Optimization of Water Polishing for and Improved Abrasive Removal

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SPCC2019
April 2-3, 2019
Portland, USA

Introduction

BACKGROUND AND OBJECTIVE

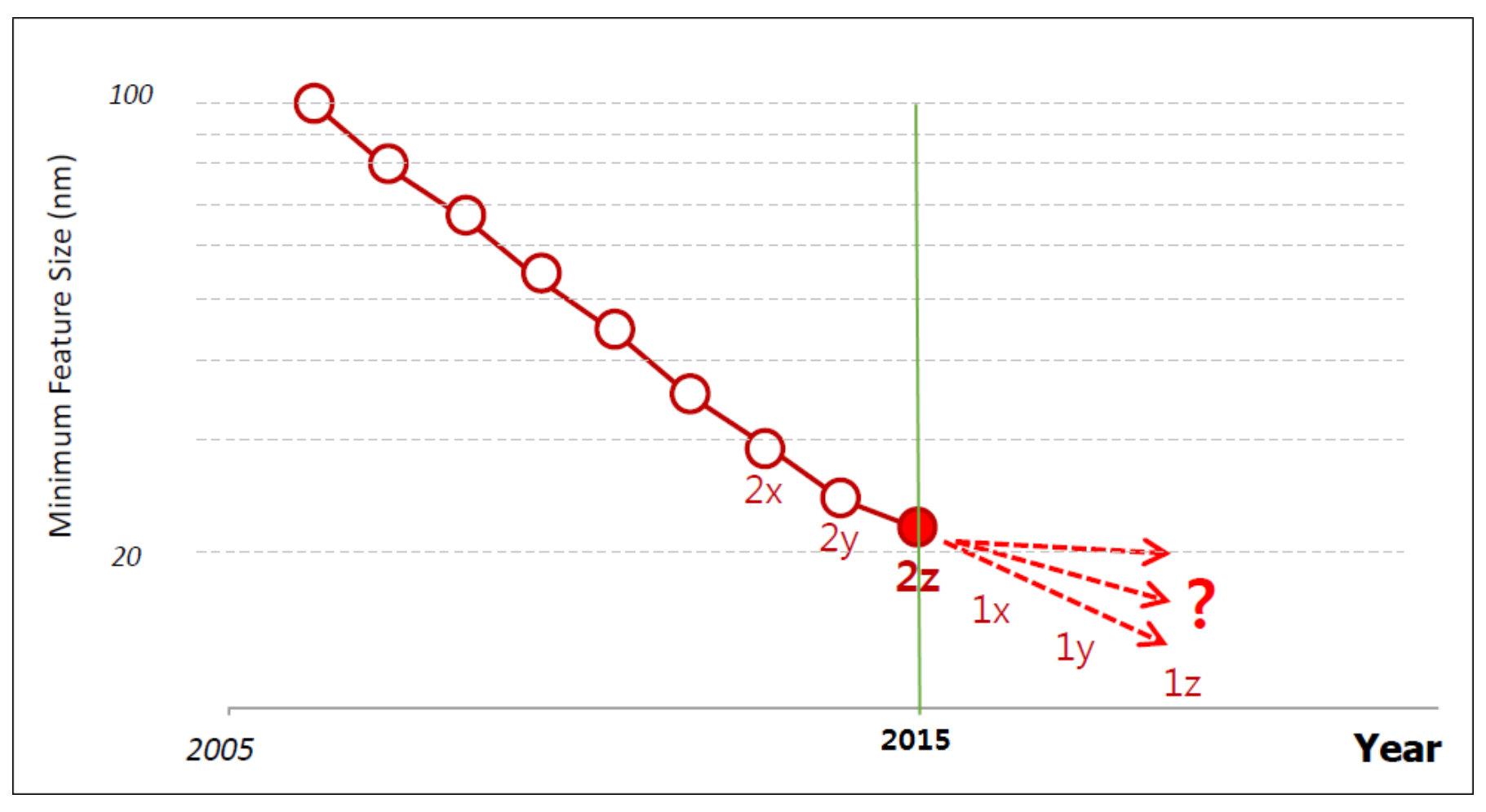


Fig. 1. DRAM Technology Trend & Future (ITRS2015)

- Design rule ↓
- Size of pattern ↓
- Required level of scratch & defect ↓ .

