

Investigation of Polishing Mechanism of Sapphire-CMP

Using Commercially Available Single-Sided Polisher

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Objective

In this study, elucidation of the polishing mechanism of sapphire-CMP and effect of each parameters on the polishing characteristics.

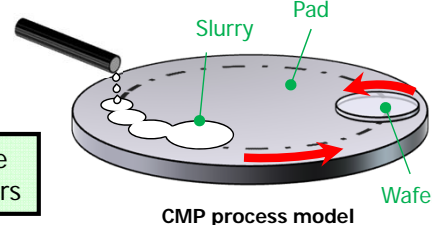
Background

- Sapphire is used for the substrate of the LEDs. However, the sapphire is categorized **hard-to-process materials**, therefore, **long time processing** is required by the lowness of efficiency of polishing (removal rate)
- The removal rate is affected by various parameters.

When changing the **rotational speed <RS>** and **Polishing pressure <PP>** ...

- Standard deviation of slurry flow velocity between the polished wafer and the polishing pad <VSD>
- Ratio of slurry flow velocity to pad liner velocity (velocity ratio) <VR>
- Stiffness of polisher <SP>
- Micro-displacement of wafer <DW>

Analysis of the each parameters



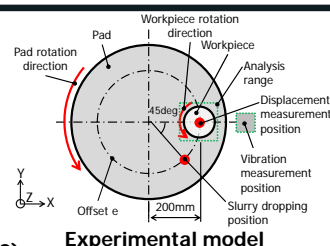
Elucidate the polishing mechanism from the **effect of each parameters on the removal rate**

Experimental method

- Slurry flow velocity**
The slurry flow velocity measured by the **DIC method**
→ **Quantitative evaluation of the displacement** by the digital **image processing**
- Micro-displacement of wafer**
The micro-displacement of wafer measured displacement in **Z-axis direction**
- Stiffness of polisher**
The stiffness of polisher measured **vibration acceleration** by **RMS**



Commercially available single-sided polisher (Engis Japan : HYPREZ-610)



Experimental model

Experimental result

Experimental condition

Type of Pad	SUEDE
Workpiece	Sapphire (4 inch)
Offset e	200 mm
Rotational speed of pad and workpiece	10, 25, 30, 45, 50, 65, 80 min ⁻¹ (CCW)
Type of slurry	Colloidal silica
Abrasive concentration	20 wt%
Polishing pressure	3.7 and 10 kPa

Analysis of each parameter by a **multiple correlation analysis**

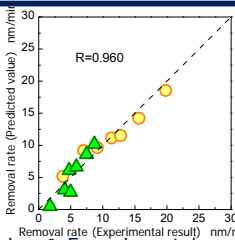
Analyze the impact of the dependent variable to the Independent variable

$$y = k_0 + k_1x_1 + k_2x_2 + \dots + k_nx_n$$

y : independent variable k : Partial regression coefficient x : dependent variable

Result of multiple correlation analysis

y-intercept		-5.187
Rotation speed	RS	0.2528
Polishing pressure	PP	0.6126
Displacement of wafer	DW	156.4
Velocity ratio	VR	-5.180
Velocity standard deviation	VSD	-0.02765
Stiffness of polisher	SP	-4.418



Positive value : **RS, PP, DW** Predicted value & Experimental result

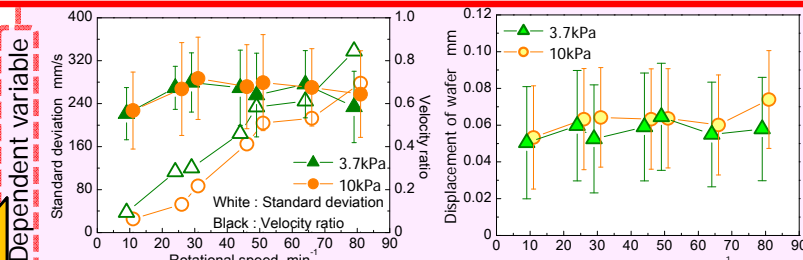
→ Removal rate **increases** as the value is **greater**

Negative value : **VR, VSD, SP**

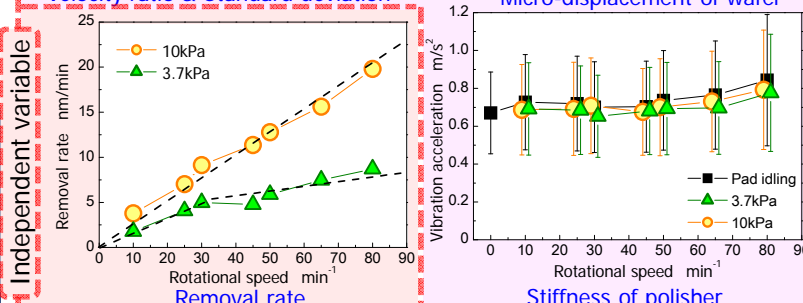
→ Removal rate **increases** as the value is **less**

Predictable of removal rate from each parameters by multiple correlation analysis

The focus on the Velocity standard deviation <VSD> and Stiffness of polisher <SP>



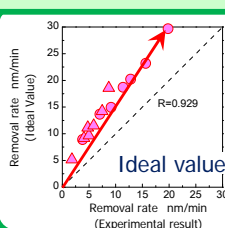
Velocity ratio & Standard deviation



Removal rate

Stiffness of polisher

Ideal value that eliminates effects of VSD and SP



Removal rate is greatly increased

As a result ...

- Control of the slurry flow
 - Increase of polisher stiffness
- are important

Conclusion

- The removal rate is increases with the increase of the rotational speed, the polishing pressure and the displacement of wafer, and with the decrease of the velocity ratio, the standard deviation of slurry flow velocity and the vibration acceleration from the results of the multiple correlation analysis.
- It can be predicted that the removal rate increases for decreasing of effects of the standard deviation of slurry flow velocity and the vibration acceleration.