CMP's Transition to 450mm Manufacturing: *Engineering Consumables to Meet Process and Efficiency Targets*

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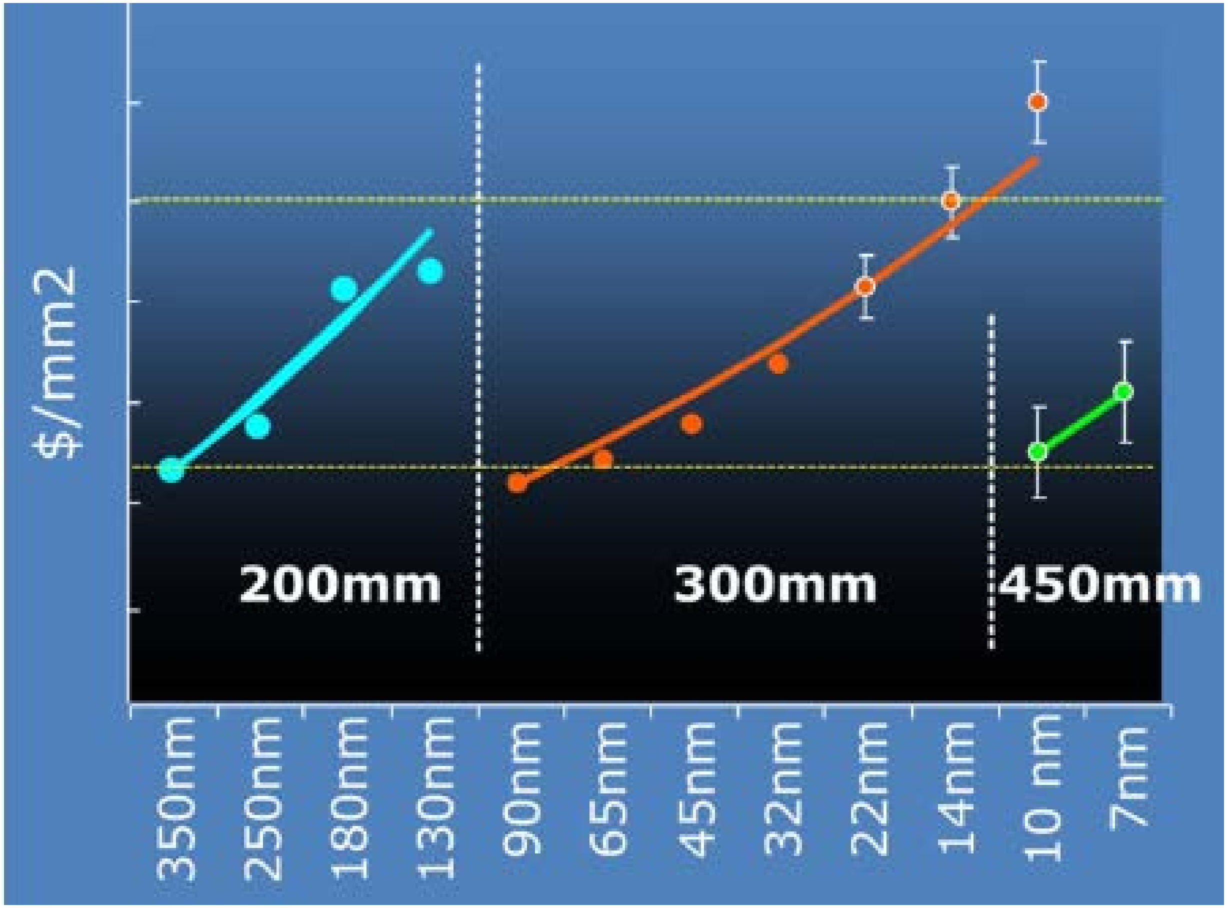
450mm Wafer / Technology HVM Intercept



- Steve Johnson, Intel, presented at the Silicon Valley Lunch Forum, April 25, 2013

"…flawless and synchronized execution across the industry is required to realize (450mm) benefits…"

Global 450mm Consortium (G450C)

What is the Global 450 Consortium (G450C) Program?