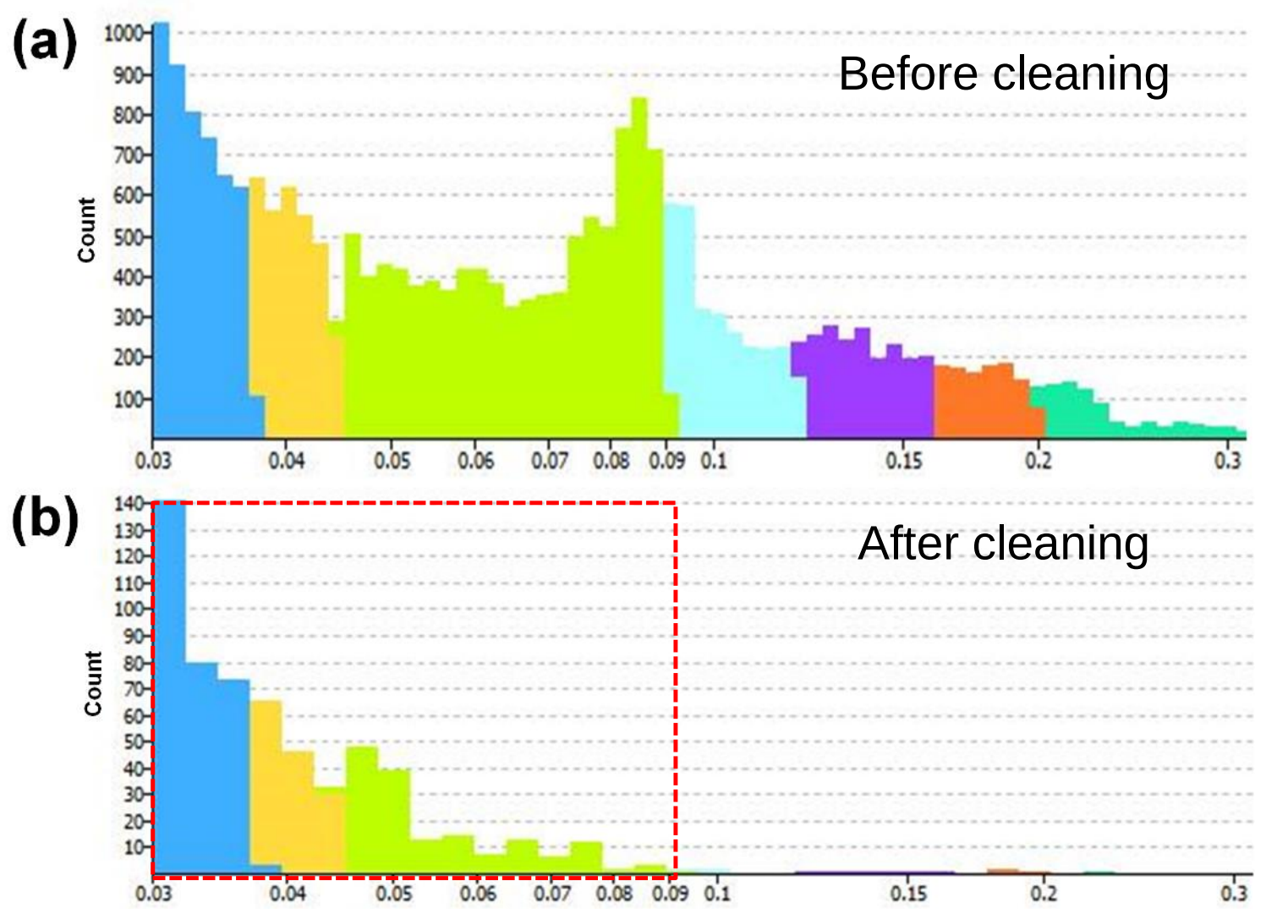


Fig. 2. Defect counts of SiO2 wafer (a) before and (b) after cleaning

- CMP → Post CMP Cleaning
- However, small particles still remain on the wafer surface.

