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DISSOLUTION BEHAVIOR OF COPPER ALLOYS IN Sn-BASED SOLDERS

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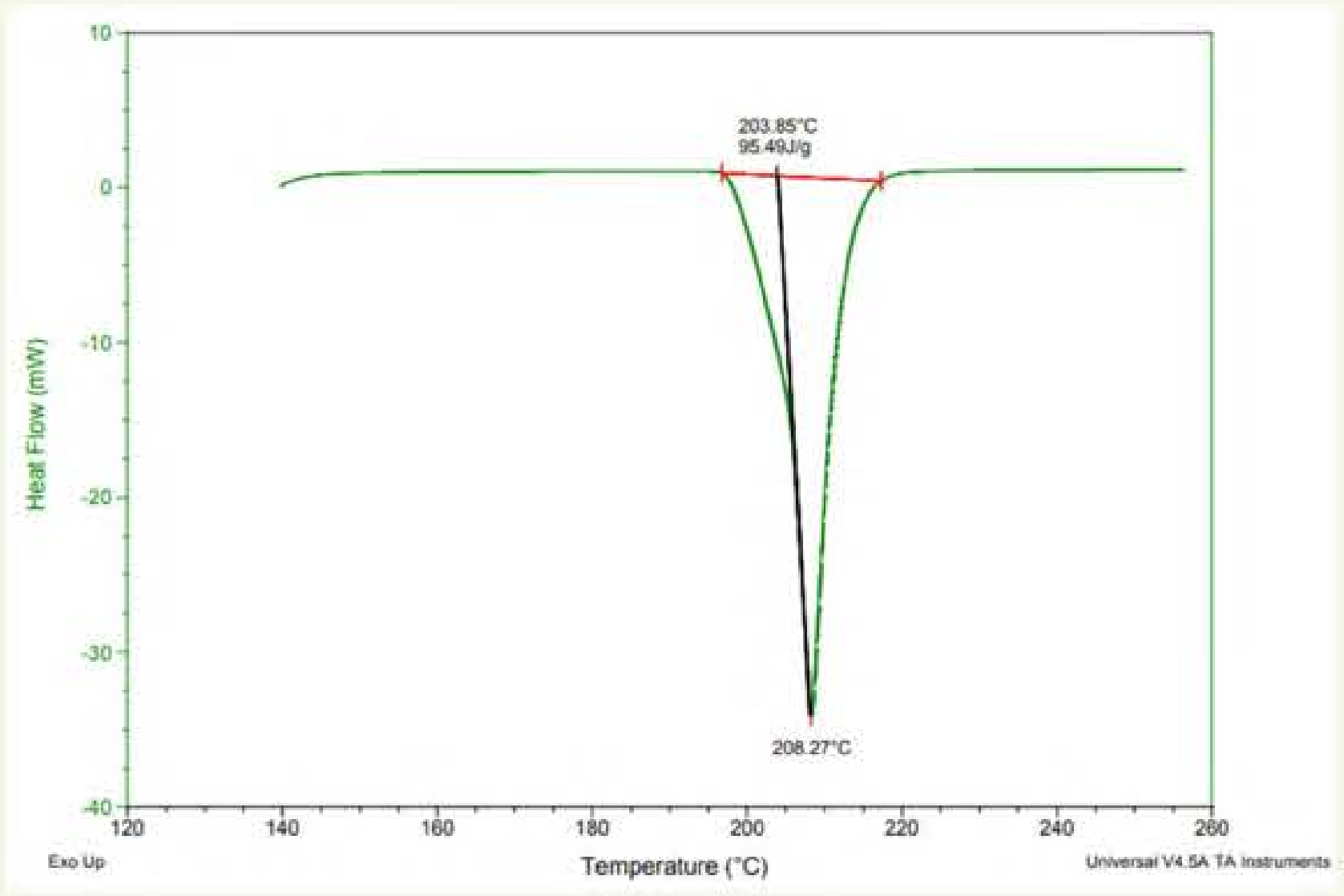
INTRODUCTION

The behavior of metal substrates, intermetallic compounds (IMCs), and molten solders has a significant impact on the soldering process. It is particularly crucial to control the dissolution of substrates during soldering, wave soldering, and reflow. By adding appropriate alloying elements, the development of interfacial IMCs and substrate dissolution behavior can be regulated. The addition of Be, Fe, or P to a pure Cu substrate shows improved mechanical properties and holds promise as an alternative. This study aims to investigate the dissolution behavior of Cu alloy substrates (+Be, +Fe, +P) in various Sn-based solders with the addition of Ag, Bi, Cu, or Zn. The study confirms and analyzes the liquid-solid interactions through materials characterization procedures. The dissolution data and behaviors presented in this study offer valuable insights for the advancement of electronic packaging.

