Sulfate ion removal by combined UV and Bake process

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Outline

- Introduction
- Experimental & Result
- Summary & Future study

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Photomask cleaning requirement	
3R **（Remove）**	**Organics：** *Photoresist, Fingerprint, Pellicle glue mark, Airborne organics*
	Particle
	Ions SO_4^{2-}、NH_4^+、$N(CH_3)_4^+$
2P **（Preserve）**	**Pattern integrity** *(SRAF)*
	Material integrity *(CrOx / MoSiON / Ru)*

SO_4^{2-} sources	
Photomask blank manufacture process	1、 Quartz cleaning process 2、 Chrome cleaning process 3、 Rework process
Photomask manufacture process	1、 Photoresist strip process 2、 In-process cleaning process 3、 Final clean process 4、 Glue mark removal process

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SO_4^{2-} measurement methodology

Step1: Preheat 500ml DI to 90 degree for 2hours

Step2: Measure the SO_4^{2-} level as baseline

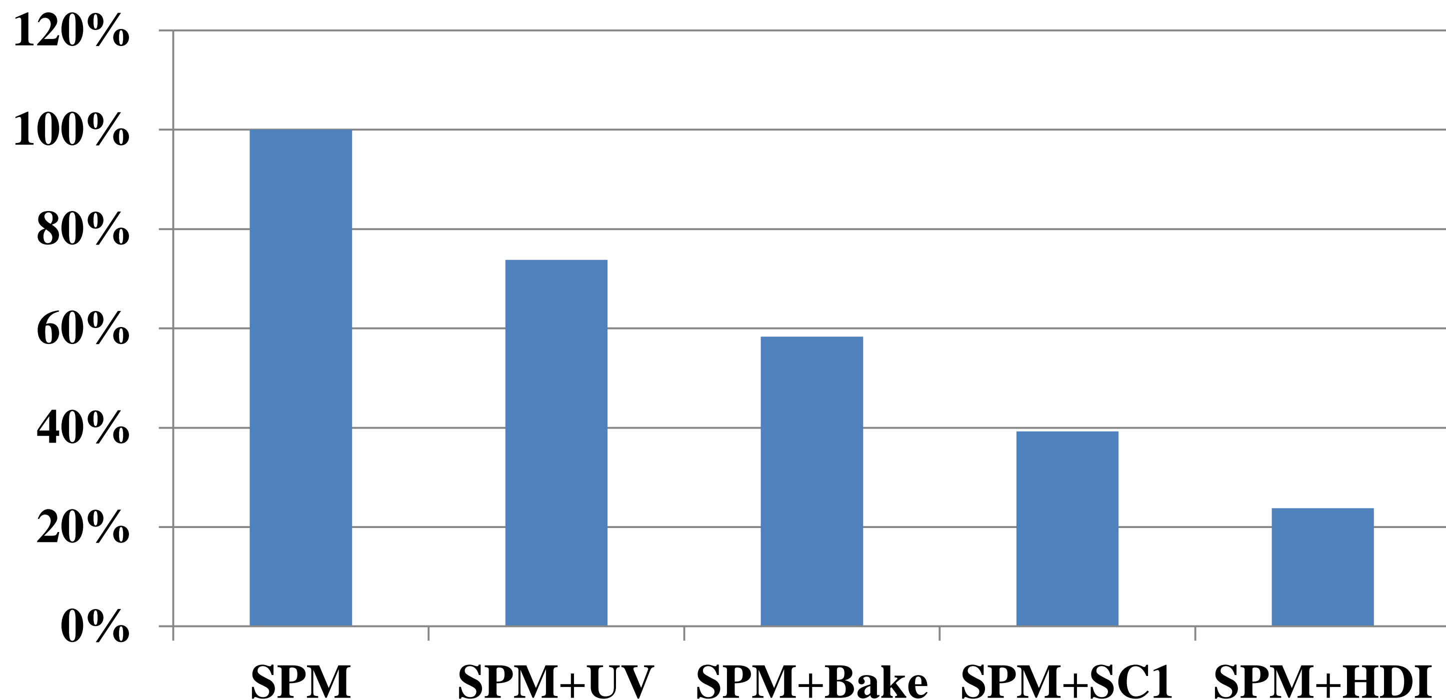
Step3: Soak sample into 90 degree DI for 2hours

