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IMPROVEMENT OF ADHESION STRENGTH OF THE COPPER NANOWIRE SURFACE FASTENER BY INVESTIGATING THE DIAMETER RATIO OF NANOWIRES

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ABSTRACT

There are many studies about nanowires because nanowires have unique characteristics which are different from bulk materials. In this study, we fabricated the copper nanowire surface fasteners (Cu NSF) which can be connected each other based on van der Waals force at room temperature. We have investigated the improvement of adhesion strength of them by connecting the nanowires with different diameters and preloads, where the adhesion strength of the Cu NSF was measured by a tensile test. As a result, the adhesion strength enhanced significantly.

Keywords: nanowires, electrical package, room temperature connecting, adhesion strength.

INTRODUCTION

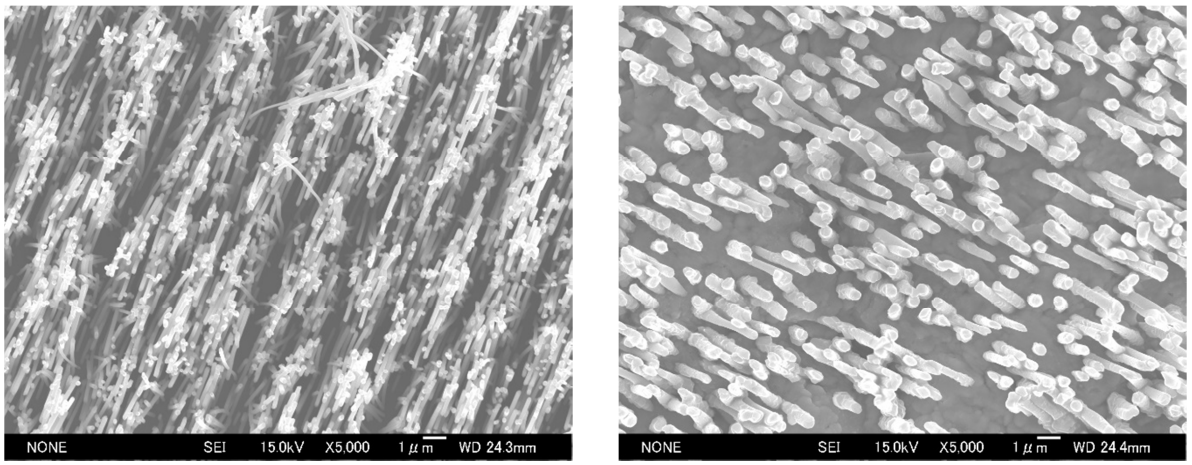
Lead-free solder has been used for surface mounting of electronic devices for conserving the environment. However, there is a concern that the electronic parts may be damaged by heating during connecting because lead-free solder has a high melting point. Therefore, the development of new connecting techniques without heating is required. In addition, because power semiconductor devices generate heat especially during operation, heat may cause deterioration and damage of lead-free solder. Furthermore, there is a problem that the Sn contained in lead-free solder may generate whiskers. On the other hand, in recent years, connecting techniques using polymer hair or carbon nanotube imitating gecko's feet as a surface fastener have been reported. These connecting techniques utilize van der Waals force generated between the surfaces of nanomaterials. However, from the viewpoint of electrical connecting, it is difficult to use them as a surface mounting technique because the electrical resistance of these materials is high.

Recently, we have developed the copper nanowire surface fasteners (Cu NSF) as an electrical conductive connector. Since copper has high electrical conductivity and is inexpensive, the Cu NSF can be expected to be practically used as a new surface mounting technique. Moreover, Cu NSF can be connected at room temperature utilizing van der Waals force, so that it is possible to avoid the damage to electronic parts during solder reflow process. However, the adhesion strength of current Cu NSF is still small as compared with traditional solders. The reason is considered that the contact areas of the nanowires were not sufficient because the nanowires collided and collapsed during connecting.

In this research, to suppress the collapse of nanowires, we fabricated the Cu NSF with different diameters nanowires. In addition, to increase the contact areas of nanowires, the increase of the preload for connecting was investigated.

RESULTS AND CONCLUSIONS

The part views of Cu NSFs having nanowires with 100 nm and 400 nm diameters are shown in Figure 1. The adhesion strength of the Cu NSFs having nanowires with 100 nm and 400 nm diameter reached the largest value, and increasing with the increase of preload. This investigation showed that the contact areas of nanowires increased and mechanical entanglement of nanowires occurred because of increasing the preload of connecting.



(a) (b)

Fig. 1 - SEM images of nanowire array with different diameters: (a) 100 nm; (b) 400 nm

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