RESULTS

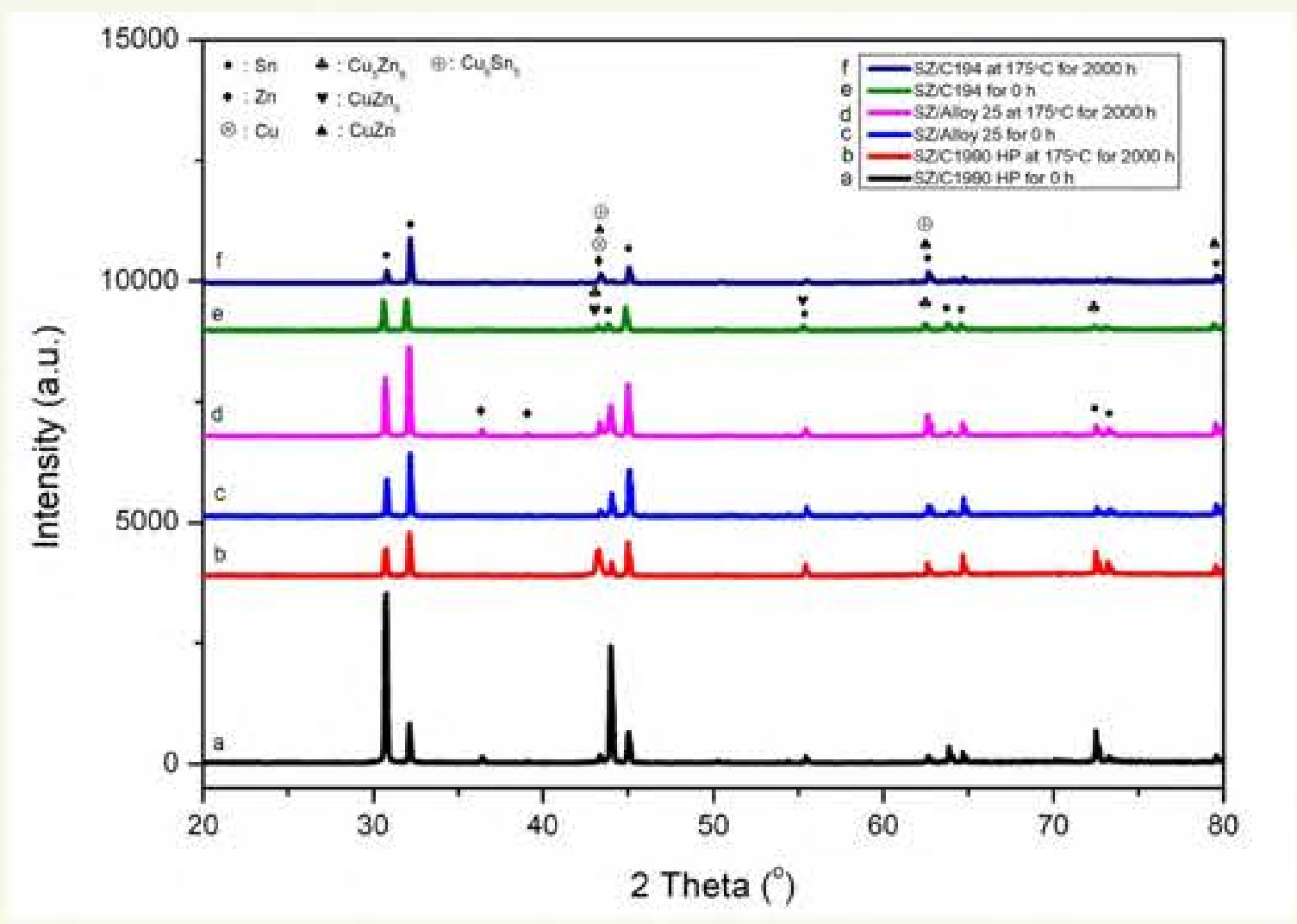
DSC

Fig 1.



XRD

Fig 2.



SEM

Fig 3.

