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The Intermetallic Layer

"How To Create The Perfect Solder Joint"

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What Does the Perfect Solder Joint Look Like

- It is concave in appearance
- It is smooth and sometimes shiny
- It has a low wetting angle
- It has no voids, blow holes, and other anomalies

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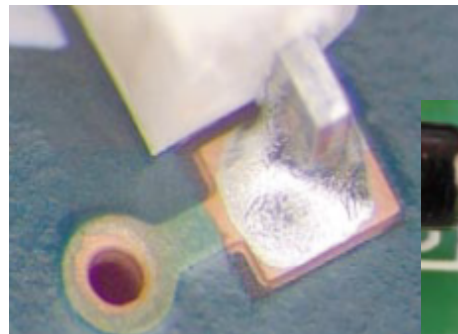
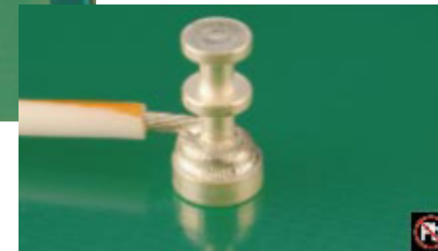
Appearance





Good Solder Joint Formation

- Joint quality is dependent on solderability
- The basic principle of soldering is for the solder to bond to the base material.
- Substrate must be fully and rapidly wetted by the tin in the solder being applied.
- Wetting is accompanied by a metallurgical reaction that produces intermetallic compounds (alloys) of specific composition

Adapted from "Paul Davis, *"Intermetallic Compound Growth and Solderability"*

Solderability

- The formation of the intermetallic plays a key role in most of the solder joint failure.
- The surface energy of the copper must exceed the surface energy of the solder for wetting to happen
- This is defined as non-wetting and de-wetting
- Flux is used to clean the copper raising its surface energies

Adapted from Ageing, *"Solder Thickness and Solder Alloy Effects on Circuit board Solderability "* by, J.K. Hagge and G. J. Davis

What is the Intermetallic?

- It is an electrochemical bonding between the solder and the copper surface
- It takes place during reflow when the Tin in the solder reacts with the Cu substrate or layer
- In Sn-rich solders on a Cu substrate, Cu_6Sn_5 (η) or Cu_3Sn (ε) intermetallic layers are formed at the solder/substrate interface

Adapted by *Influence of Initial Morphology and Thickness of Cu6Sn5 and Cu3Sn Intermetallics on Growth and Evolution during Thermal Aging of Sn-Ag Solder/Cu Joints*, by X. DENG, G. PIOTROWSKI, J.J. WILLIAMS, and N. CHAWLA

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What is the Problem?