- The G450C is focused on building the 450mm wafer and equipment development environment
- The consortium, made up of 5 member companies (Intel, TSMC, GLOBALFOUNDRIES, IBM, Samsung) and New York State partnering with the College of Nanoscale Science and Engineering (CNSE) of the University at Albany, State University of New York is:
- a New York based consortium
- funded to collaboratively work with suppliers to develop 450mm equipment
- using wafers, equipment, people and cleanroom space to develop and test equipment to meet industry needs

www.g450c.org

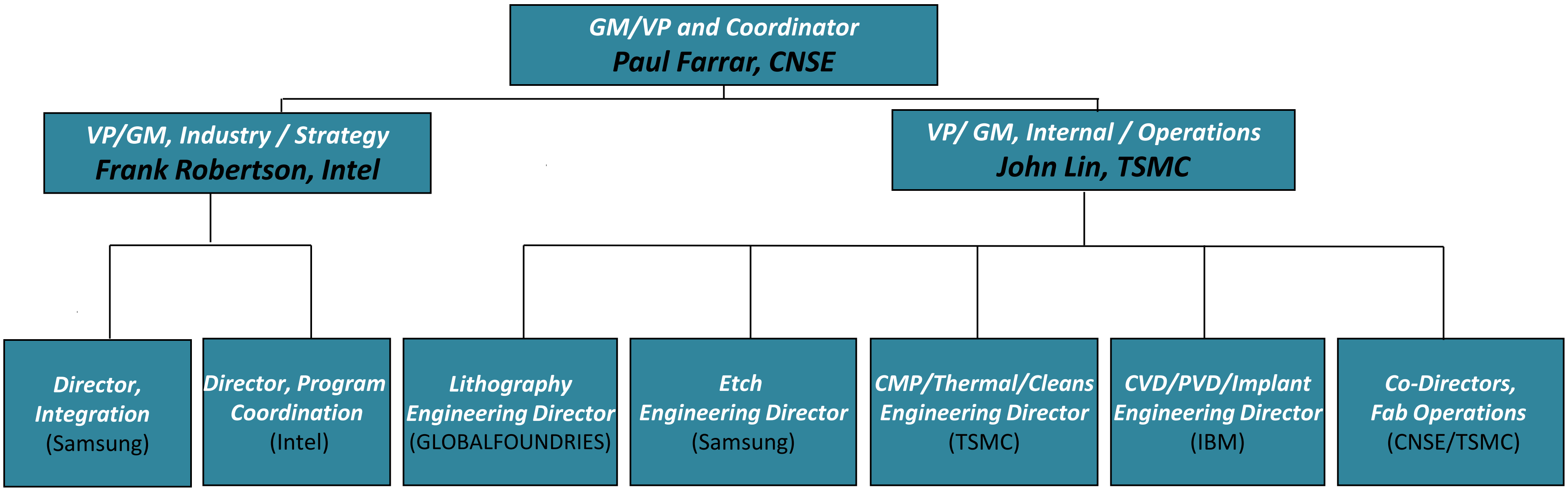
Global 450mm Consortium

Key elements

1. Near term (5-years, started ~1Q12)
   - Establish a program to develop Test Wafer fabrication infrastructure, equipment prototypes & high-volume tools to enable industry transition to 450mm

2. Long term
   - Equipment set capable of advanced semiconductor process module development installed and operational at CNSE
   - Establish, staff, and support a follow on process technology development program