Step4: Measure the SO_4^{2-} level as sample

Step5: Difference between sample and base as SO_4^{2-} level for sample

SO_4^{2-} measurement tool:
Thermo-Fischer ICS2100 with 0.05ppb detection limit

SO_4^{2-} cleaning efficiency by different methods for SPM contaminated mask

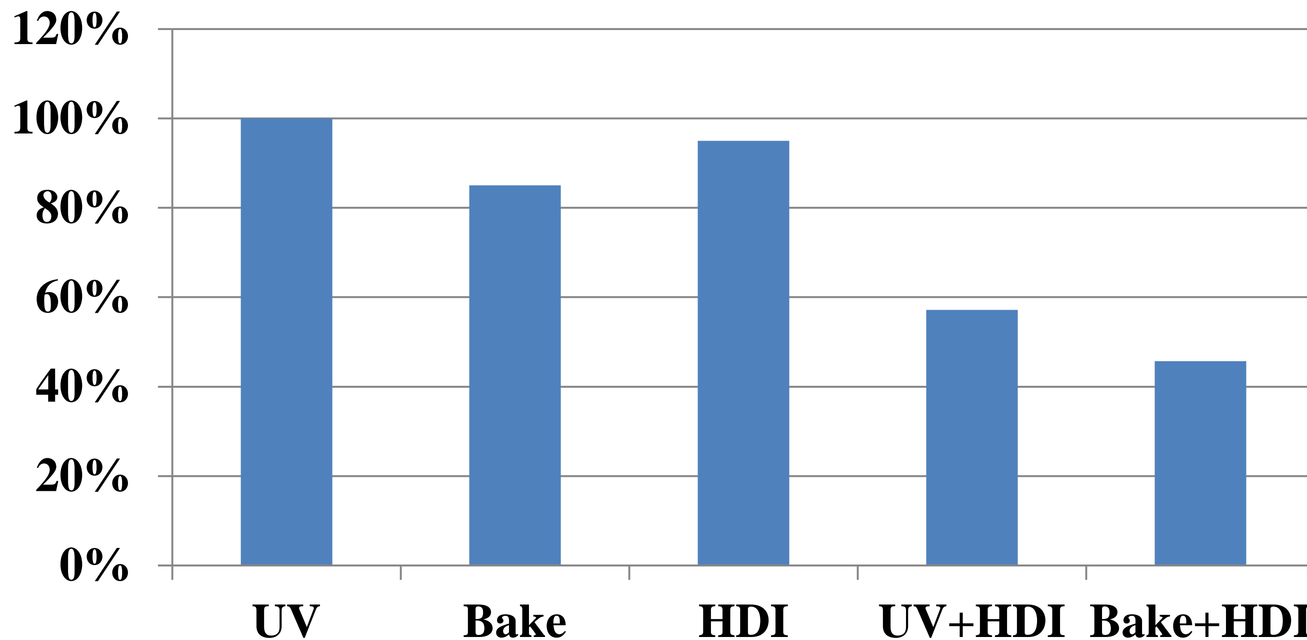


120%
100%
80%
60%
40%
20%
0%

Cond. 1 Cond. 2 Cond. 3 Cond. 4 Cond. 5 Cond. 6

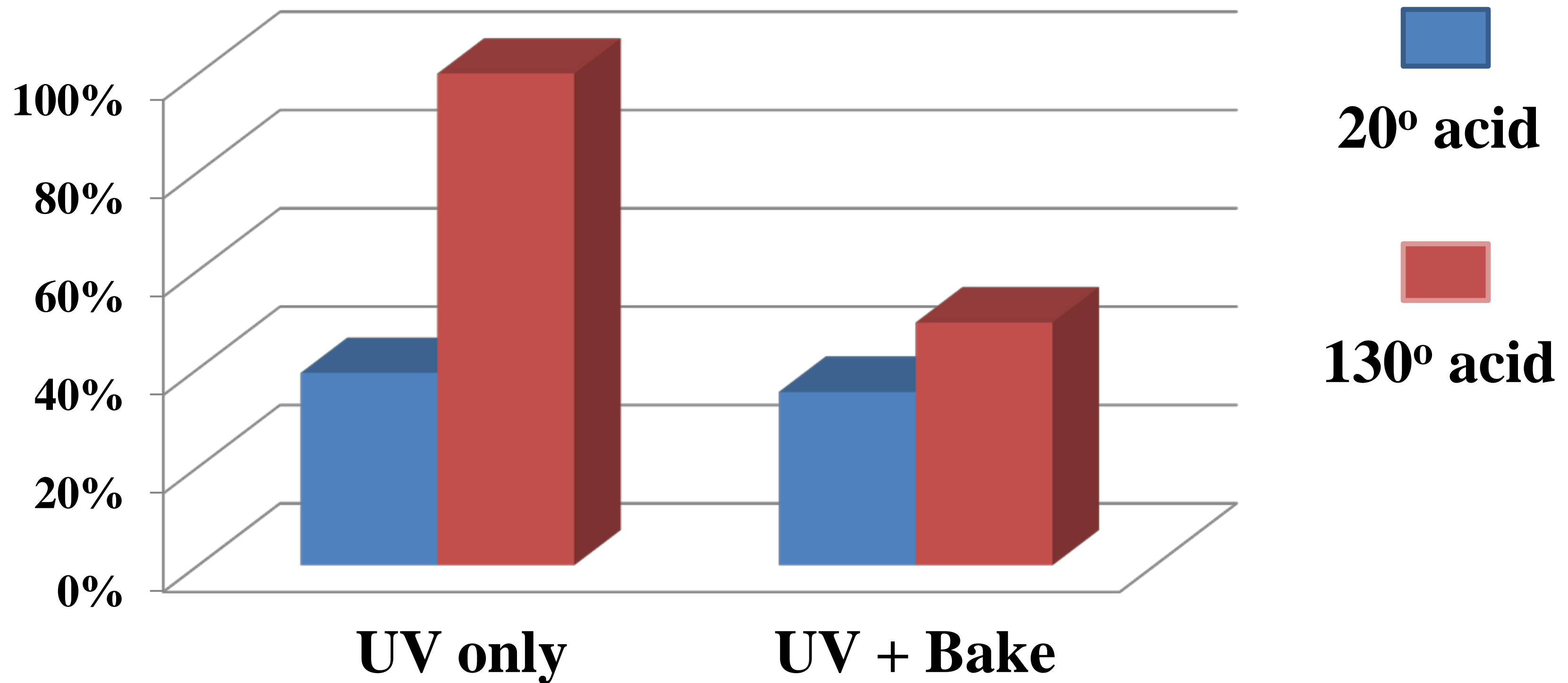
Cond. 1: Mask after regular cleaning process (SPM + 80° HDI + SC1)
Cond. 2: Cond. 1》 90° HDI soak 2hr》 80° HDI + SC1
Cond. 3: Cond. 2》 90° HDI soak 2hr》 105° bake + 80° HDI + SC1
Cond. 4: Cond. 3》 90° HDI soak 2hr》 80° HDI + SC1
Cond. 5: Cond. 4》 90° HDI soak 2hr》 105° bake + 80° HDI + SC1
Cond. 6: Cond. 5》 90° HDI soak 2hr》 80° HDI + SC1

SO_4^{2-} residue after different cleaning methods for mask treated by traditional cleaning process

