PLASMA TREATMENT OF X-WireÔ

Insulated Bonding Wire

Application Note

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INTRODUCTION

The semiconductor industry is pushing advanced packaging processes to new limits as finer pitch and stacked die applications continue to emerge. Insulated bonding wire technology, known as X-Wire™, is identified on the 2006 International Technology Roadmap for Semiconductors (ITRS) as a viable and cost-effective solution for addressing these high-density packaging concerns [1].

Pre-mold plasma, is a common process performed after wirebond and prior to transfer mold to enhance adhesion of epoxy mold compound to the integrated circuit (IC) substrate (Fig. 1). This is a surface modification technique achieved by chemical etching and/or physical sputtering reactions in order to remove contaminants and activate the surface of the substrate. This results in decreased delamination of molding compounds to the substrate surface.

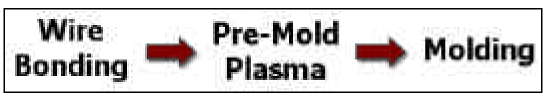


Fig. 1. Pre-mold plasma process flow

When insulated bonding wire is introduced into the wirebond step, proper process parameters must be set to ensure that the plasma energy can sufficiently activate the substrate surface, without damaging the thin film insulation coatings. In this study, 25um diameter insulated gold wire is used, with the current industry release of Microbonds' insulated bonding wire being known commercially as X-Wire™ 2.0.

Using contact angle measurements and coating integrity testing, our studies have shown that for insulated wire, pure argon gas is preferred over commonly used gas mixtures (e.g. an argon-oxygen mix may modify X-Wire™ 2.0 coating characteristics) [2]. However, due to the physical bombardment of ions in an argon plasma, the insulated coating of X-Wire™ 2.0 bonded devices may be partially reduced. This potential removal of coating during the pre-mold plasma treatment is accommodated for during the design and manufacturing of X-Wire™ 2.0. Generally speaking, the design specification for X-Wire™ 2.0 is a balance between optimum bonding performance and post-bonding packaging requirements. This study analyzes the various electrode configurations and process parameters in order to provide pre-mold plasma treatment guidelines for X-Wire™ 2.0 bonded devices.

EXPERIMENTAL METHODS

Plasma treatment increases the surface energy of a substrate, which generally translates to an increase in wettability as measured by the contact angle [3]. Contact angle measurements are a simple and non-destructive way of evaluating the effectiveness of a surface modification process (Fig. 2). Lowering the contact angle to below 30° is typically deemed to be an acceptable plasma process, which ensures good substrate-to-mold adhesion.

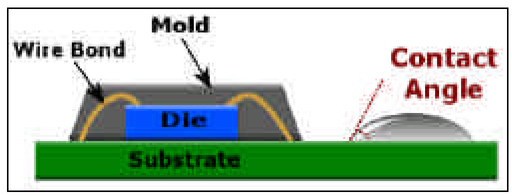


Fig. 2. Contact angle measurement

The plasma distribution in a magazine loaded chamber is highly dependent on the inherent design of the magazine. Since there is no industry standard, variability is unavoidable due to different dimensions of magazines, designs of side slots, usage of end guards, etc. In our study, an extreme case is simulated by employing a magazine with a large separation between substrates (12 mm) and omitting the end guards.

RESULTS AND DISCUSSION

The process window of pure argon plasma for X-Wire™ 2.0 is determined by verifying that the substrate contact angle is lowered to less than 30° and the insulated coating is not reduced beyond an acceptable amount. In addition, the recommended plasma process must be easily adopted into high volume manufacturing.

Direct and Downstream Plasma

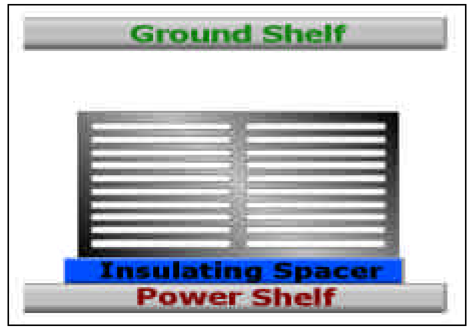
Direct and downstream plasma cleaning were configured using March's AP-1000. Downstream plasma took significantly longer to reduce the contact angle and can only be used for single layer magazine loading. Direct plasma cleaning is preferred as double layer magazine loading (alternating power and ground electrodes) can be accommodated with March's AP-1000 and shorter plasma recipes allow for high volume processing. A dummy strip is placed in the top slot due to hot spots observed in the magazine.

