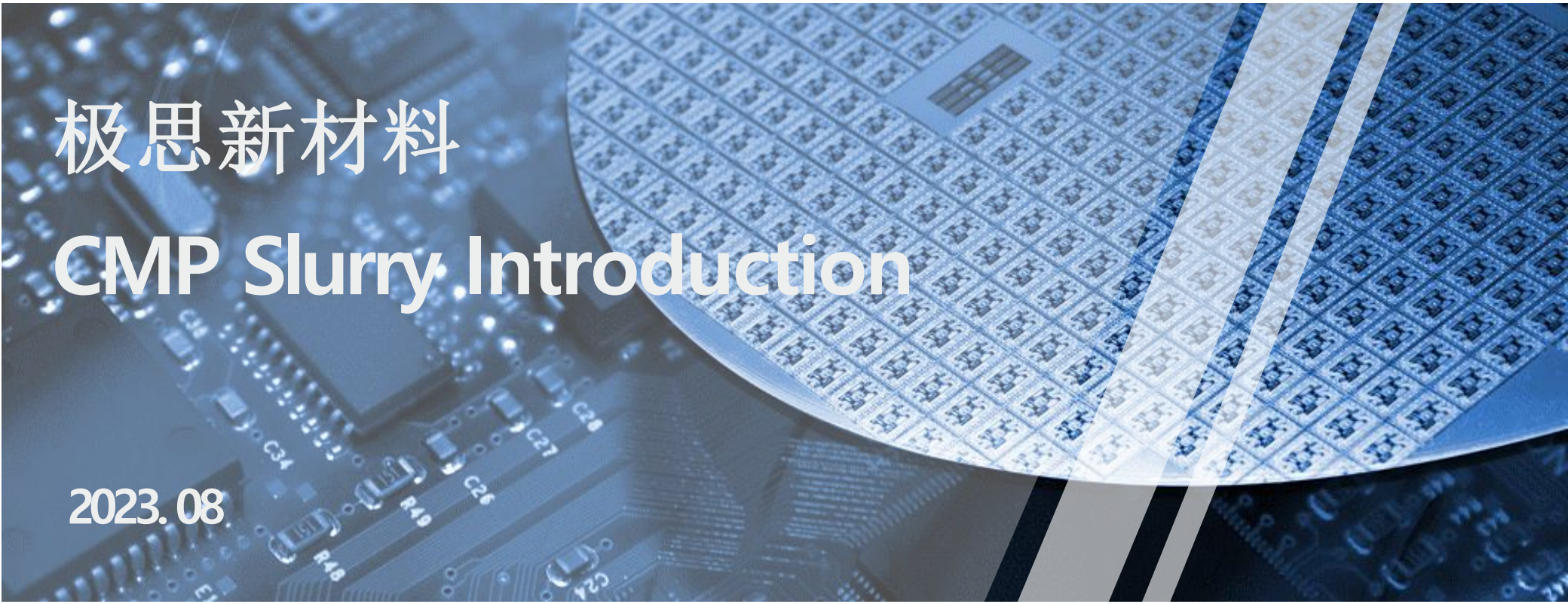
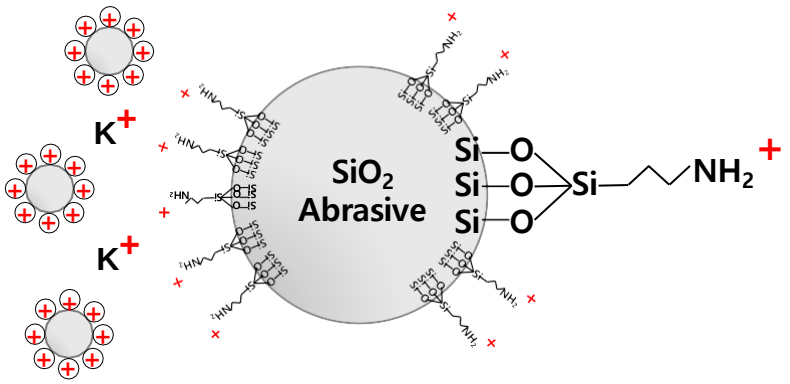


极思新材料

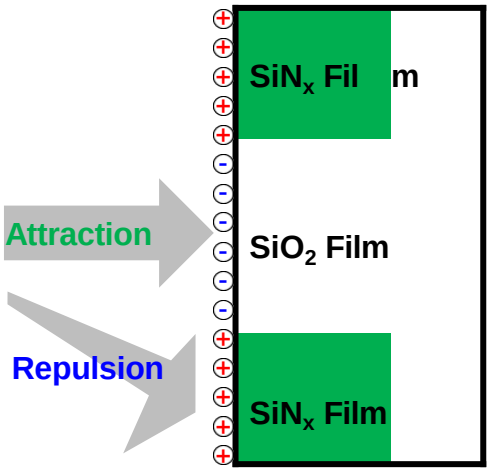
CMP Slurry Introduction

2023.08

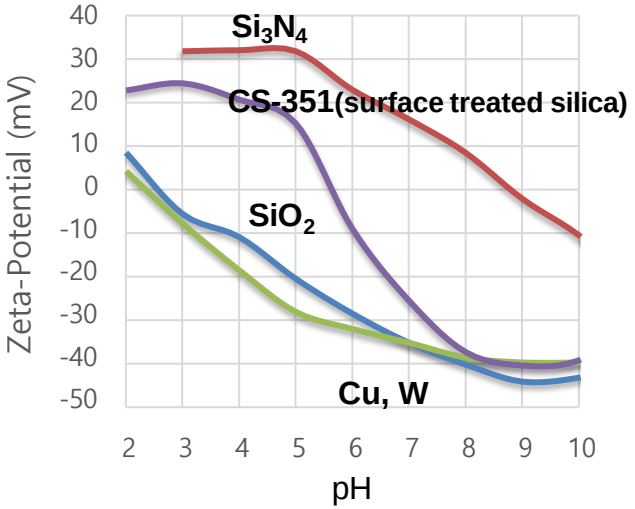
极思新材料 Silica Slurry Features



[Surface treated silica]



[Charge of Film Surface]



[Zeta-Potential of materials]

- Excellent abrasive dispersity
- Long-term storage stability
- Cation freely controllable

- Low solid contents – High Ox removal rate
  Low defect/Scratch
- Low Si_3N_4 removal rate
  High quality surface, High Ox/SiN selectivity

02 R&D Roadmap

Silica Slurry R&D Road Map

- **Fine Surface product line** : SW-300, SW-350 at W buffing, Carbon/ACL at Organic film
- **High Removal Rate product Line** : W & Cu Bulk CMP Slurry, High Removal Rate at TSV Process
- **Selectivity Control Product Line** : SW-200 at W Barrier, HPR-100 at Cu Barrier, STM-210 at TSV Hybrid

CMP Slurry Technical Road Map

ITEM		21	22	23	24	25
Metal CMP Slurry [Colloidal silica]	W Buffing (SW-300)	Customer Line Test			Commercialization	
	W Touch (SW-350)		Customer Line Test		Commercialization	
	W BM (先行 开发)			Target process discover and optimization		
	Carbon / ACL (先行 开发)			Target process discover		
	TSV Hybrid (STM-210)	Customer Line Test		Supply for R&D Base		Commercialization
	TSV HRR /SiN Finish (先行 开发)			Target process discover and optimization		
	Cu Barrier (HPR-100, SD-200)		Cost reduction		Target process discover	