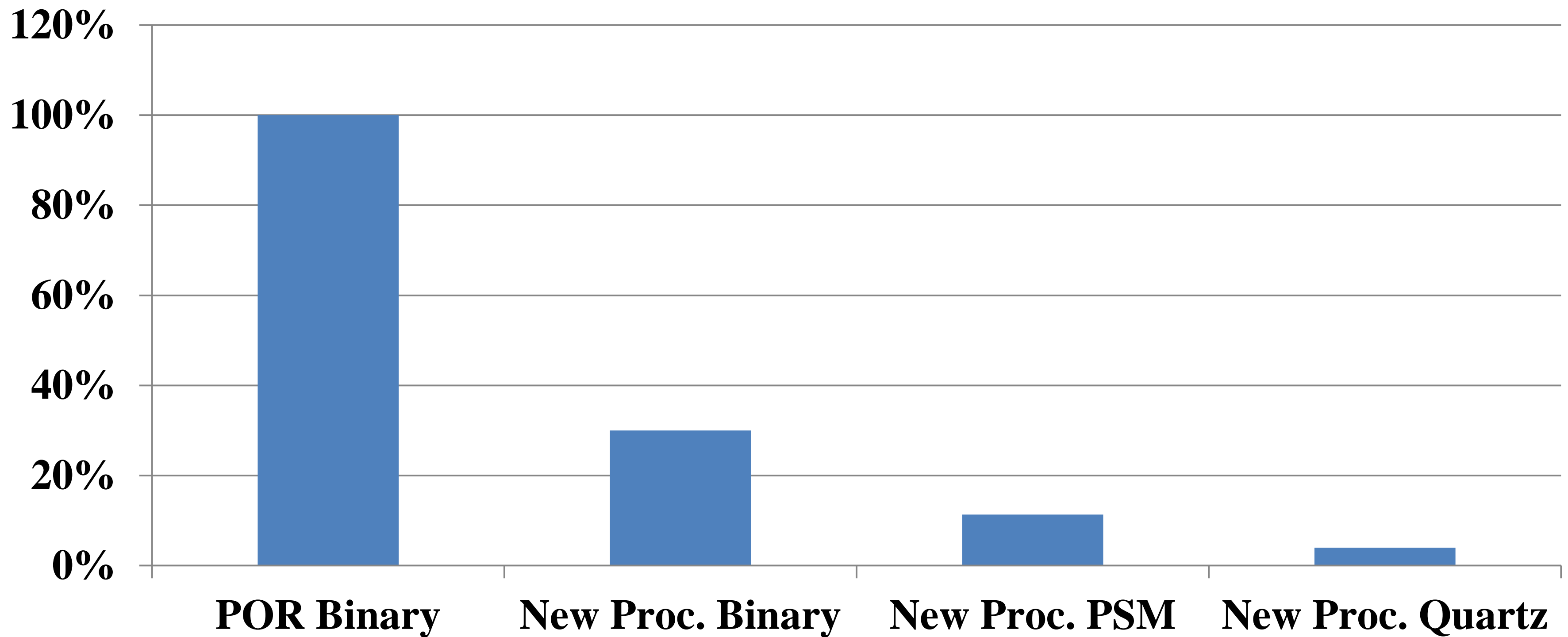


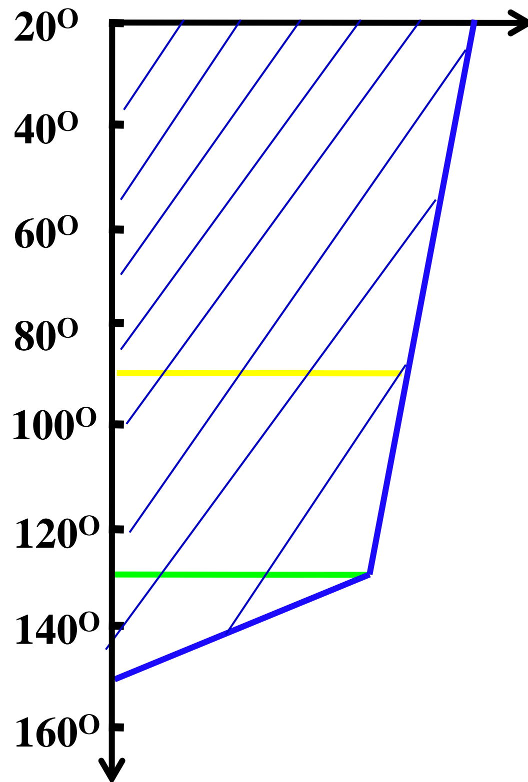
SMIC REC

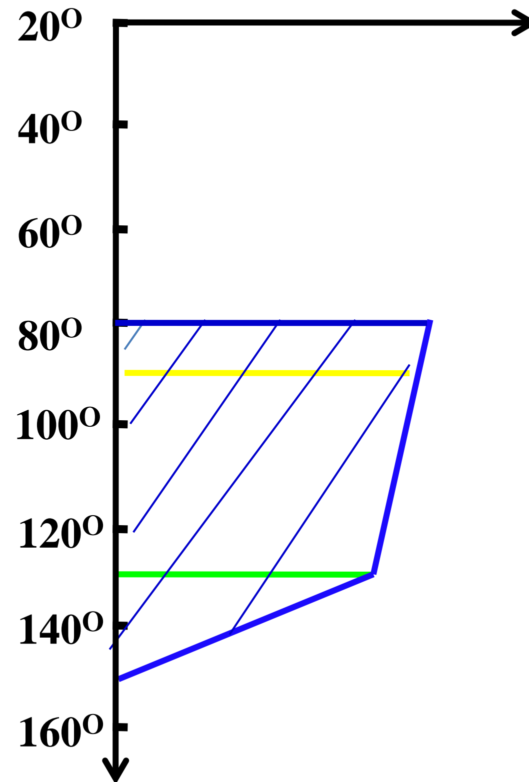
SO_4^{2-} residue after different