

Recent trend of CMP equipment platform and its requirement of process and consumables: BEOL CMP

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CMP Process Development Team



Number of CMP layers & BEOL CMP

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			,	Advance	ed logic			Over 50% of all C
	19							10-11 Cu
CMP Process	18							Co IM (3)
	17							HM (4-12)
	16						10-13 Cu (*)	W Plugs
	15						Co IM (0-2)	W-TS
	14						HM (2-6)	Co-TS
	13					8-12 Cu (*)	W Plugs	HM
	12					HM (2-4)	W-TS	SAC2
	11					W-Plugs	SAC2	SAC1
	10					W-TS	SAC1	Co Gate
of	9					SAC	W Gate	HM
Number	8					W-Gate	НМ	РОР
	7				9-10 Cu (*)	НМ	POP	ILD0
	6			9-10 Cu	W-Plugs	РОР	ILD0	Gate Poly
	5		7-8 Cu	W	W-TS	ILD0	Gate Poly	III-V
	4	7-8 Cu	w	Al / W Gate	Al/W Gate	Gate Poly	SiGe	SiGe
	3	w	Al Gate	POP	POP	HM	НМ	HM
	2	ILD	ILD	ILD	ILD	STI2	STI2	STI2
	1	STI	STI	STI	STI	STI1	STI1	STI1
# CMP Layer		10	12	14	15	18-25	24-30	25-34
Technolo	my Node	65nm	45nm	28nm	20nm	16/14/10nm	7nm	5nm
recimolo	gy Node	Planar		НКМС		- FinFETs		GAA
								(DOW)

BEOL CMP

3 platen Cu CMP process



- Cu bulk and Cu clear in separate platens (Platen 1 and 2)
- Little attention to Cu polishing rate
- More options on platen 2 to reduce polishing defects
- High CoO due to lower run rate than 2 platen process tools

2 platen Cu CMP process



- Platen1 and 2: Cu bulk+Cu clear
- Platen3 and 4: Barrier/Oxide CMP
- 2 polishing units:

Platen 1 and 3 & Platen 2 and 4



(Source: EBARA)

- Polisher A and C: Cu bulk+Cu clear
- Polisher B and D : Barrier/Oxide CMP

 2 polishing units: Polisher A and B & Polisher C and D

- Pro : Higher run rate than 3 platen Cu CMP Better tool availability
- Con: 1 platen for Cu bulk + clear

Endpoint in 2 platen Cu CMP

	Cu overburden	C polishii	u ng time		Barrier polishing	
Lower Layers	1X	1x		0.6x		
Middle Layers	1.2x	1.2x			0.7x	
High Layers (3 platens)	3.8x	1.1x	1.1x		0.9x	

- Longer Cu polishing time than Barrier polishing due to 1 platen Cu polishing
 - Run rate improvement restricted by Cu polishing time
 - Higher chance of defects due to longer Cu polishing time per platen



Scratch defect source – Cu blanket test Cu polishing or Barrier polishing?



How to reduce Cu polishing time?

- Process
 - Pressure and RPM
- Incoming Cu overburden
 - Reduction of Cu plating thickness
- Consumable
 - Pad, Slurry and Conditioner

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Process – Pressure or Velocity?

- Removal Rate = $K_p \times Pressure \times Relative velocity$
- Pressure or Velocity?
 Image: second sec

– Pressure is more dominant factor for removal rate increase

• What is maximum allowable Cu polishing pressure in your mind?

Process – pressure increase



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Incoming Cu overburden



Reduced Cu overburden and Cu polishing time

Cu polishing time VS. Cu overburden



Normalized Cu overburden

- More than 30% Cu endpoint decrease
- Concern of under-fill

Within Die Uniformity post Plating



1.00X Cu overburden

0.50X Cu overburden with plating optimization

- Optimization of Cu electroplating
- No degradation even 0.5X Cu overburden

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Consumable for higher Cu removal rate

- Slurry
 - High static etch rate
 - Risk of corrosion defects and over polishing
 - High abrasive content
 - Risk of scratch defects and severe dishing
- Pad
- Conditioner

Pad for Cu polishing

- Requirements
 - Planarization: Less dishing
 - Uniformity: Uniform E-test data across wafer
 - Low defects: Less scratch
 - Higher Cu removal rate: Without quality degradation
 - Longer life: Low cost of ownership
 - Conditionability: Consistent pad cut rate

Pad for Cu polishing

- Hard or Soft?
- Recent pad development trend



New pad test

Normalized Cu Removal Rate

Normalized Cu Polishing Time



- Higher removal rate than baseline (1.2X)
- Shorter polishing time than baseline (0.8X)
- Comparable defect to baseline

Conditioner & Pad surface

Defect

Planarization

Removal rate









- Lower contact pressure
- Less scratch
- Better planarization



Conventional conditioner Conditioner displacement VS. Down force



Designed Surface Diamond Conditioner CVD Diamond Conditioner



Pad Texture Histogram VS. Conditioners



Conventional Conditioner



CVD Diamond Conditioner



• Tight pad asperity control with CVD diamond conditioner (0.6X)



Summary

- BEOL CMP equipment platform
 - From 3platen to 2 platen
 - 1 platen for Cu bulk and Cu clear CMP
- Critical Cu removal rate control
 - Process
 - Incoming Cu overburden
 - Consumable
 - Forecast of Cu polishing