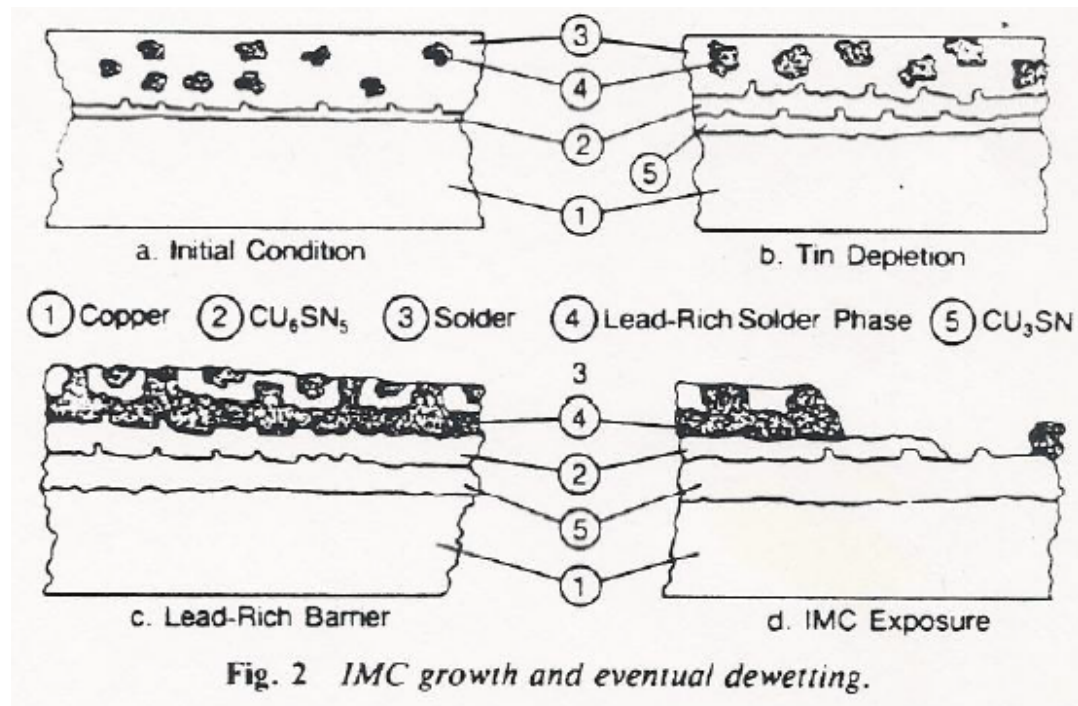

Fig. 2 *IMC growth and eventual dewetting.*

Ageing, Solder Thickness and Solder Alloy Effects on Circuit Board Solderability*

J. K. Hagge and G. J. Davis

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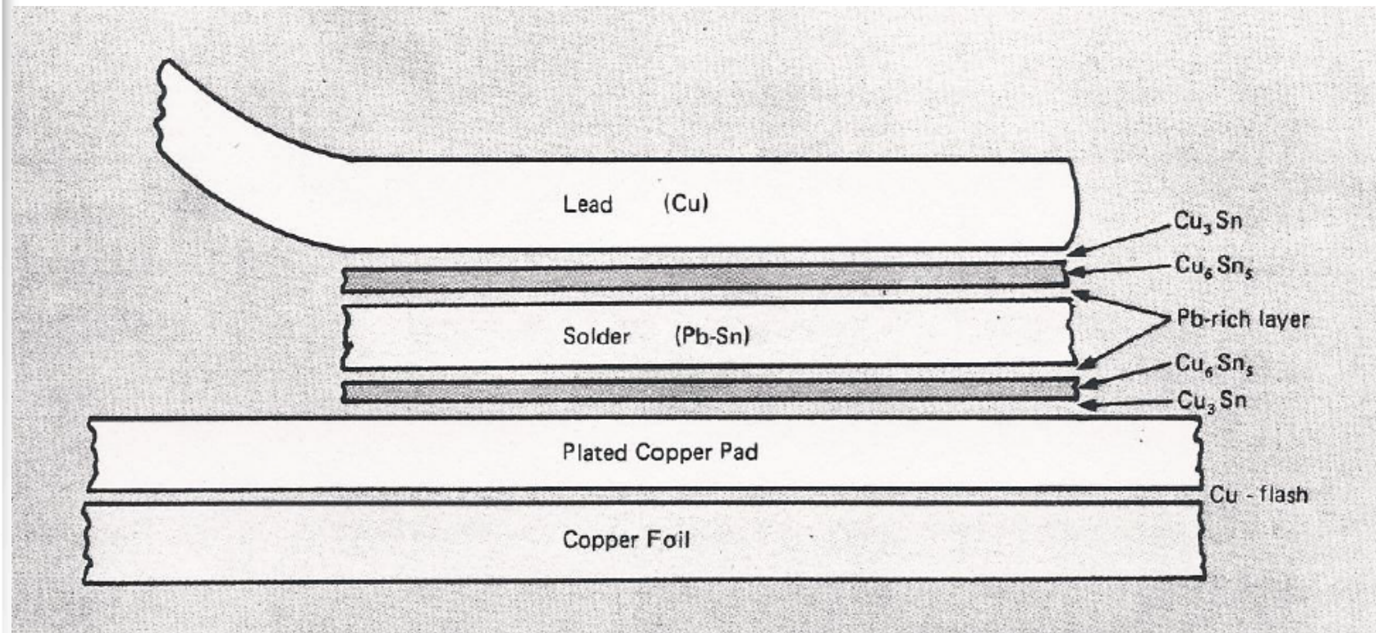
Copper-Tin Intermetallic



