Stripping Process Development using SAPS Megasonic Technology

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***Abstract*-Integrated circuit(IC) design, IC manufacturing and IC packaging constitute the three pillars of IC industry. With the development of chip integration and high-density circuit packages, more photolithographic technology step were used in IC industry. As we all know, the purpose of photoresist stripping is to remove photoresist (PR) residues, particles and metal which come from the pattern structures. The photoresist (PR) stripping process is an important factor after photolithography technology which plays a key role in the yield of products. Residual photoresist can cause device layer failure or even damage the device layer.**

Conventional wet PR stripping, soaking and single chamber stripping is widely used for removal photoresist in advanced packaging. Wet PR stripping uses a specific chemical to dissolve the PR layer. During PR removal process, it will need 20~30min bench soaking method and 5~10min single chemical rinse to accomplish PR strip step which may lead to a low throughput.

space alternated phase

of PR stripping. The mega sonic power could pass through the deep hole of patterns or other complicated patterns with sustained energy, facilitating the removal of photoresist completely. Moreover, the optical microscope was carried out to examine the results of PR removal effects in different pattern wafers and AOI was used to evaluate first pass yield (FPY). Mega sonic energy with different powers and different applied reaction time was rigorously investigated the removal effects of photoresist.

Keywords-Advanced packaging, Photo-resist, Wet stripping, Megasonic, Solvents

I. INTRODUCTION

Conventional wet PR stripping, soaking and single chamber stripping are the common strategies for removing photoresist in advanced packaging. However, the soaking and single chamber stripping strategies are greatly restricted by their time-consuming process. It has been accepted that mega sonic energy is conducive to 31/Lang (el-GB)c>BDC BT-onduciv c clrnrR sonic energy is evenly distributed on the wafer surface to avoid the damage of wafer pattern. The maximum working frequency of SAPS mega sonic can reach 3MHz and the maximum power can reach $3W/cm^2$.

Compared with conventional bench soaking and single rinse, mega sonic stripping reveals unique advantages for some complicated structure, such as TSV pattern. The active ingredients of chemical liquid are difficult to reach the bottom of TSV simply through the diffusion of the liquid with the general stripping method. Whereas the cavitation effect of SAPS is easily to make the liquid reach the bottom of TSV and evenly distribute throughout the deep hole structure with its oscillating stirring effect, which could effectively remove PR in the deep hole. Space Alternative Phase Shift (SAPS) mega acoustic wave technology can be applied for the stripping process of other complicated structures like PR after dry etch.

II. EXPERIMENTAL

In this study, space alternated phase shift (SAPS) mega sonic technology was used as an auxiliary strategy for the PR stripping. Space alternated phase shift (SAPS) mega sonic waves enhance the wettability of chemicals, resulting in a fast chemical migration in the corner of patterns or other complicated patterns with sustained and uniform energy during the process. (Fig. 1). Compared to conventional bench soak or single rinse methods, SAPS megasonic technology presents great photoresist removal efficiency. Besides, SPAS megasonic technology exhibits lower material etch rate, resulting in less damage to structures (1), (2) in Fig. 1.

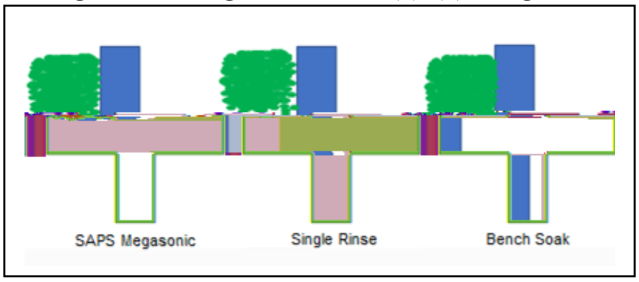

Fig.1. The chemical wettability for corner of pattern by single rinse, bench soak and SAPS megasonic.

