김일성종합대학학보 JOURNAL OF KIM IL SUNG UNIVERSITY
(자연과학) (NATURAL SCIENCE)
주체103(2014)년 제60권 제6호 Vol. 60 No. 6 JUCHE 103(2014).

Study on the Preparation and Characteristics of the InCdSn Low Temperature Solder for High Power LD

Im In Rak, Han Ju Myong

The great leader Kim Jong Il said:

"Scientists and technicians, basing themselves firmly on reality, must take the problems arising in practical socialist construction as the subjects of their scientific research, and solve the scientific and technological problems appearing in the application of the achievements of their work to production, in a responsible manner."

The miniaturization and increasing power of the semiconductor devices result in increasing demands for the minimizing of thermal resistance and stresses that largely influence reliability and lifetime of the devices.

In recent years, in order to solve this problem, many attempts have been made to develop the low temperature solder with small thermal resistance and better ductility [1, 2].

In this work, the lead-free In-Cd-Sn low temperature solder has been prepared and its characteristics have been evaluated in comparison with conventional bonding materials.

1. Preparation of Bonding Materials

While alloy materials have low electrical and thermal conductivity compared to individual simple metals, they are more suitable in reliability improvement and in mounting of semiconductor devices due to its controllable melting point, ductility and mechanical strength according to composition ratios. The melting points of In, Cd and Sn are 156.3, 320.9, 231.9℃, respectively. Via a change of metal content ratio in alloys we can select the suitable ductility and the melting temperature for improving of device performance. The ductility is improved with increasing In-amount in alloy, but it is easy to oxidize in air, and the wetting property can be deteriorated. On the other hand, increase of Cd-content allows improving the wettability, but causes raised melting point.

By many experiments we have estimated the optimal composition ratio of In:Cd:Sn=35:23:42(wt%) for the operation characteristics and the mounting of devises to fabricate.

The bonder was prepared as follows:

① Pieces of In, Cd and Sn metals with purity of 99.8% were mixed, charged in a quartz ampoule and sealed with vacuum evacuation.

② The quartz ampoule was kept for an hour at 400℃.

2. Results and Discussion

The melting temperature of the In－Cd－Sn ternary alloys is 133℃ that is far lower than their components' ones. Chip bonding experiment of the high power LDs was carried out by means of the prepared low temperature bonder. To prevent the oxidation of bonder, the semiconductor chips have been bonded in the H_2 environment. Bonding temperature, pressure on the chip and bonding time are 140℃, 0.2MPa and 2s, respectively. In a case of bonding in atmosphere, the bonding materials were compressively shaped in sheets of 50～100 μm thickness, dipped in the resin-ethanol solution and pulled out, and then dried at room temperature.

By using this method the resin film on the sheet-shaped bonder was formed. Thermal fatigue in soldered areas was examined in two solder alloys: 35In-23Cd-42Sn solder and 63Sn-37Pb solder (as a reference). For the thermal fatigue testing the periodical repeat of temperature increase-decrease from －30℃ to 80℃ was carried out 50 and 100 times.

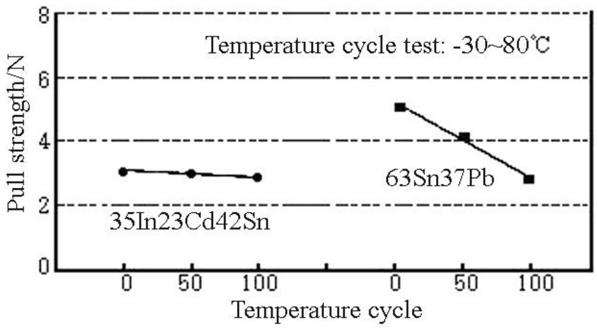
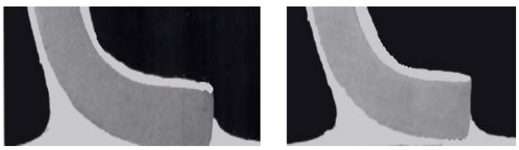


Fig. 1. Fatigue properties of soldered areas

As shown in Fig. 1, after cycle testing the pull strength (bonding strength) of 35In-23Cd-42Sn solder at the soldered areas is constant, but one of 63Sn-37Pb solder was decreased significantly.

The microscopic investigation after fatigue testing shows that solder has a remarkable tendency to develop cracks during temperature cycle testing, but no change was observed in the micro-structure of the 35In－23Cd－42Sn solder after temperature cycle testing (Fig. 2 and Fig. 3).


a) b)
Fig. 2. Microphotograph before (a) and after (b) fatigue test (63Sn-37Pb)


a) b)
Fig. 3. Microphotograph before(a) and after (b) fatigue test (35In-23Cd-42Sn)

The ductility measurement results from different bonding materials were compared in Fig. 4.

As is shown in Fig. 4, the ductility of newly prepared 35In-23Cd-42Sn solder is about 4 times higher than 63Sn-37Pb and similar to 50In-50Pb.

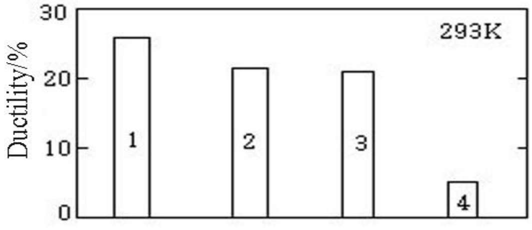


Fig. 4. Ductility of the bonding materials
1－In, 2－50In-50Pb, 3－35In-23Cd-42Sn, 4－36Sn-37b

Conclusion

The $35In23Cd42Sn$ alloy with melting point of 133℃ is usable as the low temperature bonding material for the high power LD. The attach strength of the conventional $63Sn37Pb$ bonder after fatigue testing deceases remarkably, but, in case of ternary alloy, is nearly invariable and shows no crack development, and also has high ductility.

References

[1] Caiyuan Wang, Modern Applied Science, 3, 12, 50~56, 2009

[2] Hadis Morkoç and Cole W. Litton, Proc. of SPIE , 6894, 1~9, 2008