Environmental Effects on Peel Strength between copper and Polyimide Films

Ho-Nyun Lee, Yoon Sung Han, Jang-hun Lee,
Jin-Young Hur, Hong-Kee Lee

Korea Institute of Industrial Technology 7-47,
Songdo-dong, Yeonsu-gu, Incheon 406-840, Korea

1. Introduction

Polyimide films have been used as insulator film, electric insulator, and flexible printed circuit board (FPCB) owing to excellent thermal stability, mechanical strength, and chemical resistance. [1,2] Accordingly, copper coated polyimide films are commonly used as FPCB in the electronic industry. However, the adhesion between the copper and polyimide films is an important issue in the field of electronic packaging devices. The poor adhesion between the copper and polyimide films needs to be overcome to increase the flexibility and the reliability of fabricated devices. As a result, many investigations have been made in order to improve the adhesion between copper and the polyimide films by depositing an additional metal layer or modifying surface characteristics of polyimide film using chemicals, ultraviolet light and plasma treatment.[3-6] Nevertheless, the reports of the environmental effects on the interfacial adhesion strength remain insufficient. In this study, we investigated the environmental effects on peel adhesion strength between copper and polyimide films.

2. Experimental

The polyimide film of Dupont was used as a substrate for electroless plating. Before the plating, the polyimide film was sensitized for 4 min and then activated for 2 min. The sensitization and activation solutions consist of mainly tin chloride ($SnCl_2$) and palladium chloride ($PdCl_2$), respectively. The electroless copper plating with 10 μm thickness was performed in a solution of copper sulfate ($CuSO_4\,5H_2O$) for 20 min. To evaluate interface adhesion strength with the variation of aging period, T-peel test was carried out with a sample of 100 mm in length and 12.7 mm in width. Focused ion beam (FIB) system was used for observing the interface structure between copper and polyimide films. The inter-diffusion and chemical bonding were also investigated using X-ray photoemission spectroscopy (XPS).

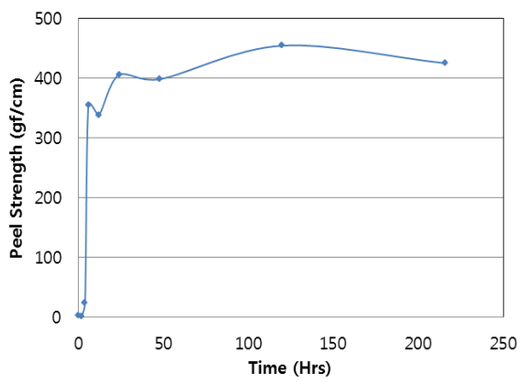

Fig.1 Peel strength between the copper and polyimide films with the variation of aging periods

Aging was performed in atmosphere for designated times between electroplating and peel test. The adhesion strength between copper and polyimide films were shown in figure 1. The interfacial adhesion strength was increased rapidly in 4 to 6 hours and then saturated as time progressed about 24 hours.

3. Results and Discussion

To analyze the effect of aging on adhesion strength between copper and polyimide films, the interface structure was observed using FIB system. There was no noticeable difference in cross sectional images before and after aging of 24 hours. However, XPS results showed that there was some inter-diffusion between copper and polyimide films. The inter-diffusion could increase the interfacial area and the chemical bonding density of Cu-O-C and Cu-O-N [7,8]. As a result, the adhesion strength could increase, as shown in Fig.1.

Aging process could be adapted for improving the flexibility and reliability in the manufacturing process of FPCB because aging in the air at the temperature of 25 ^{o}C was very simple and cheap process. To analyze clearly the reason for enhancement of the interfacial strength, we are now studying the aging effect on interfacial strength in other conditions.

Acknowledgement

This work was supported by the Industrial Strategic Technology Development Program (10039210) funded by the Ministry of Knowledge Economy(MKE, Korea)

References

1. S. J. Park, K. S. Cho, S. H. Kim, Hwahak Konghak, 40 (2002) 613.
2. J. W. Choi, T. S. Oh, Y. H. Kim, J. Kor. Inst. Met. & Mater., 35 (1997) 542.
3. B. S. Min, K. H. Seo, W. S. Chung, I. S. Lee, S. H. Park, J. Kor. Inst. Met. & Mater., 40 (2002) 886.
4. A. Ebe, E. Takahashi, Y. Iwamoto, N. Kuratani, S. Nishiyama, O. Imai K. Ogata, Y. Setsuhara, S. Miyake, Thin Solid Films, 281 (1996) 356.
5. S. H. Kim, J. K. Park, K. S. Oh, J. Kor. Fiber Soc., 31 (1994) 57.
6. H. J. Kim, Y. J. Park, J. H. Choi, H. S. Han, Y T. Hong, J. Industr. Engin. Chemi., 15 (2009) 23.
7. W. J. Lee, Y. S. Lee, S. K. Rha, Y. J. Lee, Appl. Surf. Sci. 205 (2003) 128
8. J.-Y. Park, Y.-S. Jung, J. Cho, W.K. Choi, Appl. Surf. Sci. 252 (2006) 5877