In this work, we have explored the influence of PR removal efficiency for megasonic and the removal efficiency of PR under different megasonic power. According to the experiment results of PR removal efficiency and first pass yield (FPY), chemicals with megasonic disclose superior performance for PR removal and good wettability to propagate to the corner of pattern. The 50pcs PR thickness 80um normal structural wafers were used for evaluating photoresist removal performance for experiment I, while the 50pcs PR thicknesses 12um complicated structural wafers were also used for evaluating photoresist removal performance for experiment II. The 50pcs PR thickness 2um normal structural wafers were applied for evaluating influence with different megasonic power for experiment III. In experiment I, normal structural wafers was split into two equitable groups: One group wafers are cleaned with conventional single-wafer rinse cleaning, and the other group wafers are cleaned with SAPS megasonic. In experiment II, complicated structural wafers were split into two equitable groups: One group wafers are cleaned by conventional single-wafer rinse cleaning, and the other group wafers are cleaned by SAPS megasonic. In experiment III, normal structural wafers are split into two equitable groups: One group wafers are cleaned with megasonic by power 15W, and the other group wafers are cleaned with megasonic by power 30W. In this work, OM inspection is executed to detect the presence of photoresist residue, while AOI is implemented to evaluate first pass yield (FPY).

III. RESULTS

In experiment I, OM inspection results confirm that no PR residues present on all wafers. The wafers cleaned with megasonic reveal the best first pass yield and fewer particles on the wafers. In experiment II, the wafers cleaned with conventional single-wafer rinse method emerge obvious PR, whereas the wafers worked with megasonic method present no PR on the wafers at the same experimental conditions. And AOI exploration further verifies that wafer cleaned by megasonic method exhibit excellent yield. In experiment III, higher megasonic power is conducive to improve the efficiency of PR removal.

Throughput is an important indicator for fab. Experiment I demonstrates that both conventional single rinse and megasonic rinse can remove the PR completely. However, it takes only 186s (Fig.2 a) to remove all PR via megasonic method, and it takes almost twice the time of 350s (Fig.2 b) to remove all PR. According to AOI exploration, megasonic method discloses better first pass yield (FPY) compared to single rinse recipe method (Fig. 3). Benefiting from the megasonic high efficiency of removing particles, fewer impurities present on the sample surface.

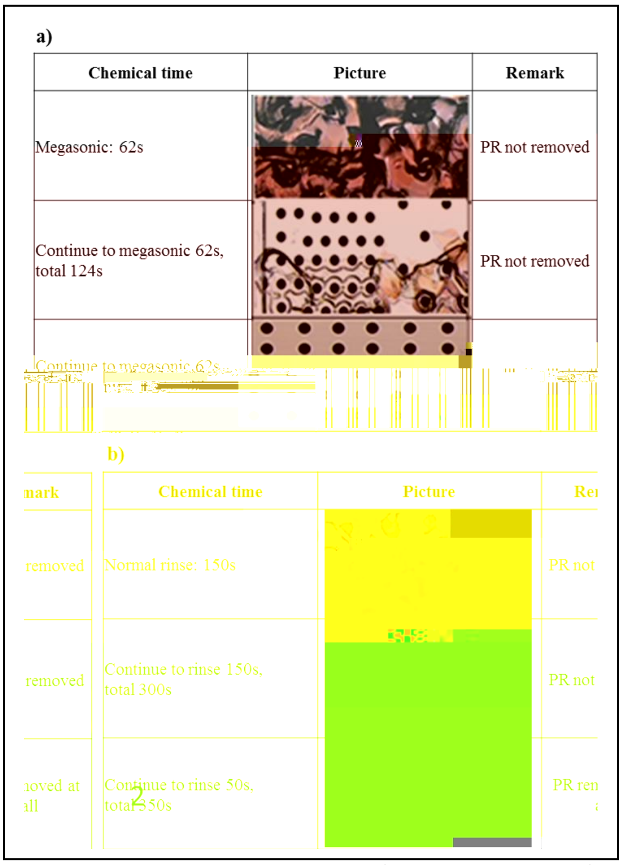

Fig.2 PR residue and chemical rinse time for normal structural wafer: a): clean with megasonic, b): clean with conventional rinse.

Fig.3 First pass yield of conventional rinse and mega sonic rinse.

In experiment II, the wafers reveal obvious PR on the corner of the patter after 240s processing time, indicating that the PR cannot be removed through conventional single rinse. However, it takes only 62s to remove PR completely via megasonic method (Fig.4), and megasonic method exhibits excellent yield.