Legacy & Leading Edge Both are Winners

Techcet CMP Consumables 2015 Market Update

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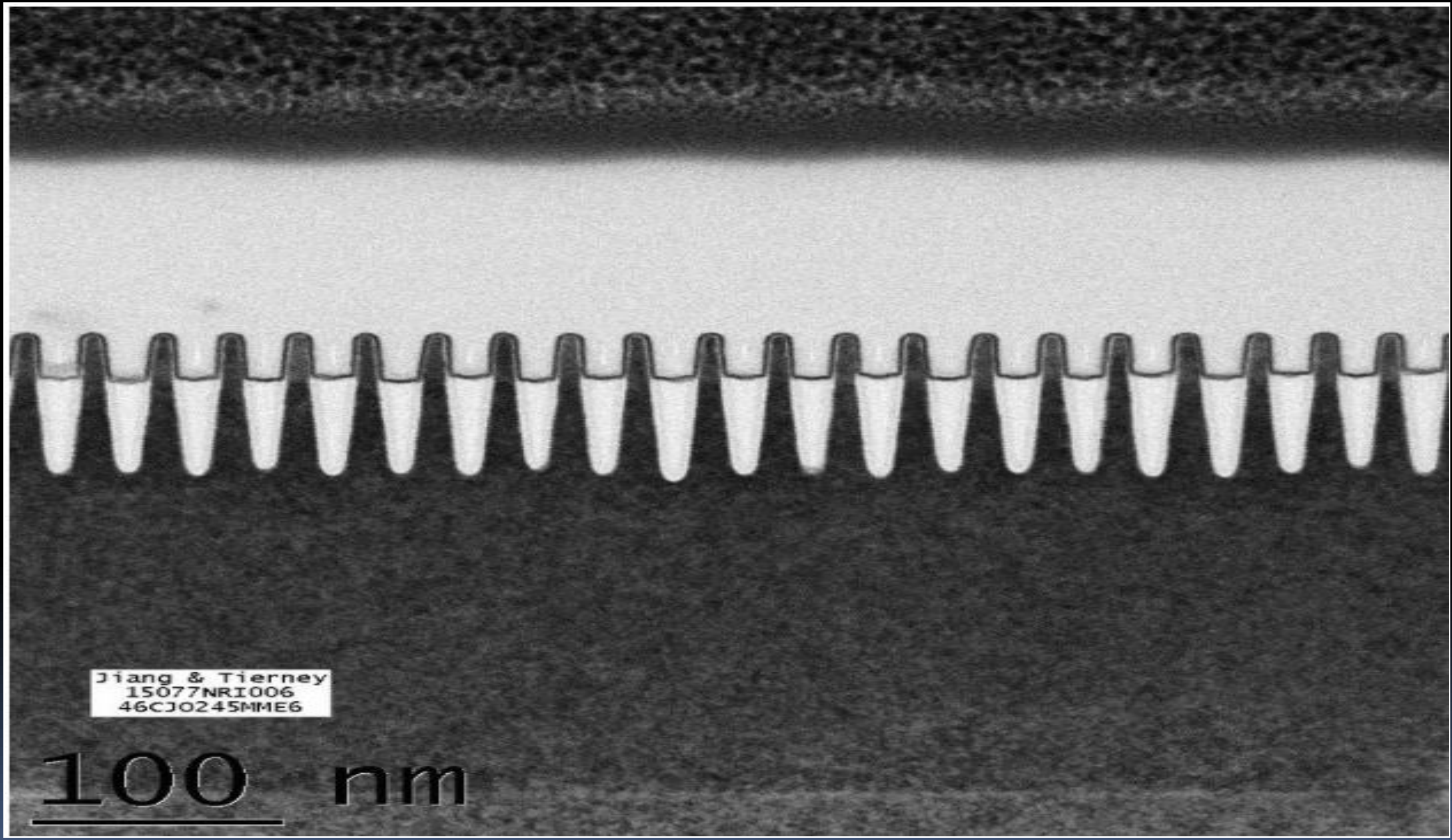
Outline

- Semiconductor Outlook
- 2015 CMP Research Themes
- CMP Market
- Wrap Up

Semiconductor Outlook

Innovation is Alive & Well



New York Times, IBM Research

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Semiconductor Outlook

Mobile Market Continues to Evolve

- Mobile - Key IC growth driver
- Emerging Markets driving smart phone market
- Mobile July 2015 Mobile forecast (units shipped):
  - All mobile up 1.5%
  - Smartphones up 3.3%
  - Ultramobiles down 5.3%
  - Tablets decrease 5.9%
  - PC's down >5%
- SSD market will continue to grow
  - Key driver – cloud computing
  - Key challenge – cost