03 Major Product Portfolio

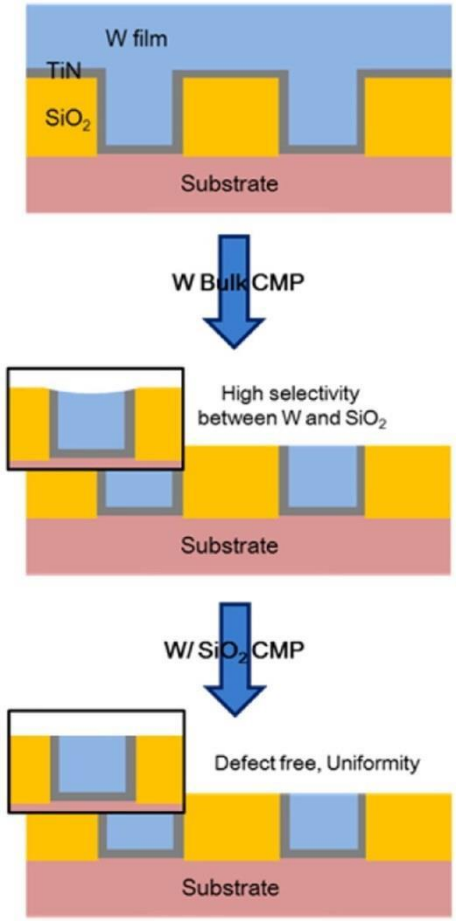
Silica Slurry Product Portfolio

Product			Properties	Advantages
Silica-Based	W Bulk	SW-100	- W = 3000~4000 Å/min	High dilution ratio x10
	W BM W buffing	SW-200 SW-300	- W = ~200 Å/min, Ox = 1000 Å/min - W = 20~40 Å/min	Low price & low defects
	Cu Barrier	HPR-100 SD-200	- Cu = 300~700 Å/min, Ta = ~500 Å/min - Ox = 1000~1400 Å/min	Low trace metal (low defects)
	Poly-Silicon	SPS-100	- Poly-Si = 3000~4000 Å/min - Ox = <50 Å/min	Low dishing at wide pattern
	TSV	STM-210 HTSV-100 ST-500	- Cu = 1000~3000 Å/min - Ox = 1000~4500 Å/min - SiN = 50~2500 Å/min	High Removal rate Good surface quality
	Carbon / ACL	SAC-100	- Low defect, Planarization Efficiency ↑ - Carbon High Removal Rates	
	Nitride	NTS-300 (极思-CE-10)	- Nit = 600~900 Å/min - Poly-Si/Ox = 10 Å/min ↓	High removal rate SiN Low defects

◆ Tungsten Slurry

- Tungsten bulk & barrier process in a damascene architecture
- Lower defect levels and higher yields
- Lower Cost-of-Ownership

ITEM	SW-100	SW-200	SW-300	SW-300B2
Abrasive	CS*	CS	CS	HPCS*
Particle Size by DLS	120nm	42nm	42 nm	120 nm
pH	Acidic	Acidic	Acidic	Acidic
Solid Content (Only abrasive)	3.5 wt%	0.1~1 wt%	3.0 wt%	3.5 wt%
Surface charge	Negative	Positive	Positive	Negative
W RR	3000~4000	3000~4000	200~300	200~500
Ox RR	800~1000	15~30	1000~1200	800~1000
H2O2(%)	2.8	2.8	0.5	0.5
Application	W bulk CMP		W/SiO2 CMP	

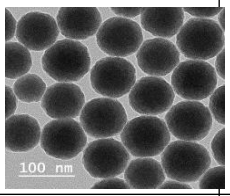
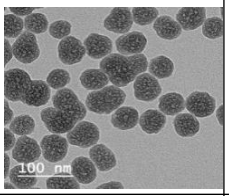
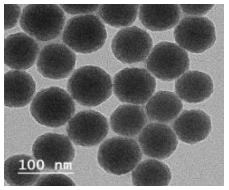


1) W bulk CMP condition ➔ Polisher : AP-300, Pad : 极思 HD-319B, W/P: 3.2/3.0/3.0/3.0/3.0 psi, R-Ring : 10.5 psi, Head/Table: 100/101 rpm, Slurry : 250 ml/min
2) W/SiO2 CMP condition ➔ Polisher : AP-300, Pad : 极思 HD-319B, W/P: 1.0/1.0/1.0/1.0/1.0 psi, R-Ring : 3.0 psi, Head/Table: 100/101 rpm, Slurry : 250 ml/min
3) W/SiO2 B2 CMP condition ➔ Polisher : AP-300, Pad : IC1010, W/P: 3.7/3.5/3.5/3.5/3.5 psi, R-Ring : 8.5 psi, Head/Table: 100/101 rpm, Slurry : 250 ml/min
* CS : Colloidal Silica, HPCS : High Purity Colloidal Silica

◆ Cu Barrier Metal Slurry

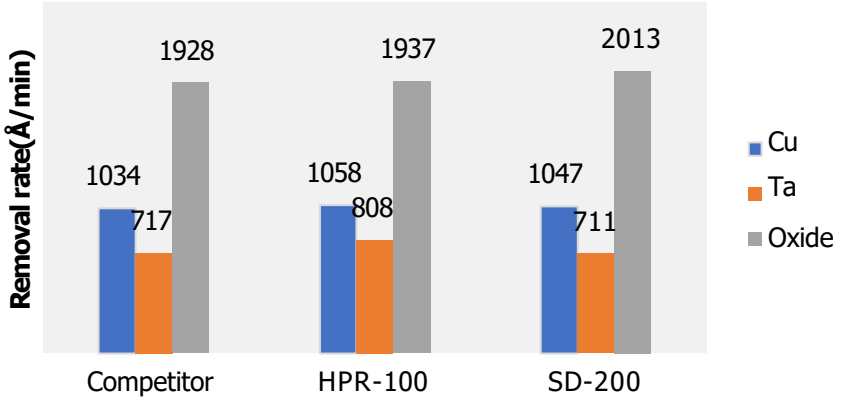
- Defect reduction by special chemical treatment & pure silica
- Tunable Cu/Ta/Ox removal rates

◆ Basic Properties & Performances

ITEM	Competitor	HPR-100	SD-200
Abrasive	CS	HPCS	CS
TEM Images			
Particle Size by DLS	86nm	67nm	81nm
pH	Basic	Basic	Basic
Solid Content (Only abrasive)	14~16 wt%	8~10 wt%	14~16 wt%
Zeta potential(mV)	Negative	Negative	Negative

* CS : Colloidal Silica, HPCS : High Purity Colloidal Silica

◆ CMP Test Results & Selectivity



Polisher : AP-300, Pad : Fujibo pad, W/P: 5.5/2.2/2.4/2.2/2.1 psi,
R-Ring : 6.3 psi, Head/Table: 103/97 rpm, Slurry : 270 ml/min

◆ Defect Analysis Results

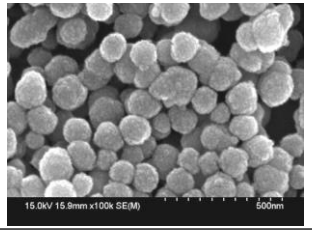
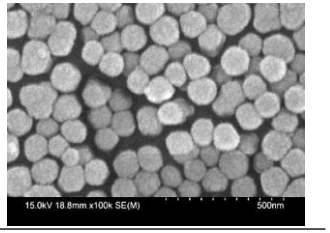
Defects(ea)	Competitor	HPR-100	SD-200
Ox blanket wafer	159	63	64
Cu blanket wafer	1303	704	671
MIT Pattern wafer	1893	925	1035

* Inspection : KLA Tencor AIT-XP+

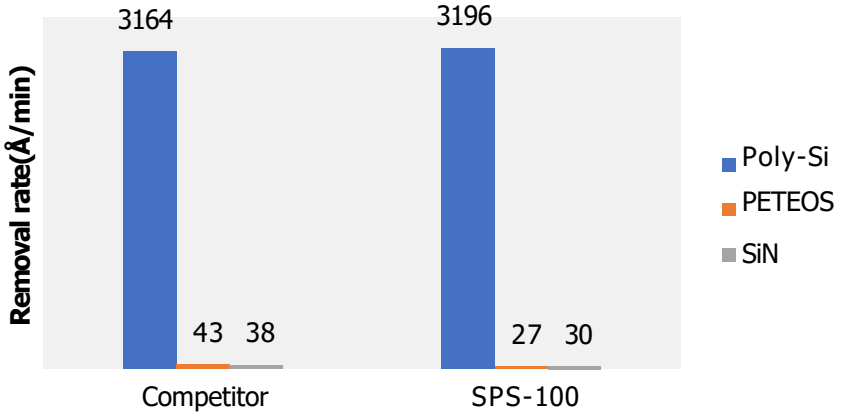
◆ Poly-Silicon Slurry

- Special chemical treatment at Poly-Silicon
- High selectivity Poly-Si/Ox or SiN films
- Low dishing at wide range Poly-Si patterns

