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Low Pressure High Speed Spin Dryer for Realizing Water Mark Free Surface

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1. Introduction

Many kinds of spin dryers or IPA dryers have been commonly used for drying wafers in the wet processes. On the hydrophobic Si surface, however, a conventional spin dryer often leaves water marks, which reduce the functional yields of LSIs. On the other hand, IPA drying remains the IPA residue on the wafer surface. It is known that, especially, residual IPA after room temperature IPA drying tends to form a direct bonding of Si-C in the wafer surface during hot process[1].

Then, we have developed a novel spin dryer, which is equipped with high speed rotation capability and a pumping and purging system for ambient control inside a drying chamber. In this paper, we discuss the performance of this new spin dryer through the mechanism of the water mark formation.

2. Characteristics of the new spin dryer

Figure 1 shows the schematic diagram of the low pressure high speed spin dryer. The wafers without carrier are transferred from a chemical bath to the dryer after wet treatment and set in the three bars covered with PTFE. 8 inches, 50 wafers can be rotated at 3000 rpm under the 50-100 Torr N_2 ambient in the chamber. The acceleration time is only 2 seconds up to 3000 rpm of a constant rotation. The rotation speed and the acceleration speed are responsible for the suppression of water mark formation. The other key parameter in this drying process is the reduced total pressure and the gas evacuation speed during N_2 purging. This ambient control suppresses the dissolution of oxygen into the remaining water on the wafer surface during drying. Also, it was found that the reduced pressure gives less particle adders even in the high speed rotation. On the other hand, the wafer temperature is changed by the reducing pressure as shown in Fig.2. The pressure control prevents water from bumping and freezing or super-cooling on the wafer surface.

The water marks on the wafers were evaluated through the metal-silicide formation on CMOS-patterned wafers after hydrophobic treatment. This process is very sensitive to water marks and clearly figures them out. The number and size of water marks were measured by the defect inspection system (KLA 2135).

3. Results and discussion

Figures 3 shows the size distribution of water marks in the silicide surface. The number of water marks in new spin dryer was less than that in the conventional one. Especially, 10 - 100μm size of water marks disappeared completely on the wafer surface by new spin dryer. Therefore, the total area of water marks became less than 1/100 in compared with a conventional one.

Figure 4 shows the comparison of low pressure and high speed rotation effects for the suppression of water marks. It was found that high speed rotation was more effective than low pressure ambient control, while each parameter takes a part to suppress the water mark formation.

However, a few of the water marks still remains on the wafer surface. This reason is as follows. In this cleaning system, wet wafers are exposed to the clean room air during the transportation from the chemical bath to the spin dryer after chemical treatment. Si atoms in the hydrophobic surface tends to dissolve into the remaining water on the surface during the wafer transportation. It can be clearly seen in Fig.5 that Si atoms dissolved into DIW increase with a dipping time. In this figure, it is very interesting to find that this phenomena was obtained only from n^+ and p^- surface and the dissolved Si atoms could not be detected from p^+ surface. Also, the water mark was evaluated using metal-silicidation process for n^+ and p^+ surface, respectively. It was found that the water mark formation occurred on only n^+ surface. This result is consistent with the dissolution data of Si atoms into DIW. It is supposed that this phenomena results in the difference of the termination of n^+ and p^+ surface.

Therefore, we tried to wash out the residual water, in which Si atoms dissolved on the surface during the wafer transportation, with rinse-showering using pure DIW inside the dryer chamber just before drying. Figure 6 shows the final shower rinse effect in the CMOS patterned wafer. Finally, the low pressure high speed spin dryer with the showering rinse suppressed the water mark formation less than 0.05 percents in compared with a conventional spin dryer.

4. Conclusion

We have developed the low pressure high speed spin dryer to realize the water mark free hydrophobic surface without IPA. It was demonstrated that high speed rotation, low pressure control with N2 purging, and shower rinsing just before drying suppressed the water mark formation on the Si surface after hydrophobic treatment.

References

1) T.Jimbo, K.Tsugane, Y.Ishii, and H.Tomioka, Proc. of Int. Symp. Semiconductor Manufacturing, p117 (1998).