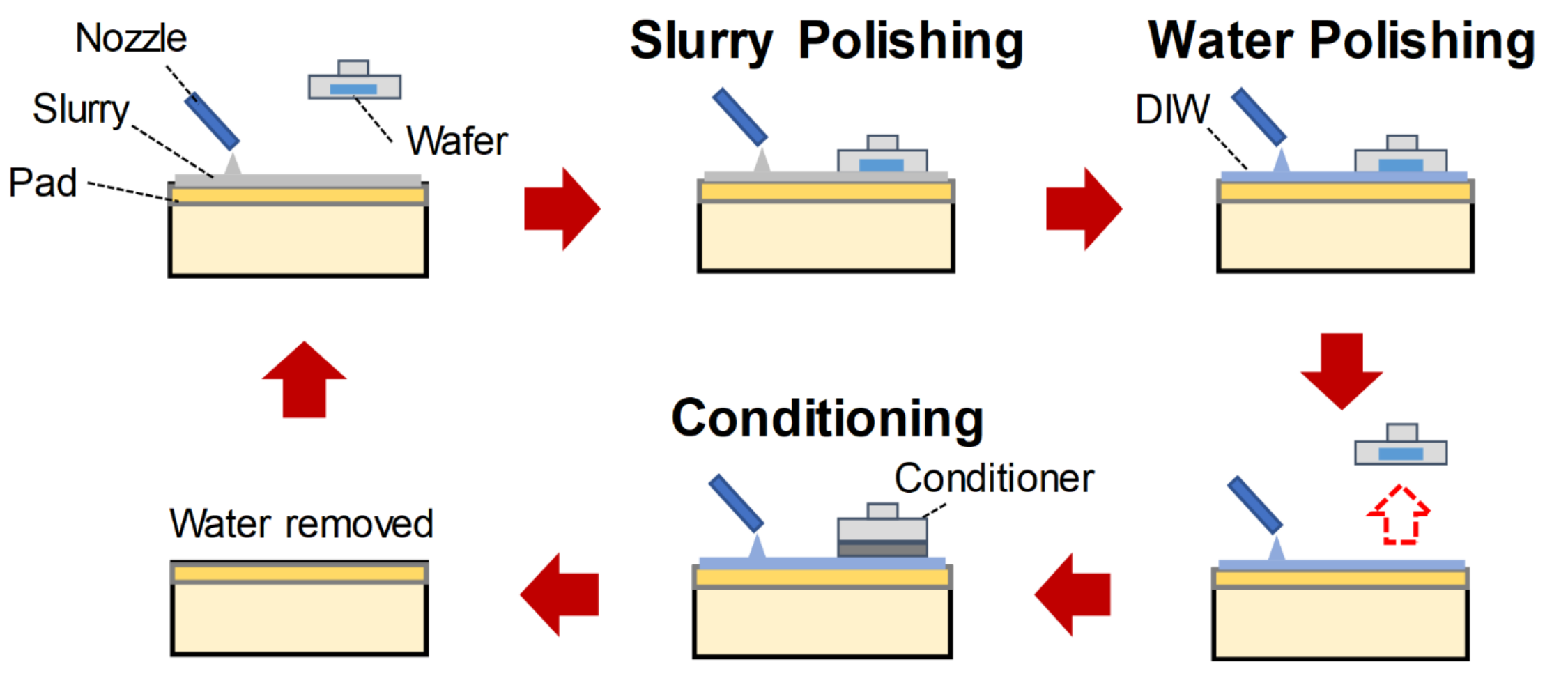


Fig. 3. Schematic of polishing step

- Slurry polishing : main process
- Water polishing : cleaning & surface treatment
- Post CMP Cleaning : removal of defects