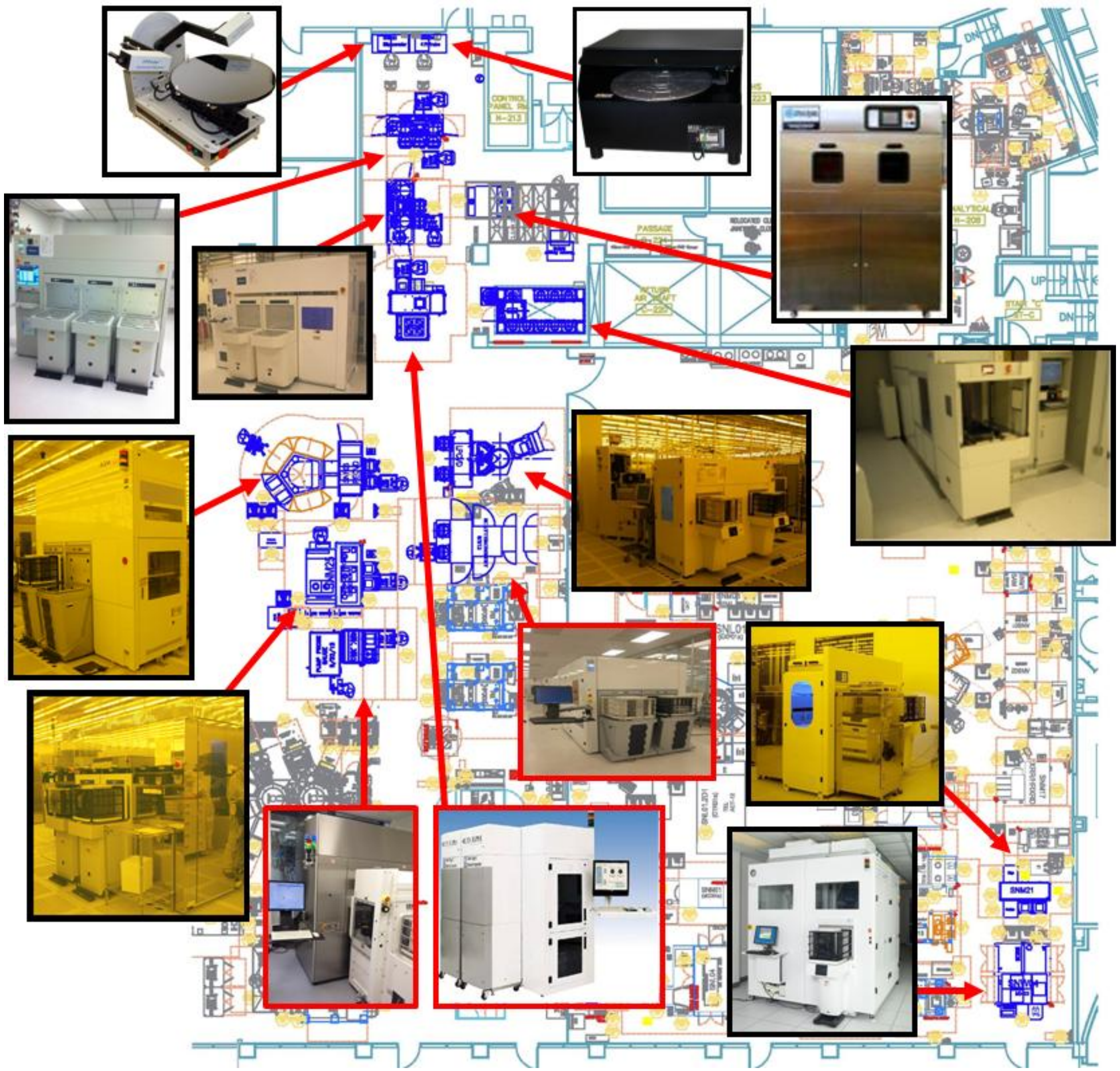
G450C Program Organization



- *Industry consortium coordinated by not-for-profit entity*
- *Leveraging NYS / CNSE funding, matched by all industry participants*
- *Broadly-shared management of Program execution*

- *Over 60 staff on board now; >100 by 2014, and >60 Supplier engineers on site*
- *CNSE infrastructure support, including synergistic engineering projects*