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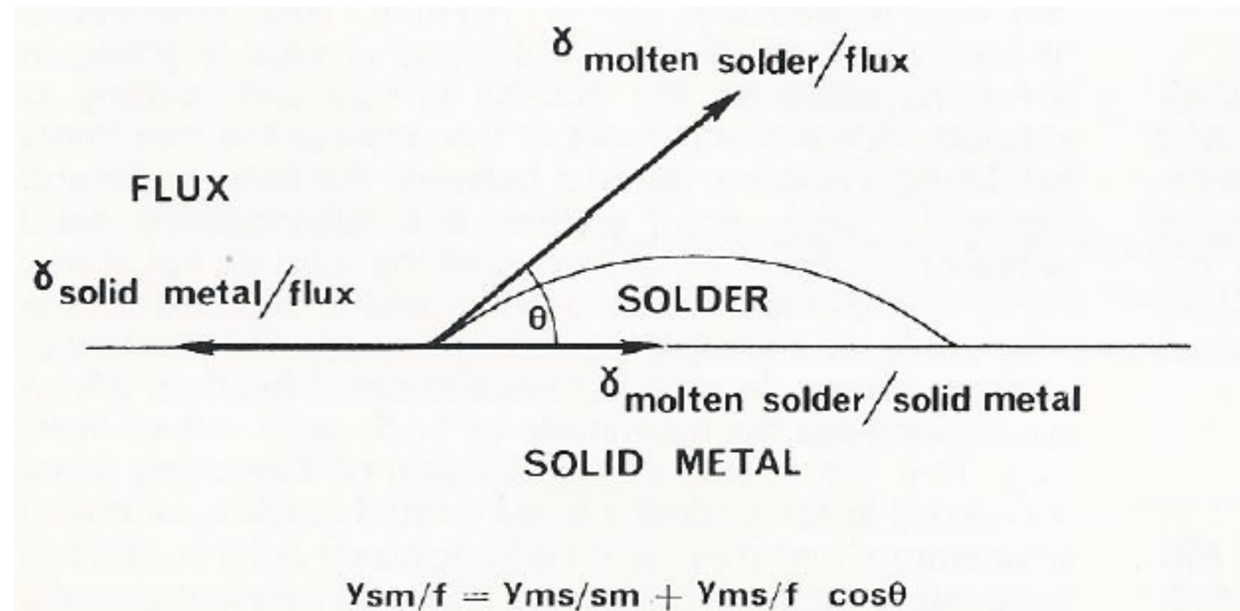
Wetting Angle



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Cu_6Sn_5 and Cu_3Sn

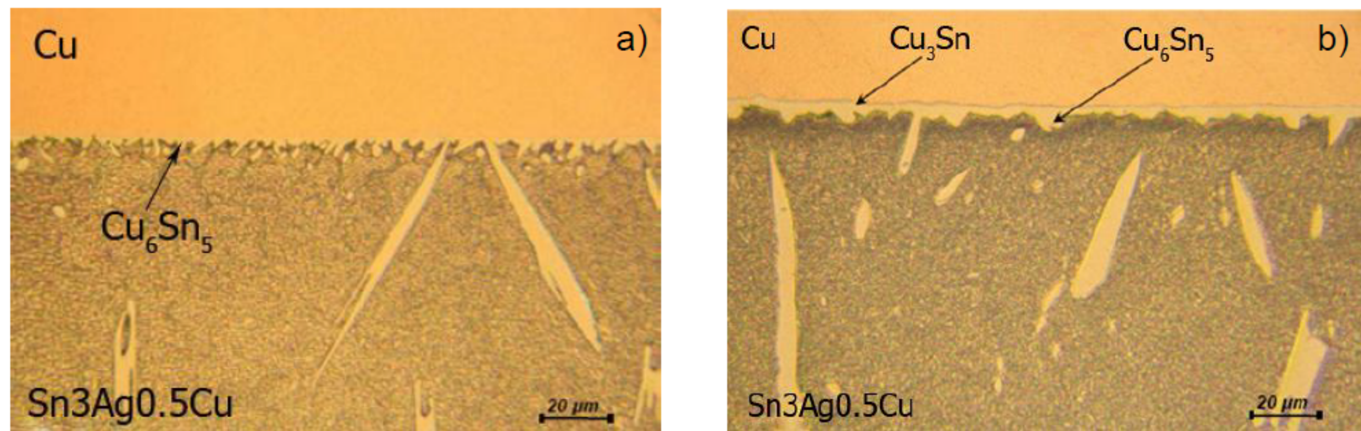

Fig. 3 Microstructure of Cu – Sn/3Ag/0,5Cu joint:
a) after soldering, b) after 793 thermal cycles

ANALYSIS OF THERMAL CYCLING INFLUENCE ON SHEAR STRENGTH AND INTERMETALLIC PHASES GROWTH OF SOLDER JOINTS MADE WITH LEAD-FREE SOLDERS

Jaroslav JANČÁR, Ivan MICHALEC, Emil LECHOVIČ, Beata ŠIMEKOVÁ, Milan MARÔNEK,

Slovak University of Technology, Faculty of Materials Science and Technology, Department of Welding,
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Dewetting