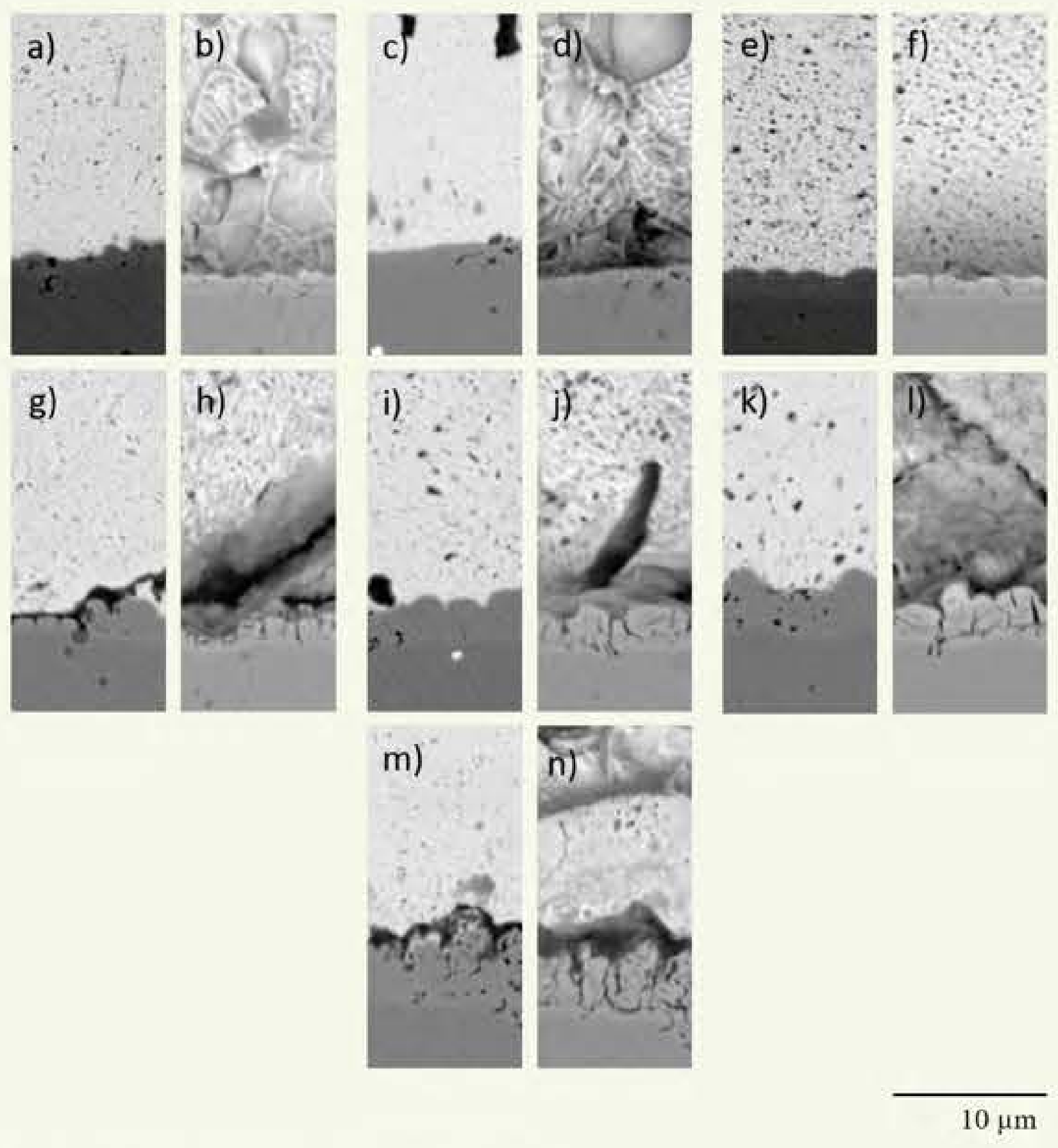


Fig 1. DSC curves of alloy Sn-9.0wt.% Zn (Sn-9Zn). This analysis is carried out before the reaction to determine the thermal properties of the solder.

Fig 2. XRD patterns of the Sn-9Zn/Cu-Ti (C1990 HP), Sn-9Zn/Cu-Be (Alloy 25), and Sn-9Zn/Cu-Fe (C194) couples aged at 0 and 2000 h. In general, the phases formed in the Sn-9Zn interface reaction with Cu-Alloy are Cu_5Zn_8 and $CuZn_5$.

