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B-1-5

New Plasma Surface Treatment for Wire Bonding Process -Effect of Sublimation with Alkyl Group Radicals-

Kazuhiro Honsho, Hirokazu Terai, Hiroshi Yamazoe, Toshiaki Tatsuta, and Osamu Tsuji
Samco International Inc.
36, Waraya-cho, Takeda, Fushimi-ku, Kyoto 612-8443, Japan
Phone: +81-75-621-7840 Fax: +81-75-621-5057 E-mail: jissou@samco.co.jp

1. Introduction

High feasibility of the wire bonding on assembling process is demanded because of the high density IC technology in the recent years. We thought there are many primary materials obstructed the wire bonding. Especially, it is said that Nickel (Ni), Ni compounds and the organic material on a gold (Au) pads have an influence on its performance. Argon (Ar) sputtering has been applied to remove them as the conventional technique [1]. The hard Ar-sputtering has a tendency to bring about problems, such as the redeposition of the sputtered materials occur [2,3].

This investigation tried for the realization of the new plasma treatment technique to improve the wire bonding performance by removing efficiently above-mentioned obstructing materials with the specific characteristic of alkyl group generated from CH_4. The new our technique can improve the wire bonding performance by removing more efficiently them with using methane (CH_4) / hydrogen (H_2) plasma. Besides, this research still has been investigated with durability of the plasma treatment effect.

2.Experimental

Dry cleaner (PXA-200N manufactured by Samco International Inc.) was used as plasma treatment machine.

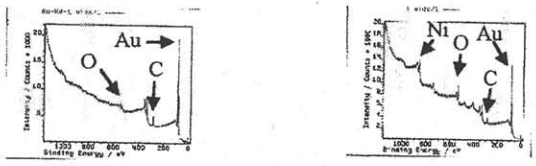
The sample treated by the new plasma treatment technique and by the conventional technique is tested with the gold-wire ball bonder (UTC-270 BI Super II manufactured by Shinkawa Inc.) and Pull tester (PTR-10 manufactured by RHESCA Inc.).

2-1. Treatment before wire bonding

In the packaging process, the feasibility of the wire bonding has been made lower owing to the obstructing materials presented and accumulated on the surface of Au pads in cure process after Die-attach process. As the obstructing factor, there are Ni and Ni compounds presented on it owing to the thermal diffusion from the Ni layer under the Au layer and organic materials accumulated on the surface of Au pads during the curing process. Fig.1 shows the condition on Au pads before and after the curing process analyzed by using XPS (XPS: X-ray Photoemission Spectroscope).

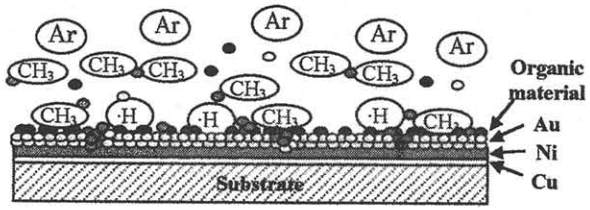
In this experiment, the substrate metallized by copper on both sides, plated with a non-electroplating of Ni (t=6um) and plated with a Flash plating of Au (t=0.07um) on the upper layer is used as the estimating samples. In the curing process, it is usually placed on hot plate in air, so we had treated the samples at 180℃ for 2 hours on a hot plate.

There are generally two methods. The first is to use the sputtering effect of Ar plasma [1] and the second is to use the deoxidization effect of H_2 plasma [2,3]. In the new plasma treatment technique, CH_4 is used as the treatment Gas. Compared with the above-methods, this new treatment removes the obstructing factor with using the sublimating effect of the compound of Ni system. Fig.2 shows mechanism of the new plasma treatment technique.



(a) Before curing process (b) After curing process

Fig. 1 Surface condition on Au pads



$CH_4 \rightarrow \cdot CH_3 + \cdot H$, $\cdot H + \cdot H \rightarrow H_2$

$H_2 + NiO \rightarrow Ni + H_2O$ (The deoxidization effect)

$3H_2 + Ni_2O_3 \rightarrow 2Ni + 3H_2O$ (The deoxidization effect)

$\cdot CH_3 + Ni \rightarrow Ni(CH_3)_x \uparrow$: The organic metal compound (The sublimating effect)

Fig. 2 Mechanism of the new treatment technique

2-2. Etching rate of Au and Ni

Fig. 3 shows the etching rate of Au and Ni versus the percentage of CH_4 and H_2 to the total flow rate of the process gas ($Ar/CH_4/H_2$). The solid line shows the etching rate of Ni. The broken line shows the etching rate of Au.

As shown in Fig. 3, when the mol ratios of CH_4/H_2 were nearly equal, the highest etching rate of Ni was attainable. Especially, in the point treated by CH_4 (6%) / H_2 (6%), the etching rate of Ni was about twice as high as the etching rate of Au.

