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Residueless soldering with Bi-In

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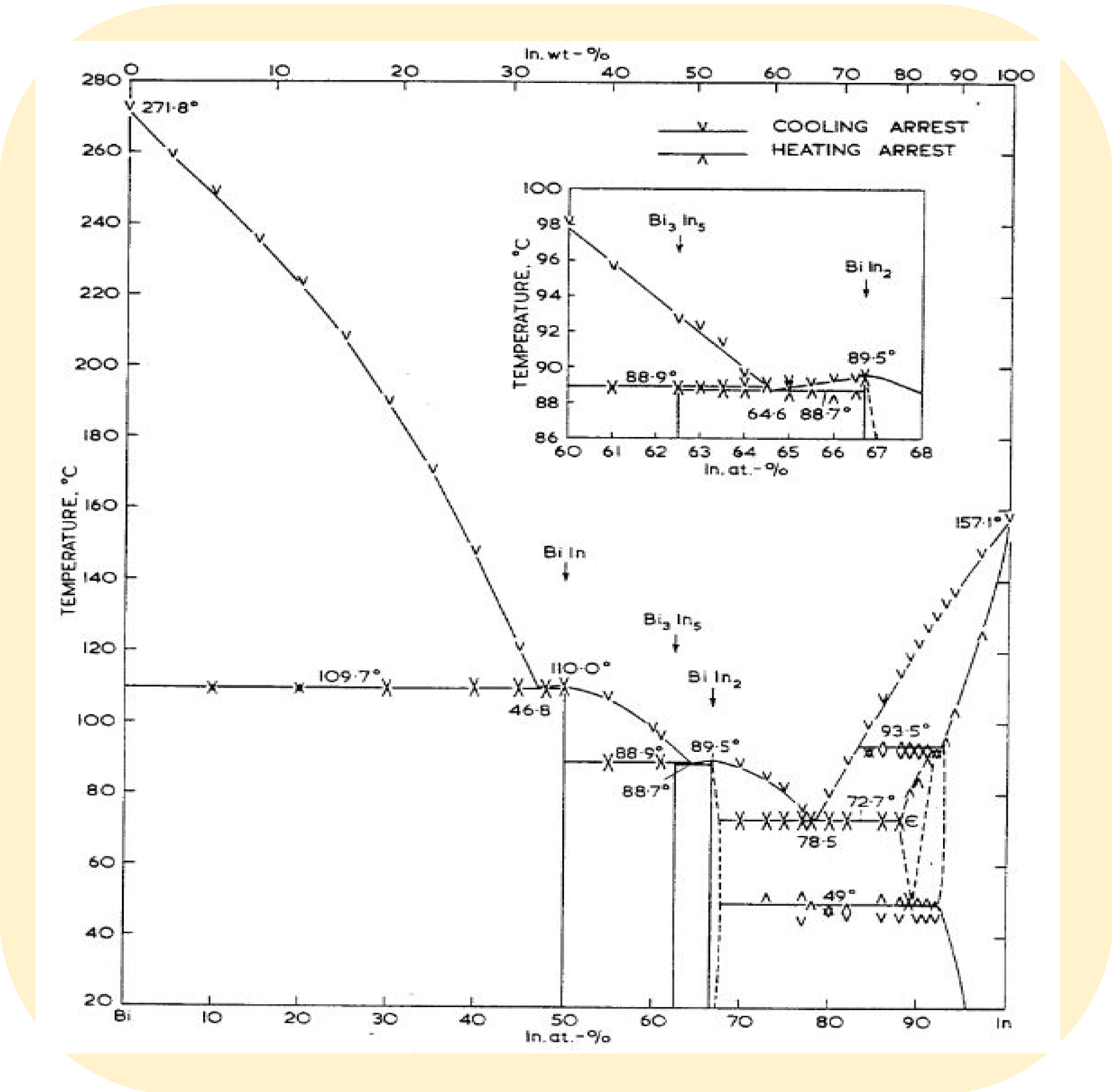
I. Introduction

Soldering of highly stress-sensitive electronic devices (e.g. Infrared detectors, photodiodes, Si-based photo multipliers (SiPM), etc.) to printed boards is a delicate issue.
Thermo-mechanical stresses built up from cool down after soldering can profoundly affect the overall performance of such devices.
To mitigate this negative effect, soldering temperature has to be kept as low as possible.

Bi-In based alloys are serious candidates for two reasons:

- The materials are inexpensive and available in sufficient quantity
- Several binary compounds and eutectic compositions exist in the Bi-In system with melting point (liquidus temperature) below 120 °C.



The binary Bi-In phase diagram [1]

It is an ordered alloy, considered as low temperature “counterpart” of a superalloy. The composition Bi51%-In49% is a near eutectic alloy having a eutectic melting temperature of 88.9°C.
Constituent phases are all 100% intermetallic compounds (Bi_3In_5 and $BiIn_2$). According to literature [2] to having very good creep resistance, ductility and strength retention.