→ **Optimization of water polishing step for more effective post-CMP cleaning**

Experimental

EXPERIMENTAL METHOD

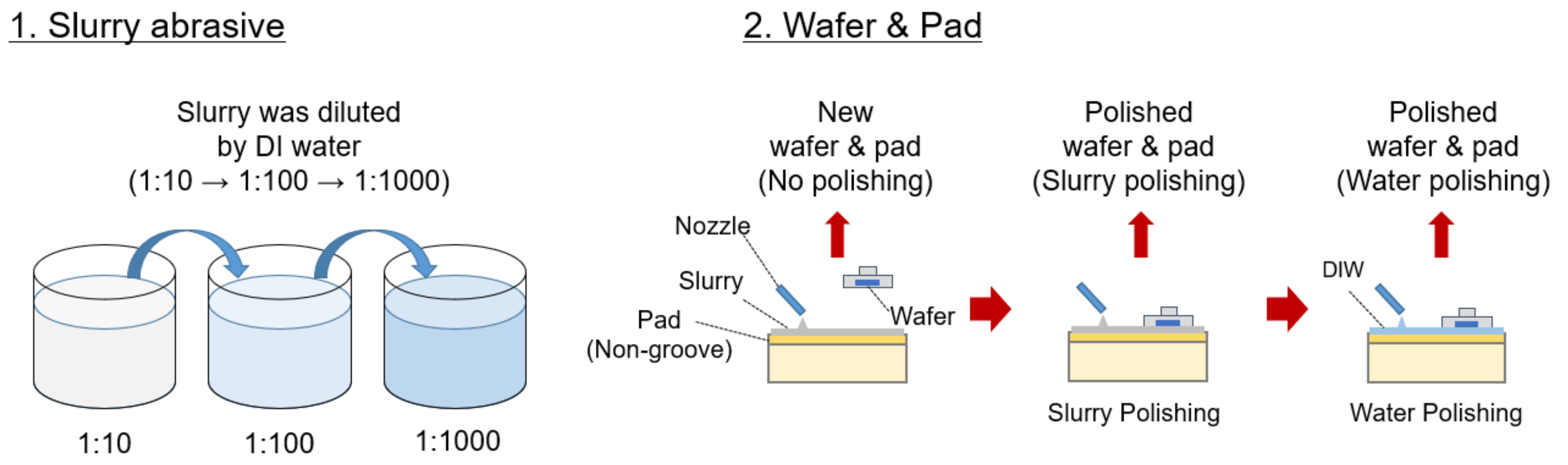


Fig. 4. Experimental process

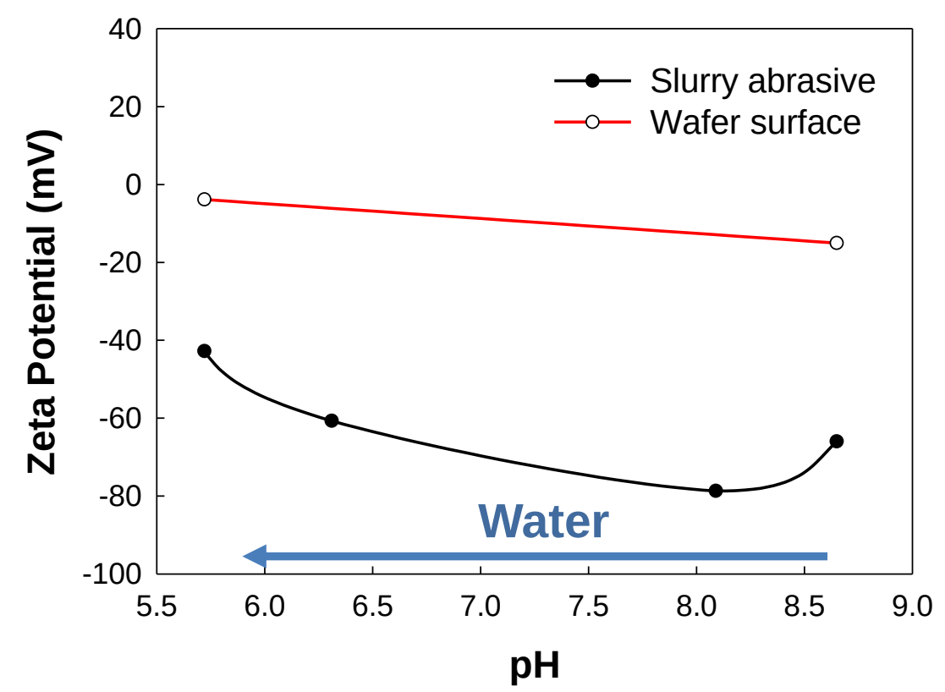


Fig. 5. Zeta potential changes of slurry abrasive & wafer surface

- Repulsion between abrasive & wafer ↓
- We need more mechanical force or other chemical.

