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Scratch reduction through new CMP slurry technologies

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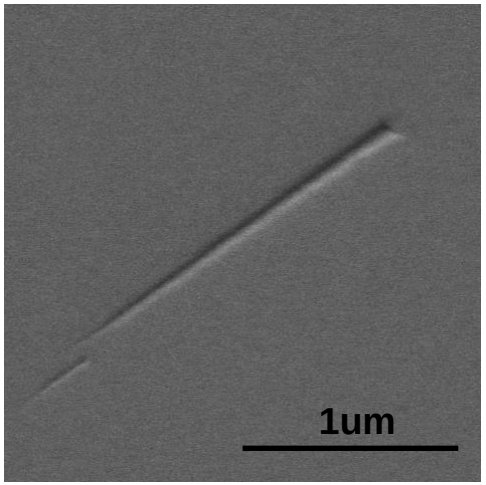
Outline

- Background
- Estimated root cause of scratch
- Correlation of scratch with abrasive property
- Summary

Background

Polishing performance

Removal rate, Planarity,
Selectivity, Non-uniformity,
Defects and Scratch

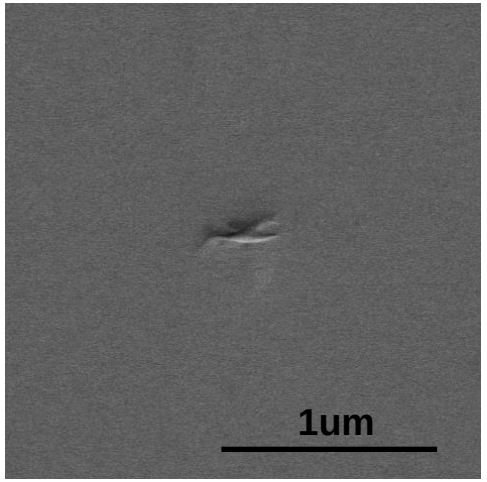


Shrinking Technology Node

(≤10 nm in 2016)

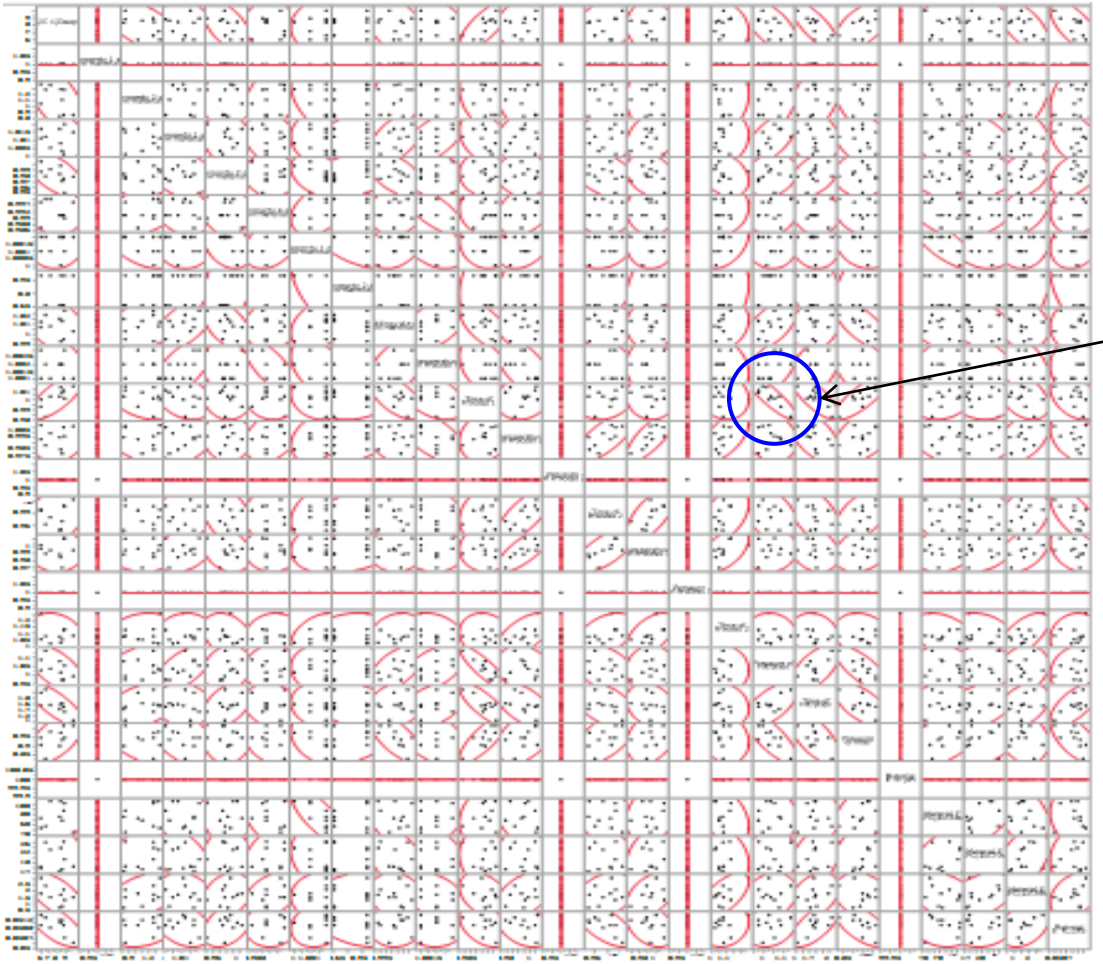
Small scratches would affect the operation of devices

