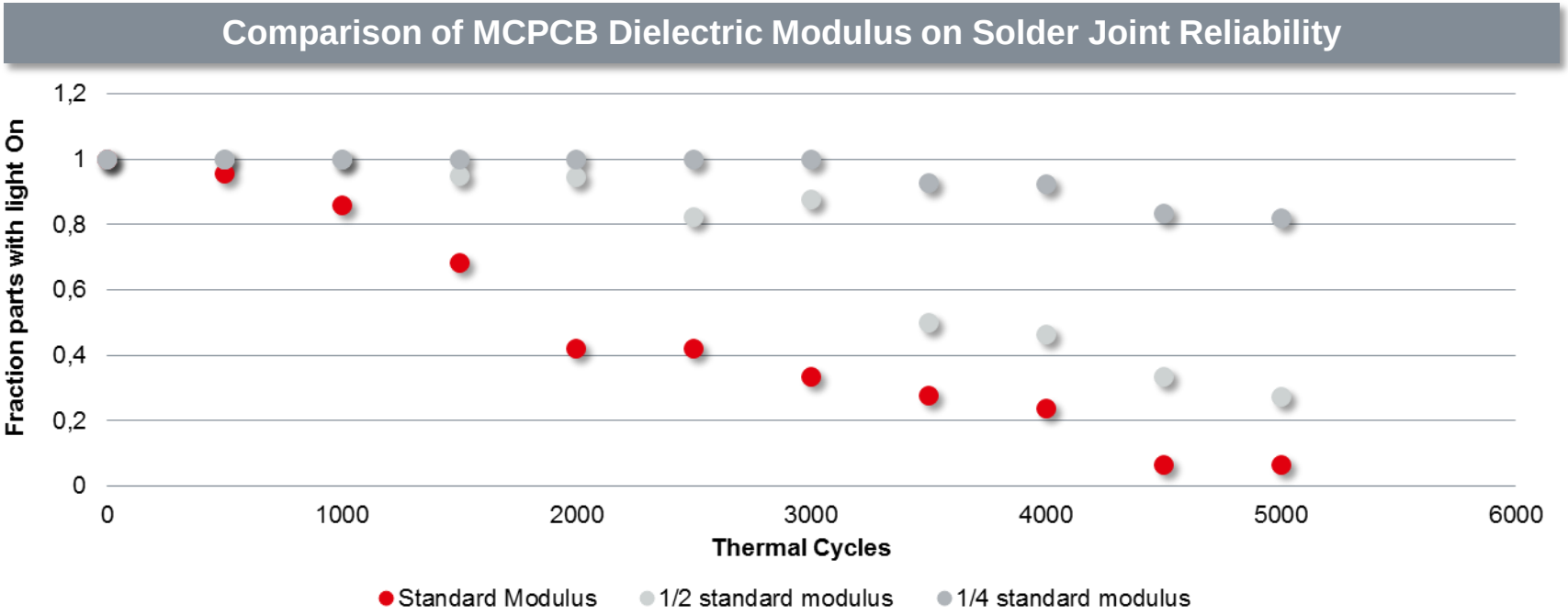
Solder Joint Testing

Test results



Solder Joint Testing

Test results



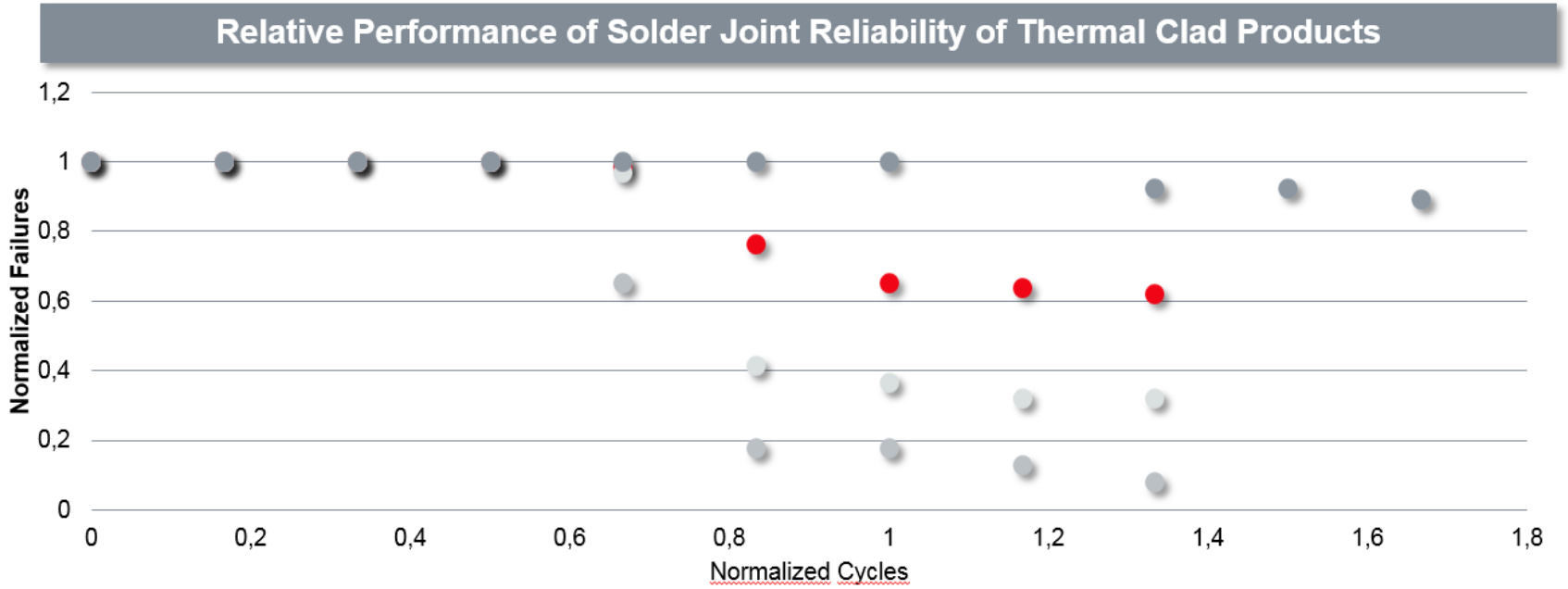
Solder Joint Testing

Test results - Conclusions

- Solder joint reliability can be improved by:
  - Minimizing the temperature swing
  - Minimizing CTE Mismatch
    - Select Copper base v. Aluminum
  - **Strain absorption of dielectric**
  - **Strain absorption of solder**

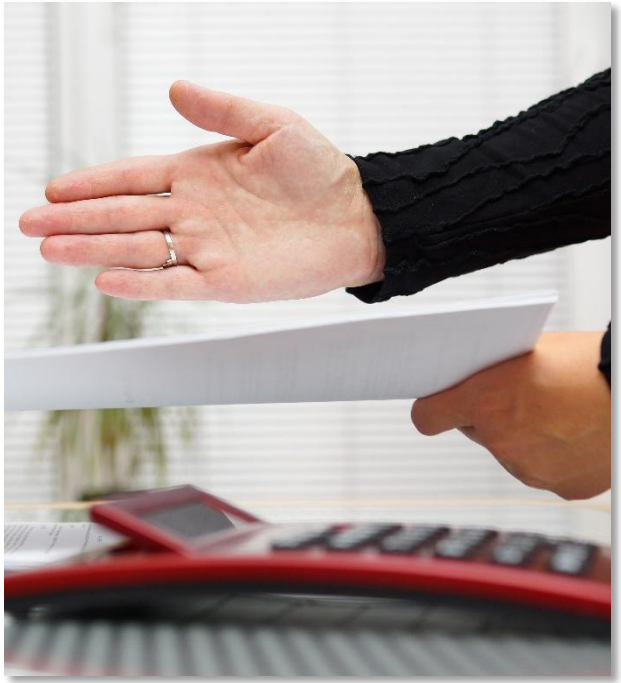
Interconnect Reliability

What can Henkel do?



Conclusions

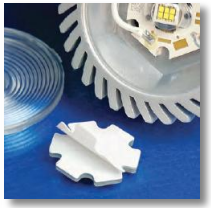
- Reliability of LED lighting solutions is key to continuing large scale adoption
- Interconnects can play a significant role in the reliability of LED assemblies in applications with thermal cycling requirements
- Solder joint reliability is determined by
  - Quality of solder joints
  - Solder types
  - Substrate materials
  - Part geometry
  - Thermal Cycles

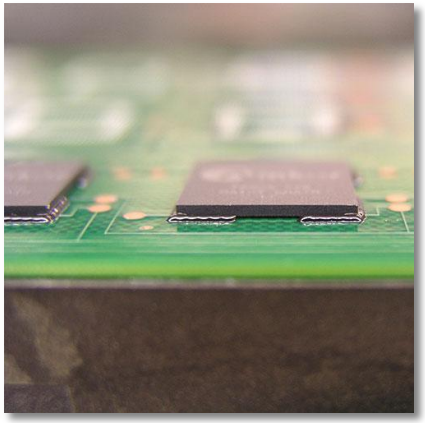


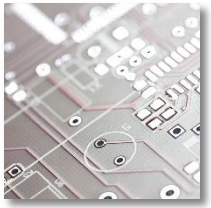
Questions?

Thank you!

For more information contact:
Aad van der Spuij
aad.vanderspuij@henkel.com
Yvan Van Gorp
yvan.vangorp@henkel.com
www.henkel-adhesives.com/electronics







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