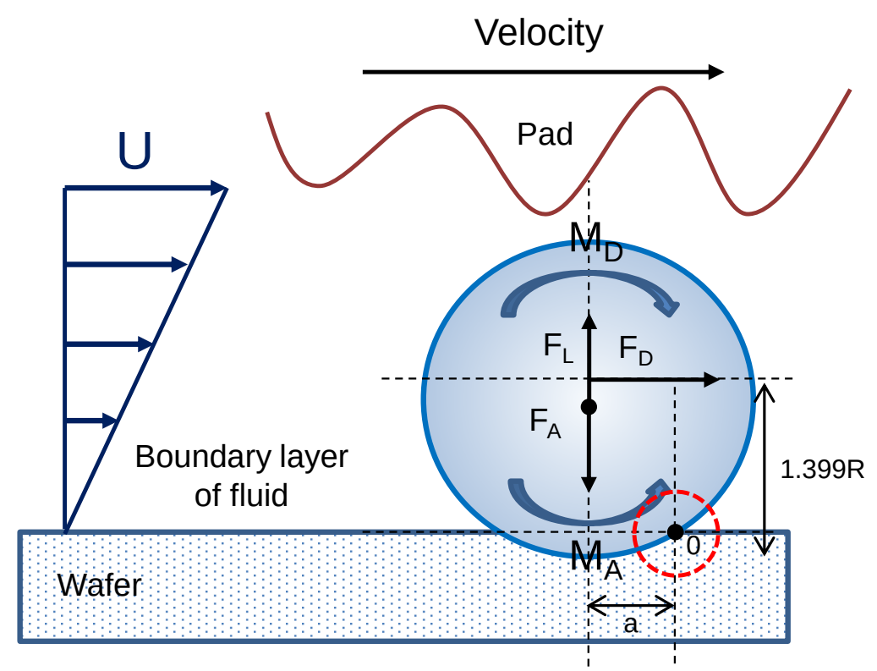


Fig. 6. Forces acting on abrasives

$$RM = \frac{F_D \times 1.399R}{(F_A - F_L)\times a} \text{ (non-contact)}$$

$$RM = \frac{I_p/\omega_p}{(F_A - F_L)\times a} \text{ (contact)}$$

→ Increasing of F_D, F_L, F_C can Induce abrasive removal

Table 1. Process conditions of water polishing

Head pressure (hPa)	50, 100, 200
Head speed (RPM)	60, 90, 120
Platen speed (RPM)	61, 91, 121
Flow rate (ml/min)	100, 500, 1000
Polishing time (sec)	5, 10, 30
Water temperature (℃)	4, 20, 50

Contact area(%) between the pad & wafer is very low (<1%)