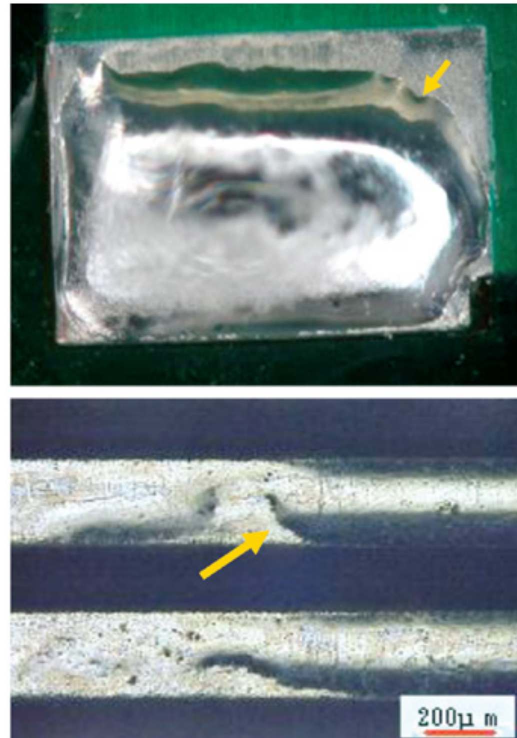

Figure 9: *Dewetting of the solder coating*

Adapted from *"Hot Air Solder Leveling in the lead free era"* by Keith Sweatman, Nihon Superior

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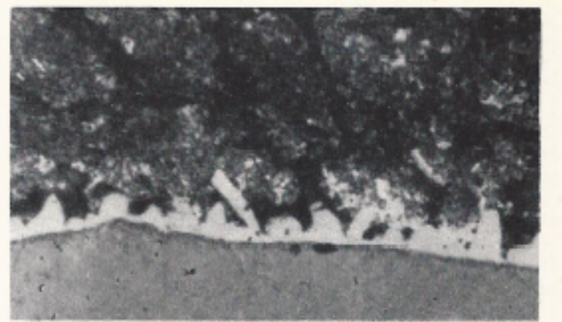
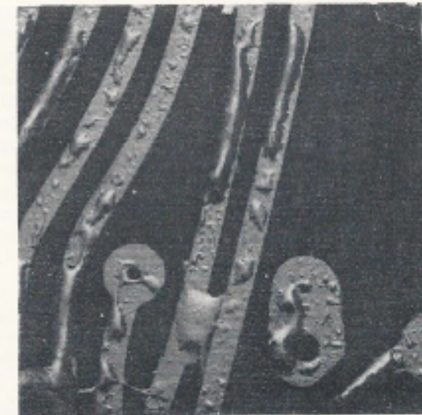


[Courtesy Tin Research Institute.

Fig. 3 Intermetallic compound formed during the wetting of copper by molten tin–lead solder. The prominent serrated white layer is the phase Cu_6Sn_5 and a thin blue-grey line of Cu_3Sn is often seen between this and the copper substrate. × 2000.



[Courtesy Tin Research Institute.

Fig. 17 Typical appearance of dewetted solder film on copper tracks of a printed circuit cleaned with an abrasive medium.

Adapted from *"The Attainment of Reliability in Modern Soldering Techniques for Electronic Assemblies"*

By C.J. Thwaites, M.Sc A.R.S.M,

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Dewetting

[Courtesy Tin Research Institute.

Fig. 16 Electron micrograph showing particles of abrasive embedded in the surface of copper-clad laminate after a dry buffing treatment. × 20 000.

Adapted from *"The Attainment of Reliability in Modern Soldering Techniques for Electronic Assemblies"*

By C.J. Thwaites, M.Sc A.R.S.M,

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What's Next?

- Make sure the surfaces to be soldered are clean
  - No abrasive cleaners
- Watch the soldering dwell times while the solder is molten as this will dissolve more copper through liquid state diffusion

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What's Next?

- The intermetallic will also grow through solid state diffusion, so watch your storage environments
- Places where this is more evident
  - Side 2 of the surface mount soldering process
  - Rework and repair area
  - Hand soldering areas

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What's Next?

- Train the people in making good solder joints as quick as possible keeping the dwell time as short as possible.
- Institute a one touch soldering process
- Watch the plating thickness of tin and tin/lead coating on the boards as this can be a problem area if the coating is too thin.
- Follow the specifications for plating thickness and understand your modifications

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Conclusion

- Intermetallics are real and they are necessary, so understand how they impact your process.
- You judge the solder joint by visual observation, but it is what is underneath that counts, so know what to do when the solder joint doesn't look like it is supposed to.

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Thank You

Questions?

Further Information

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Next Webinar topic is undetermined , if you had a topic let me know

For questions regarding this webinar, please contact Leo Lambert at leo@eptac.com

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