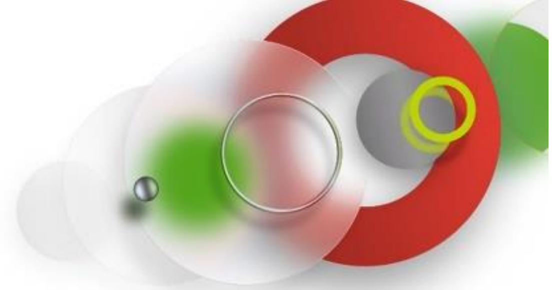

CSTIC 2024 POSTER

Amorphous Silicon Bump Defect Mechanism Analysis and Improvement Strategy

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ABSTRACT

In this study, we investigated the failure mode and its root cause to understand the relationship between Amorphous silicon (a-Si) peeling defect and underlayer Tetraethyl orthosilicate (TEOS) film surface quality, and finally, we proposed an improvement method of low wet etch rate (LWER) TEOS to customer, along with the results of a-Si peeling defect improvement, it demonstrates that significant increase in production quality.

INTRODUCTION

a-Si has been widely used as mandrel layer for pattern transfer [1]. However, a-Si films obtained through traditional furnace or PECVD process always contain hydrogen, due to hydrogen-containing nature of the precursors (Silane), and it may affect adhesion to underlying TEOS or PEOX films, and even undesirable peeling from underlayer, which is a high value problem to many customers. In this work, we studied the failure mode and proposed an improvement strategy based on that, and it finally demonstrated significant improvement.

METHODOLOGY

The a-Si bump defect mechanism analysis is described as below:

1). Figure 1 is the schematic diagram of a-Si film for the dissociation processes of SiH_4 molecules into a variety of chemical species in the thermal process, SiH_3 diffuse to surface and react with surface SiH, leaving Si dangling bond, and two SiH will combine to form H_2 and leaving two Si dangling bond, and finally the surface Si dangling bond re-combined to form Si-Si bonding [2, 3].

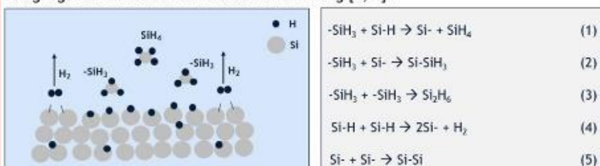

Figure 1: Schematic Diagram of a-Si Film from SiH_4 Molecules

2). During a-Si film growth process, H diffuse through a-Si and form H_2 at a-Si/TEOS interface, which hard to diffuse through a-Si, beyond certain concentration, it will form bubble [4]. It's more likely to cause bubble formation when the solid solubility limit of underlayer is reached, it occurs on longer queue time from underlayer to a-Si deposition or bad underlayer film quality, due to underlayer cannot accommodate all H. The hypothesis for bubble defect related to underlayer was poor film surface quality, which is provide more weak point to bubble formation, as shown in Figure 2.

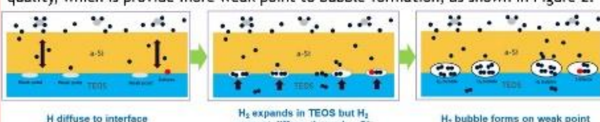

Figure 2: Schematic Diagram of H_2 Bubble Defects Formation on a-Si/TEOS Interface

RESULTS & DISCUSSION

To explain the relationship between bubble defect and underlayer film quality, further design of experiments for bubble decreased were carried out.

1). Firstly, replaced the TEOS to PEOX film to check the effect for bubble defect. Next, different power and pressure TEOS film were checked for bubble defect window. Finally, the high temperature (Temperature-1.2X) LWER TEOS film was adopt for underlayer to check the bubble defect.

2). Based on the experiment results, the key condition is Temperature-1.2X LWER TEOS for bubble defect improvement. LWER TEOS (WER ~0.7Y of BSL) has good film surface quality than Temperature-X normal TEOS (BSL, WER is Y). The a-Si defects with baseline TEOS film underlayer can divide into three types: flake, buried, and bump, and most of all is comes from bump defect according to the results of defect review.

3). The comparison of defect performance between baseline Temperature-X normal TEOS and Temperature-1.2X LWER TEOS is observed: as Figure 3 shows, the results demonstrated a significant improvement to bubble defect with underlayer LWER TEOS film, It provides less heterogeneous nucleation sites or weak points for H2 bubble formation.

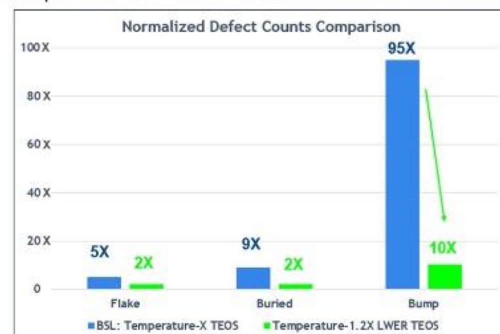

Figure 3: The Comparison of Defect Performance between Baseline TEOS and LWER TEOS

SUMMARY

Significant bubble defect reduction is achieved for a-Si film deposited on LWER TEOS underlayer. LWER TEOS makes good film surface quality and eliminated the bubble formation largely. Bubble defect reduction showed significant increase in production quality and beneficial income can be expected eventually.

Reference

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