◆ Basic Properties & Performances

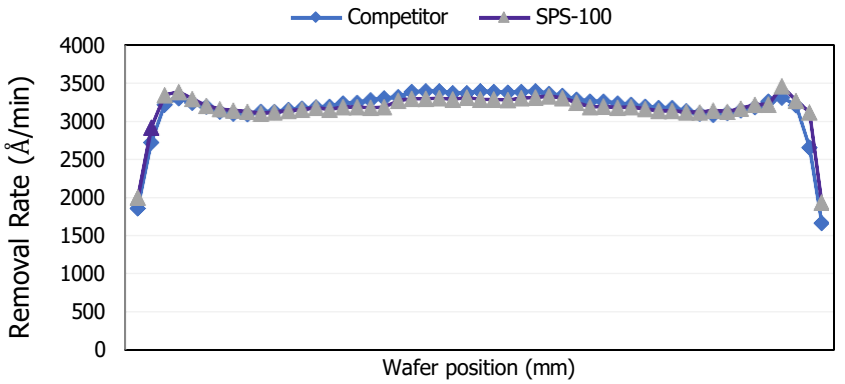
ITEM	Competitor	SPS-100
Abrasive	HPCS	HPCS
SEM Images		
Particle Size by DLS	133nm	129nm
pH	Basic	Basic
Solid Content (Only abrasive)	3~4 wt%	2~3 wt%
Viscosity(cps)	1.2 ~ 1.3	1.2 ~ 1.3

◆ CMP Test Results & Selectivity



Polisher : AP-300, Pad : 极思 HD-319B, W/P: 4.0/2.5/2.5/2.5/2.5 psi,
R-Ring : 6.5 psi, Head/Table: 103/97 rpm, Slurry : 300 ml/min

◆ 300mm Profile



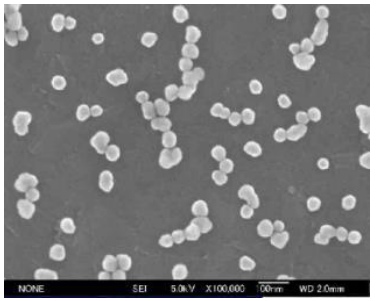
03 Major Product Portfolio

Product_Nitride Slurry

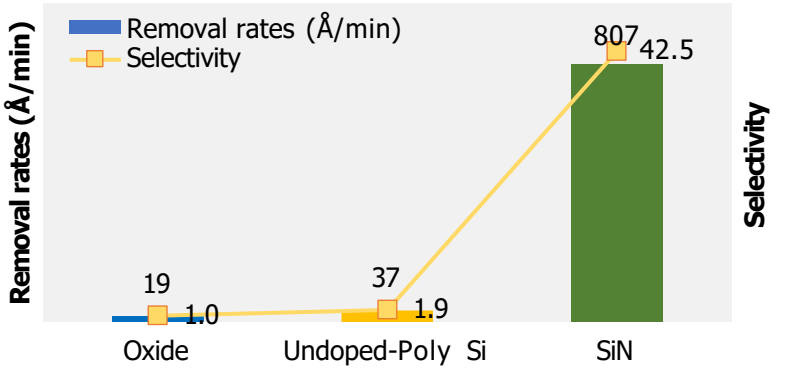
◆ Nitride Slurry

- Excellent selectivity (High Removal Nitride)
- Low Oxide dishing
- 3D-NAND application

◆ Basic Properties & Performances

ITEM	NTS-300
Abrasive	CS
SEM Images	
Particle Size by DLS	35nm
pH	Acidic
Solid Content	8~10 wt%
Zeta potential(mV)	Negative
Slurry : DIW rate	1:1 ~1:3 mixing

◆ CMP Test Results & Selectivity



Polisher : AP-300, Pad : 极思 HD-319B, W/P: 4.5/2.1/2.1/2.1/2.15 psi, R-Ring : 6.5 psi, Head/Table: 63/59 rpm, Slurry : 300 ml/min

CMP Performances	Data
Nitride R/R (Å/min.)	700~900
Selectivity	Oxide : Poly : Nitride 1 : 1 : 15~20
Uniformity (Å)	46~73 Å
cell center-edge deviation (Å)	Edge : ~16 Å Middle : ~24 Å Center : ~21 Å
Dishing & Dent	none
Ox blanket defects	<100 ea
3D NAND PW defects	8~63 ea
Shelf life (month)	12 month

03 Major Product Portfolio

Product_ACL Slurry

◆ ACL Slurry

- High R/R(various removal rates of SAC-100)
- Lower defect levels and higher yields
- Pad contamination free

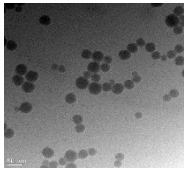
◆ Concept of SAC-100

Abrasive
▪ **Abrasive Size Optimization** ▪ **Pad Contamination Improvement**

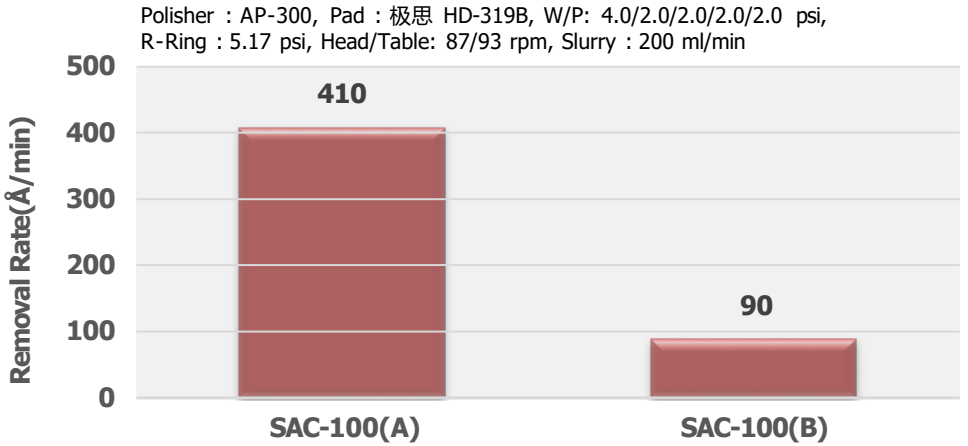
Accelerator
▪ **ACL Removal Rate Enhancer** ▪ **Defect↓**

Stabilizer
▪ **Effects of Metal Chelating** ▪ **Improved Satability of Accelerator**

Surfactant
▪ **Increase Wettability** ▪ **Residual & Defect↓**

ITEM	SAC-100
Abrasive	CS
SEM Images	
Particle Size by DLS	45nm
pH	Acidic
Solid Content	3 ~ 6 wt%

Pad contamination free



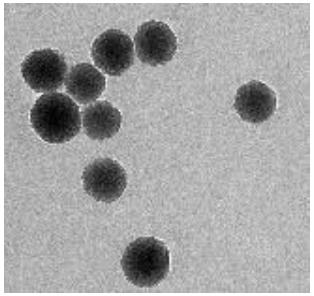
- SAC-100(A) : High R/R, Good Defect
- SAC-100(B) : Advanced Roughness, Long Lifetime

Product_TSV Cu Slurry

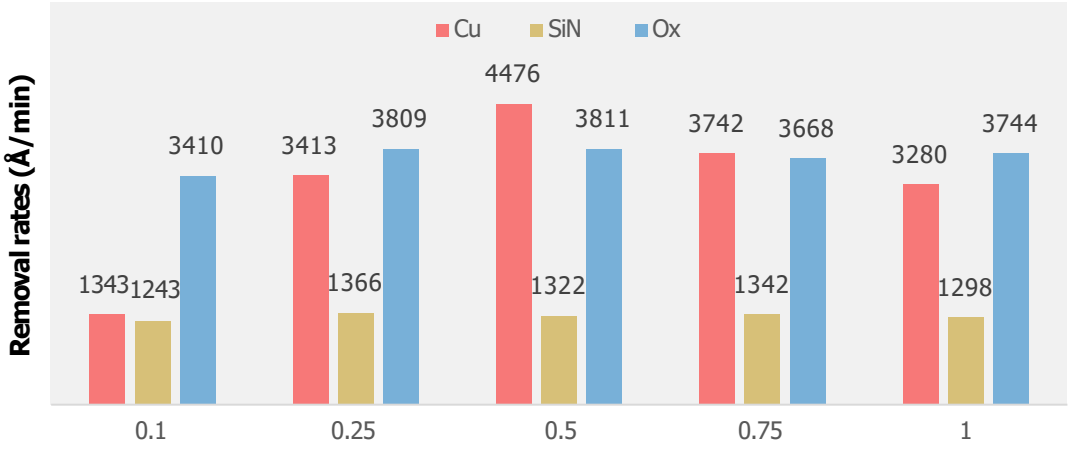
◆ TSV Cu Slurry

- Cu RR range = 800 ~ 5,500 Å/min
- Ox RR range = 200 ~ 3,900 Å/min
- Controllable Cu & Ox RR with selectivity
- Acidic type