II. Vapour Phase Soldering Technology

Vapour phase soldering is a technology very well suited for soldering objects of high thermal mass.
The latent heat of condensation of the boiling liquid is used to provide heat for the soldering.

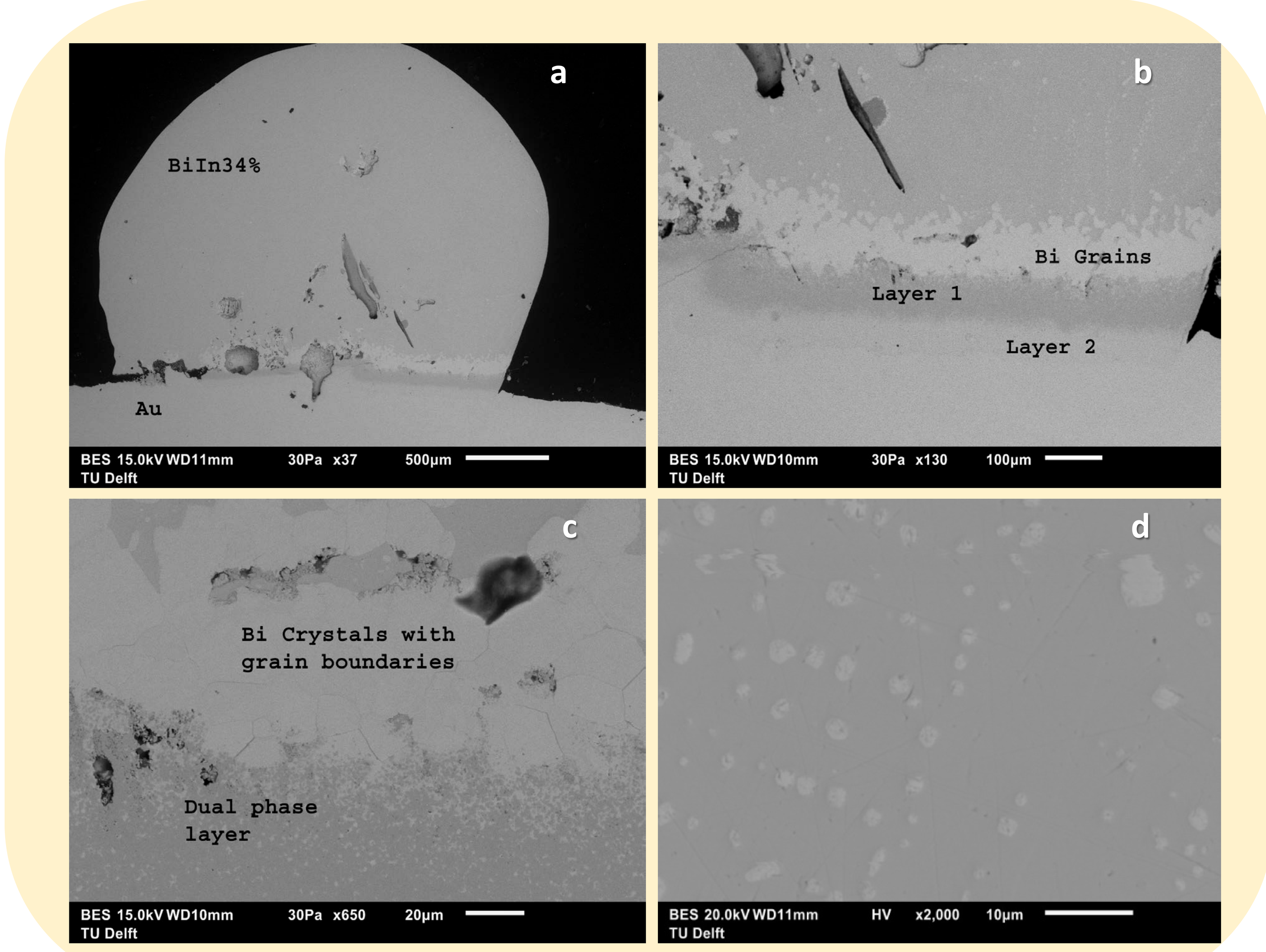
The peak soldering temperature is the boiling temperature of the inert liquid at atmospheric pressure.
It heats uniformly, and no part on the surface (irrespective of its geometry) exceeds the fluid-boiling temperature.

In our case a low boiling carboxylic acid formulation was used to provide both the heat and flux action. This approach leaves no potential corrosive residues after soldering.

