Contact characteristic for Iridium-coated probe

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This study considers the issue of higher probe contact resistance associated with oxidation of Al attached to the probe surface. In an experiment involving Al electrodes, there was virtually no increase in contact resistance after 185,000 repetitions. Results such as flexing resistance were highly encouraging.

Keywords – Contact resistance, Iridium-coated probe, large-scale integrated circuits, oxidation, scrubbing quantity.

Introduction

Probe testing of electronic circuits created on silicon (Si) wafers is a key element of the large-scale integration (LSI) development and production process. But repeated contact between the aluminum (Al) bonding pad can lead to oxidization of Al residue on the probe surface, resulting in higher contact resistance. A simple probe design has been developed that involves long-lasting iridium (Ir) coating on the probe tip to prevent Al accumulation and keep contact resistance as low as possible. The probe consists of 25 mm diameter tungsten (W) wire with 0.5 mm silver (Au) buffering layer coated with Ir to a thickness of 0.65 mm. The outermost layer of the probe was confirmed to be coated with Ir. When the probe was repeatedly brought into contact with an Al electrode, the increase in contact resistance was less than 0.5 Q after 80,000 repetitions. This demonstrates the excellent performance of the Ir-coated probe compared to conventional W wire probes.

This study examined contact properties of the Ir-coated probe, namely the flexural properties, scrub amount and contact repetitions, as well as overdrive.

Performance evaluation of Ir-coated probe

1. Ir-coated probe

In this study, W and ReW (rhenium tungsten, Re: 3 wt %) was used as the core material. The core material was covered with a buffer metal layer Au, which was then coated with Ir.

IC probers generally use a straight or cantilevered probe. For the purpose of this study we created cantilever prototypes using W core wire and ReW wire of diameter 25 µm as the core material. The tip of the probe had a diameter of 15 µm. This was augmented with a 0.5 µm Au buffer metal layer and a 0.65 µm Ir-coating-layer formed via plating.

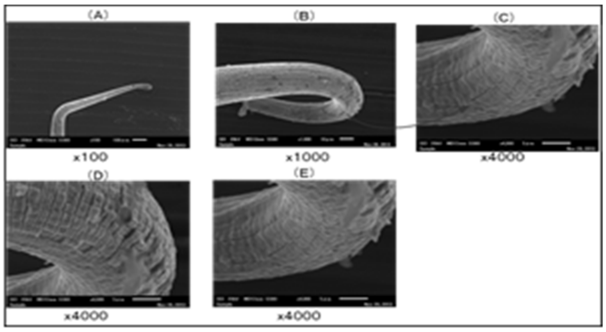

Fig. 1. SEM image of sharp bend in probe tip.

2. Bending test

First, the bending test of the Ir-coated W probe was performed as follows. A bending stress was intentionally applied to the probe to form an extremely bent portion, and the tip portion of the cantilever was observed by SEM.

Fig. 1 shows the SEM image of the tip of the probe with an extremely bent portion. Fig. 1A) is 100 times, Fig. 1B) is 1000 times, Fig. 1C) – Fig. 1E) is 4000 times. Fig. 1C) – Fig. 1E) are SEM images of the bending portion shown in Fig. 1B) observed from three directions. From Fig. 1A) and Fig. 1B), the shape of deliberately formed bent part is known. Furthermore, it was found from Fig. 1C) – Fig. 1E) that peeling of the outermost Ir coating layer does not occur at all even if an extremely bent portion is formed on the cantilever type probe after plating.

3. Measure contact resistance

Since the probe prepared in this research is covered with Ir, it becomes difficult for Al to adhere and it is possible to maintain low contact resistance. The contact resistance depends on the diameter of the tip of the probe and the needle pressure.

The probe was brought into contact with a gold plate (a 100 mm diameter plate with gold-plated surface), and the contact resistance value was measured while varying the overdrive amount in increments of 1 μm. The above measurement was performed nine times with the same probe. For the measurement, the gold plate and the cantilever type probe were contacted with a probe card inspection apparatus (MPC 120), and the value of the contact resistance was measured with a measuring instrument using PXI-1031 manufactured by National Instruments Japan Corporation.

It was found that Ir-coated W probe provides lower contact resistance with less overdrive amount than uncoated W probe.

4. Measurement of relationship between contact number and contact resistance

We examined the relationship between the contact repetitions (number of contacts) and resistance contact when Ir-coated W probes and uncoated W probes were brought into contact with a Si substrate with 1 μm Al deposit. The probe was brought into contact with a different part of the Si substrate each time so as not to contact the same place on the Si substrate. This was achieved using a device capable of making contact with the probe while micro-moving the XY stage carrying the Si substrate.

For contact between the probe and the Si substrate, overdrive was set to 50 μm, the overdrive speed was 50 μm/sec, and load per probe was 8×10 – 2N.

Fig. 2 shows the correlation between frequency of contact and contact resistance for the Ir-coated ReW probe and the uncoated ReW probe.

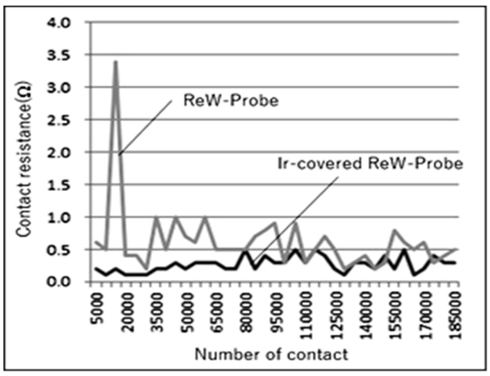

Fig. 2. Contact resistance vs. frequency of contact for Ir-coated ReW probe and ReW probe.

