T 형의 waveguide를 이용한 Post CMP용 메가소닉 세정장치에 대한 연구

김태곤, 이양래*, 임의수*, 강국진*, 김현세*, 박진구
한양대학교, *한국기계연구원

Study of T Type Waveguide in Single Wafer Megasonic Cleaning for Post CMP

Tae-Gon Kim, Yanglae Lee*, Euisu Lim*, Kookjin Kang*, Hyunse Kim*, and Jin-Goo Park
Hanyang University, *Institute of Machinery and Materials

Abstract : Transverse sonic wave was generated by T type waveguide for single wafer cleaning application. T type megasonic waveguide was analyzed by acoustic pressure measurements and particle removal efficiency. Compared to conventional longitudinal waves, not like longitudinal waves, transverse waves showed changes of direction and phase which increased the cleaning efficiency.

Key Words : Megasonic, Single Wafer Cleaning, Transverse Sonic Wave, Particle Removal

1. Introduction

Single wafer cleaning process has been developed for the next generation cleaning process. Commercial megasonic cleaning system has been used for the particle removal on the single wafer surface [1, 2].

The effective sonic wave for the particle removal is a longitudinal wave which is widely used in the commercial megasonic cleaning system. When a megasonic transducer is located on the bottom side of wafer front surface, the direction of sonic wave peak is perpendicular to the particles on the surface. If the peak is perpendicular to the particles, higher cleaning efficiency could be expected due to the direct contact between the sonic wave and the particles.

It is well known that a transverse wave can be generated from longitudinal wave in a cross waveguide structure at low frequency level. Figure 1 shows the schematic diagram for the longitudinal and transverse waves when the megasonic transducer is located on the wafer surface. If the transverse sonic wave is generated at high frequency, this wave can be applied in the megasonic single wafer cleaning process.

In this research, the acoustic pressure field was measured acoustic pressure in order to confirm the creation of the transverse wave in vertical waveguide region and was investigated the particle removal efficiency on silicon wafer in DI water.

2. Experimental Materials and Procedure

The megasonic cleaning system was simply composed of a spinner with a wafer chuck, UPW supply and a T type waveguide which was made of aluminum which was connected to a megasonic transducer. Figure 2 shows the schematic diagram of a megasonic system for single wafer cleaning experiments.

For the particle removal experiment, 0.3 μm PSL particles were used as contaminants. The particles were deposited on the 6 inch blanket silicon wafer surface using an aerosol spray method. A contaminated wafer was set on the spin chuck and the T type waveguide was closely positioned to the wafer surface maintaining a gap distance of 3.5~4 mm. Ultra pure water was supplied on the center of the wafer surface at a flow rate of 2.4 l/min. The wafer was spun at 60 rpm during cleaning process. After the cleaning process, the wafer was spin dried at 1500 rpm for 3 min. The removal efficiency was measured by counting particles before and after cleaning. A surface particle scanner (SurfScan 5500, KLA-Tencor Co.) was used to measure the number of particles on the surface.

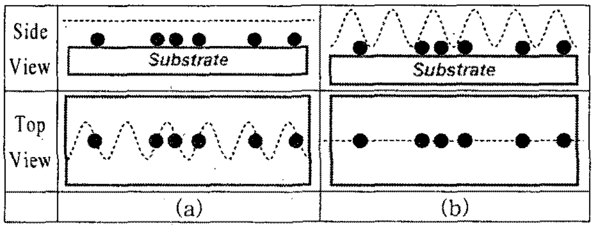

Figure 1. The schematic diagram of (a) longitudinal and (b) transverse sonic waves when the megasonic transducer is located on the wafer surface.

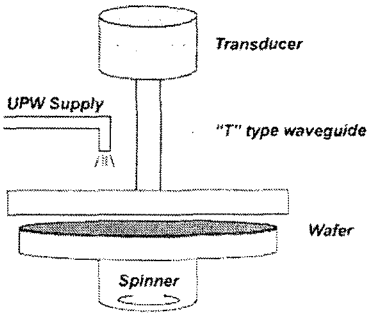

Figure 2. The schematic diagram of a megasonic cleaning tool.

