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Development and Status of Cu Ball/Wedge Bonding in 2012

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Starting in the 1980s and continuing right into the last decade, a great deal of research has been published on Cu ball/wedge (Cu B/W) wire bonding. Despite this, the technology has not been established in industrial manufacturing to any meaningful extent. Only spikes in the price of Au, improvements in equipment and techniques, and better understanding of the Cu wire-bonding process have seen Cu B/W bonding become more widespread—initially primarily for consumer goods manufacturing. Cu wire bonding is now expected to soon be used for at least 20% of all ball/wedge-bonded components, and its utilization in more sophisticated applications is around the corner. In light of this progress, the present paper comprehensively reviews the existing literature on this topic and discusses wire-bonding materials, equipment, and tools in the ongoing development of Cu B/W bonding technology. Key bonding techniques, such as flame-off, how to prevent damage to the chip (cratering), and bond formation on various common chip and substrate finishes are also described. Furthermore, apart from discussing quality assessment of Cu wire bonds in the initial state, the paper also provides an overview of Cu bonding reliability, in particular regarding Cu balls on Al metalization at high temperatures and in humidity (including under the influence of halide ions).

Key words: Wire bonding, Cu bonding, ball/wedge bonding, quality, reliability

INTRODUCTION

Over the last 20 years, thermosonic (TS) ball/wedge (B/W) bonding with Cu wire has cropped up time and again as a cost-efficient alternative to conventional Au wire when the price of the latter rises on the international markets, which Fig. 1 shows is currently the case.[1–5]

Advocates of Cu bonding have also continued to forward additional, hard to dispute arguments over the years, including Cu's superior electrical, thermal, and mechanical properties (Table I).

Furthermore, these studies also hold that Cu has superior reliability characteristics, particularly under high-temperature (150°C to 200°C) loading, due to the lower interdiffusion velocities of the Al-Cu compared with the Al-Au system. Here, aluminum (pure or as an alloy with Si and/or Cu) is currently the most widely used chip metalization, on which the first (ball) bond of an electric wire bond interconnect (loop) is manufactured.[1,2,4–8] In the 1980s, wire bonding was performed almost exclusively with Au wire, as the problems associated with Cu bonding were still too great[9–13] and as Cu has high propensity for oxidation and higher hardness (strength), including its tendency to more strongly work-harden compared with Au.[6,8] The latter led to challenges in the ball flame-off process (use of forming gas, control of the gas flow), optimization of the bonding parameters [avoiding cratering in the chip, splashing (squeezing out) of the bond pad's Al underneath the ball during bonding], and the need for specialized bonding capillaries.[1,2] Since these issues have been largely resolved and the process mastered, use of Cu has been growing steadily in an increasing number of application areas.[1,2,4,7] However, now

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