cleaning methods for mask treated by different acid temperature



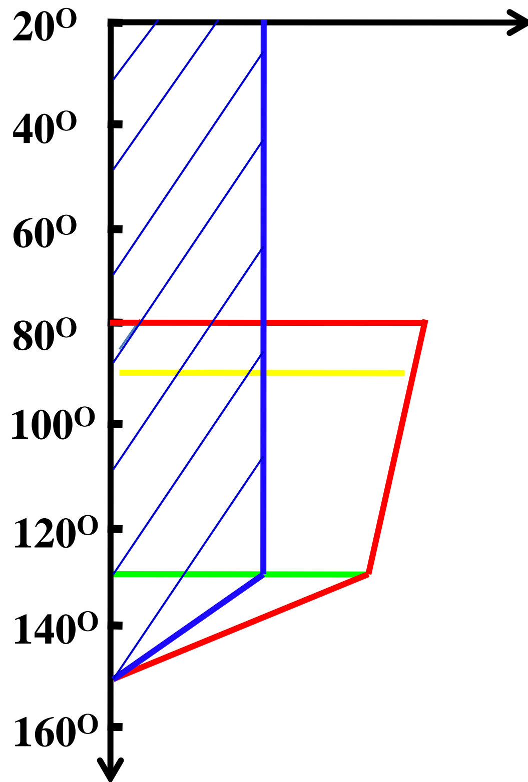
SO_4^{2-} residue after new cleaning process for different masks



