POLİTEKNİK DERGİSİ

JOURNAL of POLYTECHNIC

ISSN:1302-0900 (PRINT), ISSN: 2147-9429 (ONLINE)

URL: http://dergipark.gov.tr/politeknik

Effect of melting temperature on wettability of Sn-Ag-Cu alloys on Cu Substrate

Ergime sıcaklığının Cu altlık üzerinde Sn-Ag-Cu alaşımlarının ıslatabilirliğine etkisi

***Yazar(lar) (Author(s))**: Ahmet Mustafa ERER*

ORCID: 0000-0003-4358-4010

Bu makaleye şu şekilde atıfta bulunabilirsiniz(To cite to this article): Erer A.M., "Effect of melting temperature on wettability of Sn-Ag-Cu alloys on Cu substrate", ***Politeknik Dergisi***, 21(3): 587-589, (2018).

Erişim linki(To link to this article):http://dergipark.gov.tr/politeknik/archive

DOI: 10.2339/politeknik.399077

Effect of Melting Temperature on Wettability of Sn-Ag-Cu Alloys on Cu Substrate

Araştırma Makalesi / Reseacrh Article

Ahmet Mustafa ERER*

Science Faculty, Physics Department, Karabük Universty, Turkey

(Geliş/Received : 26.04.2017 ; Kabul/Accepted : 29.05.2017)

ABSTRACT

In this study, effect of melting temperatures of Sn-3Ag (SAC300), Sn-3Ag-0.5Cu (SAC305) and Sn-0.3Ag-0.7Cu (SAC0307) ternary Pb-free solder alloys on wettability were investigated. The sessile drop technique was used in order to evaluate the contact angles of Pb-free solder alloys on Cu substrate at predetermined temperatures (250, 280 and 310 ℃). The melting temperatures of alloys were examined by differential scanning calorimeter (DSC) that SAC305 Pb-free alloy has lower than those of SAC300 and SAC0307 alloys. The best wettability was found for SAC305 and this was followed by SAC300 and SAC0307. The lowest value of contact angle for SAC305 was 41.90° at 310 ℃ on Cu substrate.

Keywords: Contact angle, melting temperature, wettability.

Ergime Sıcaklığının Cu Altlık Üzerinde Sn-Ag-Cu Alaşımlarının Islatabilirliğine Etkisi

ÖZ

Bu çalışmada, Sn-3Ag (SAC300), Sn-3Ag-0.5Cu (SAC305) and Sn-0.3Ag-0.7Cu (SAC0307) dörtlü kurşunsuz lehim alaşımlarının ergime sıcaklıklarının ıslatabilirliğine etkisi araştırılmıştır. Önceden belirlenmiş sıcaklıklarda (250, 280 and 310 ℃) Cu altlık üzerinde kurşunsuz lehim alaşımlarının temas açılarını belirlemek için Sessile damla tekniği kullanılmıştır. Alaşımların ergime sıcaklıkları diferansiyel tarama kalorimetresi ile incelendi. Buna göre SAC305 kurşunsuz lehim alaşımının ergime sıcaklığı, diğer SAC300 ve SAC0307 alaşımlarınınkinden daha düşüktür. SAC305 alaşımının en iyi ıslatabilirliğe sahip olduğu bulunmuştur ve bunu sırasıyla SAC300 ve SAC0307 alaşımları takip etmektedir. En küçük açı değeri, SAC305 için Cu altlık üzerinde ve 310℃ 'de 41.90° 'dir.

Anahtar Kelimeler: Temas açısı, ergime sıcaklığı, ıslatabilirlik

1. INTRODUCTION

For the last 20 years, the restriction of lead in industrial fields has been strongly supported because of the environmental protection on trial chamber of air, water and soil [1]. This tendency was reinforced in Europe by the RoHS and WEEE directives [2]. That's why, instead of Sn–Pb lead solder alloys utilized by the electronic industry as a solder material, required works are spent in development of alternative alloys. In susceptible studies, since melting temperature was reported at a point close to the eutectic Sn– Pb alloy (198℃) and they have low-cost, SAC300, SAC305 and SAC0307 Pb-free solder alloys were taken into consideration [3].

A Pb-free solder alloy drop spreads to enlarge on the Cu substrate and comes to rest making an angle.

Under equilibrium conditions this angle is called contact angle which is decided by the surface and interfacial tensions. It is usually accepted that the smaller the contact angle, the better the wettability [5]. In order to get perfect wettability of Pb-free solder alloys as substitutes for Sn-Pb solder alloys, Sn-Ag-Cu alloy systems have been studied in the previous work [6-9]. However, effect of melting temperature on contact angle must also be studied. The aim of this study is to investigate and to compare the wettability of SAC300, SAC305 and SAC0307 alloys which is effected by melting temperature on Cu substrate in Ar atmosphere

The solderability is directly related to the wettability of two surfaces being joined. The efficiency of manufacturing and reliability of electronic devices depend upon the quality of solderability thus wettability [4].