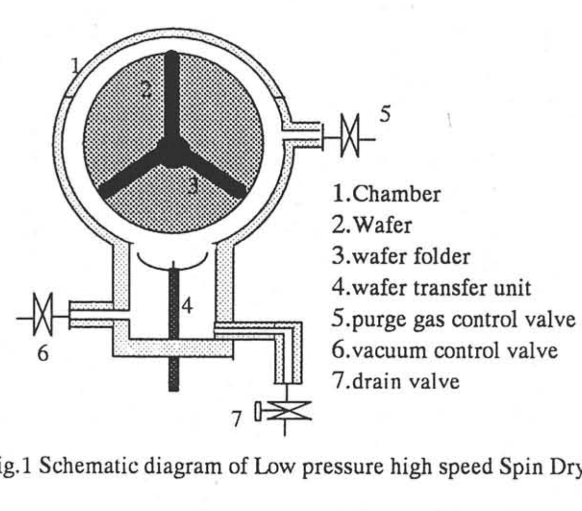

Fig.1 Schematic diagram of Low pressure high speed Spin Dryer.

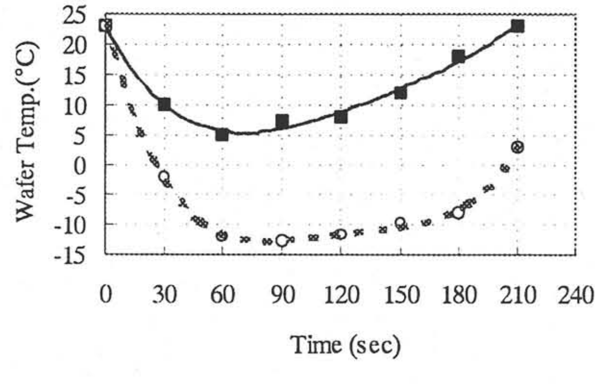

Fig.2 Change of wafer temperature in low pressure high speed spin dryer. The solid line shows the result under 13kPa. The dotted line shows under 1kPa.

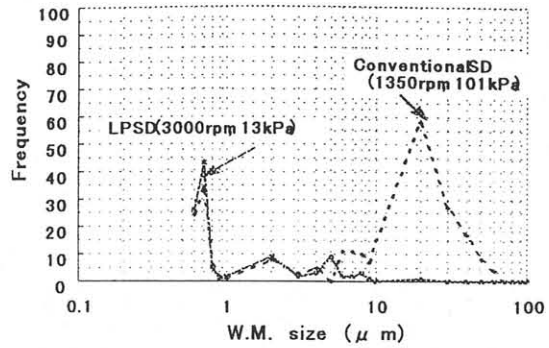

Fig.3 Comparison of conventional and low pressure high speed spin dryer .The solid line shows low pressure high speed spin dryer. The dotted line shows conventional one.

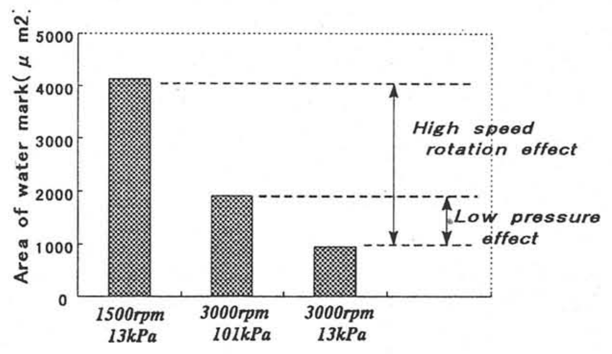

Fig.4 Comparison of low pressure and high speed rotation effect.

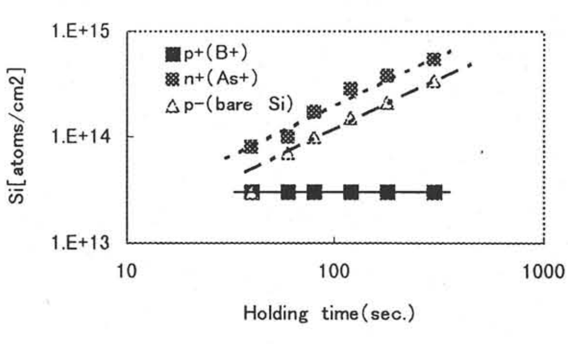

Fig.5 Concentration of dissolved Si atoms into DIW.

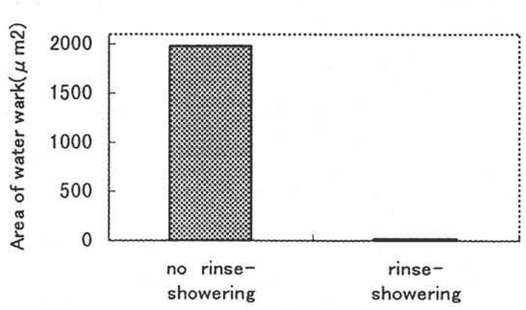

Fig.6 Effect of rinse-showering just before drying