➡ It is necessary to reduce scratches



Statistical Analysis

We have investigated correlation of scratch with manufacturing process factor, raw materials property and slurry property.



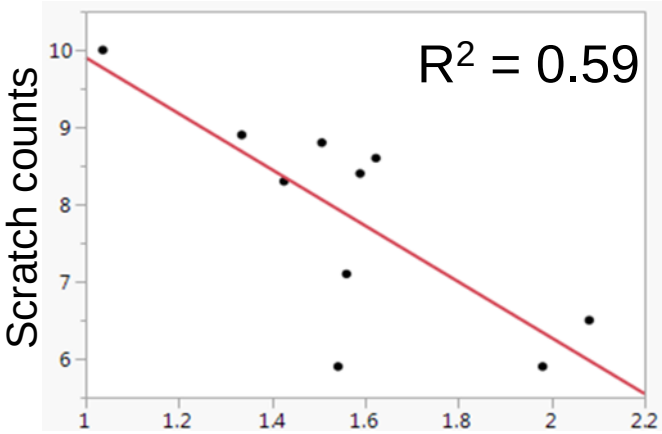
Moderate correlation

We need further analysis

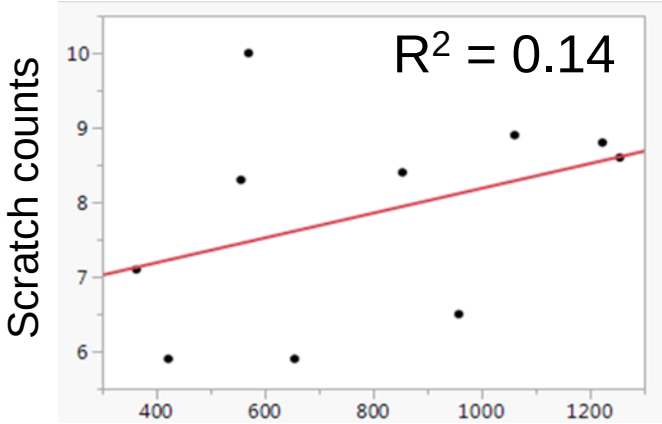
Analysis for 3 parameters

We chose three parameters to obtain better correlation with scratch.

