Honeywell

WAFER THINNING MATERIALS WHITE PAPER

Honeywell Silicon Texture Etchant

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OVERVIEW

Honeywell Electronic Materials has added Silicon Texture Etchant, for polishing the backside of a wafer, to its extensive semiconductor processing product portfolio. Honeywell's world-class production facilities and techniques produce an etchant with excellent batch-to-batch product uniformity. This product uniformity results in consistent drum-to-drum and bottle-to-bottle wafer polishing and etching characteristics such as surface roughness and etch rate.

A stable etcher as well as a consistent etchant is needed to ensure a stable wafer backside etching process. Honeywell Electronic Materials, in collaboration with SEZ America, Inc., has completed designed experiments to investigate the effects of equipment parameters on wafer polishing and etching performance. The effects of process temperature, chuck rotational speed, etchant flow rate, as well as dispense profile on the silicon surface roughness and etch rate are presented. A SEZ 200 mm Model 203 Spin-Processor etcher located at the SEZ America, Inc. research lab in Phoenix, AZ was employed for this study.

DESIGNED EXPERIMENT

A reduced four-factor, three-level, Box-Behnken response surface employing 20 runs (and 20 wafers) was used. The etcher parameters (factors) and their settings are presented in Table I. Column one contains the etcher parameters that were varied. Columns two through four contain the high, middle, and low values respectively of the etcher parameter settings.

Table 1. Etcher Parameters and Their Settings

	SETTING		
ETCHER PARAMETER	High	Middle	Low
Temperature (ºC)	60	55	50
Chuck Speed (RPM)	600	450	300
Flow Rate (L/min.)	1.6	1.3	1.0
Dispense Profile (mm)	50	45	40

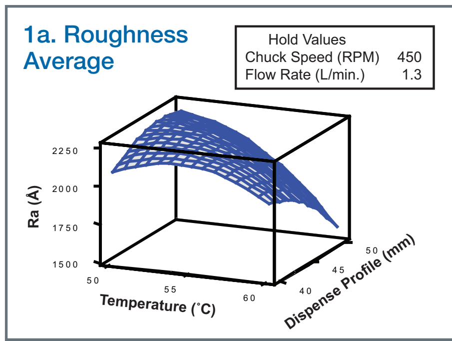
The SEZ single-wafer spin-processor dispenses chemistry on to the surface of a wafer, which is rotating on a process chuck. Chuck rotation speed, chemical flow rate, temperature, and dispense profile (track of the chemical dispense nozzle relative to the speed of the track across the wafer) are all highly controlled parameters throughout processing to achieve specific etch characteristics on the wafer. A combination of these parameters dictates etch characteristics, such as etch rate, uniformity, and wrap-around on the bevel edge to the wafer front side.

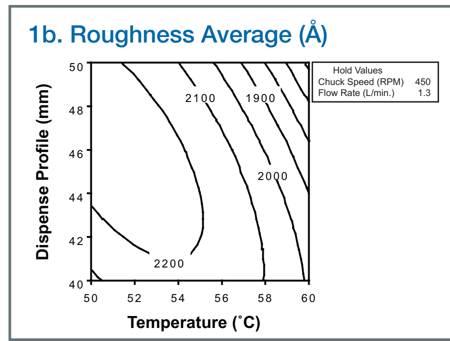
The average silicon loss, (Δd), was determined by averaging the difference in wafer thickness at 29 locations on each 200mm wafer prior to and after etching. The post-etch surface roughness average, Ra, of a wafer was determined by measuring the center of that wafer after etch using a KLA-Tencor P2 profilometer.

POST ETCH SURFACE ROUGHNESS AVERAGE

Surface and contour plots of the post etch surface roughness average, Ra, of the Honeywell Silicon Texture Etchant as a function of dispense profile and temperature when the settings of the other tool parameters (chuck speed and flow rate) are held at their middle settings are presented in figures 1a and 1b respectively (see page 2). A calculated maximum Ra of 2250Å occurs at a temperature of 52ºC and a dispense profile of 46mm. Changing either the dispense profile or temperature settings will decrease the surface roughness. At low temperature, the surface roughness is high and the dispense profile has little effect on the surface roughness. At higher temperatures, surface roughness is low and decreases with increasing flow rate. For example, Ra decreases from 2000 to 160Å as the dispense profile increases from 40 to 50mm while the temperature is held constant at 60ºC. When the dispense profile is large, Ra decreases with increasing temperature. For example, Ra decreases from approximately 2200 to 1600Å as the temperature increases from 50 to 60ºC while the dispense profile is held constant at 50mm. A large dispense profile coupled with a high temperature will produce the smoothest surface (i.e. lowest Ra value).

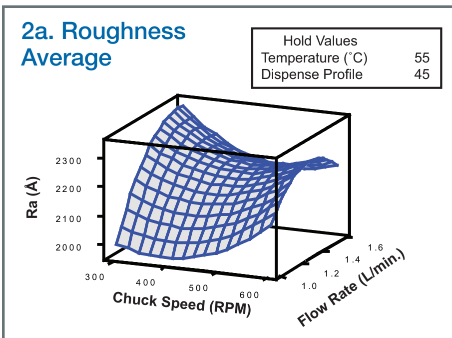
The chuck speed and flow rate have a small effect on Ra. Surface and contour plots of Ra as a function of chuck speed and flow rate when the settings of the other tool parameters (dispense profile and temperature) are held at their middle settings are presented in figures 2a and 2b respectively see page 2). At low chuck speed, roughness increases with increasing flow rate. For example, Ra increases from 2000 to over 2300Å as the flow rate increases from 1.0 to 1.6 L/minute while the cheek speed is held constant at 300 RPM.