Drag force > contact force
→ more dominant

$$F_{drag} = 3\pi\mu d_p V_{rel}$$

μ ↑, V_{rel} ↑ → F_{drag} ↑

Results

RESULTS AND DISSCUSSION

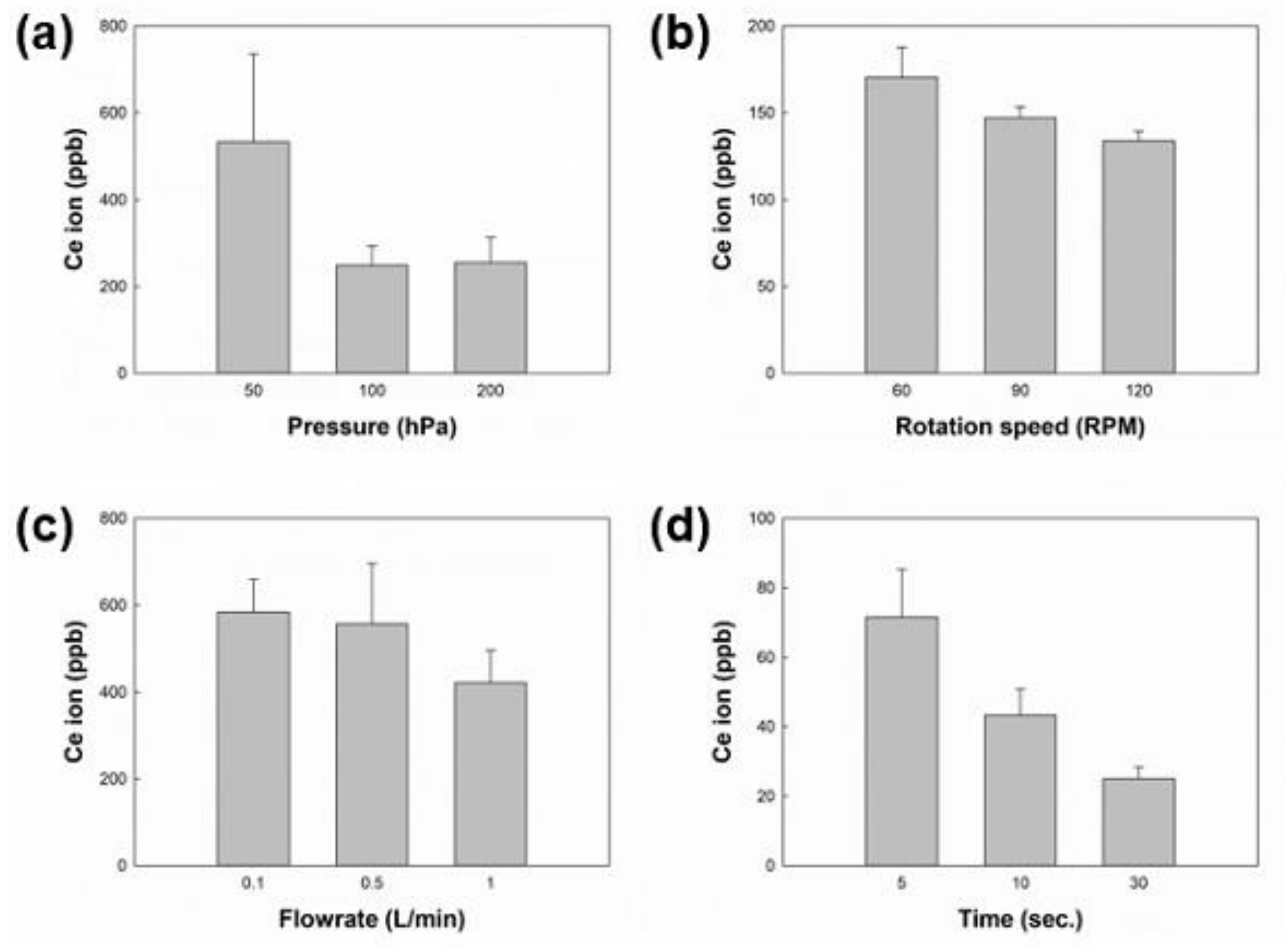


Fig. 7. Residual Ce-ion change on wafer surface according to (a) pressure, (b) rotation speed, (c) flowrate and (d) processing time using ICP-MS