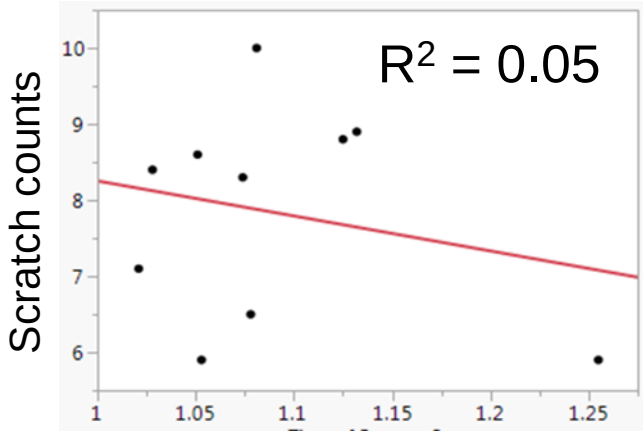
Time of Process A



Slurry property B



Raw material property C



Each correlation was not so good

Combined parameter

Three parameters was combined to obtain better correlation

Combined parameter

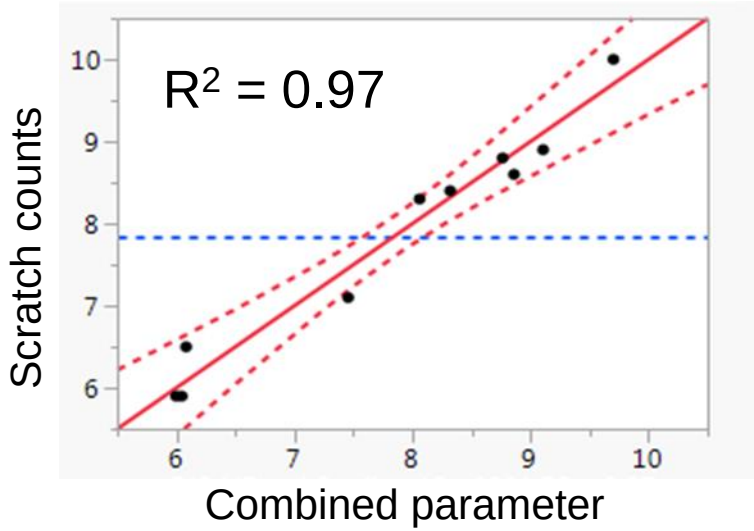
= a x Time of Process A

+ b x Slurry property B

+ c x Raw material property C

+ d

*a, b, c, d = constant



The combined parameter could correlate to scratch.
Now we control three parameters to reduce scratch.

Estimated root cause of scratch

Large Particle Count
(LPC)
- Large abrasive
- Agglomerate abrasive
- Contamination