Wettability generally involves the measurement of contact angles as the primary data, which specifies the degree of wetting when a solid and liquid interact. Thus, the measurement of the contact angle gives an estimate on wetting behaviour. To determine the wettability of a solid metal substrate by molten solder alloy, Young's equation is conventionally used:

$$\cos\theta = \gamma_{SV} - \gamma_{SL}/\gamma_{LV}$$

2. MATERIALS AND METHOD

In this work, SAC300, SAC305 and SAC0307 Pb-free solder alloys and oxygen-free Cu were chosen as the soldering materials and the substrate, respectively. The

chemical compositions of the studied Pb-free solder alloys are listed in Table-1.

Casio-Pro EX-F1, 600 FPS Model camera employed to capture views of drops at the 5th, 10th, 15th, 30th, 60th, 90th, 120th and 150th seconds and these analysis were carried out while specimens in maximum 30 mg weight and at 40-300 °C temperature range (5 min.) [10]

Table 1. Chemical composition of Pb-free solder alloys (wt. %)

Pb-free alloys	Ag	Cu	Sb	Bi	Pb	As	Sn
SAC300	3,05	0,05	0,12	0,1	0,1	0,03	Rest
SAC305	2,98	0,52	0,1	0,1	0,1	0,03	Rest
SAC0307	0,35	0,73	0,05	0,05	0,1	0,01	Rest

At present, in determination of wetting properties of SAC300, SAC305 and SAC0307 ternary lead free solder alloys, 99.85% pure electrolytic copper substrate were used. the wetting tests made by the Sessile drop technique. By means of this technique, SAC300, SAC305 and SAC0307 ternary lead free solder alloys were dropped on copper substrate at various temperatures of 250, 280 and 310℃. Images were transferred into Corel Draw X-5 Software to measure contact angles of each drop from the right and left profiles. Because of these processes repeated for each temperature, mean angle values were calculated and new diagrams were drawn through the Sigma Plot 12.0 Software. To determine melting temperatures of alloys, the DSC

3. RESULTS AND DISCUSSIONS

Fig. 1 shows the relationship between the contact angle and the temperature and the time. For SAC300, SAC305 and SAC0307 Pb-free solder alloys, the contact angle has not decrease suddenly with temperature but changes with time. A sharp decrease in the contact angle was observed for the Pb-free solder alloys at each temperature for approximately the first 30 s. The values of contact angle exhibit the degree of wettability [11].

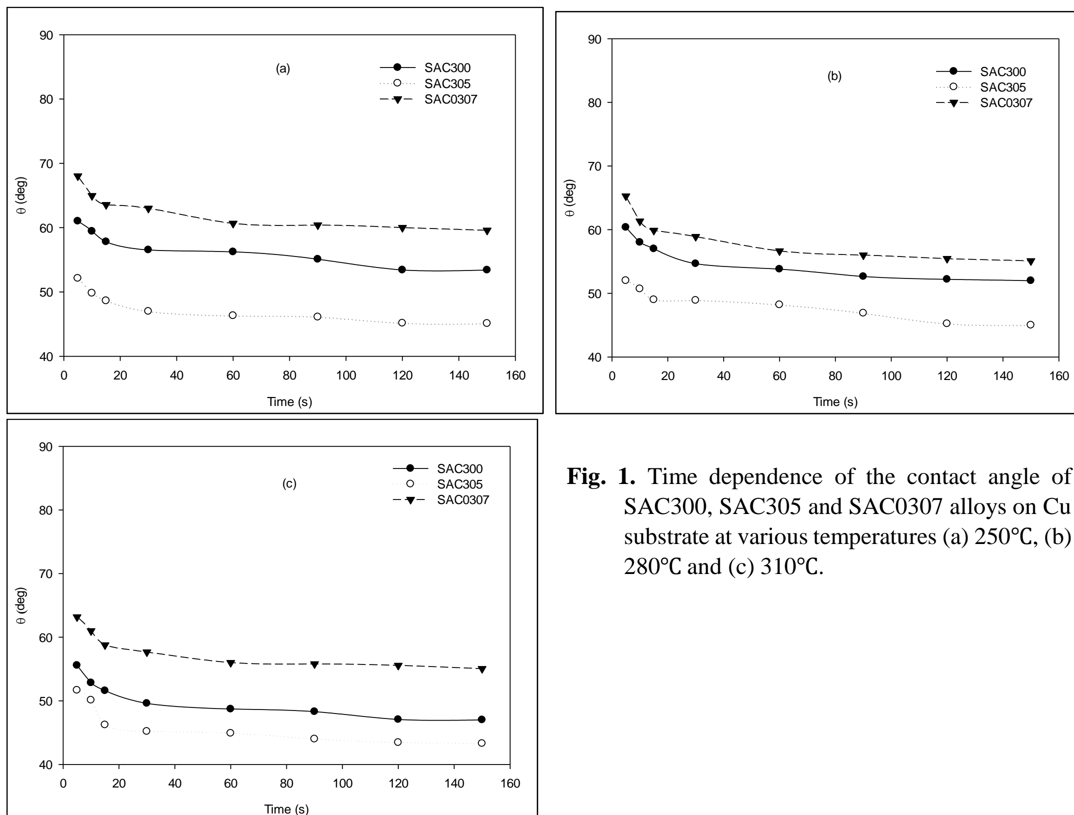

Fig. 1. Time dependence of the contact angle of SAC300, SAC305 and SAC0307 alloys on Cu substrate at various temperatures (a) 250℃, (b) 280℃ and (c) 310℃.