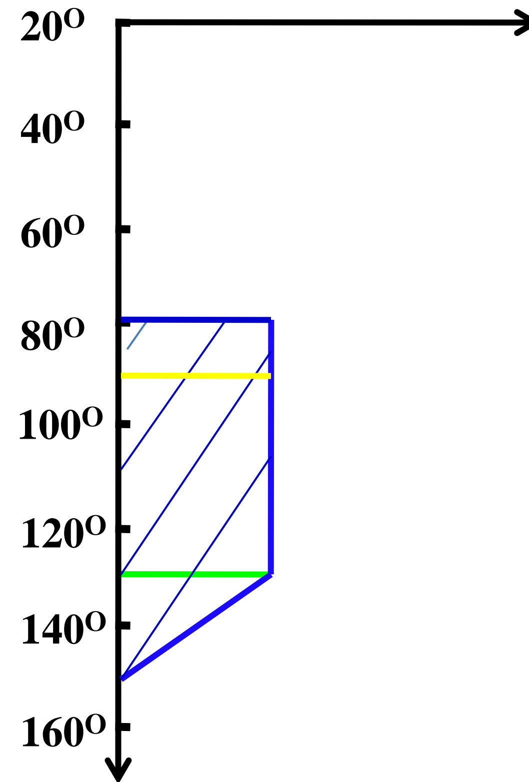

130º SPM
20º
40º
60º
80º
100º
120º
140º
160º


130º SPM
80º HDI
SC1
20º
40º
60º
80º
100º
120º
140º
160º

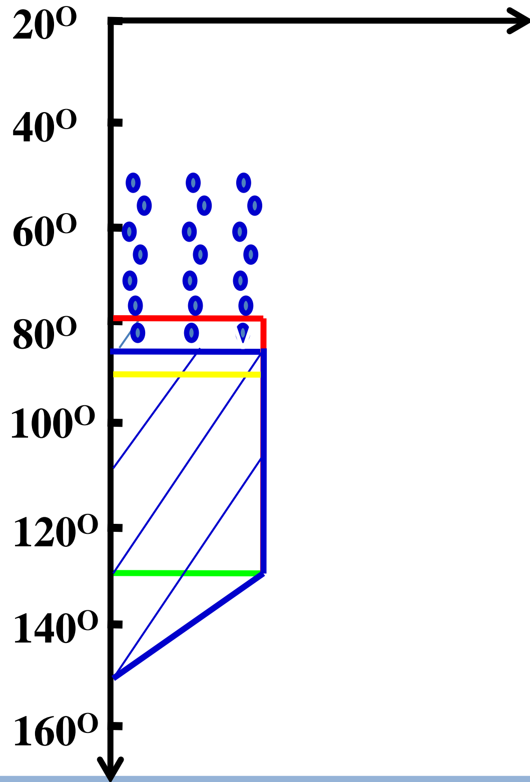
130º SPM
80º HDI+SC1
130º Bake

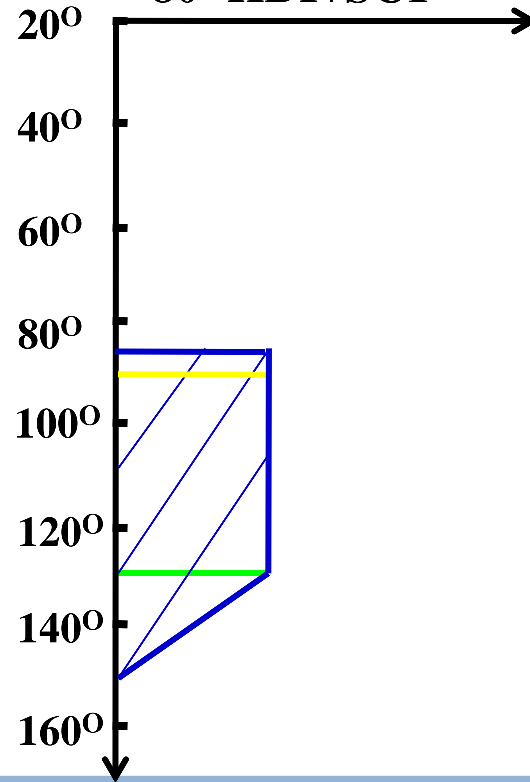


130º SPM
80º HDI+SC1
130º Bake
80º HDI+SC1



130° SPM	130° SPM
80° HDI+SC1	80° HDI+SC1
130° Bake	130° Bake
80° HDI+SC1	80° HDI+SC1
UV + 60° Bake	UV + 60° Bake
	80° HDI+SC1





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Summary

- **Hot DI rinse has the best SO_4^{2-} removal efficiency comparing to UV, Bake, SC1**
- **Bake process can resurface SO_4^{2-} by diffusion mechanism**
- **Bake process can enhance SO_4^{2-} removal effect of UV process**
- **By combing UV and Bake process, the SO_4^{2-} removal efficiency improved 70% comparing to POR process. The SO_4^{2-} residue can reach <0.2ppb for PSM mask**

Future Study

Further optimize the process parameters for better production control in terms of organics removal, particle removal, pattern damage prevention, phase change minimization, CD loss minimization, etc.

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Thank You!