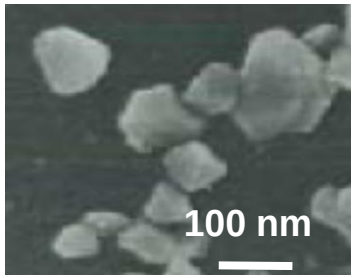
Abrasive hardness
- Harder
- Softer

Scum
- From wafer edge
- From polishing pad
- Agglomerate abrasive

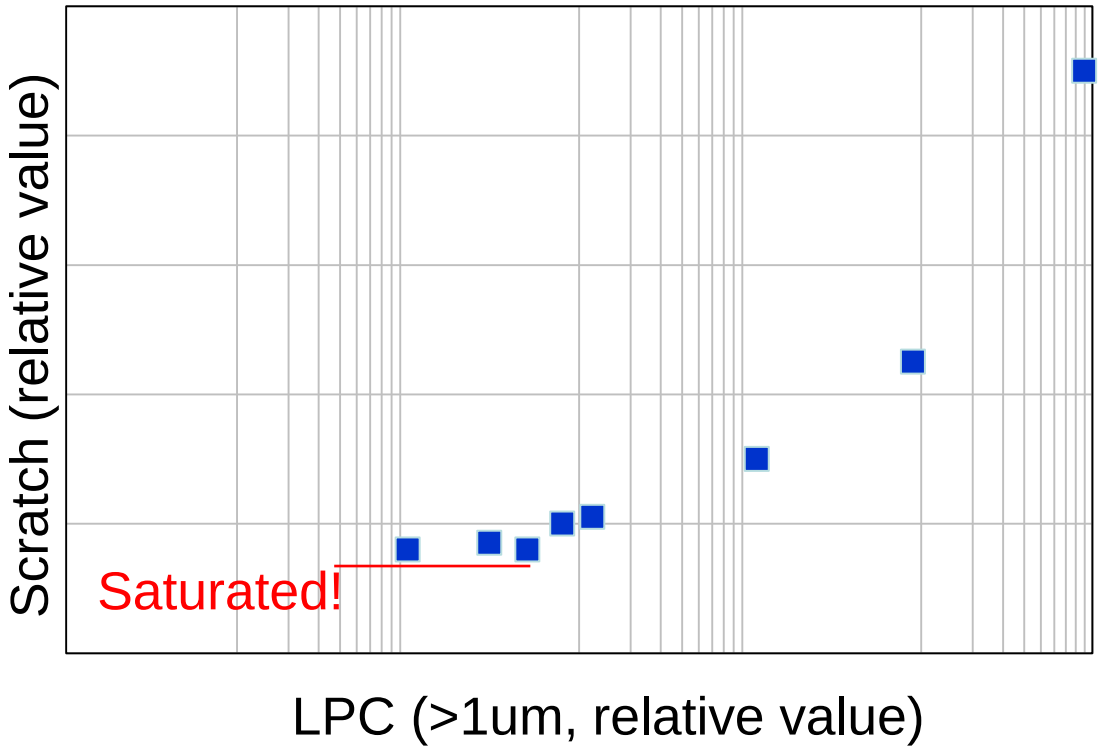
Abrasive type
- Ceria
- Silica
- Alumina
- Diamond

Contamination
- Metal
- Ceramic

Effect of Large Particle Count (LPC) on Scratch



Calcined Ceria



LPC correlated scratch. But scratch count saturated at a critical point.

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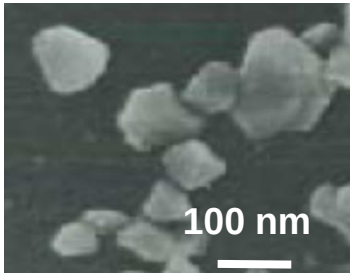
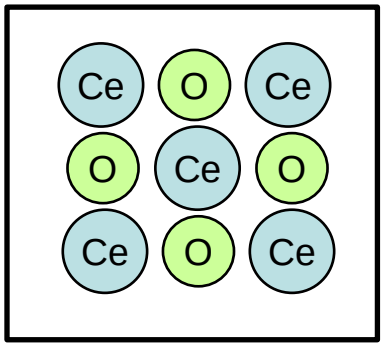
Measurement of abrasive hardness

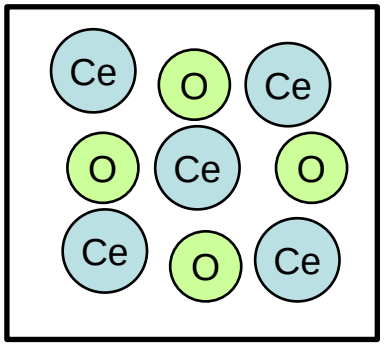
Three kind of calcined Ceria abrasive were made by changing manufacturing process