◆ Basic Properties & Performances

ITEM	HTSV-100
Abrasive	CS
TEM Images	
Particle Size by DLS (nm)	42
pH	Acidic
Solid Content (wt%)	7.5 ~ 15
Zeta potential(mV)	Positive

◆ CMP Test Results & Selectivity



[CMP condition]
Polisher : AP-300 / Pad : 极思-HD-319B, Pressure: 5.5/3.0/3.0/3.3/3.0,
R-Ring : 8.0 psi, Carrier/Platen: 117/120 rpm, SFR: 300 ml/min

◆ Slurry Performance

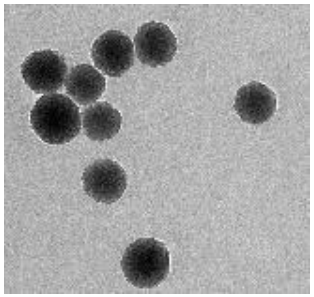
H_2O_2 (%)	Removal rates (Å/min)			Selectivity		
	Cu	SiN	Ox	Ox/SiN	Ox/Cu	SiN/Cu
0.10	1343	1243	3410	2.74	2.54	0.93
0.25	3413	1366	3809	2.79	1.12	0.40
0.50	4476	1322	3811	2.88	0.85	0.30
0.75	3742	1342	3668	2.73	0.98	0.36
1.00	3280	1298	3744	2.88	1.14	0.40

Product_TSV HRR Slurry

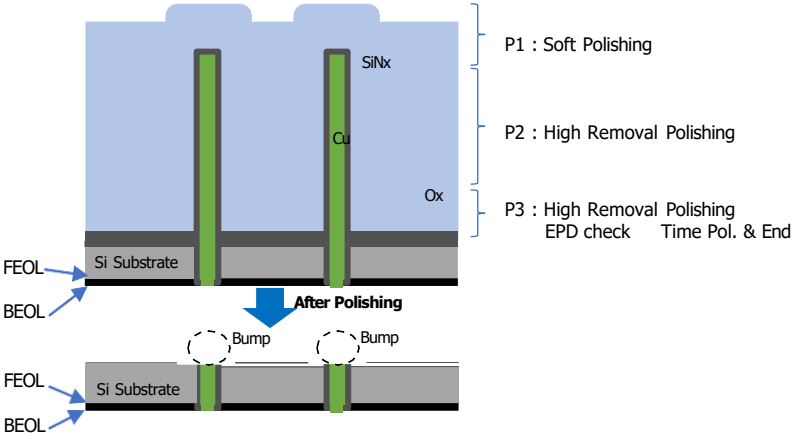
◆ TSV HRR Slurry

- High Ox Removal Rate
- High Selectivity(Ox/SiN selectivity >11)
- Controllable Cu & SiN RR

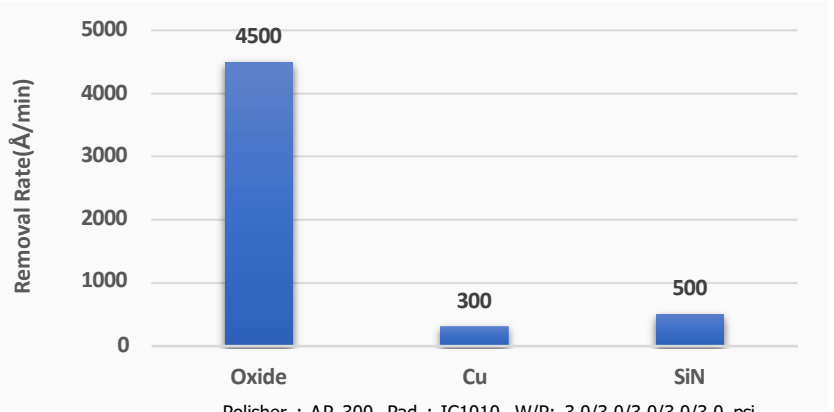
◆ Basic Properties & Performances

ITEM	HTSV-100
Abrasive	CS
TEM Images	
Particle Size by DLS (nm)	45
pH	Acidic
Solid Content (wt%)	15
Zeta potential(mV)	Positive

◆ Slurry Performance



◆ CMP Test Results & Selectivity

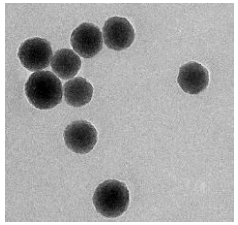


Polisher : AP-300, Pad : IC1010, W/P: 3.0/3.0/3.0/3.0/3.0 psi,
R-Ring : 6.0 psi, Head/Table: 87/93 rpm, Slurry : 300 ml/min

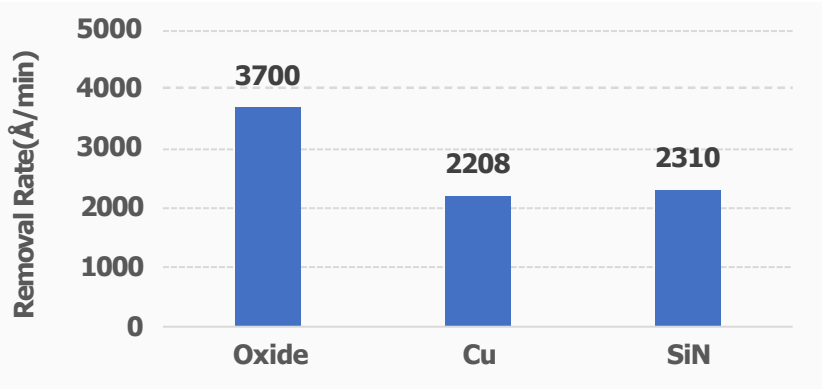
◆ TSV Advanced Slurry

- High Removal Rates & Low Defect
- Controllable Cu & Ox RR with selectivity
- TSV Hybrid & New concept target slurry

◆ Basic Properties & Performances

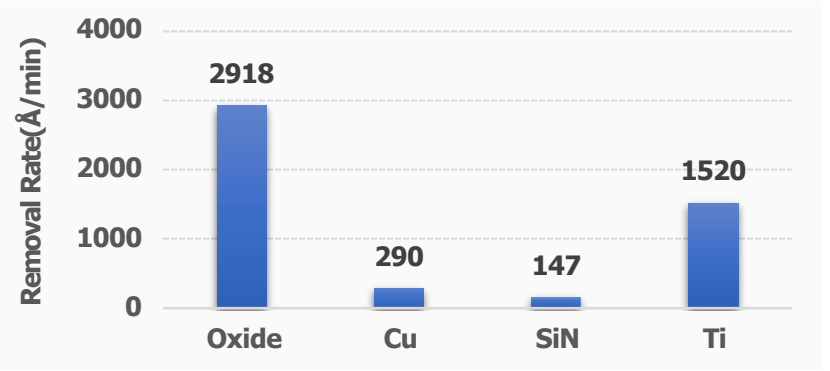
ITEM	STM-210	ST-500
Abrasive	Colloidal Silica	
SEM Images		
Particle Size by DLS	45nm	
pH	4.1	4.1
Solid Content (Only abrasive)	15 wt%	5 wt%
Zeta-potential	< +20 mV	
Conductivity	< 1 mS/cm	< 1 mS/cm

◆ Hybrid Slurry CMP Test Results(STM-210)



Polisher : AP-300, Pad : IC1010, W/P: 3.0/3.0/3.0/3.0/3.0 psi,
R-Ring : 6.0 psi, Head/Table: 87/93 rpm, Slurry : 300 ml/min

◆ SiN Finishing Slurry CMP Test Results(ST-500)



Polisher : AP-300, Pad : IC1010, W/P: 3.0/3.0/3.0/3.0/3.0 psi,
R-Ring : 6.0 psi, Head/Table: 87/93 rpm, Slurry : 300 ml/min