Source: Gartner

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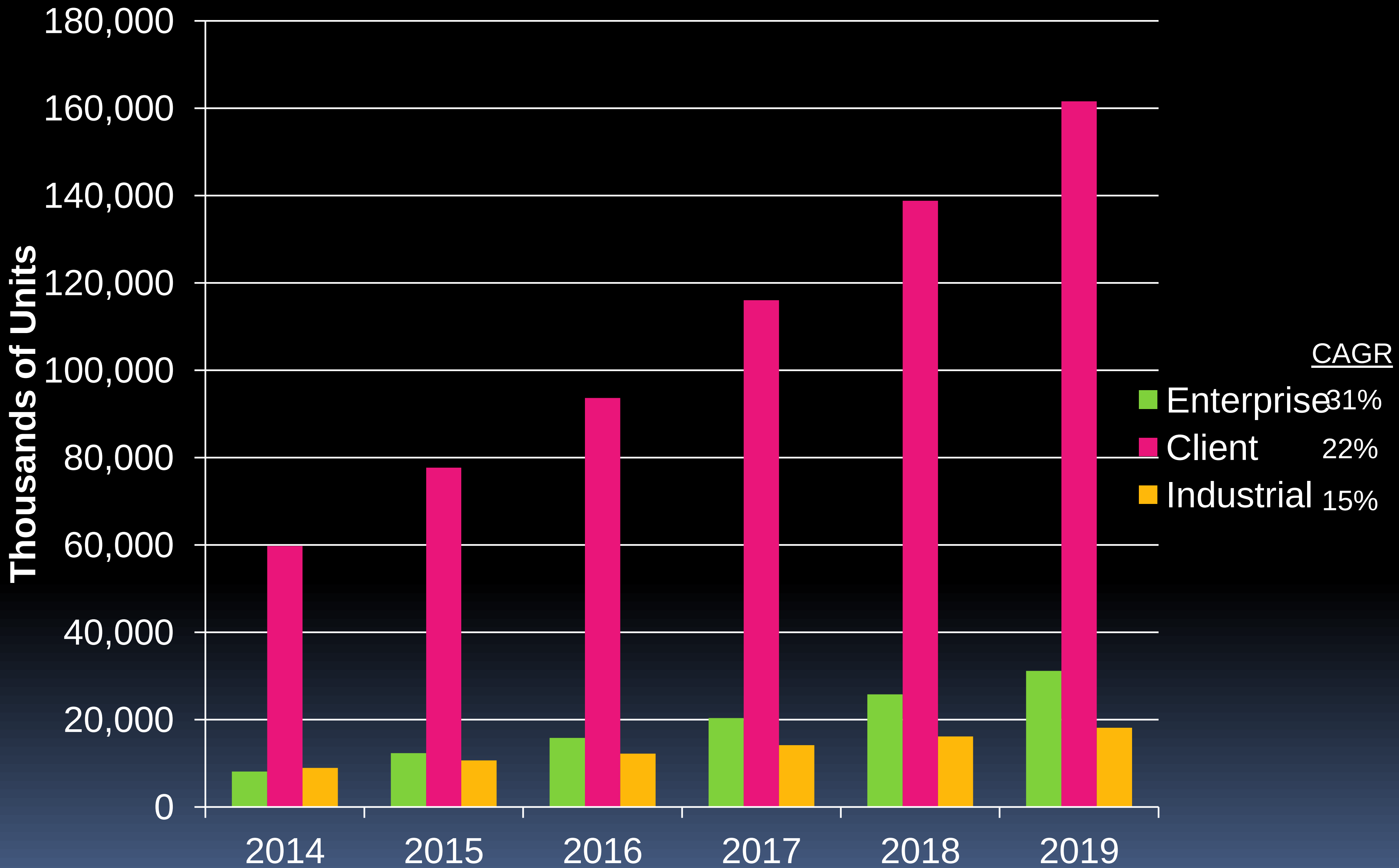
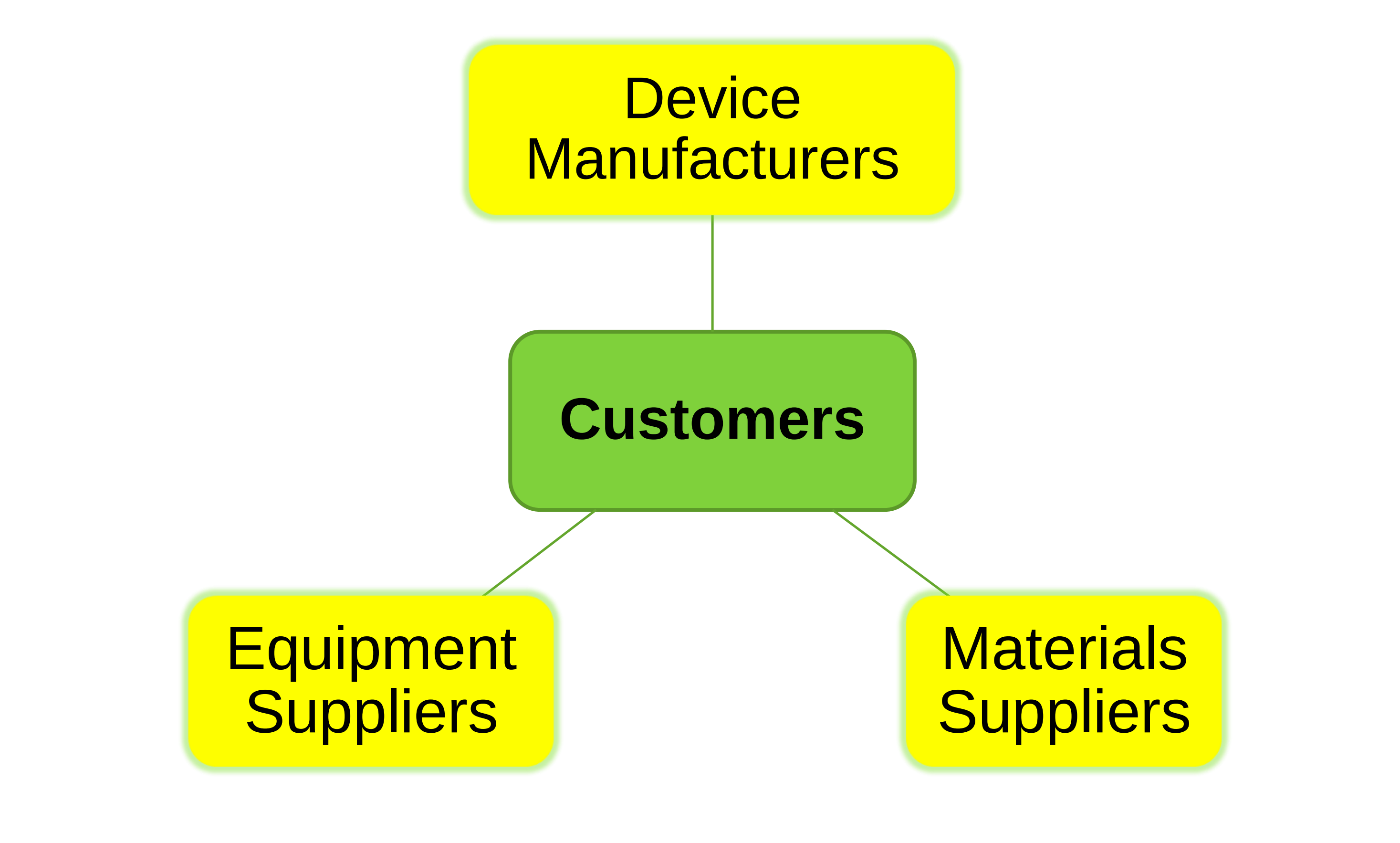
SSD Forecast