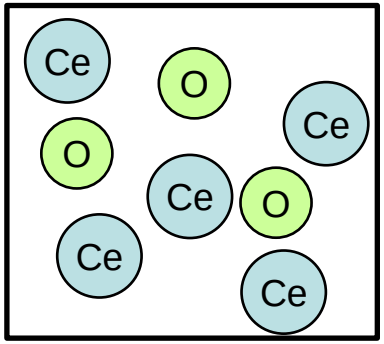
Calcined Ceria



Abrasive A



Abrasive B

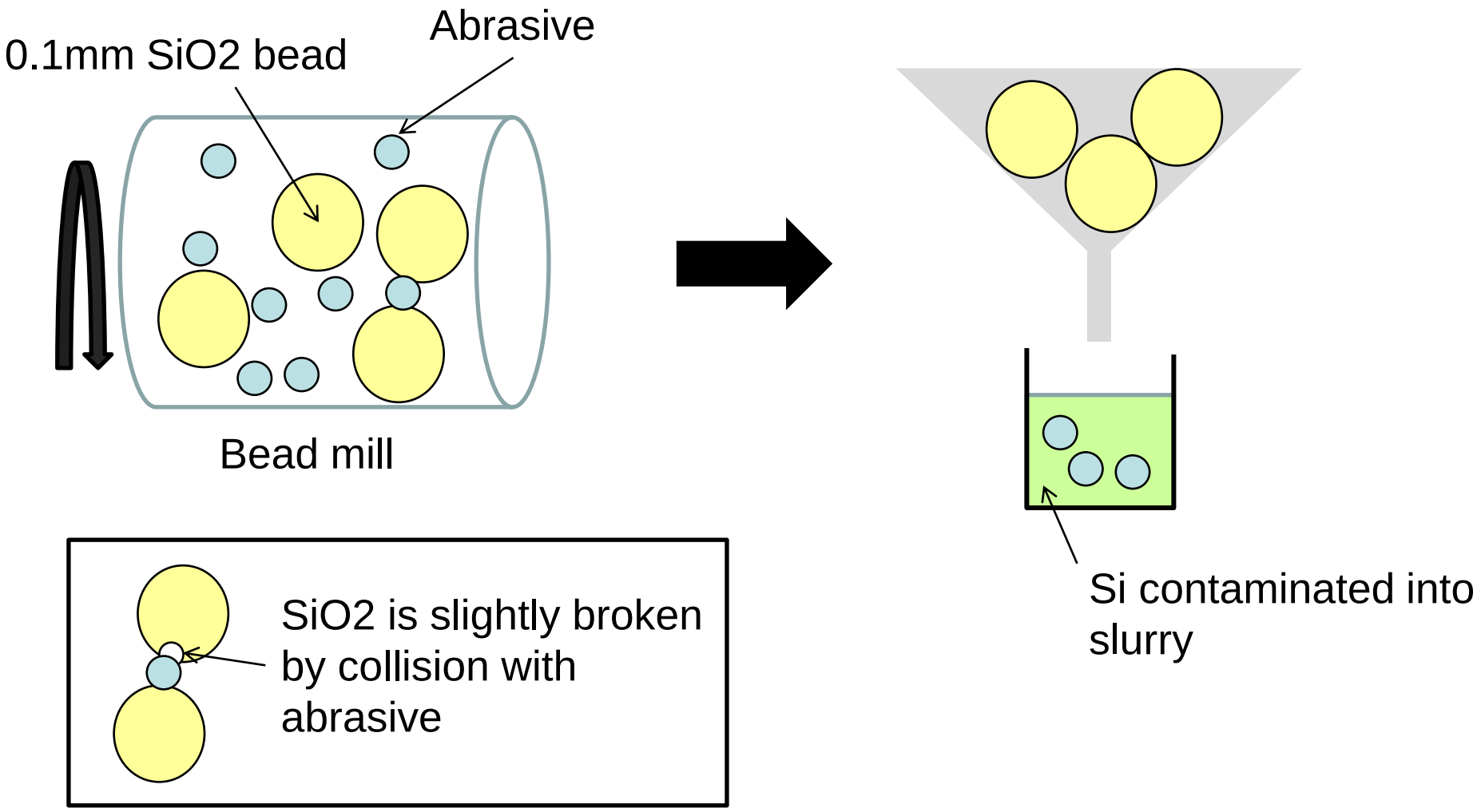


Abrasive C

It is difficult to measure hardness of abrasive directly.