F_{drag} ↑ = $3\pi\mu d_p \mathbf{V}_{\mathbf{rel}}$ ↑

Pressure (P) ↑
Rotation velocity (V) ↑
Flowrate (Q) ↑
Processing time (t) ↑

⇩

Abrasive removal ↑

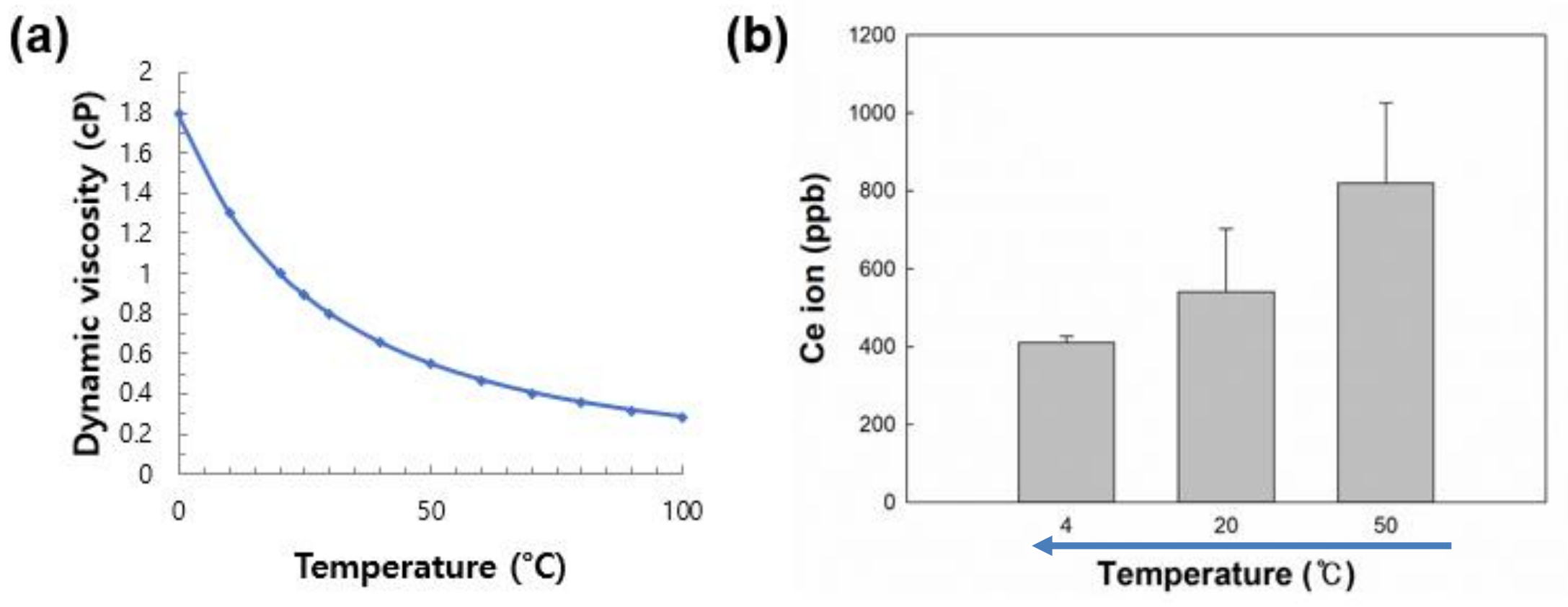


Fig. 8. (a)Viscosity of water with temperature, (b)residual Ce-ion with water temperature