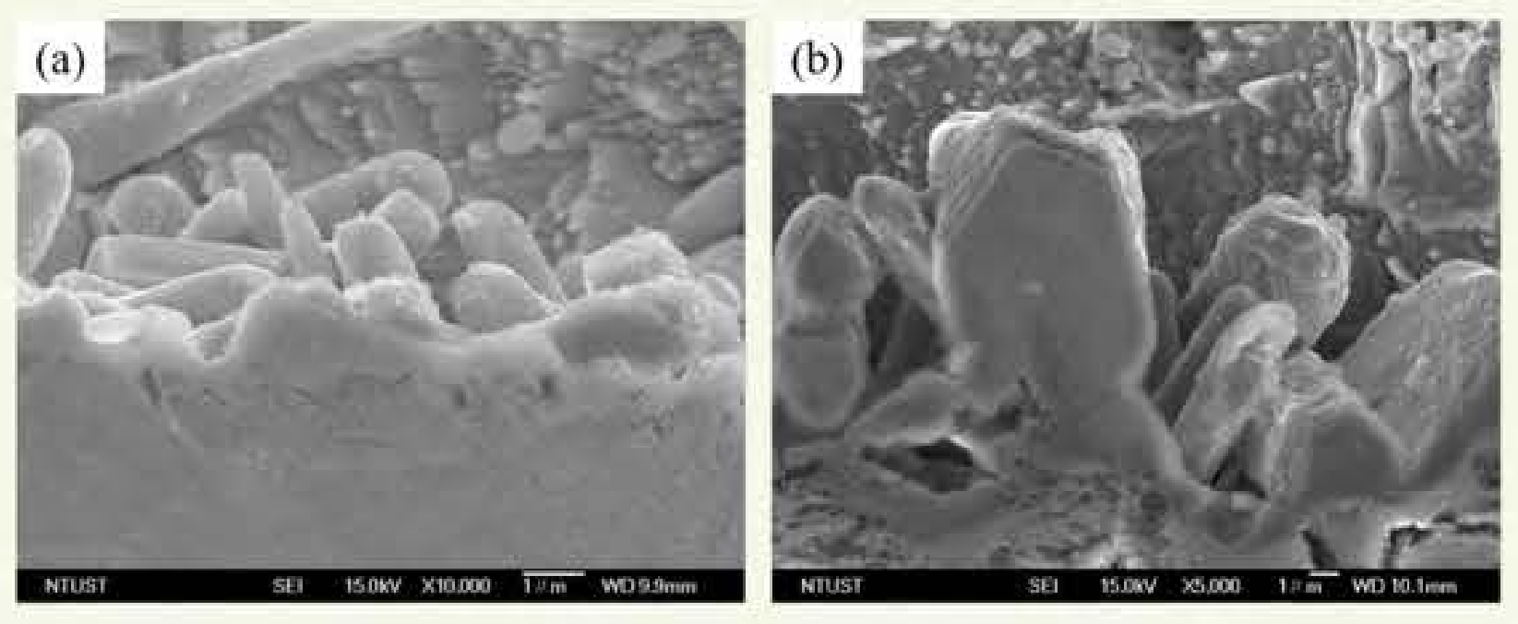
Fig. 3. BEI Micrographs of Sn-9Zn/Cu-Be (Alloy 25) couples for 240 °C for at (a-b) 5 min; (c-d) 10 min; (e-f) 20 min; (g-h) 30 min; (i-j) 45 min, (k-l) 70 min, (m-n) 100 min. Before etching (a, c, e, g, i, k, m) and after etching (b, d, f, h, j, l, n). These results indicate that a dense layer with slow growth of intermetallic compound inhibits substrate consumption.

Fig. 4. SEI image of the interface exposed by the acid etching of the Sn/Cu-Be (Alloy 25) couple. Increasing reaction time from (a) 5 min to (b) 70 min at 240 °C with growth more enormous in grain dimension accelerates the dissolution behavior of the Alloy 25 substrate into the molten solder during the reaction

Fig. 5. EDS analysis with the existence of minor elements of (a) Sn/Cu-Fe-P (C12910), (b) Sn-3.0wt.% Ag 0.5wt.% Cu/-Cu-Fe-P (C19210), (c) Sn/Cu-Be (Alloy 25), and (d) Sn-3.0wt.% Ag 0.5wt.% Cu/Cu-Be (Alloy 25) reaction couples at interface.