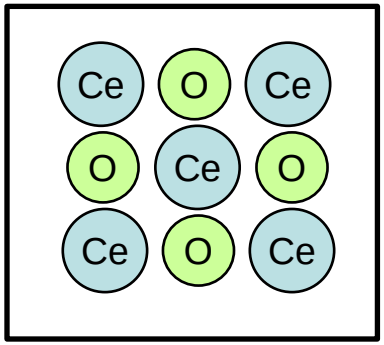
Measurement of abrasive hardness

We estimated hardness of abrasive to use a beads mill

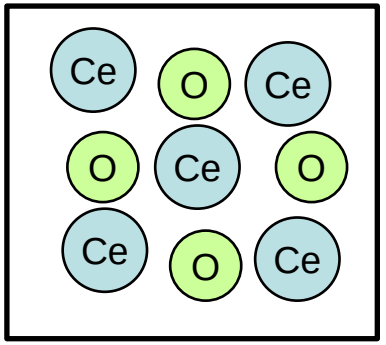


Measurement of abrasive hardness

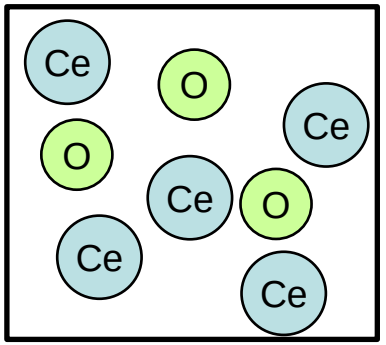
Result of contaminated Si amount after milling



Abrasive A



Abrasive B



Abrasive C

Samples	Abrasive A	Abrasive B	Abrasive C	Blank (Bead only)
Si amount (relative value, ICP-MS)	133	120	111	100
Scratch count (relative value)	111	103	100	-

Bead mill method can be estimated abrasive hardness and scratch level

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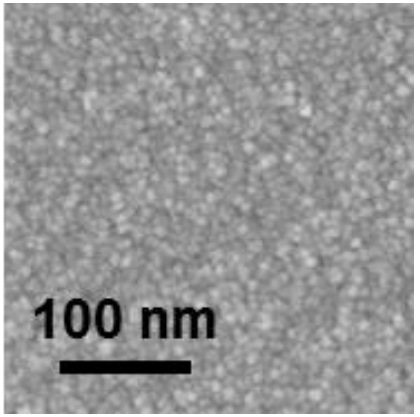
Abrasive size effect

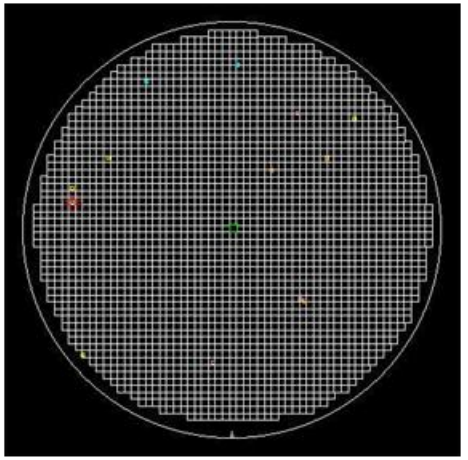
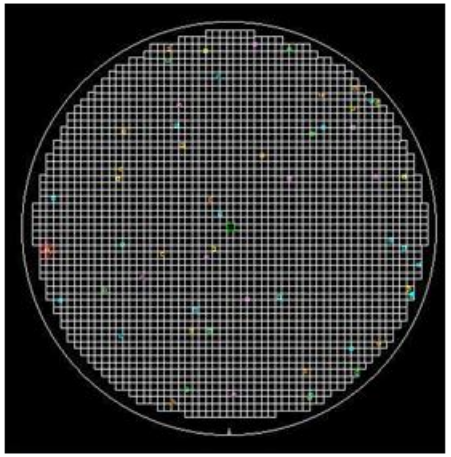
Nano Size Cerium
(NSC)