G450C Operations - CNSE NFN Cleanroom



12 tools installed in NY cleanroom,

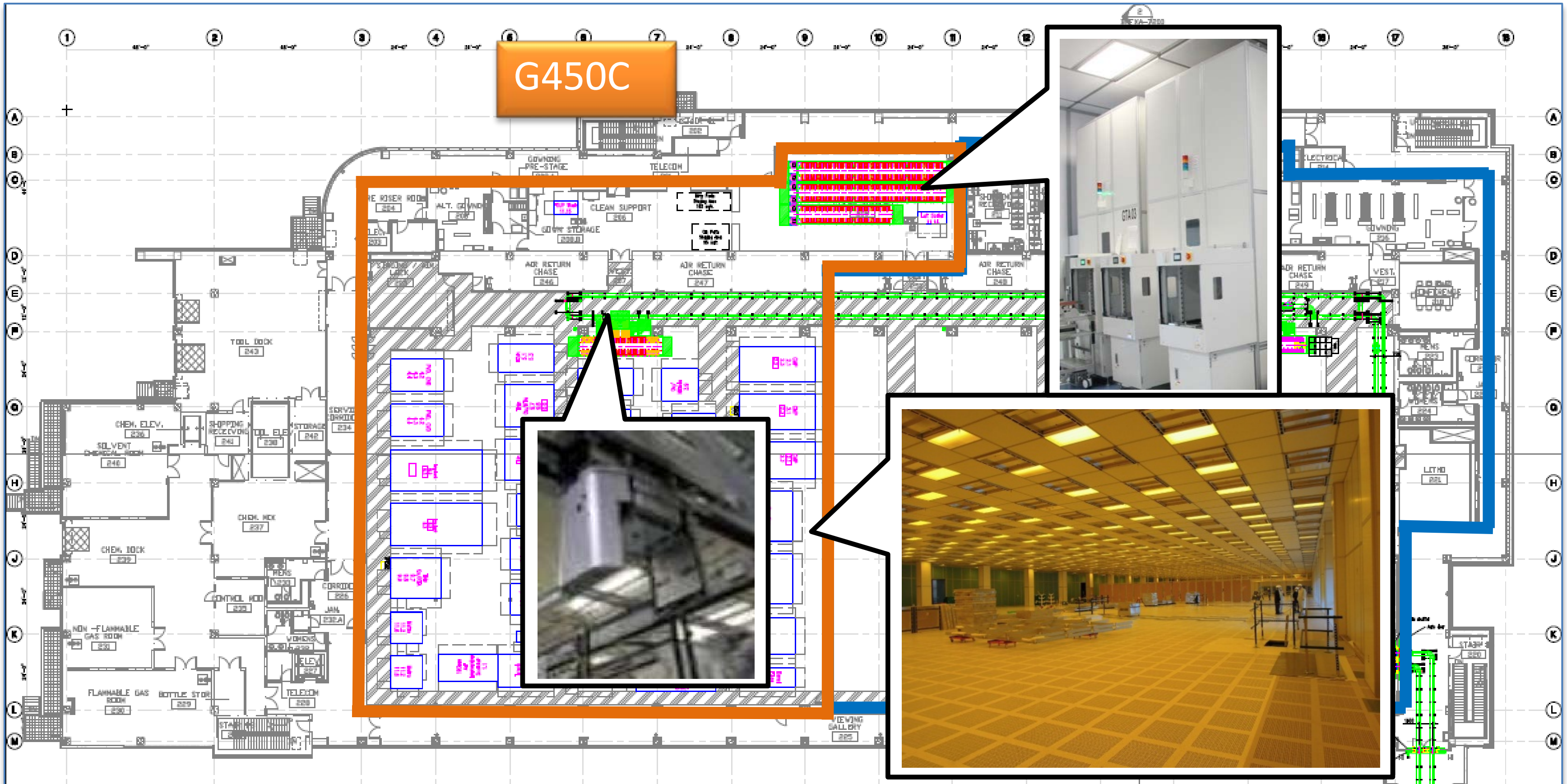
Sorter, Stocker, FOUP wash
PECVD Ox
LPCVD Poly
SE/scatt, XRR, XRF
Bare wafer particle
Macro/bevel inspect