F_{drag} ↑ = $3\pi \boldsymbol{\mu}$↑$d_p V_{rel}$

Temperature (T) ↓
↓
Abrasive removal ↑

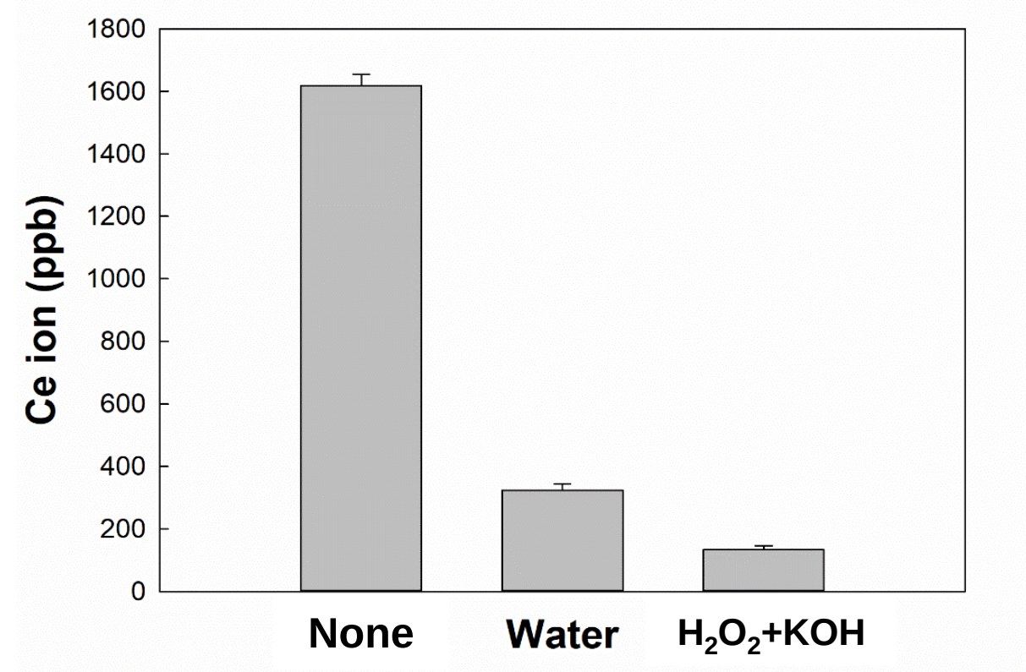


Fig. 9. Residual Ce-ion with chemical

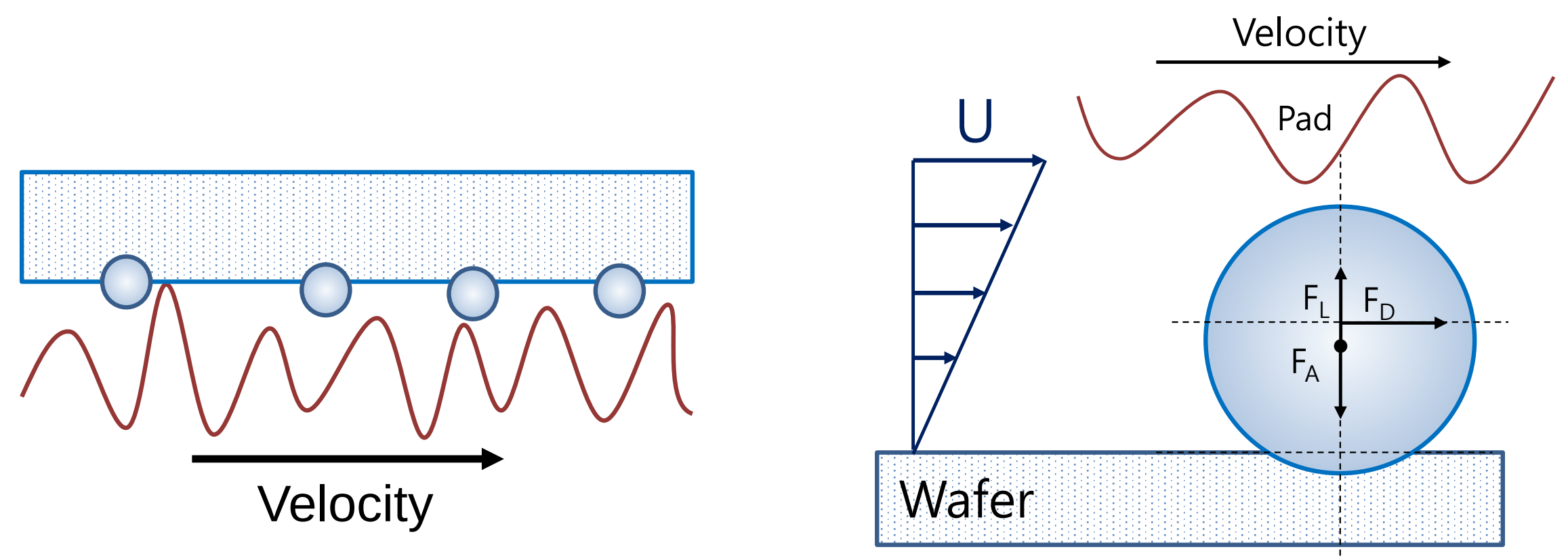
Chemical → Repulsion ↑ → F_L ↑

Water with chemical can increase abrasive removal.

Conclusion

SUMMARY AND CONCLUSION

❖ Suggested mechanism of abrasive removal



$$\textbf{Abrasive removal} = f(C, F_{drag}) = f\left(C, P, V, Q, \frac{1}{T}\right)$$

C : **Chemical enhancement** (Electrical repulsion, hydrophilicity…)

F_{drag} = f(Pressure, Rotation speed, Temperature, Flowrate)

Conclusion

- Abrasive removal increased with pressure, rotation speed, flowrate and processing time.
- Lower temperature increases abrasive removal with increasing drag force.
- Water with chemical increases abrasive removal.
- Increasing drag force and chemical enhancement can help removing abrasives during water polishing.

References

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