	NSC	Calcined ceria
Material	$Ce(OH)_4$	CeO_2
Particle size (nm)	5	150-500
Large particle count (>1 μm, relative value)	1	>1000
Zeta potential	Positive	Negative

Particle size and LPC of NSC are extremely low

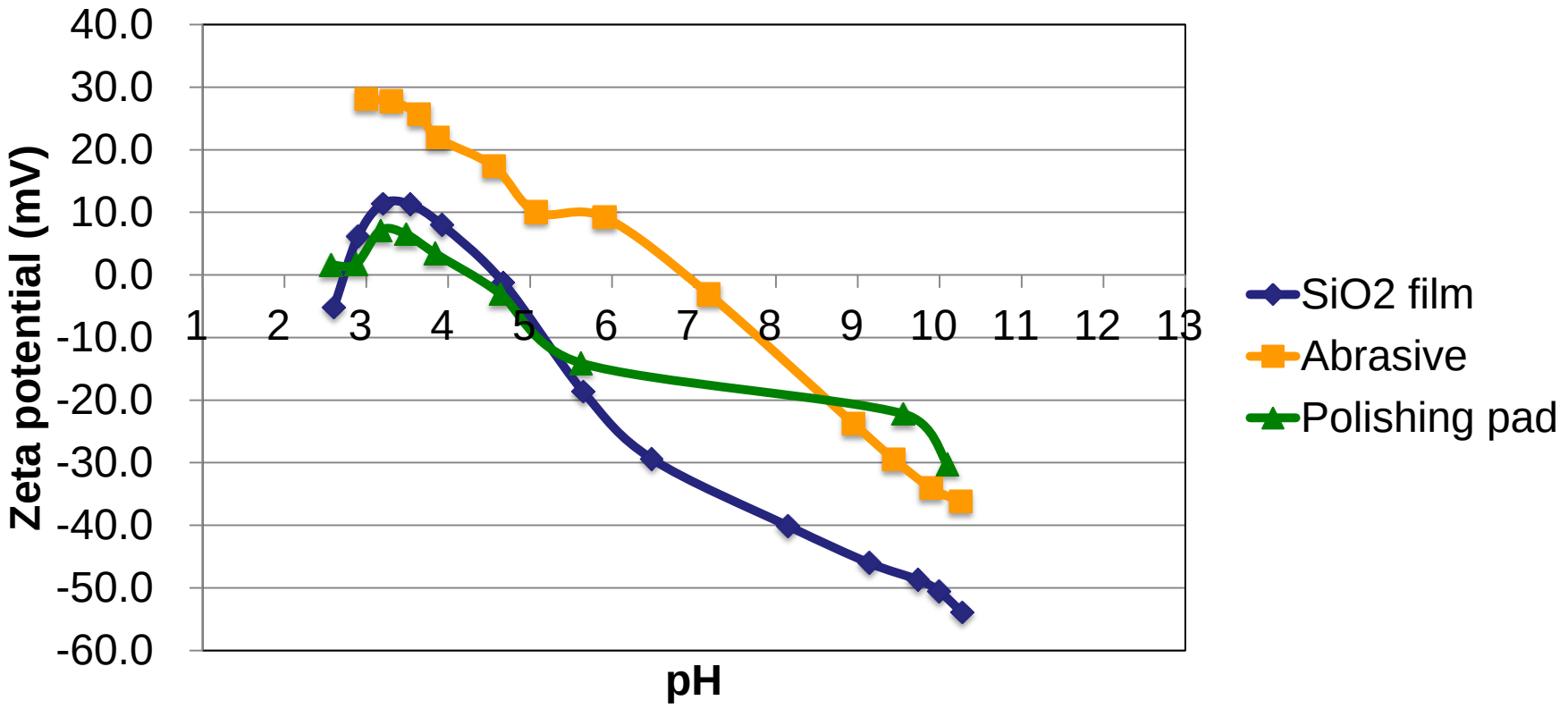
SiO_2 Removal Rate and Scratch Count

	NSC	Calcined ceria
SiO_2 removal rate (nm/min)	280	200-300
Defect map		
Scratch count (relative value)	1	30

SiO2 removal rate of NSC slurry is equivalent to calcined ceria slurry.
NSC slurry can reduce scratch count.