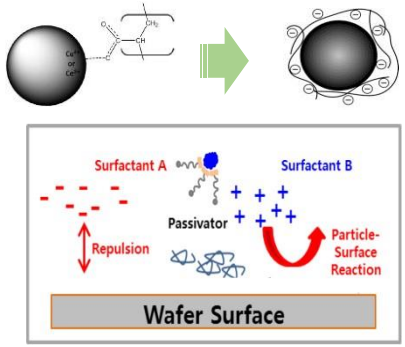
极思新材料 Ceria Slurry Features

Process Optimization

- High-pressure Microfluidizer
- Zirconia-free milling process
- Separation and Filtration optimization
- Impurity-free, Low LPC control

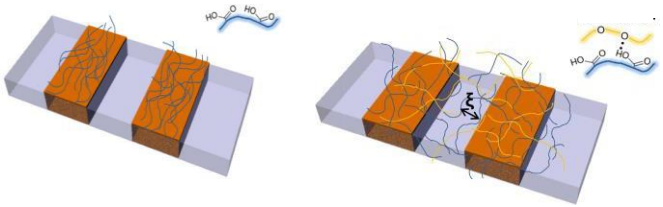
Lower Defect and Scratch

- Particle surface modification
- Surface zeta-potential control (+, -)
- Dispersant, Stabilizer, Surfactant
- Formulation optimization

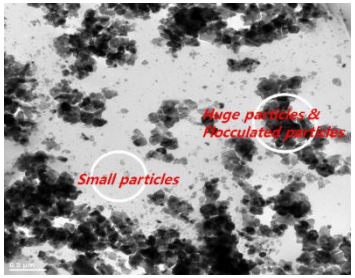
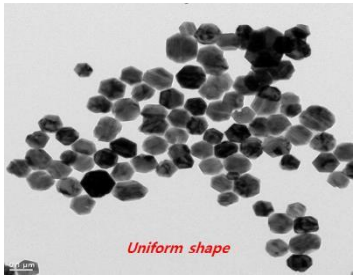
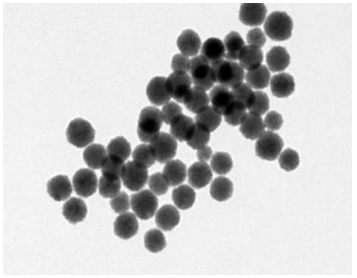
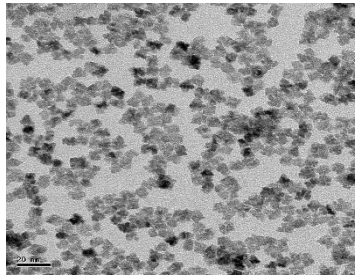


Selectivity Control Pattern Performance

- High selectivity for process application
- Dispersant, Dishing agent, pH adjust
- Skew agent, Surfactant, etc.
- Chemical formation optimization



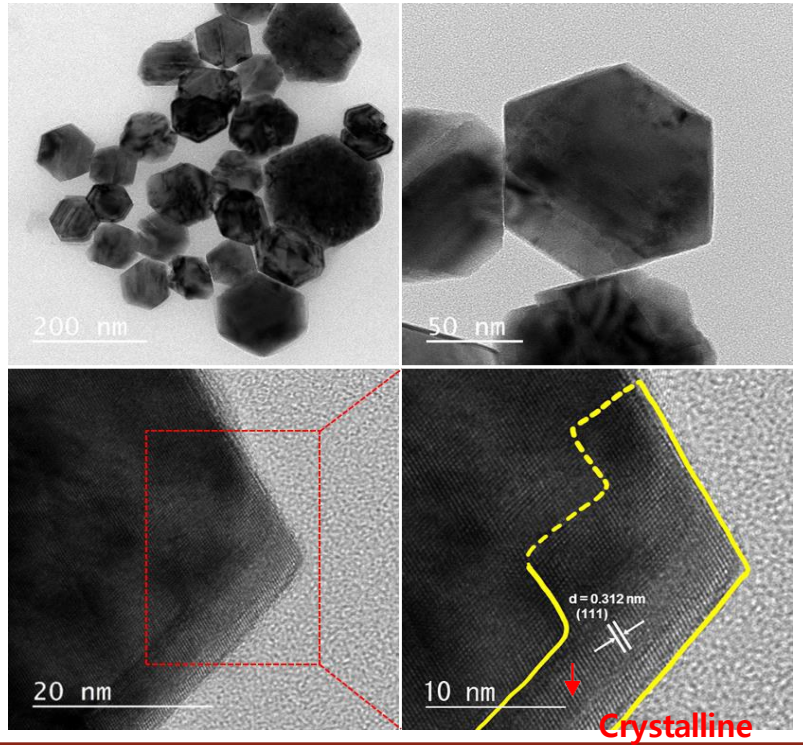
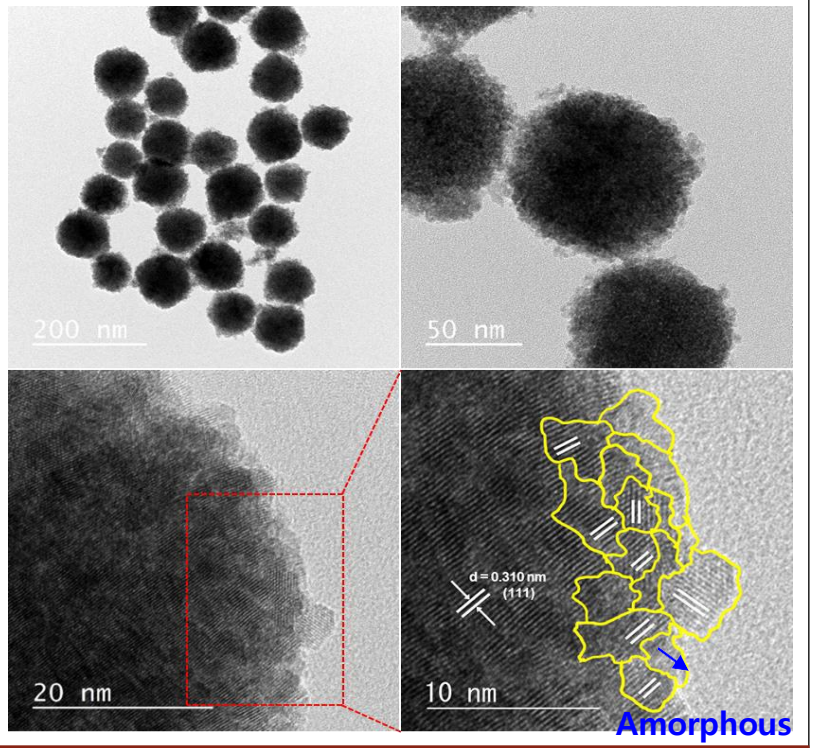
◆ Introduction : Ceria Slurry Abrasive Type

Name	Conventional Slurry	极思 Slurry		
Abrasive Type	**Calcined Ceria**	**Colloidal Type1**	**Colloidal Type2**	**Next Generation**
Image				
Abrasive size	50~300nm	80~120nm	60~150nm	30nm & <10nm
shape	Non-spherical	Hexagon	Round	Hybrid

Products			Properties	Remark
Ceria-Based (Colloidal)	SDN-S4000	Low Defect/Scratch	- Ox = 2000~3000 Å/min - Ox : Nit = 1 : 25~50 / Low Dishing	Colloidal Type1
	SWC-3000	High Removal Rate	- Ox = 20K Å/min	Colloidal Type2
	SWC-5000	Super Fine Ceria	- Ox = >1K Å/min - Scratch Free	

◆ Introduction : Ceria Slurry Abrasive Type

- Structure: HC60 **Crystalline**, 极思 Abrasive **Amorphous**
- Shape: HC60 **Angular Colloidal**, 极思 **Spherical Colloidal**
- Secondary Particle Size: HC60 **100nm±40nm**, 极思 **100nm~150nm ±20nm** **Size Controllable**

