Wafer bow effects on CMP performance

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INTRODUCTION

Wafer bow is defined as the deviation of the center point of the median surface of a free, un-clamped wafer from the reference plane, where the reference plane is defined by three corners of equilateral triangle [1]. An illustration is shown here. Wafer bow can be negative or positive, depending on stress type. With the convention of semiconductor equipment manufacturer, the bow is positive shown on the right due to compressive stress in the film. A tensile stress in the film will cause negative bow.

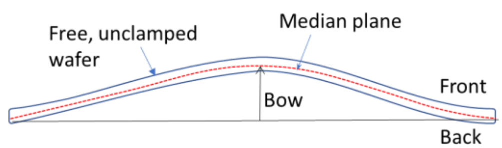

Figure 1 shows our measurements of wafer bow in relation with oxide film thickness on the front side for both Teos and thermal oxide films. The thermal oxide data were obtained from multiple lots of various frontside thicknesses. It should be emphasized here that the relationship between wafer bow (or film stress) and film thickness depends on the deposition chemistry, process conditions including the thermal scheme.

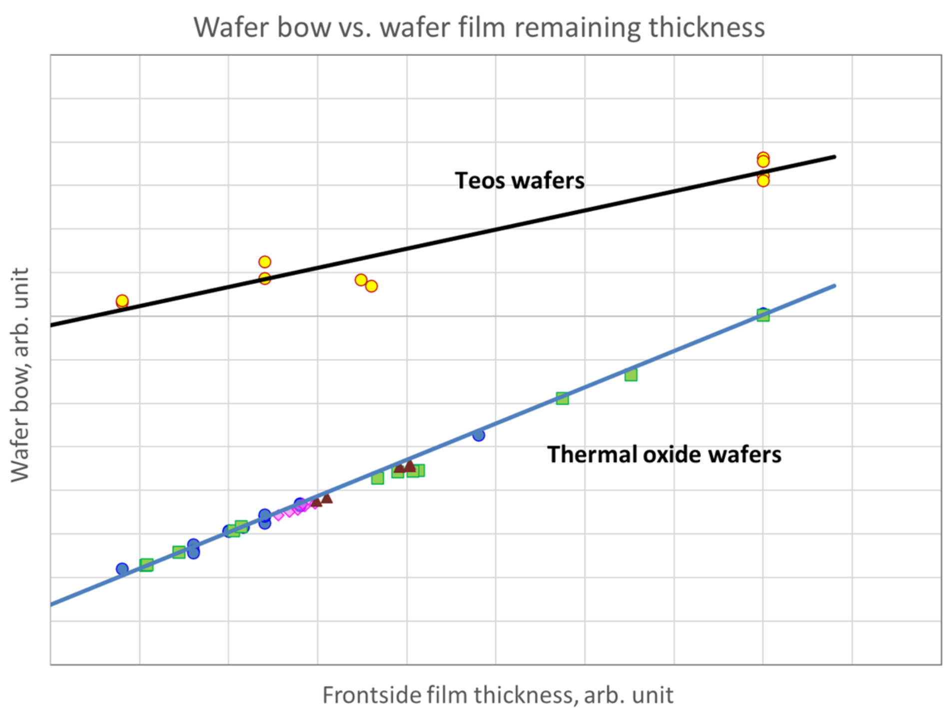

Figure 1. Wafer bow in relationship with frontside film thickness for Teos and thermal oxide blanket wafers.

Figure 1 clearly demonstrates an important fact: irrespective of incoming film stress type/level, as surface film is removed during CMP process, wafer bow will change continuously. Depending on the initial bow and the amount of film to remove, the change of wafer bow can have a significant impact on the result of CMP.

It is thus very important to understand the impact of wafer bow and to find ways to reduce the negative impact of wafer bow on CMP performance.

MATERIALS

All wafers used in this study were purchased commercially with new substrates. This is to avoid the impact from substrate of reclaimed wafers.

RESULTS

Figure 2 shows the polish result (removal) for three wafers. Wafer A is a new thermal oxide wafer with oxide film on both sides. Wafer B is a wafer from the same lot as wafer A but the oxide film is cleared from its backside. Wafer C is a typical Teos wafer, which has film deposited on the front side. All wafers have similar oxide film thickness prior to polish and all wafers were polished with the same recipe.

The impact of wafer bow is abundantly clear from this result. Between wafer A & B, film property of these thermal oxide wafers is the same. The large difference in removal profiles is due to wafer bow. We notice that removal profile changed from relatively flat (wafer A) to edge very slow with a large "fast band" inside (wafer B).

On the other hand, wafer B shows considerable similarity to wafer C – a Teos wafer with oxide film deposited only on the front side. The similarity in removal profiles come from the fact that both wafers have large positive bow. The different degrees of bow seem to correlate with the far edge rate quite well.