In-line Plasma

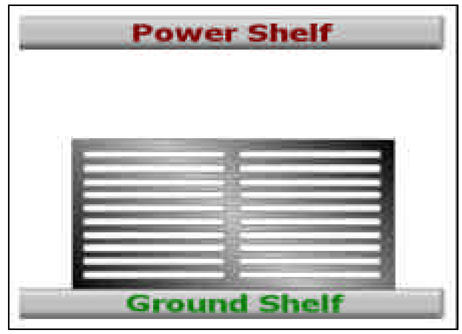
March's automated FlexTRAK™ is an in-line plasma processing system that is becoming a popular alternative to batch processing. The smaller chamber size allows for a more uniform plasma distribution and improves the surface modification consistency [4]. In order to plasma clean X-Wire™ 2.0 bonded devices, the existing transport railing must be electrically isolated from the power electrode. In this case, the contact angle was lowered without significantly degrading the insulated coating in short, but controlled process times.

Validation of an Acceptable Plasma Process

Two direct plasma electrode configurations are studied in detail as shown in Fig. 3. In configuration A, the magazine is floating and electrically isolated from the power shelf (magazines are typically anodized, however after prolonged use, the bottom gets scraped and the magazine can get electrically charged). In configuration B, the magazine sits on the ground shelf. The electrode separation for both cases is 9". The plasma process conditions used in this study are listed in Table 1 (these extreme settings are used for experimental purposes only).



(a) Configuration A



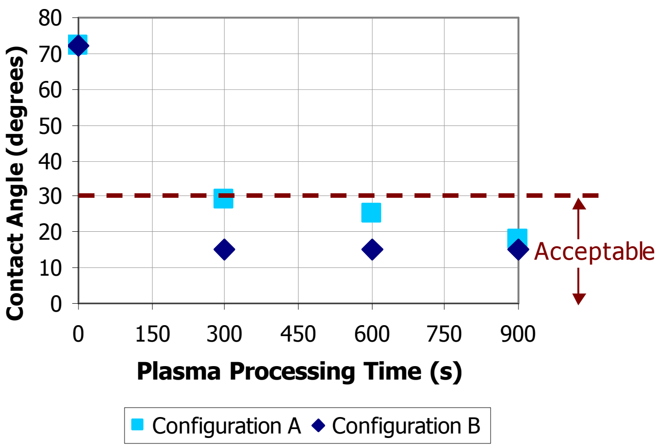
(b) Configuration B

Fig. 3: Direct plasma electrode configurations compared in this study

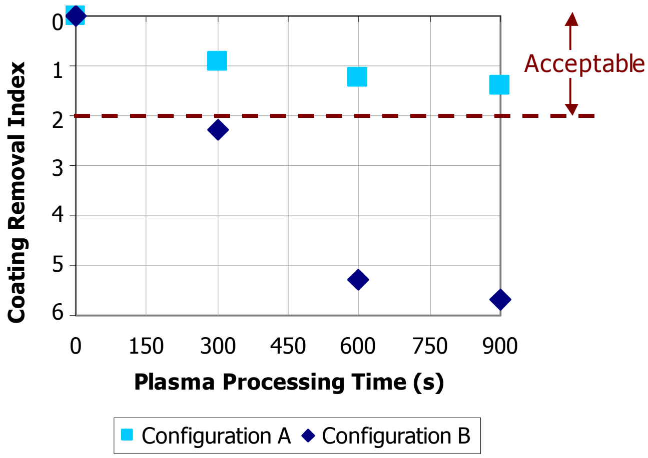
Table 1: Plasma process conditions used in this study

Parameter	Setting
RF Power	400W
Pressure	150mT
Processing Gas	100% Ar

Fig. 4(a) shows that the contact angle is lowered to less than 30° after 300s of plasma for both configurations A and B. Fig. 4(b) shows that for configuration A, even after 900s, the removal of the insulated coating is within the recommended limit. After 300s, configuration B degrades the X-Wire™ 2.0 insulation coating by more than the threshold and is deemed unacceptable.



(a) Contact angle measurements



(b) Degree of coating removal

Fig. 4: Results of different electrode configurations for prolonged plasma processing

Recommended Pre-Mold Plasma Process for X-Wire™ 2.0

For batch processing, we suggest using March's AP-1000 plasma equipment with the electrode configuration illustrated in Fig. 3(a). Argon plasma is recommended due to the physical nature of the sputtering mechanism. The presence of reactive species, such as oxygen, changes the characteristics of the X-Wire™ 2.0 coating. Based on our studies, it is recommended that the RF power should not exceed 400W and the chamber pressure for effective cleaning should be in the range of 100-260mT. It is also recommended that the maximum accumulative processing time for X-Wire™ 2.0 bonded devices should not exceed 300s.

SUMMARY

X-Wire™ 2.0 is insulated bonding wire technology that can address the demand of tight tolerances required in the advanced packaging industry. Pre-mold plasma treatment reduces substrate-to-mold delamination during transfer molding, but may potentially reduce the effectiveness the insulated coating. Through optimization of plasma chamber configuration and correct choice of process parameters, an acceptable plasma processing window that cleans the substrate for good mold compound adhesion, without significantly degrading the X-Wire™ 2.0 insulated coating is readily attained.

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