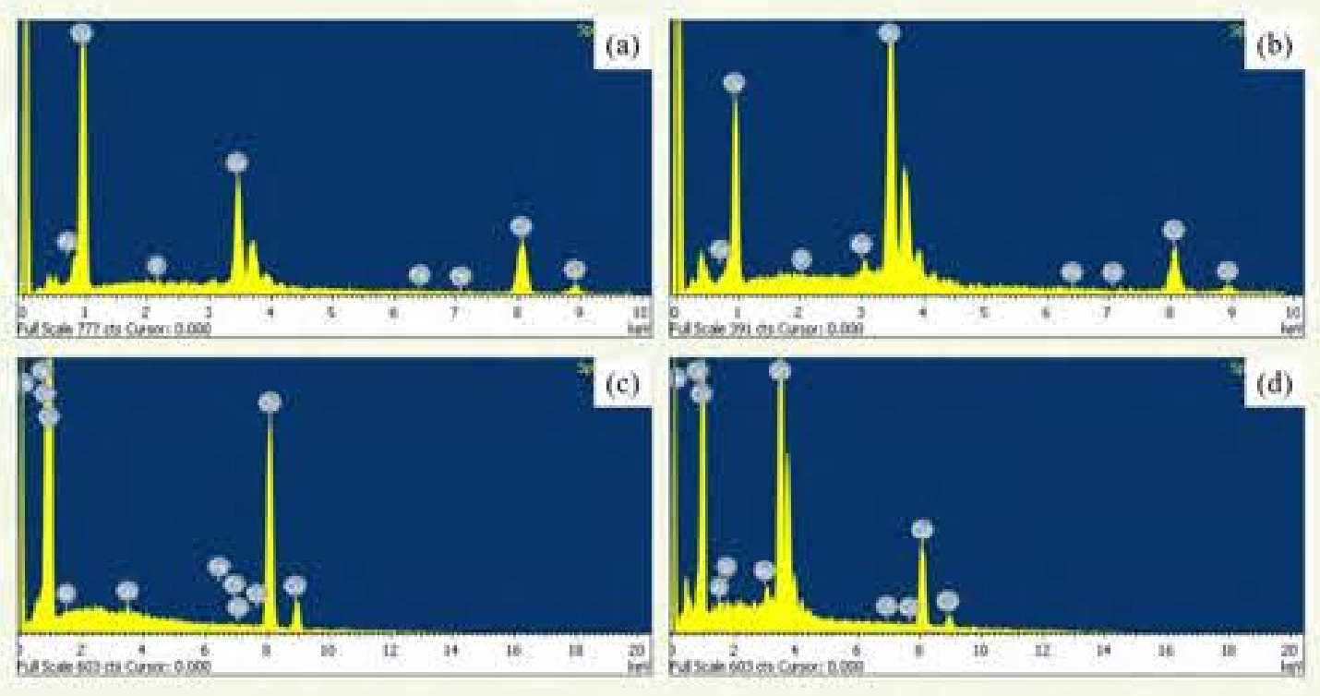
DEEP-ETCHED SEM

Fig 4.



EDS

Fig 5.



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CALCULATION OF PHASE DIAGRAM