	Colloidal Type 1	Colloidal Type 2
Shape		

02 R&D Roadmap

Ceria Slurry R&D Road Map

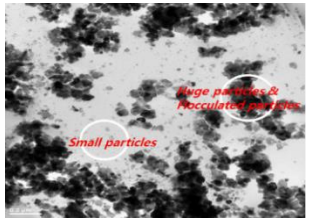
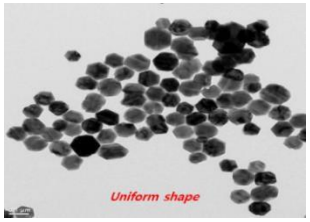
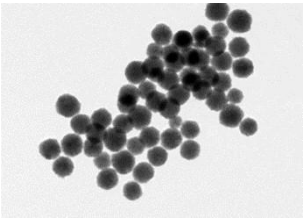
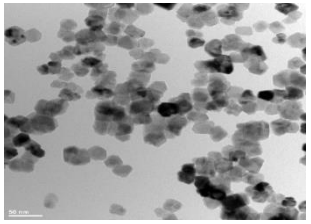
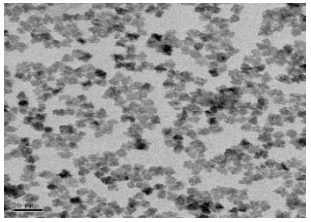
- **High Selectivity product line** : SDN-S4000, SDN-A4000 (Good Ox, SiN Selectivity with Chemical Additive, Low Defect)
- **High Ox Removal Product** : HRR (Advanced Product, High Removal Rate>20kÅ/min, Good Planarization)
- **Low Defect Product** : SFC (Super Fine Abrasive <10nm, Low Concentration but High Removal Rate >2kÅ/min)

CMP Slurry Technical Road Map

ITEM		21	22	23	24	25
Oxide CMP Slurry [Wet Ceria]	DRAM (SDN-S4000)	Target process optimization		Customer Line Test		Commercialization
	ILD (SDN-S4000, A4000)	Target process optimization		Customer Line Test		Commercialization
	HRR (Developing)		Developing		Target process discover and optimization	
	SFC (Developing) [Nano ceria]			Developing		

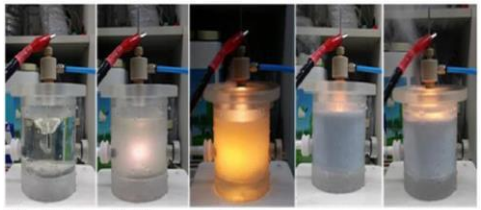
◆ Next Generation Ceria Abrasive

- Super Fine Ceria Abrasive : Uniform Shape and Size Distribution, Ce^{3+}/Ce^{4+} Control based Chemical Reaction Improvement

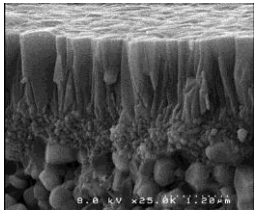
Name	Conventional Slurry	极思 SFC Slurry			
Abrasive Type	Calcined Ceria	Present		Developing	
Image					
Abrasive size	50~300nm	80~120nm	60~160nm	25±5nm	10±5nm
Shape	Non-spherical	Hexagon	Round	Hybrid	Hybrid

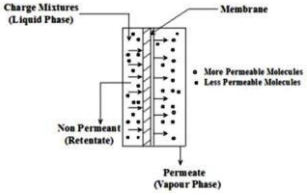
◆ SFC Manufacture Process

- Abrasive synthesis method differentiation : Underwater Plasma Reaction
- Fine Membrane – Filtering Slurry for high purity

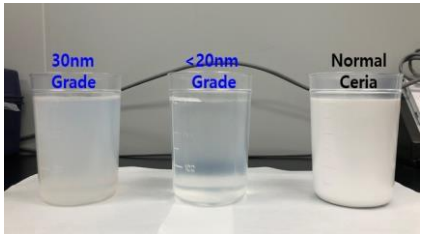


Underwater Plasma Reaction based Ceria Synthesis





Nano porous membrane filtering slurry condensation and



Transparent SFC Slurry (1wt%)

03 Major Product Portfolio

Ceria Slurry Product Portfolio

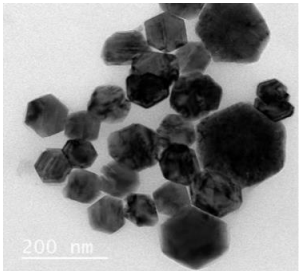
Product			Properties	Advantages
Ceria-Based	STI/ILD	SDN-S4000 SDN-A4000	- Ox. = >3000Å/min - Nit. = 30±5Å/min	Low Dishing & defects High Selectivity & Low Dishing
	HSS	SWC-2000	- Nitride & Poly R.R <20Å/min	High selectivity Low defect levels & high yields
	HRR	SWC-3000	- OX RR ~20,000Å/min - Good Wafer Uniformity, Oxide Self Stop	High Oxide Removal Self Stop Slurry
	SFC	Developing	- Ox >1000 Å/min	Good surface quality

Major Product_SDN-S4000

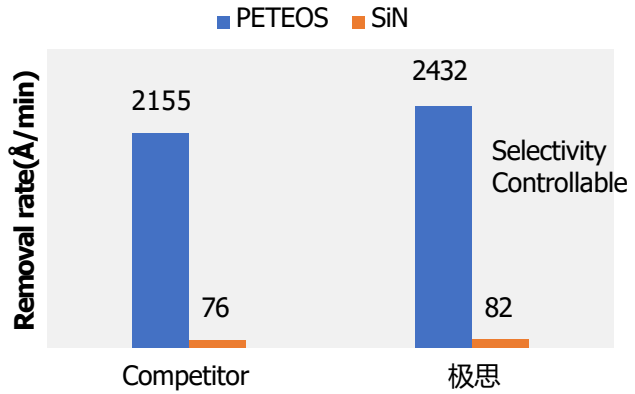
◆ Introduction : Ceria Slurry for STI CMP

- Low Dishing & colloidal ceria particle
- Multi-Selectivity (Stop on nitride or poly silicon layer)
- Nitride Stop = Selectivity 20~40 : Oxide dishing <150 Å
- Lower defectivity levels and higher yields

◆ Basic Properties & Performances

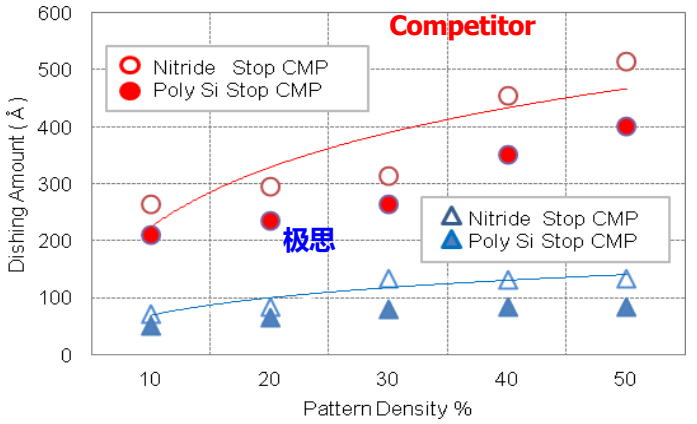
ITEM	SDN-S4000
Abrasive	Colloidal
Particle Size (DLS method)	140 nm
pH	Basic
Solid Content	3 ~5 wt%
Zeta-Potential	Negative
Metal Impurity (ppm)	≤ 10 ppm
Abrasive TEM images	

◆ CMP Test Results & Selectivity



Polisher : AP-300, Pad : IC1010, W/P: 3.5/3.0/3.0/3.0/3.0 psi,
R-Ring : 6.5 psi, Head/Table: 87/93 rpm, Slurry : 250 ml/min

◆ Dishing Performance



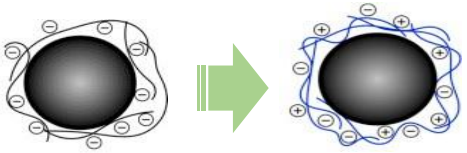
◆ Major Product: SDN-S4000

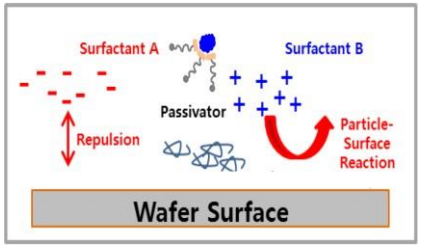
- Targe: Ox R/R >3,000 Å/min
- Low Defect & Scratch process