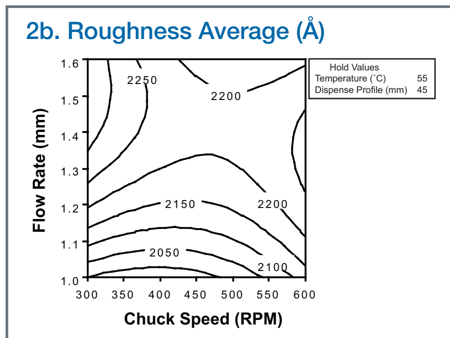




Figures 1a and 1b.

Surface (1a) and contour (1b) plots of the post etch surface roughness average, Ra, of the Honeywell Silicon Texture Etchant as a function of flow rate and temperature when the settings of the other tool parameters (chuck speed and dispense profile) are held at their middle settings.





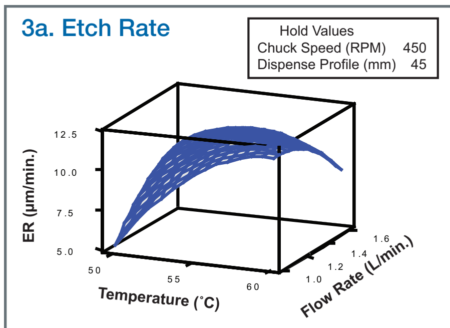
Figures 2a and 2b.

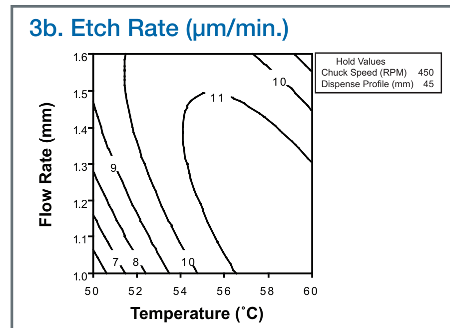
Surface (2a) and contour (2b) plots of the post etch surface roughness average, Ra, of the Honeywell Silicon Texture Etchant as a function of chuck speed and dispense profile when the settings of the other tool parameters (flow rate and temperature) are held at their middle settings.

SILICON ETCH RATE

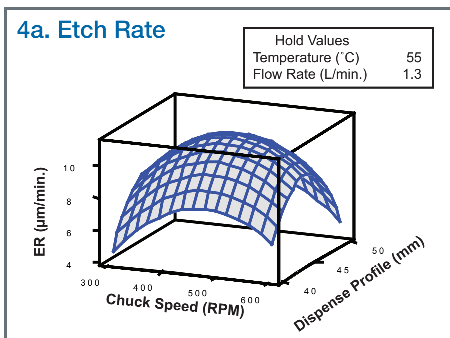
Surface and contour plots of the silicon etch rate of the Honeywell Silicon Texture Etchant as a function of flow rate and temperature when the settings of the other tool parameters (dispense profile and chuck speed) are held at their middle settings are presented in figures 3a and 3b respectively. Low temperatures coupled with low flow rates or high temperatures coupled with high flow rates yield low silicon etch rates. High temperatures coupled with low flow rates yield high etch rates. The silicon etch rate, for example, increases from approximately 5 to 11.5 μm/minute as the temperature increases from 50 to 60ºC while the flow rate is held constant at 1.0 L/minute.

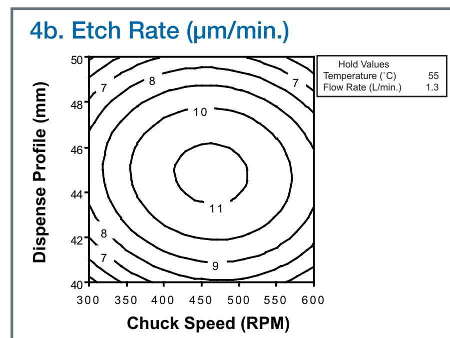
The chuck speed and dispense profile also have an effect on the silicon etch rate. Surface and contour plots of the silicon etch rate as a function of chuck speed and dispense profile when the settings of the other tool parameters (flow rate and temperature) are held at their middle settings are presented in figures 4a and 4b respectively (see page 3). A calculated maximum value in the etch rate of 11.0 μm/minute occurs at a chuck speed of 475 RPM and a dispense profile of 45mm. Changing either the chuck speed or dispense profile settings will decrease the etch rate.





Figures 3a and 3b.
Surface (3a) and contour (3b) plots of the silicon etch rate of the Honeywell Silicon Texture Etchant as a function of flow rate and temperature when the settings of the other tool parameters (chuck speed and dispense profile) are held at their middle settings.





Figures 4a and 4b.
Surface (4a) and contour (4b) plots of the silicon etch rate of the Honeywell Silicon Texture Etchant as a function of chuck speed and dispense profile when the settings of the other tool parameters (flow rate and temperature) are held at their middle settings.

SUMMARY AND ACKNOWLEDGEMENTS

Honeywell is producing a Silicon Texture Etchant with excellent batch-to-batch product uniformity. A designed experiment study has been completed to investigate the effects of etcher parameters on wafer etching performance. This study has shown that the post etch surface roughness is a function primarily of the dispense profile and temperature. In addition, this study has shown that the silicon etch rate is a function primarily of the temperature. The silicon etch rate increases with increasing temperature.

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