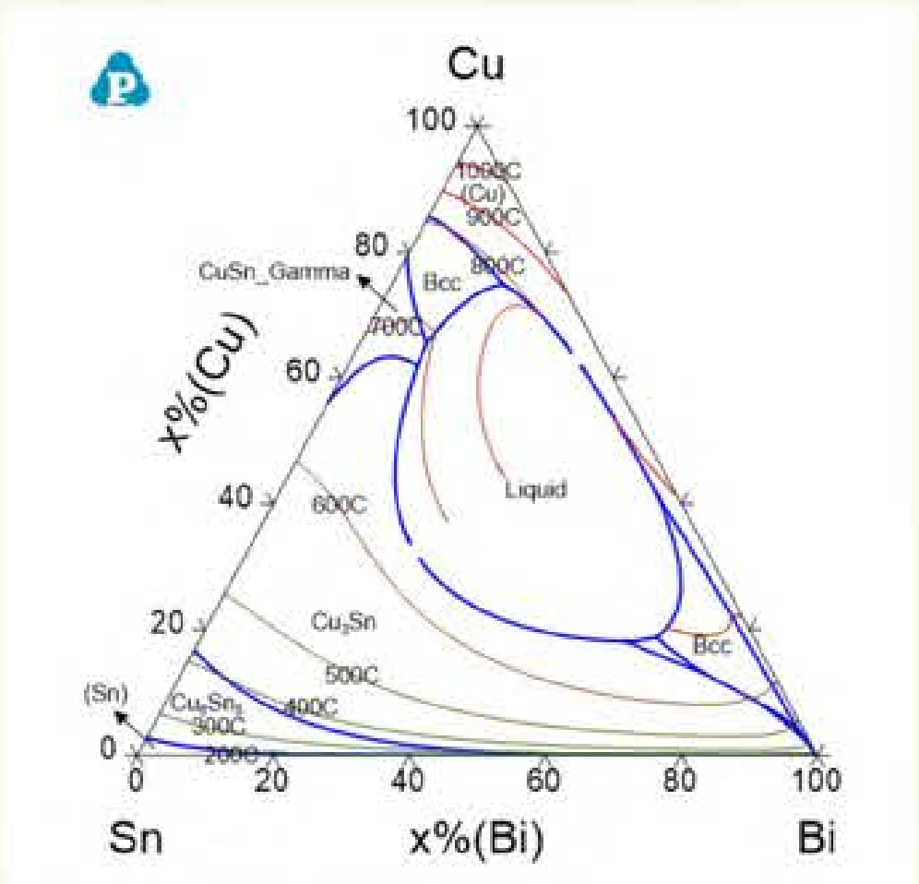

Fig. 6. Calculated Liquidus Projection of Bi-Cu-Sn. The calculation is to predict the phase that will form at a certain temperature

TEM

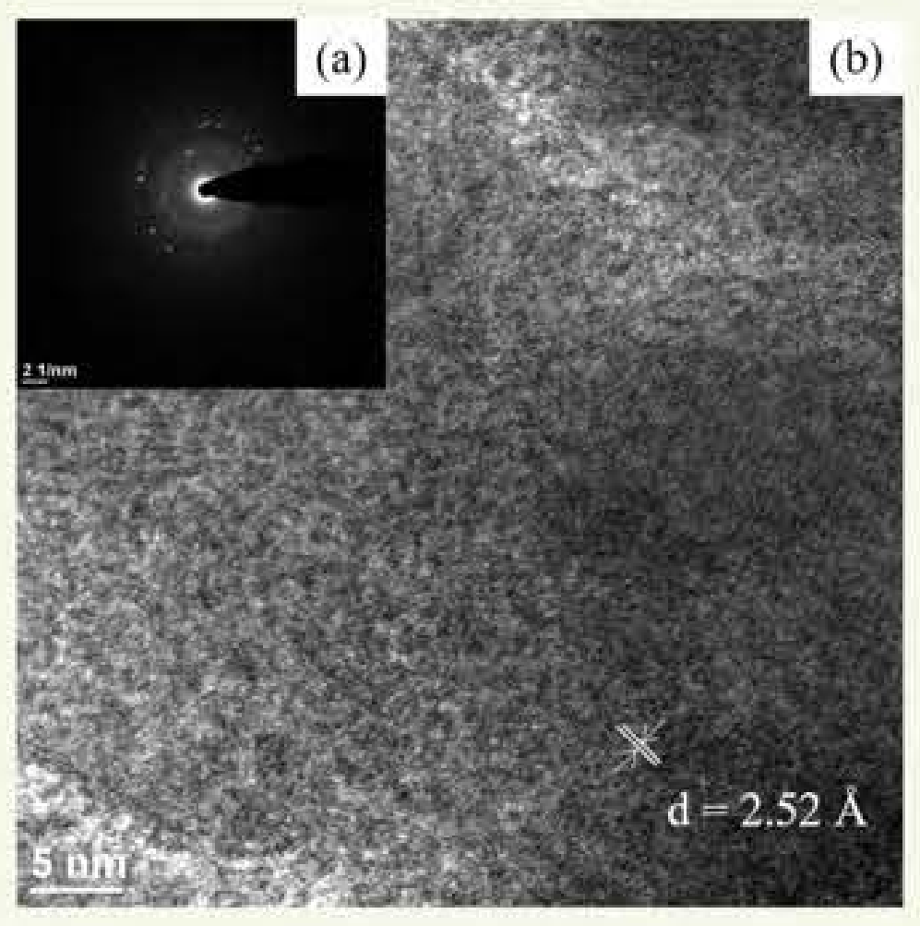

Fig. 7. Selected area electron diffraction and (b) High-resolution transmission electron microscopy at the Sn-58.0wt.% Bi /Cu-Be (Alloy 25) interface. There is a polycrystalline structure formed.