- Negative Wet-Ceria

• Abrasive dispersity improvement, Agglomeration suppression

• Oxide wafer Defect/Scratch controllable

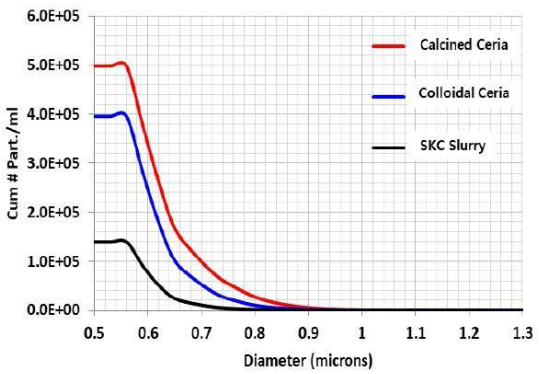


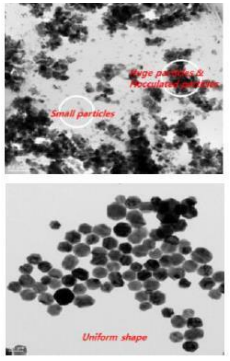


- Large particle removal by improving dispersion process

• Bead-free milling dispersion (zirconia impurity free)

• High pressure microfluidizer + Separator : large particle removal

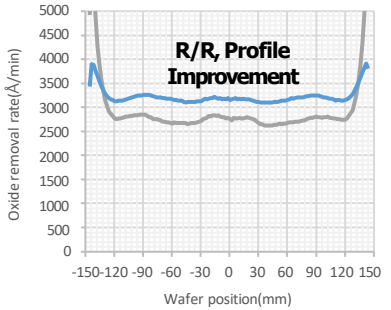




- Dispersant optimization

• Dispersant content control
→ Ox R/R Improvement

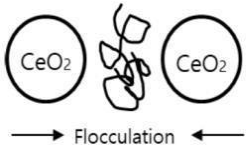
• Dispersant MW control
→ Ox CNT Profile improvement

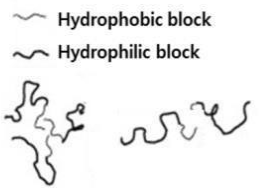


- Defect control

• Stabilizer : Preventing particle aggregation, Uniform Size control

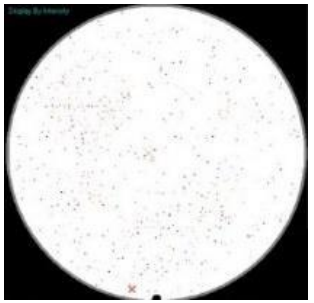
• Surfactant: Preventing debris aggregation from polishing process



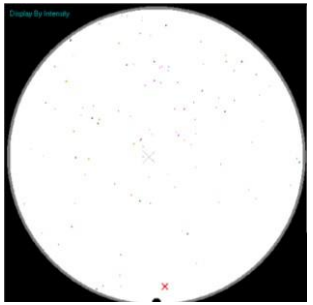


※ Defect count 20% decrease

POR : 555ea



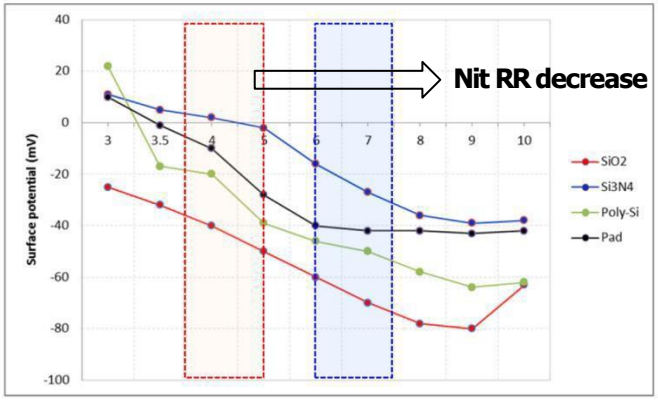
极思 : 110ea



◆ Major Product: SDN-A4000 (Additive for ILD Process)

- Slurry Surface-potential optimization for selectivity control

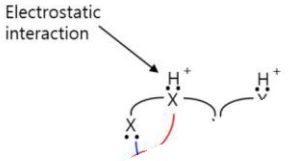
• Negative-type chemical formulation base Dishing control

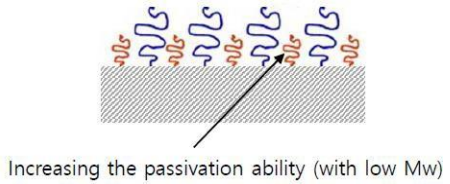


- Dishing performance improvement

• Negative-type chemical - Electrostatic & Hydrophobic interaction
: Amine & Hydroxide group controllable chemical

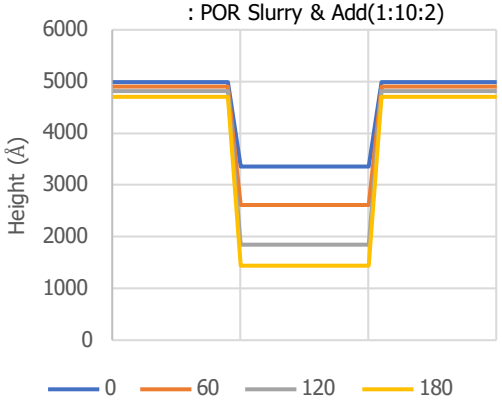
• High & Low MW Surfactant
: Passivation density control based low dishing



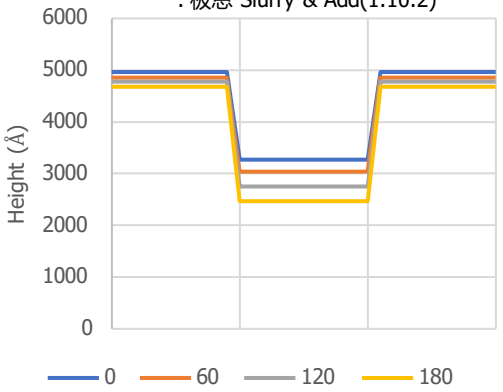


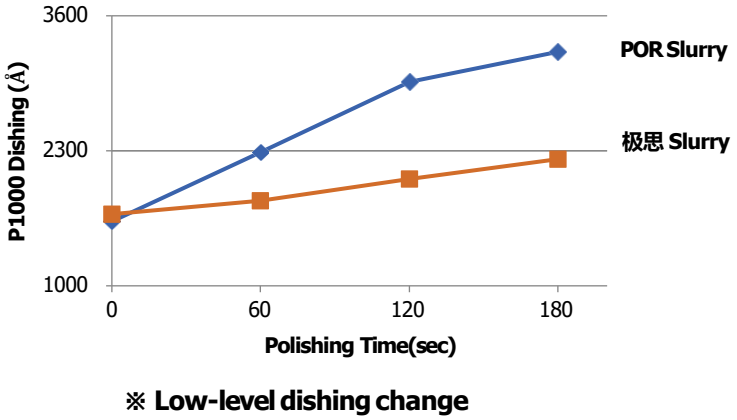
◆ Dishing Performance

SKW 3-2 PW P1000
Dishing Profile
: POR Slurry & Add(1:10:2)



SKW 3-2 PW P1000
Dishing Profile
: 极思 Slurry & Add(1:10:2)





※ Low-level dishing change

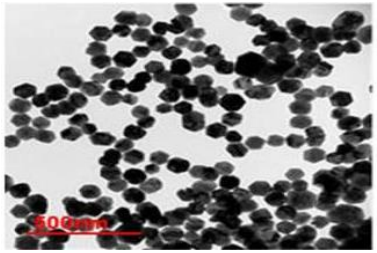
03 Major Product Portfolio

Product_SWC-2000

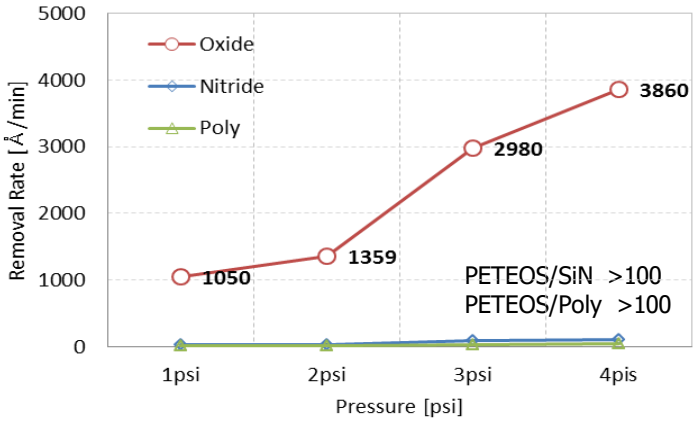
◆ Ceria Slurry for High Selectivity

- Low Dishing & colloidal ceria particle
- Excellent PETEOS/SiN/Poly selectivity
  : Nitride & Poly R.R <20Å/min
- Lower defect levels and higher yields