3 additional metrology tools incoming 2Q'13

Rs, CD AFM
Defect Review SEM

>8000 wafers
>400 carriers

G450C Operations – NFX Cleanroom



- **RFE December 2012 – G450C ~22K ft^2 clean space**
- **450mm OHV ready for inter-bay transport between fabs ~end 2Q13**
- **4 pieces of 450mm equipment have arrived in G450C space**

Equipment Performance Metrics (EPM)

- G450C will evaluate CMP equipment versus the current published Equipment Performance Metrics (EPM)

www.g450c.org

2 CMP			
2.1	CMP	Dielectric CMP	Planarization Dielectric Films
2.2	CMP	Metal CMP	Tungsten Plug Polish
2.3	CMP	Metal CMP	Damascene - Copper Polish

Priorities among the many attributes included in the EPM are generally as follows:

- *Process performance, including defectivity, is a baseline requirement; it must be at 450mm as good as or better than that for the equivalent 300mm tools*
- *450 mm tool productivity must be as good as or better than 300mm tools on a per-wafer basis for the same tool configuration by the time of HVM.*
- *Other components of performance such as batch size, process control, MTBF, etc. must be optimized to achieve the two overarching goals above*

CMP EPM - Oxide

2.1 Dielectric CMP – Planarization Dielectric Films

Category	Attribute	Units	14nm Metrics	Notes
Equipment Performance	auto pad condition	NA	required	
	in-situ thickness monitoring	NA	required	
	end point detection	NA	required	
	automated process control	NA	required	host communicate incoming
	integrated with post CMP clean	NA	required	
	dry-in & dry-out	NA	required	
Process Targets	RR total variability (3σ)	%	< 4	
	RR wafer to wafer uniformity (3σ)	%	< 2	
	RR total uniformity (3σ, 49pts)	%	< 6	
	RR within wafer uniformity (3σ, 49pts)	%	< 3	
	dielectric thinning (10~20% over polish)	nm	SOBT3	SOBT3 = same or better than 300mm tool
	removal rate	nm/min	SOBT3	
	removal rate stability parameter	%	< 5	drift, pad life > 500 wafers
	dishing/over/under erosion, patterned wafer	nm	5	
	edge exclusion	mm	1.5	

CMP EPM – Oxide (continued)

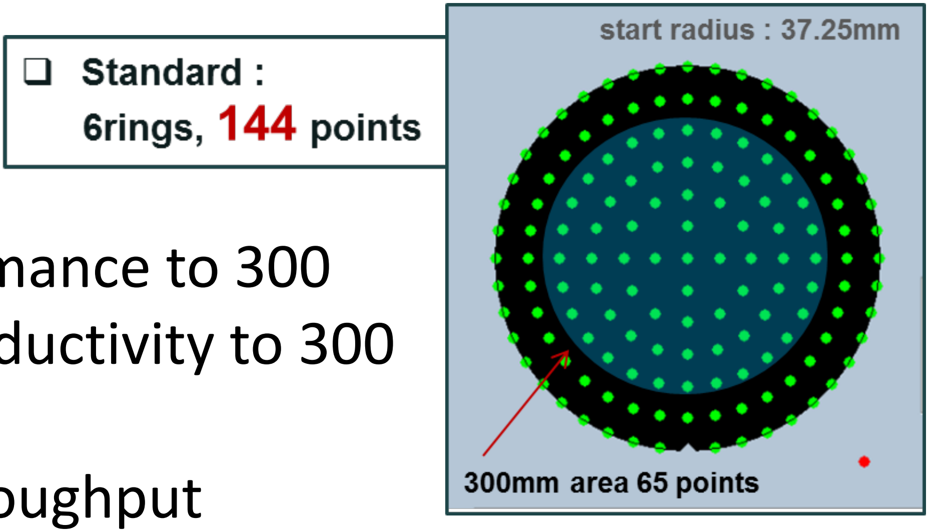
Process Characteristics	slurry waste	LPM/wafer	< 1.5X of 300mm	
	pad consumption	wafers	> 1200	rate on per platen basic / all platens
Defect Performance	PWP on bare Si	#/cm2	≤ 0.002 @ ≥ 30nm	
	PWP on backside Si	#/cm2	≤ 0.28 @ ≥ 50nm	
	critical scratch length	nm	10	
	critical scratch count	#/wafer	50	
Manufacturing Target (@HVM)	Availability	%	> 95	
	MTBF	hours	> 350	
	MTTR	hours	< 3	
	productivity scalar relative to 300mm		≥ 1	
	foot print scalar relative to 300mm		≤ 1	normalized to run rate

