Evolution model of wafer surface flatness based on Chemical Mechanical Polishing

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1. Introduction

Evaluating the surface quality of wafers generally takes into account surface roughness, surface defects and flatness[1]. In the CMP process, the polishing process parameters have a great influence on the surface quality of the wafer[2,3]. Many scholars have studied the influence of CMP process parameters on wafer quality by experimental method, but can't know in advance the flatness after polishing. In this paper, the modified parameter k_p in Preston equation is obtained by experimental method, and the polishing pressure is obtained by finite element method, and the relative velocity is obtained by numerical calculation method. Based on the Preston equation, a prediction model of wafer surface flatness is created, which can predict the surface flatness of wafers after CMP machining under different process parameters. The influence of different process parameters on the flatness of Wafer is also analyzed.

2. Flatness modeling method

$$\Delta z = 0.06579 w_h + 0.106161 w_d + 0.013246 F - 1.50566 \quad (1)$$

$$k_p = \frac{s\Delta z}{vFt} \quad (2)$$

The modified parameter k_p is obtained by experimental method, show in Table 1-3 and the corresponding k_p can be calculated under any process parameters by eq.(1,2).

Table 1 Effect of polishing head rotational speed on material removal

w_h	20	30	40	50
Δz	9.84	10.04	10.4	11.8

Table 2 Effect of polishing pad rotational speed on material removal

w_d	20	30	40	50
Δz	10.2	9.76	11.48	12.2

Table 3 Effect of polishing pressure on material removal

F	250	350	450	550
Δz	8.72	10.04	12.44	14.04

3. Simulation of pressure and relative velocity

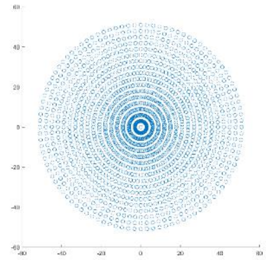

Fig.1 Scatter distribution

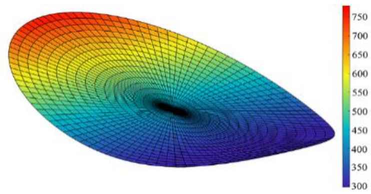

Fig.2 Velocity diagram

By calculating the relative velocity between the polishing head and the polishing pad, the relative velocity corresponding to the surface points of the wafer in the polishing is obtained. Fig.1 is the corresponding point coordinates, Fig.2 is the result of the calculation

By means of finite element simulation, the pressure distribution of wafer surface at different times is obtained, and the pressure reaches steady state after starting polishing 13s,show in Fig.3.

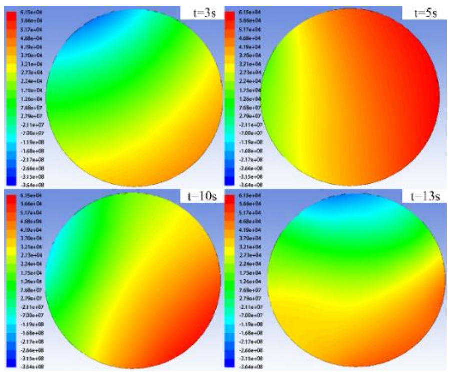

Fig.3 surface pressure distribution

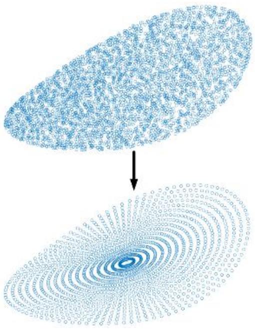

Fig.4 Pressure distribution interpolation

By means of interpolation, the irregular pressure distribution through simulation is transformed into the distribution of rules,show in Fig.4.

4. Flatness modeling

The actual surface morphology of the wafer is converted into a numerical morphology which can be used for calculation by Gaussian method,show in Fig.5 and Fig.6.

Based on Preston equation, the evolution model of wafer surface flatness is created. It is found that the center of wafer surface is higher than the edge after polishing, but the flatness quality is improved, which is in line with the actual situation.show in Fig.7

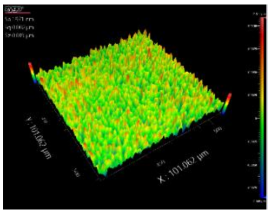

Fig.5 Local 3D topography

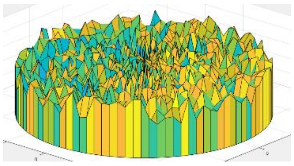

Fig.6 Surface topography model

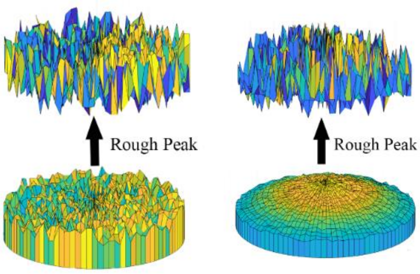

Fig.7 Surface morphology before and after polishing using predictive models

5. Effect of process parameters on flatness

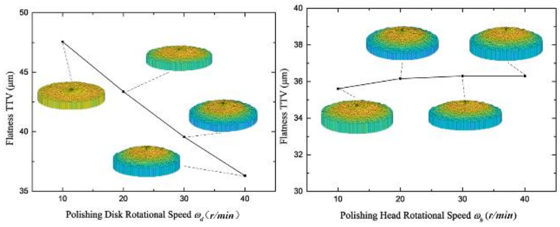

Fig.8 Effect of w_d and w_h on flatness

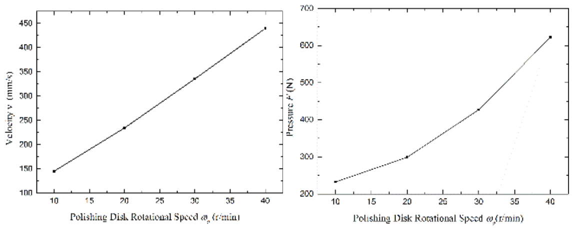

Fig.9 Effect of w_d on v and F

Based on the analysis of this model, Fig.8 indicates that the relative velocity has a significant effect on flatness, and the Fig.9 indicates that the rotational speed of the polishing pad has a linear effect on the relative velocity.

Conclusions

1. Based on Preston equation, the evolution model of wafer surface flatness is established.
2. Based on this model, it is analyzed that the relative velocity has a significant effect on flatness, and improving the rotational speed ratio of polishing pad to polishing head can make the wafer surface flatter.

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