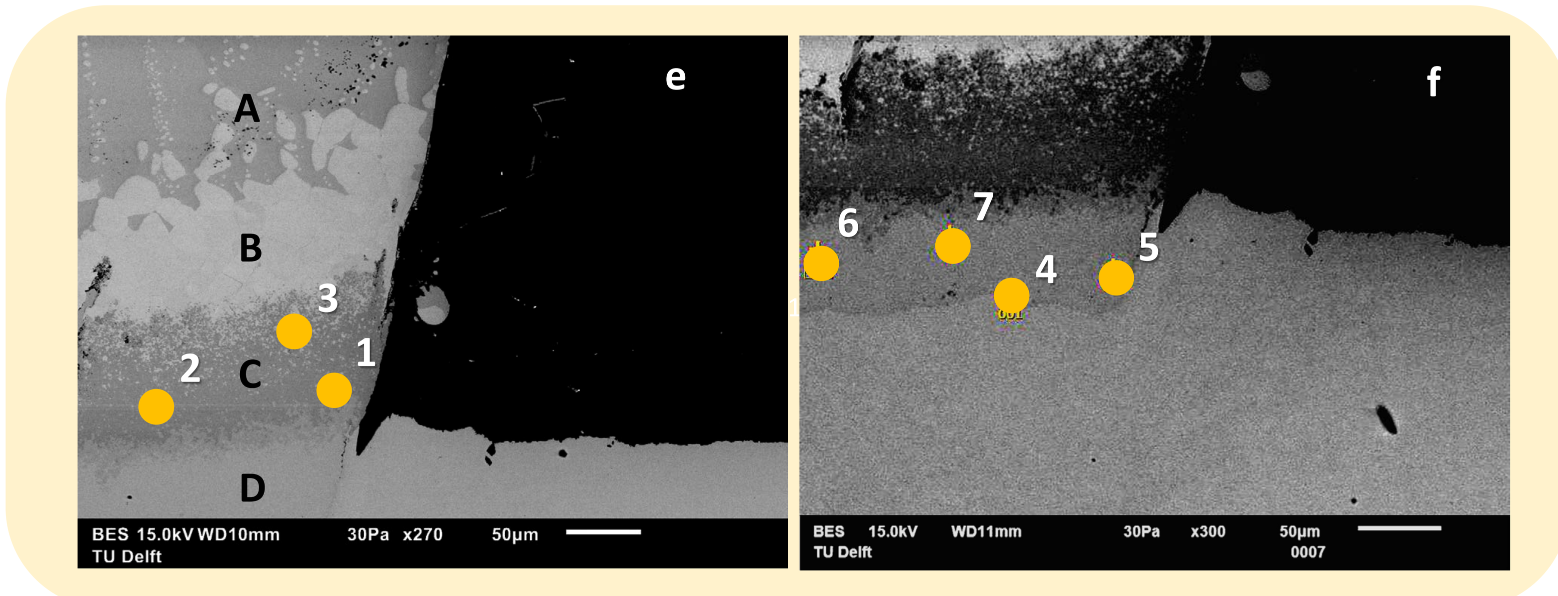
III. Annealing Procedure

Samples with the reflow composition of Bi67%-In33% were aged inside an air furnace at 85°C for 720 hours.

IV. Results for aged $Bi_{66}In_{34}$ on Au



Scanning electron micrographs after ageing for 720h at 85°C in air of a) reflowed and aged solder on gold substrate b) intermetallic layers at the triple point with a layer of Bi grains c) a dual phase intermetallic layer growth d) microstructure within the bulk solder with Bi grains etched out



In fig. e) A is the unperturbed solder Bi66In34. The area indicated with B consists mainly of pure recrystallized Bi, resulting from the depletion of the Indium, which has merged with the Au.
The C and D areas have been analyzed using EDS in standardless point analysis mode at different locations to determine the average concentration in wt%. It is found that in layer C, hosting points 1,2 and 3, the composition is Au 54.6 wt% and In 45.3 wt%.
In layer D, shown in fig. f) hosting points 4,5,6 and 7 the composition is Au 81.4 wt% and In 18.3% wt%.

V. Discussion

The EDS Analysis confirms that there is no Bi within the intermetallic. This can also be visually seen in image d, where it is clearly visible that the Bi grains are “left behind” within the solder, whilst only In interacting with the Au interface.
XRD analysis further confirms this hypothesis as only $AuIn_2$ is detected at the interface of the reaction surface.

VI. Resume

- Samples of Ag, Ni and Pd show no detectable growth diffusion layer.
- Samples of Cu show severe intermetallic formation
- Lack of a ‘visual’ layer does not mean there is no diffusion. This points to the need of the samples to be aged for more time to expedite this process of forming and intermetallic. This apparent lack of diffusion is due to the larger incubation time that is needed for these substrates to start the diffusion process.

VII. References

1. Dinsdale, A, Vizdal, J, “Atlas of phase diagrams for lead free soldering”, COST531, Volume 1, 2008.
2. Ueshima, M, Sugomito, J, Proc. ECTC, 2008, pages 1265-1271.