Further approach to reduce scratch

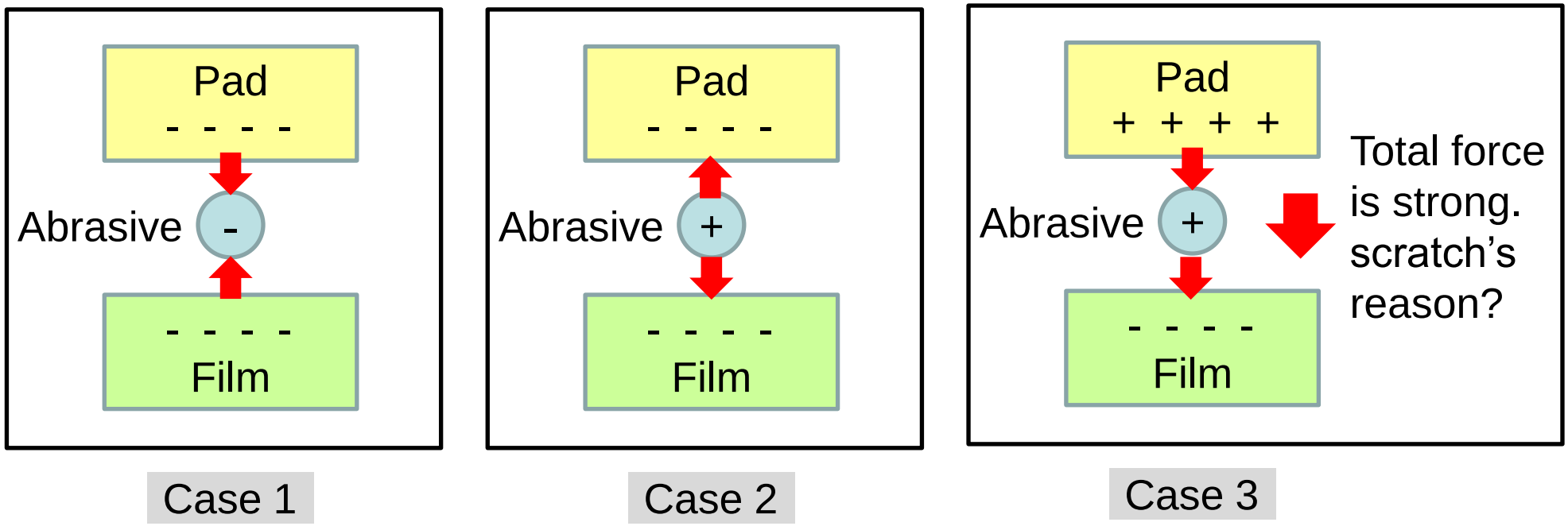
Surface potential of SiO2, Abrasive and polishing pad



Is there correlation between surface potential and scratch?

Further approach to reduce scratch

Combination between film, abrasive and polishing pad



We try to control each surface potential of material(film, abrasive and pad)
And we investigate relationship between surface potential and scratch

Summary

- The influence of scratch becomes ever more critical in the overall CMP process.
- Large particle in slurry may cause scratch.
- We have investigated correlation of scratch with abrasive size, shape, hardness and other factors in CMP. It is suggested that hard abrasive cause scratch.
- Now we try to control the interaction between wafer surface, slurry abrasive and polishing pad surface to reduce scratch.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