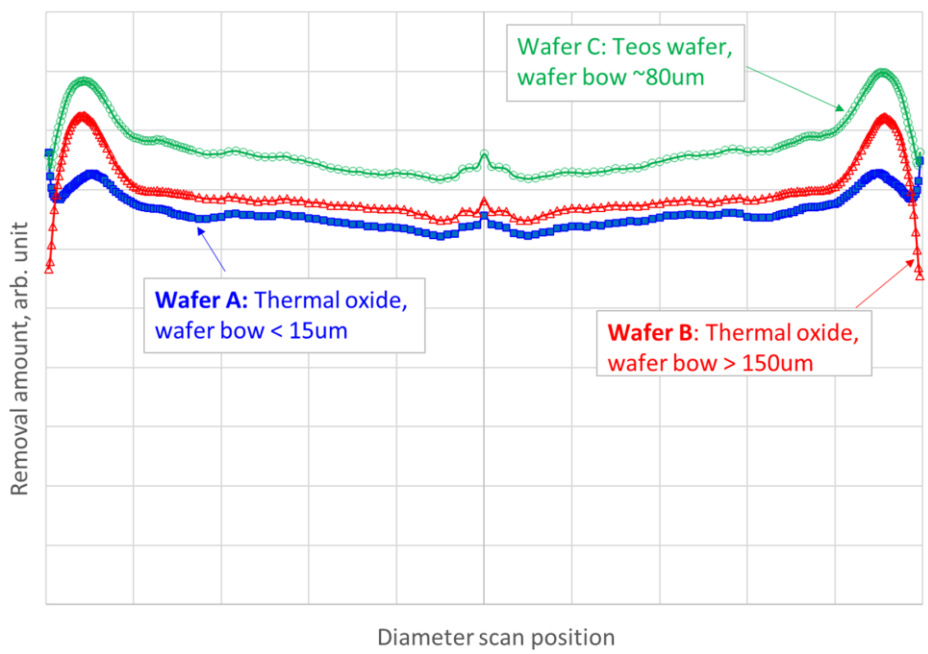

Figure 2. Removal profiles of three different wafers with different starting wafer bow. The dramatic difference between wafer A & B demonstrates the impact of wafer bow, and the similarity between wafer B & C demonstrates the dominance of wafer bow effects even for different film types.

DISCUSSION

Fabs frequently use blanket wafers to qual and monitor tool status. This result shows the importance of maintaining consistent quality of wafers in order for process monitoring to be meaningful.

For device wafers, the impact of wafer bow on photolithography has long been recognized [2,3] and various mitigation schemes have been proposed [4,5]. However, the challenge of wafer bow to CMP has not received sufficient attention. As thicker films are used for 3D structures, wafer bow will present more challenges for CMP. This likely will require modification in process integration to reduce wafer bow.

On the other hand, wafer bow may never be fully eliminated before arriving at CMP. Recognizing the importance of dealing with wafer bow, we have developed a methodology in conjunction with the Fullvision® on Applied Reflection® LK Prime®. Figure 3 shows result of one of such studies.

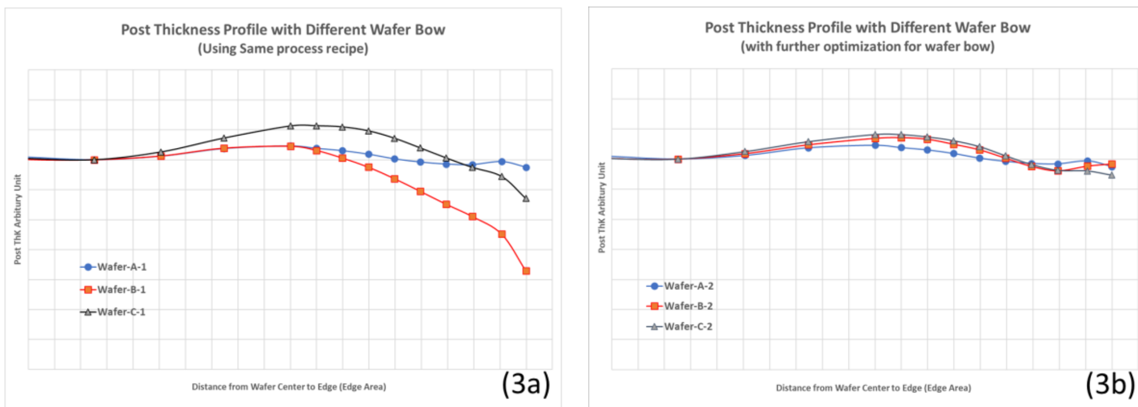

Figure 3. Illustration of wafer bow impact on post profiles. Wafers of three different degrees of bow were shown here: A, B and C. A CMP process was optimized for bow A, the same recipe generated much less than desired results for B and C (3a). With further optimization along with Fullvision®, much consistent results are obtained (3b).

CONCLUSIONS

We have demonstrated clearly the impact of wafer bow on CMP removal profiles. All wafers through CMP process will undergo the changes in wafer shape (bow and warp), and thus the phenomena presented in this study is universal, only differ from each other in magnitude.

The thicker films of 3D structure are likely to present more challenges for CMP to deal with large bow from incoming wafers. An approach from process integration side similar to that for lithography could help with the situation, so does a more robust CMP process such as the one demonstrated in this work.

REFERENCES

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