DISSOLUTION DATA

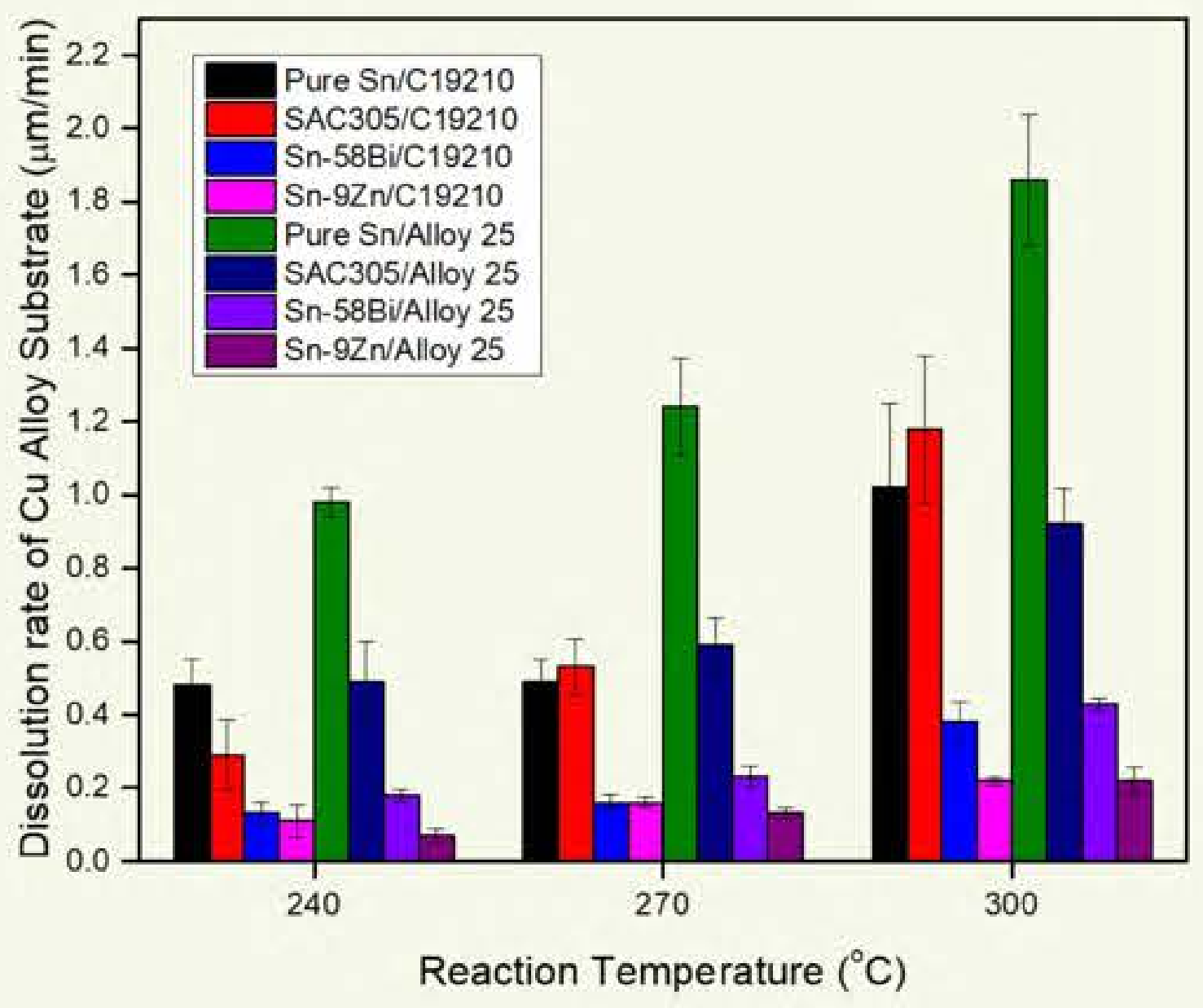

Fig. 8. Histograms of dissolution rates of Cu alloy substrates in molten lead-free solders (LFSs) at various reaction temperatures.