◆ Basic Properties & Performances

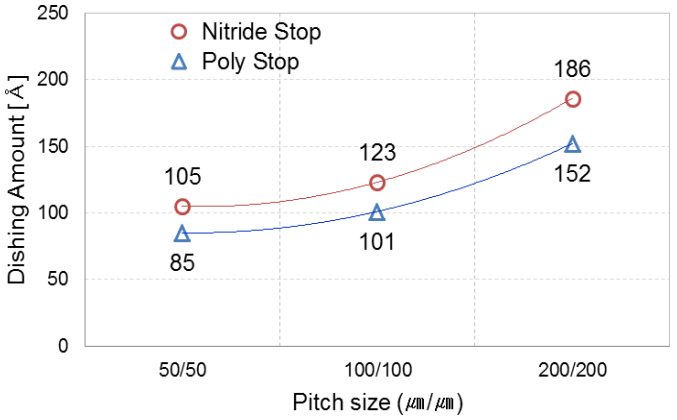
ITEM	SWC-2000
Abrasive	Colloidal
Particle Size (DLS method)	140 nm
pH	Acidic
Solid Content	3 ~5 wt%
Zeta-Potential	Positive
Metal Impurity (ppm)	≤ 10 ppm
Abrasive TEM images	

◆ CMP Test Results & Selectivity



Polisher : AP-300, Pad : IC1010, W/P: 3.5/3.0/3.0/3.0/3.0 psi,
R-Ring : 6.5 psi, Head/Table: 87/93 rpm, Slurry : 200 ml/min

◆ Dishing Performance



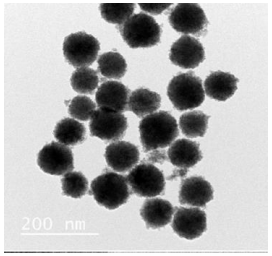
03 Major Product Portfolio

Product_SWC-3000

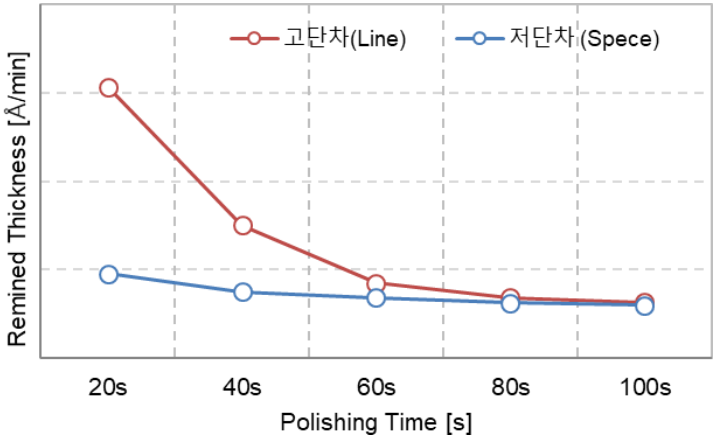
◆ Ceria Slurry for High R/R

- Hybrid colloidal ceria particle
- Oxide Removal Rate >20K Å/min
- Oxide Self Stop
- Dishing <200 Å

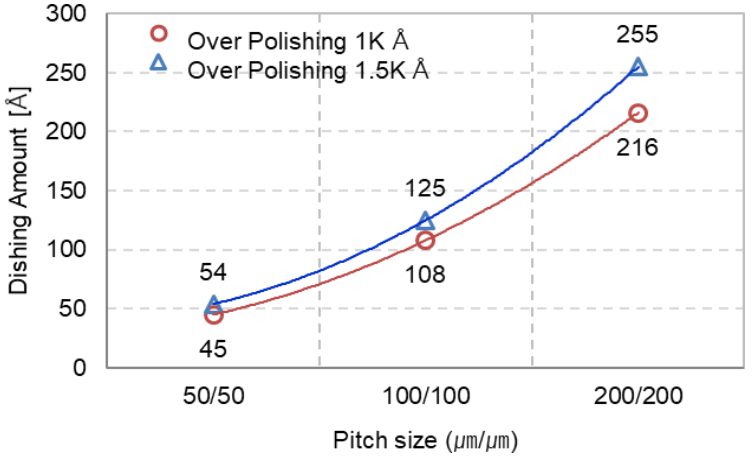
◆ Basic Properties & Performances

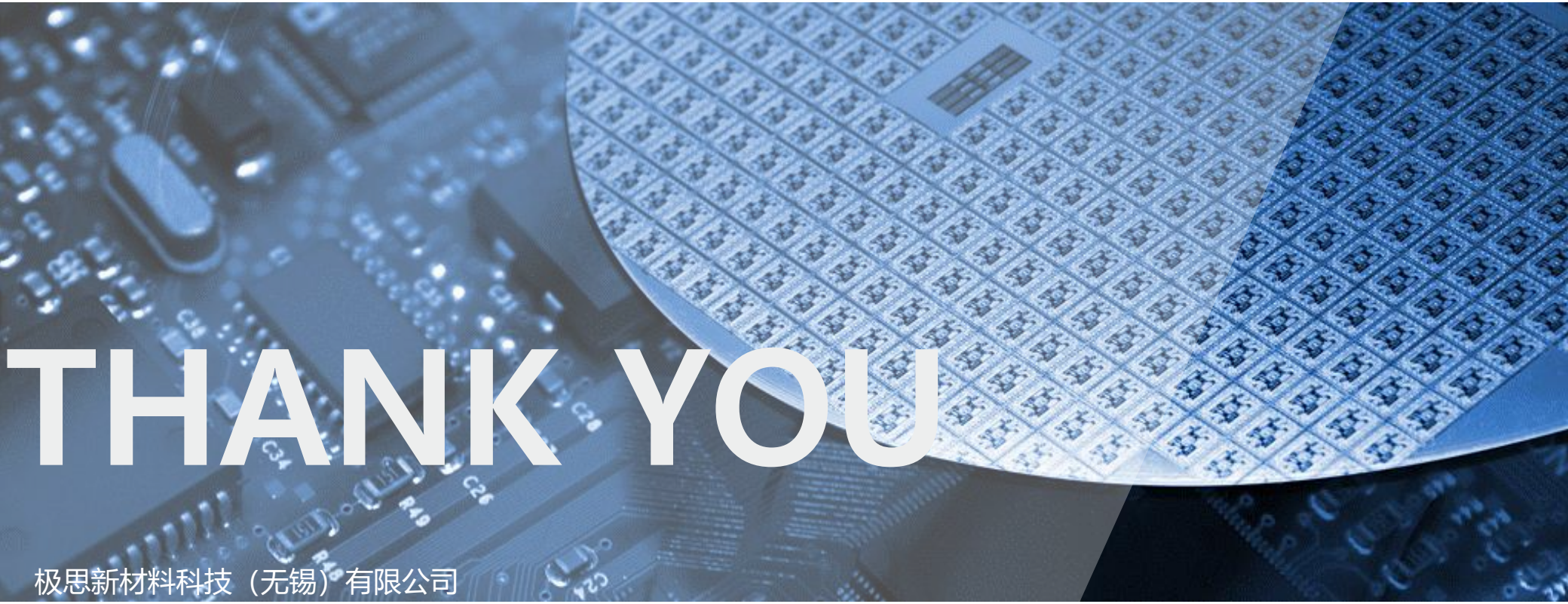
ITEM	SWC-3000
Abrasive	Hybrid Colloidal
Particle Size (DLS method)	100 nm
pH	Acidic
Solid Content	3 ~5 wt%
Zeta-Potential	Positive
Metal Impurity (ppm)	≤ 10 ppm
Abrasive TEM images	

◆ CMP Test Results & Selectivity



◆ Dishing Performance





THANK YOU

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