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Effect of Annealing Twins on Electromigration in Ag-8Au-3Pd Bonding Wires

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An innovative Ag-8Au-3Pd bonding wire with a high twin density has been produced. The grain size of this annealing-twinned wire changes moderately during electrical stressing, unlike that of the conventional grained wire, which increases drastically and even leads to a bamboo structure. In addition, the durability against electromigration of the annealing-twinned Ag-8Au-3Pd alloy wire is higher than that of the conventional grained wire. This higher durability can be ascribed to the surface reconstruction of a stepwise morphology and slow grain growth resulting from the abundance of annealing twins in this wire.

Key words: Electromigration, Ag-8Au-3Pd alloy wire, annealing twins, surface reconstruction

INTRODUCTION

Annealing twins may have the potential to improve material performance, and thus they have drawn much attention in recent years. It is known that twin boundaries have an interfacial energy of only 5% of the conventional high-angle grain boundary.[1] Based on this principle of physical metallurgy, annealing twins have been reported to have beneficial effects on the mechanical properties of structural materials such as austenitic stainless steel,[2] Ni-based superalloy,[3] and two-phase brass.[4] For electronic applications, Lu et al.[5,6] also reported that a pulsed electrodeposited Cu foil with a large amount of annealing twins possessed a tensile strength about 10 times higher than that of conventional coarse-grained specimens, while retaining an electrical conductivity comparable to that of pure copper. Chen et al.[7] further indicated that the interfacial structure and atomic diffusion behavior of grain boundaries in a Cu thin film were changed by the annealing twins, which retarded the electromigration by one order of magnitude.

Such an advantageous effect has also been verified in the development of high-performance bonding wire for electronic packages. In our previous study, an annealing-twinned Ag-8Au-3Pd alloy wire was shown to possess high thermal stability during high-temperature exposure. This new bonding wire exhibited negligible grain growth after prolonged air storage at 600°C for up to 180 min, whereas the grain size of traditional Au and Cu wires grew obviously under the same conditions.[8] In addition, the grain growth in a conventional Ag-8Au-3Pd bonding wire has been shown to be greater than that in the annealing-twinned wire.[9] What is even more attractive is that the annealing twins in this innovative bonding wire simultaneously increased the tensile strength and ductility with aging time, yet the electrical conductivity remained almost unchanged.[8,9] For the wire-bonding process in an electronic package, the high thermal stability of the grain structure in the annealing-twinned Ag-8Au-3Pd alloy wire resulted in a smaller heat-affected zone (HAZ) near the ball bond.[9] This present study further explores the effect of annealing twins on the durability against electromigration of this bonding wire.

Electromigration is known to be a failure mode of electronic products. It is the result of mass transport in a metallic conductor after stressing with a high electrical current density. For several decades, this phenomenon has been observed in the integrated

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