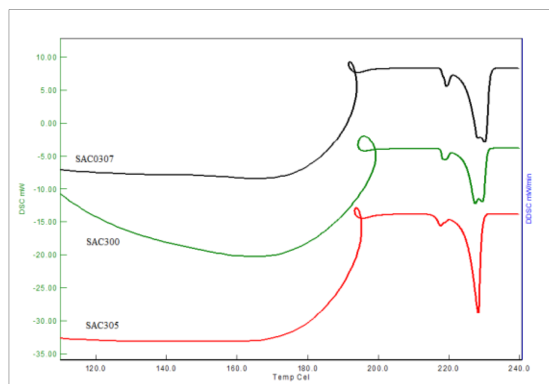

Fig. 2. DSC analysis results of SAC300, SAC305 and SAC0307 alloys.

According to DSC analysis results, the melting temperature of SAC305 is lower than those of SAC300 and SAC0307. That is, It has lowest melting temperature, 217.8 ℃ [8, 9, 11, 12]. Thus, the wettability of SAC305 Pb-free solder alloy is better than those of SAC300 and SAC0307 Pb-free solder alloys.

4. CONCLUSION

In summary, effect of melting temperature on contact angle of SAC300, SAC305 and SAC0307 Pb-free solder alloys on wettability were investigated by the sessile drop method in Ar atmosphere. The experimental results showed that equilibrium contact angles (θ) proportionally decreased with increasing temperature. The lowest θ and melting temperature was obtained as 41,90° and 217.8 ℃ respectively for SAC305 Pb-free solder alloy.

REFERENCES

[1] Çağlarırmak, N., Hepçimen, A. Z., "Effect of Heavy Metal Soil Pollution on Food Chain and Human Health", ***Akademik Gıda,*** 8(2): 31-35 (2010).

[2] Das, S.K., Sharif, A., Chan, Y.C., Wong, N.B., Yung, W.K.C., " Influence of small amount of Al and Cu on the microstructure, microhardness and tensile properties of Sn–9Zn binary eutectic solder alloy", ***J. Alloys Comp.,*** 481(1-2): 167-172 (2009).

[3] Yang M., Ji H., Wang S., Ko Y.H., Lee C. W., Wu J., Li M. "Effects of Ag content on the interfacial reactions between liquid Sn-Ag-Cu solders and Cu substrates during soldering" ***Journal of Alloys and Compounds,*** 679:18-25, (2016).

[4] Duong, N. B.,Ariga, T., Hussain,L. B. and Ismail, A. B., " Wettability of lead-free solders on gold-plated copper substrates", ***Materials Transactions,*** 49(6): 1462-1466 (2008).

[5] Yoon, S. W.,Choi,W. K. and Lee, H. M., "Interfacial reaction between Sn-1Bi-5In-9Zn solder and Cu substrate***", Scripta Materialia,*** 40(3): 297–302 (1999).

[6] Yuan, Y., Lee, T. R., " Contact Angle and Wetting Properties", ***Surface Science Techniques***, Springer Series in Surface Sciences, 51: 3-34 (2013).

[7] Kumar, G., Prabhu, K. N., "Review of non-reactive and reactive wetting of liquids on surfaces", ***Advances in Colloid and Interface Science,*** 133(2): 61–89 (2007).

[8] Zhang, X.,Yuan, Z., Zhao, H., Zang, L. and LI, J., "Wetting behavior and interfacial characteristic of Sn-Ag-Cu solder alloy on Cu substrate" ***Chinese Science Bulletin,*** 55(9): 797-801 (2010).

[9] Zhang, X., Matsuura, H.,Tsukihashi, F.and Yuan,Z., " Effect of Addition of Small Amount of Zinc on Microstructural Evolution and Thermal Shock Behavior in Low-Ag SnAgCu Solder Joints during Thermal Cycling", ***Material Transactions,*** 53(5): 926-931 (2012).

[10] Omac, F., Ozyurek, D.and Erer, M., "Investigation of the Wetting Properties of Ternary Lead-Free Solder Alloys on Copper Substrate", ***Acta Physica Polonocia- A,*** 131(1):165-167 (2017).

[11] Erer, A. M., Candan, E., Güven, M. H., Turen, Y., "Measurement and prediction of contact angles of Pb-free SnAg solder alloys on Cu substrate", ***Eur. Phys. J. Appl. Phys.*****,** 54(1), 1-4, (2011).