Journal of ELECTRONIC MATERIALS, Vol. 42, No. 2, 2013
DOI: 10.1007/s11664-012-2340-y

The Role of Pd in Sn-Ag-Cu Solder Interconnect Mechanical Shock Performance

TAE-KYU LEE,[1,4] BITE ZHOU,[2] THOMAS R. BIELER,[2] CHIEN-FU TSENG,[3] and JENG-GONG DUH[3]

1.—Component Quality and Technology Group, Cisco Systems, Inc., San Jose, CA 95134, USA. 2.—Michigan State University, East Lansing, MI, USA. 3.—National Tsing Hua University, Hsinchu, Taiwan. 4.—e-mail: taeklee@cisco.com

The mechanical stability of solder joints with Pd added to Sn-Ag-Cu alloy with different aging conditions was investigated in a high-*G* level shock environment. A test vehicle with three different strain and shock level conditions in one board was used to identify the joint stability and failure modes. The results revealed that Pd provided stability at the package-side interface with an overall shock performance improvement of over 65% compared with the Sn-Ag-Cu alloy without Pd. A dependency on the pad structure was also identified. However, the strengthening mechanism was only observed in the non-solder mask defined (NSMD) pad design, whereas the solder mask defined (SMD) pad design boards showed no improvement in shock performance with Pd-added solders. The effects of Sn grain orientation on shock performance, interconnect stability, and crack propagation path with and without Pd are discussed. The SAC305 + Pd solder joints showed more grain refinements, recrystallization, and especially mechanical twin deformation during the shock test, which provides a partial explanation for the ability of SAC305 + Pd to absorb more shock-induced energy through active deformation compared with SAC305.

Key words: Pb-free solder, Pd, Sn orientation, shock test, interconnect, microalloying

INTRODUCTION

Recent trends in electronic devices toward lighter and more portable devices along with higher-functionality, components require improved mechanical stability and shock resistance.[1,2] To increase the stability against shock environments, an ideal system should consist of a flexible board and component that can absorb all the energy from the bending momentum, but given the fact that the silicon die is stiff for most components, there are limitations in flexibility. To absorb or endure shock, interconnections need to tolerate a mechanical strain which develops in a way that depends upon the interactions between the component location and the applied shock.[3–6] As already seen in other shock-related studies, the solder interconnects between a component and the printed circuit board (PCB) are one of the weakest connection points, often being the fracture site after applied shock.[7] However, as presented in an earlier publication, the weakest link can be shifted from the solder to adjacent interconnect interfaces; for example, the major failure mode for solder joints with non-solder mask defined (NSMD, Fig. 1) pads is actually laminate cracks (or cratering, as evident in Fig. 1c) rather than at the solder joint itself.[8] In contrast to NSMD pad boards, the solder mask defined (SMD) pad design reveals crack propagation along the board-side intermetallic compound (IMC) interface in Fig. 1d, which became the dominant fracture site in thermally aged SMD pad board designs.[9]

Given that the weakest interface changes with the package design, identifying methodologies or

(Received May 8, 2012; accepted October 29, 2012; published online December 11, 2012)