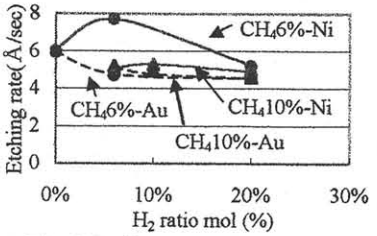


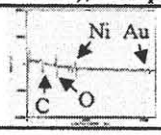
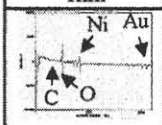
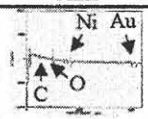
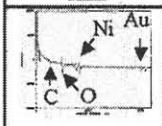
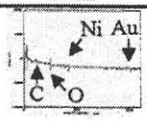
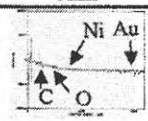
Fig. 3 Etching rate of Au and Ni

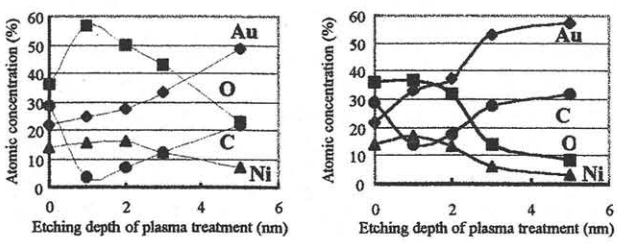
2-3. Surface analysis

Table. I shows the results of analyses in each Au surface etched respectively (0, 2, 3, 5nm in depth) by the conventional technique and the new technique. AES (Auger Electron Spectroscope) is used as the surface analysis. Fig. 4 shows the values determined atomic concentration of each element (Au, O, C, Ni) on each surface shows in table. I . Fig. 4(a) shows the surface condition in case of Ar plasma treatment. Fig. 4(b) shows the surface condition in case of $Ar/CH_4/H_2$ plasma treatment.

The value of Ni binding peak on the surface of the sample treated by $Ar/CH_4/H_2$ plasma is vanished faster than by Ar plasma as shown in table. I . In case of Ar plasma treatment, it is possible to confirm Ni peak even 3-5nm in etching depths. Afterwards, we had investigated about whether such a quantity of Ni obstructed. As shown in fig. 4(b), the quantity of C increases and the quantity of Ni decreases in the large way, when the sample was treated by $Ar/CH_4/H_2$ plasma. As can be seen in Fig. 4(a), (b), degrees of deoxidization of Ni compounds on surface of Au pads above 3nm etched by new technique are lager than those of conventional technique. In the neighborhood that the value of Ni seriously changed, it is thought that the CH_4 radical combines with Ni and sublimates as a metal organic compound.

Table. I Analytical results of each Au surfaces.

Heat process only(180℃-2hr), Non-plasma treatment			
			
Etching depth of Ar Plasma treatment			
1nm	2nm	3nm	5nm
			
Etching depth of $Ar/CH_4/H_2$Plasma treatment			
1nm	2nm	3nm	5nm
			



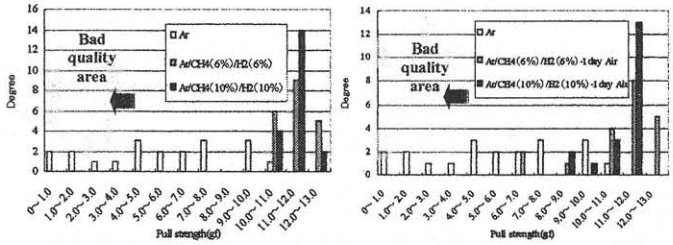
(a) Ar plasma (b) $Ar/CH_4/H_2$ plasma

Fig. 4 Depth profile of each element in a Au pad

3. Results

Fig. 5-(a) shows the results of the pull strength values of wires when the samples were bonded immediately after the plasma treatment. Fig. 5-(b) shows the results measured the pull strength of wires on the sample; those samples have left in air for 1 day after the plasma treatment. In Fig. 5-(a), the pull strength value of wires on the sample bonded by the wire-bonding machine as soon as it has been treated by conventional Ar plasma are shown, widely distributed around the area under 5gf strength. But, in Fig. 5-(b), those values of wires on the sample treated by the new plasma treatment technique is distributed in the area far over 5gf and concentrates between 11gf and 12gf.

The pull strength value of wires on the sample treated by the new plasma treatment technique is far over 5gf even if the sample treated by this new technique has left in air for 1 day. On the other hand, when the sample was treated on the same plane as Ar plasma treatment, it was impossible to make practicable.



(a) Immediately (b) After 1 day

Fig. 5 Results measured the pull strength of wires on the samples

4. Conclusions

It is possible to remove efficiently the obstructing material on a Au pad owing to the new plasma treatment technique, which makes use of the specific characteristic of alkyl group generated from CH_4.

The pull strength values of wires on the samples treated by the new plasma treatment technique are higher than by the conventional technique.

Even if the sample treated by this new plasma treatment technique has left in air for 1 day, the sample has the high trust of the wire bonding and is a level of a quality item.

References

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[2] N. Korner, E. Beck, A. Dommann, N. Onda and J. Ramm, "Hydorogen plasma chemical cleaning of metallic substrates and silicon wafers", Surface and Coatings Technology 76-77(1995), 731-737

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