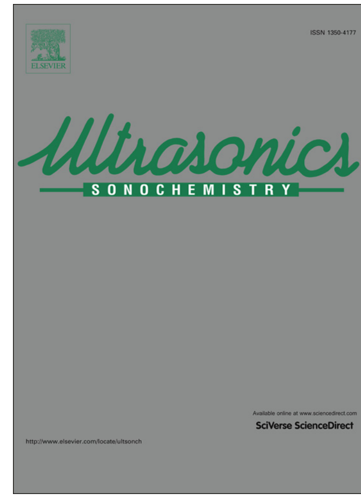
Accepted Manuscript



Interactions at the planar Ag_3Sn/liquid Sn interface under ultrasonic irradiation

Huakai Shao, Aiping Wu, Yudian Bao, Yue Zhao, Lei Liu, Guisheng Zou

PII: S1350-4177(17)30264-X
DOI: http://dx.doi.org/10.1016/j.ultsonch.2017.05.042
Reference: ULTSON 3723

To appear in: *Ultrasonics Sonochemistry*

Received Date: 12 May 2017
Revised Date: 31 May 2017
Accepted Date: 31 May 2017

Please cite this article as: H. Shao, A. Wu, Y. Bao, Y. Zhao, L. Liu, G. Zou, Interactions at the planar Ag_3Sn/liquid Sn interface under ultrasonic irradiation, *Ultrasonics Sonochemistry* (2017), doi: http://dx.doi.org/10.1016/j.ultsonch.2017.05.042

Interactions at the planar Ag_3Sn/liquid Sn interface under ultrasonic irradiation

Huakai Shao[a], Aiping Wu[a,b,c], Yudian Bao[a], Yue Zhao[a,c], Lei Liu[a,b], Guisheng Zou[a,c]

[a] Department of Mechanical Engineering, Tsinghua University, Beijing 100084, China

[b] State Key Laboratory of Tribology, Tsinghua University, Beijing 100084, China

[c] Key Laboratory for Advanced Materials Processing Technology, Ministry of Education, Beijing 100084, China

Abstract: The interactions at the interface between planar Ag_3Sn and liquid Sn under ultrasonic irradiation were investigated. An intensive thermal grooving process occurred at Ag_3Sn grain boundaries due to ultrasonic effects. Without ultrasonic application, planar shape of Ag_3Sn layer gradually evolved into scalloped morphology after the solid-state Sn melting, due to a preferential dissolution of the intermetallic compounds from the regions at grain boundaries, which left behind the grooves embedding in the Ag_3Sn layer. Under the effect of ultrasonic, stable grooves could be rapidly generated within an extremely short time (<10 s) that was far less than the traditional soldering process (>10 min). In addition, the deepened grooves leaded to the formation of necks at the roots of Ag_3Sn grains, and further resulted in the strong detachment of intermetallic grains from the substrate. The intensive thermal grooving could promote the growth of Ag_3Sn grains in the vertical direction but restrain their coarsening in the horizontal direction, consequently, an elongated morphology was presented. All these phenomena could be attributed to the acoustic cavitation and streaming effects of ultrasonic vibration.

Key words: Soldering; Ultrasonic; Intermetallic compounds; Dissolution; Thermal grooving

1. Introduction

The demand for power devices operated at high temperatures is widely proposed in industrial applications such as automotive, aerospace, deep-well drilling and energy productions, which brings many challenges for chip materials and packaging technologies [1, 2]. In recent years, a wide band gap semiconductor technology has emerged in the electronics industry, such as silicon carbide (SiC) and gallium nitride (GaN), which possess superb electronic, physical, chemical and mechanical properties that enable them to withstand harsh environments (> 400 ℃), therefore, they have been confirmed as the potential semiconductors for the next generation of power nodules [2-4]. Traditional packaging materials and micro joining approaches cannot meet the requirements of power devices packaging, such that new low-temperature interconnection technology should be developed. As one of the most promising candidates, transient liquid phase (TLP) bonding can achieve the purpose of bonding at low temperatures (< 300 ℃) while working at high temperatures due to the formation of intermetallic compounds (IMCs) joint. However, the TLP process is highly time-consuming, in most cases up to tens of minutes, due to relatively slow interfacial reaction [5].

Ultrasonic waves have been introduced to assist the TLP bonding because their applications can remarkably improve the joining efficiencies [6-9]. Previous studies propose that acoustic cavitation in the liquid solder induced by ultrasonic transmission directly impacts on the surface of bare substrate, which leads to a strong dissolution of the substrate elements into the melting interlayer; upon