3. Results and Discussion

The particle removal efficiency (PRE) as a function of cleaning time at three different megasonic powers of 44, 90 and 120 W with a T type waveguide was tested as shown in Fig. 3. The highest particle removal efficiency was observed at a power of 44 W. The removal efficiency even decreased at a power of 90 W, then increased at 120 W as a function of time. The results of acoustic pressure field analysis at difference megasonic powers were shown in Fig. 4.

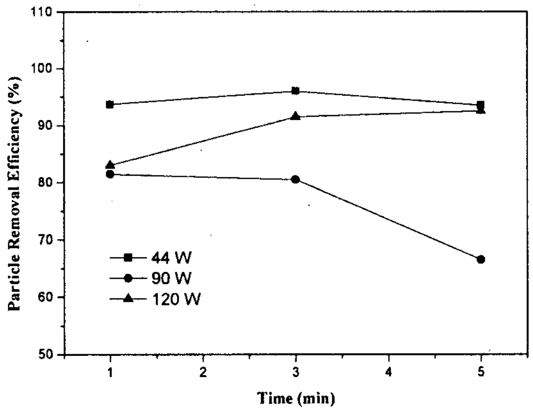

Figure 3. The particle removal efficiency as a function of cleaning time and power with a T type waveguide.

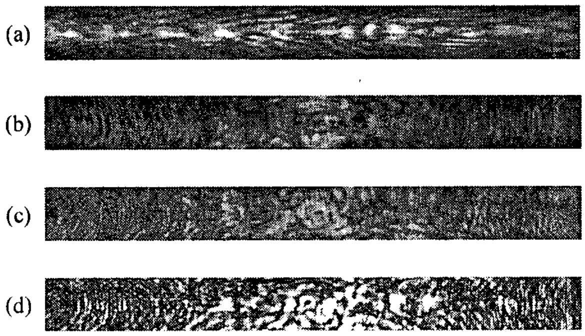

Figure 4. The acoustic field analysis for sonic wave (a) at strait waveguide and at cross waveguide (b) at 44 W, (c) at 90 W and (d) at 120 W respectively.

It should be mentioned that the particle removal efficiency was not strong functions of cleaning time and megasonic power. The matching and optimization of the megasonic transducer and waveguide played important roles in the transverse type megasonic cleaning system.

The differences in direction and phase of longitudinal and transverse sonic waves have influence on cleaning efficiency. Single sonic wave exists at a thin waveguide because wavelength is long at low frequency, but if thickness of waveguide was same, multiple sonic waves exist at high frequency region.

The direction and phase of longitudinal and transverse sonic waves in waveguide were shown in Fig. 5. The phase of longitudinal sonic wave is the same even if there are multiple sonic waves existed with same frequencies. Therefore, it creates low and high sound pressures at longitudinal direction which may cause non-uniform sound pressures. It might be the reason for low PRE in longitudinal megasonic system. However, the transverse sonic waves have phase difference at waveguide. It has effective cleaning performance because the pressure difference over the area is small. Therefore, transverse sonic wave at even lower megasonic power resulted in a good PRE.

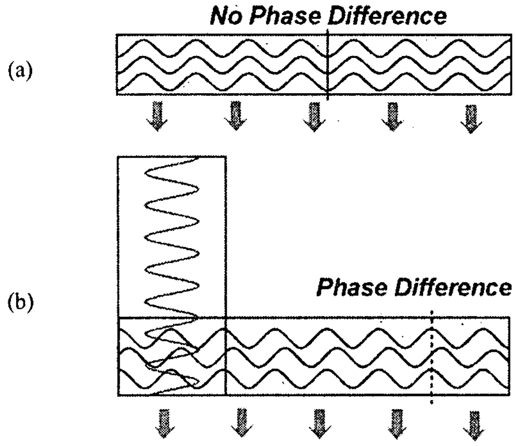

Figure 5. The schematic diagram of the direction and phase of (a) longitudinal sonic waves and (b) transverse sonic waves.

4. Conclusion

Transverse sonic wave which was generated by longitudinal sonic waves at T type waveguide was investigated for single wafer cleaning application. The designed transverse waves showed the uniform sound pressure compare to the longitudinal sonic wave at a single beam waveguide. A spinner with T type waveguide was set up to evaluate cleaning efficiency. Wave direction and phase difference determine the cleaning efficiency of a megasonic system. Transverse sonic wave at low megasonic power showed effective particle removal efficiency due to uniform acoustic surface pressure on the substrate.

Acknowledgement

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