* CMP is one of the key processes where consumables cost must be brought down significantly, either with new designs for 450 mm or engineering improvements over time

Consumables Directions for 450mm

What may drive CMP consumable differences for 450mm equipment?

- Revisit the EPM:
  - 14nm node
  - Equivalent process performance to 300
  - Equivalent equipment productivity to 300
  - Edge exclusion 1.5mm
  - Equivalent normalized throughput



- Assume the probability of equipment configuration change due to size increase (2 platens)
- Assume that requirements of process/equipment yield for 450mm will drive CMP control improvements
  - (Wafer scrap hurts 2.25x as much)

Consumables Directions for 450mm - Slurry

Slurry suppliers must work with equipment suppliers to co-develop / optimize slurry sets for larger wafers, while keeping flow rates reasonable

- Improvement of slurry stability / manufacturing tolerances
  - 14nm node requires lower defectivity; tighter particle size control
  - Better stability within drum, local reservoir, and slurry loop
  - Compatibility with inline or loop filtration (higher flow rates, more susceptible to shear)
  - Successful and stable dilution in sub-fab and on-platen
- On-platen mixing
  - Two-platen designs could drive higher instance of ‘high rate and soft-landing’ slurries on one platen
  - ‘Slurry sets’ with ensured compatibility could be much more important

Consumables Directions for 450mm - Pad

Pad development for >40 inch platen must continue along (and expand upon) recent advancing trends

- Optimization of pad materials and groove configuration
  - to complement 14nm node advanced slurry engineering
  - to maximize performance with larger wafers
  - to further enable efficient on-platen slurry mixing or transition
- Uniformity of pad material properties
  - across pad (larger area, larger wafer contact area)
  - pad-to-pad (single-cast or batch uniformity controls)
- Maintain compatibility with improving process control / endpoint systems

Consumables Directions for 450mm - Disk

Diamond conditioning, and other modes of pad refreshing or cleaning, increase in importance for >40 inch platens

- Platen size could drive disk changes
  - larger disks, and/or multiple disks per pad
  - better control / predictability at higher pressures may be required to maintain through-life pad performance
- Platen size increase would benefit from improved 'conditioner efficiency'
  - higher slurry flow rates, larger slurry 'capture area' under wafer
  - developing a better disk, the physics of which are better understood, that complements pad cleaning may have differentiating advantages

Summary

G450C's mission is to evaluate equipment capability versus the EPM specification – which begins with demonstration of the supplier-selected BKM at the 14nm node

The certainties:

- Wafer and pad get bigger, and process/equipment scrap frequency must reduce
- IDMs require zero performance degradation vs 300mm (including defectivity) and are pushing aggressive targets to consumable consumption rates

The assumptions:

- Slurry flow rate increases (probably belongs above)
- Two-platen configurations will be more prevalent

The projections:

- Consumable manufacture, and performance during process, will require tighter tolerances (slurry, pad, and disk)
- On-platen slurry mixing may become more prevalent
- Pad properties and grooving must be optimized to slurry set

450mm CMP tools are available now at supplier labs, and will be available to G450C starting 2H13 – results will confirm/refute projections and highlight new challenges