DISSOLUTION MECHANISM

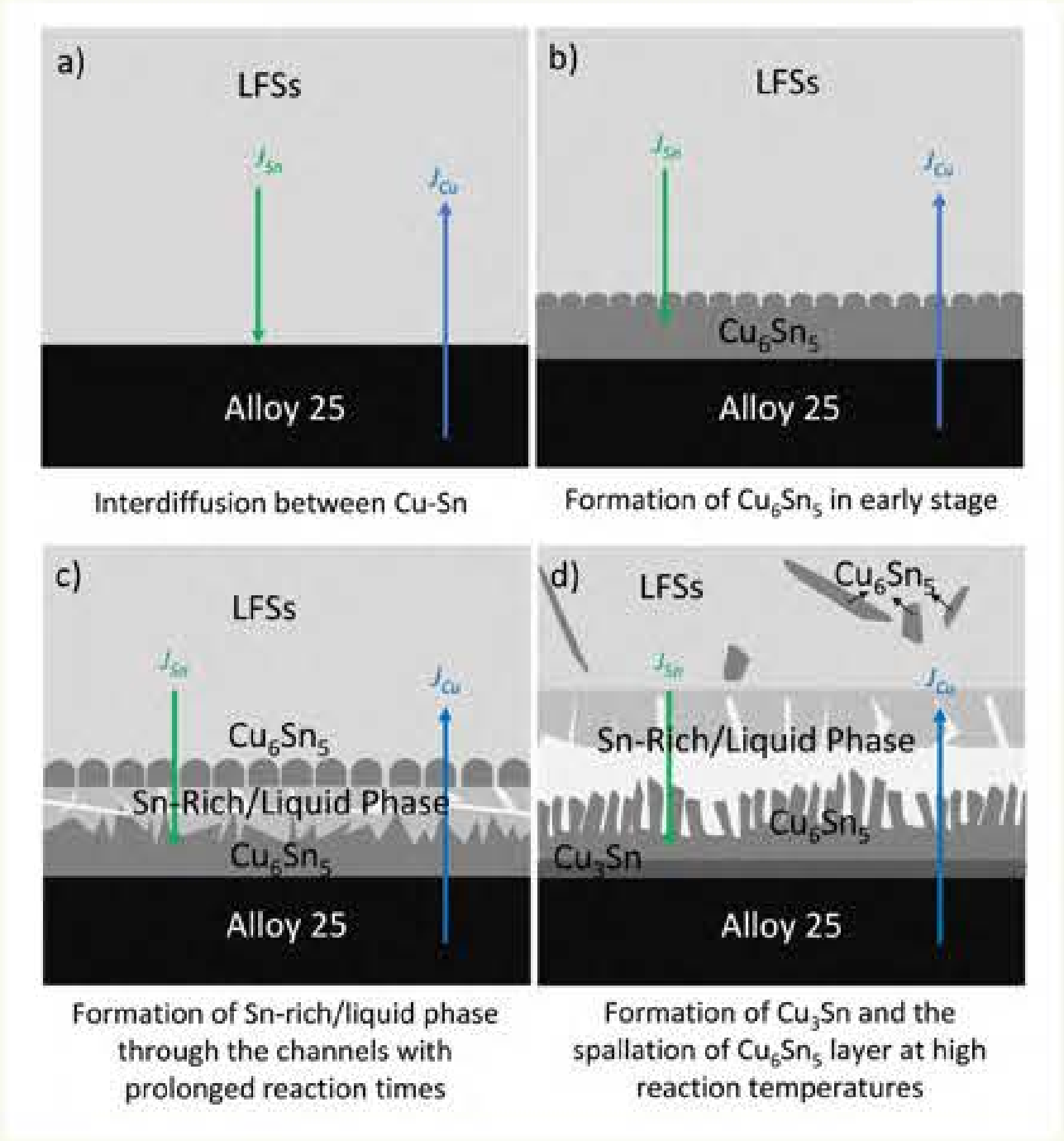

Fig. 9. The dissolution mechanisms of Alloy 25 substrate into LFSs during the liquid/solid reaction proposed in this study.

SUMMARY

The characterization shows that the effect of elements is very influential on the inhibition of substrate dissolution, especially in Bi, Zn, and Be.
The primary factors affecting substrate dissolution behavior are the diffusion and formation of intermetallic compound, both of which are influenced by the presence of additive elements.

RESEARCH EXPERIENCE

- **2016-2018** : Master degree research project on Cu-Sn-Ti reaction couple system: (Microelectron. Reliab. 96 (2019): 29-36) and (Mater. Sci. Forum. 964 (2019): 263-269). MSE, NTUST.
- **2018-2021** : Assistant professor research project on Cu-Sn-Bi reaction couple system: (J. Tribol. 33 (2022): 71-79). Institut Teknologi Kalimantan, Indonesia.
- **2021-now** : PhD Candidate in Department of MSE, NTUST with topic dissolution behavior of Cu-alloys in molten lead-free solders: (Metals 13 (2022): 12) and (JOM 75 (2023): 1889-1901). Taiwan.

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