The horizontal axis in Fig. 2 shows the frequency of contact, from 5,000 to 185,000 repetitions. The contact resistance of the Ir-coated ReW probe varied in the range 0.07 – 0.89 Ω, while the contact resistance of the uncoated ReW probe varied from 0.07 to 2.29 Ω.

At 185,000 repetitions, the minimum contact resistance of the Ir-coated ReW probe was 0.07 Ω, equivalent to the uncoated ReW probe, while the maximum contact resistance of the Ir-coated ReW probe was significantly lower (2.6 times less than the uncoated probe).

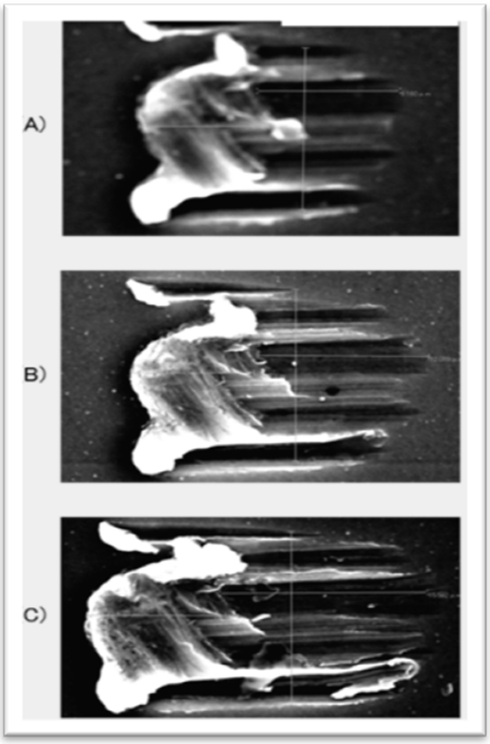

Fig. 3. SEM images showing overdrive and scrub for Ir-coated ReW probe.

The results showed that the Ir coating helped to maintain low contact resistance of less than 1 Ω in both the W and ReW probes, as opposed to the uncoated ReW probe, which had much higher contact resistance.

Observation of probe tips after the contact experiment using an optical microscope found less foreign matter adhered to the Ir-coated probe than to the uncoated ReW probe. Also, there was no evidence of peeling or flaking of the Ir coating layer. Thus we may conclude that Al scraps and foreign matter are less likely to attach themselves to the tip of the Ir-coated ReW probe and probe tip.

5. Measurement of scrub quantity

The correlation between the probe overdrive and the maximum dimensions of the trace generated when the probe comes into contact with Al (i.e. the scrubbing quantity) was measured for both the Ir-coated ReW probe and the uncoated ReW probe, as described below.

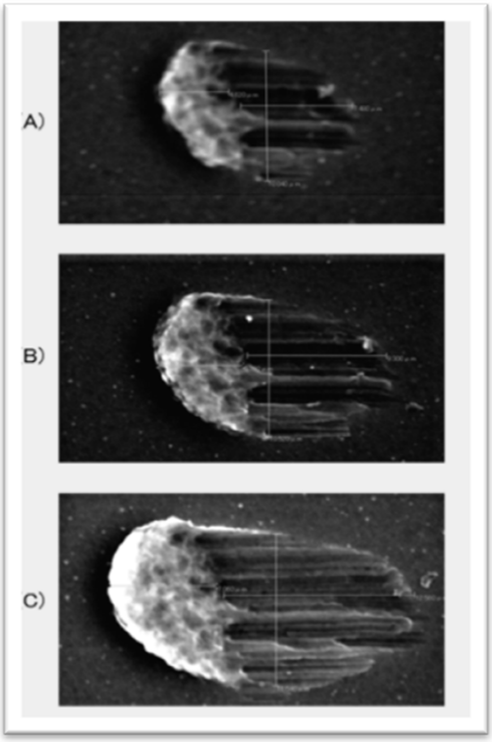

Fig. 4. SEM images showing overdrive and scrub for uncoated ReW probe.

Using an Si substrate with 1 μm thick Al deposit, we observed probe traces at different overdrive values through an SEM in order to find the maximum dimension (i.e., the scrubbing value, expressed in μm). Overdrive was varied in the range 10 – 90 μm and overdrive speed was 20 mm/sec.

Table 1

Correlation between overdrive and scrub for Ir-coated ReW probe and uncoated ReW probe

Overdrive quantity (μm)	10	20	30
Quantity of scrub of Ir-coated ReW-probr (μm)	7.48	9.3	2.58
Quantity of scrub of ReW – probe (μm)	9.16	12.08	15.58
Improvement rate of quantity of scrub (%)	18.34	23.01	19.38

Fig. 3 shows SEM images for the Ir-coated ReW probe, illustrating the relationship between overdrive and scrub while Table 1 shows the overdrive values.

Fig. 4 shows SEM images for the uncoated ReW probe, illustrating the relationship between overdrive and scrub, while Table 1 shows the overdrive values.

Comparing the Ir-coated ReW probe with the uncoated ReW probe, it is clear from the SEM images in Fig. 3 and Fig. 4 that scrub is lower. Table 1 shows an average improvement of 16% in our experiments, reaching up to 23% in some cases.

Conclusions

A vital element in the development and manufacture of large-scale integrated circuits (LSI) is inspection of electronic circuits on Si wafers using probes. This involves repeated contact between the probe and Al material in the bonding pad, which can lead to oxidation of Al particles attached to the probe. This in turn increases the contact resistance of the probe. We developed an Ir-coated probe that resists adhesion of Al matter on the probe tip, thereby maintaining low contact resistance. The probe is also long-lasting. In this study we investigated contact characteristics of the Ir-coated probe including flexural properties, scrub amount and frequency of contact, and found it to have good flexural properties and low scrub, making it suitable for repeated contact with Al electrodes over extended periods.

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