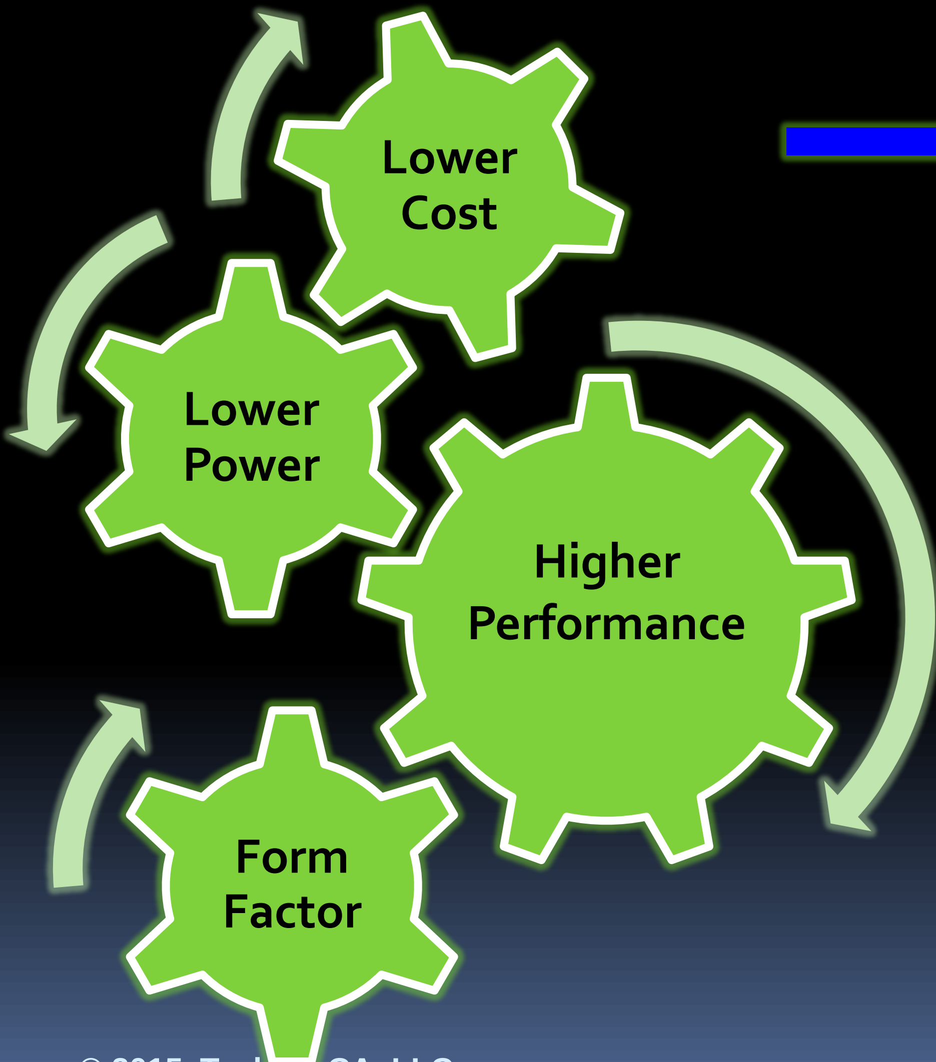
Source: IHS

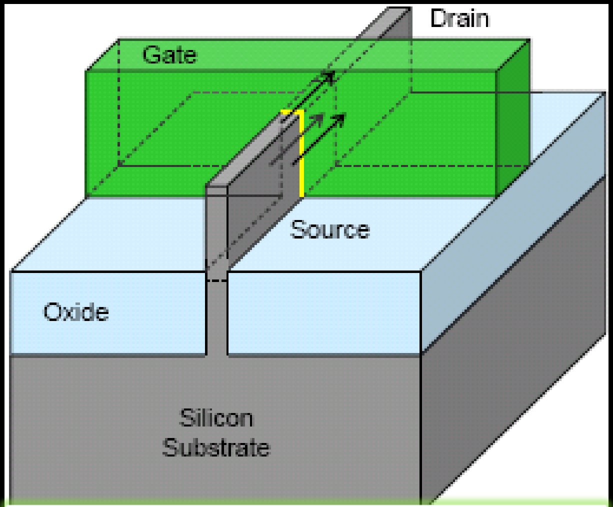
Semiconductor Outlook

Demand Driven by a Few Customers

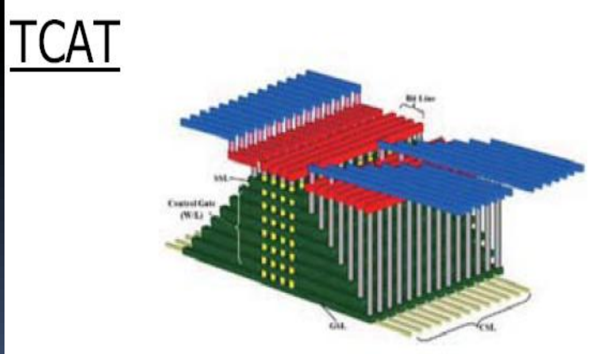


Requirements for the Semiconductor Industry





SemiWiki



[J. Jang et al., 2009 VLSI Tech.]

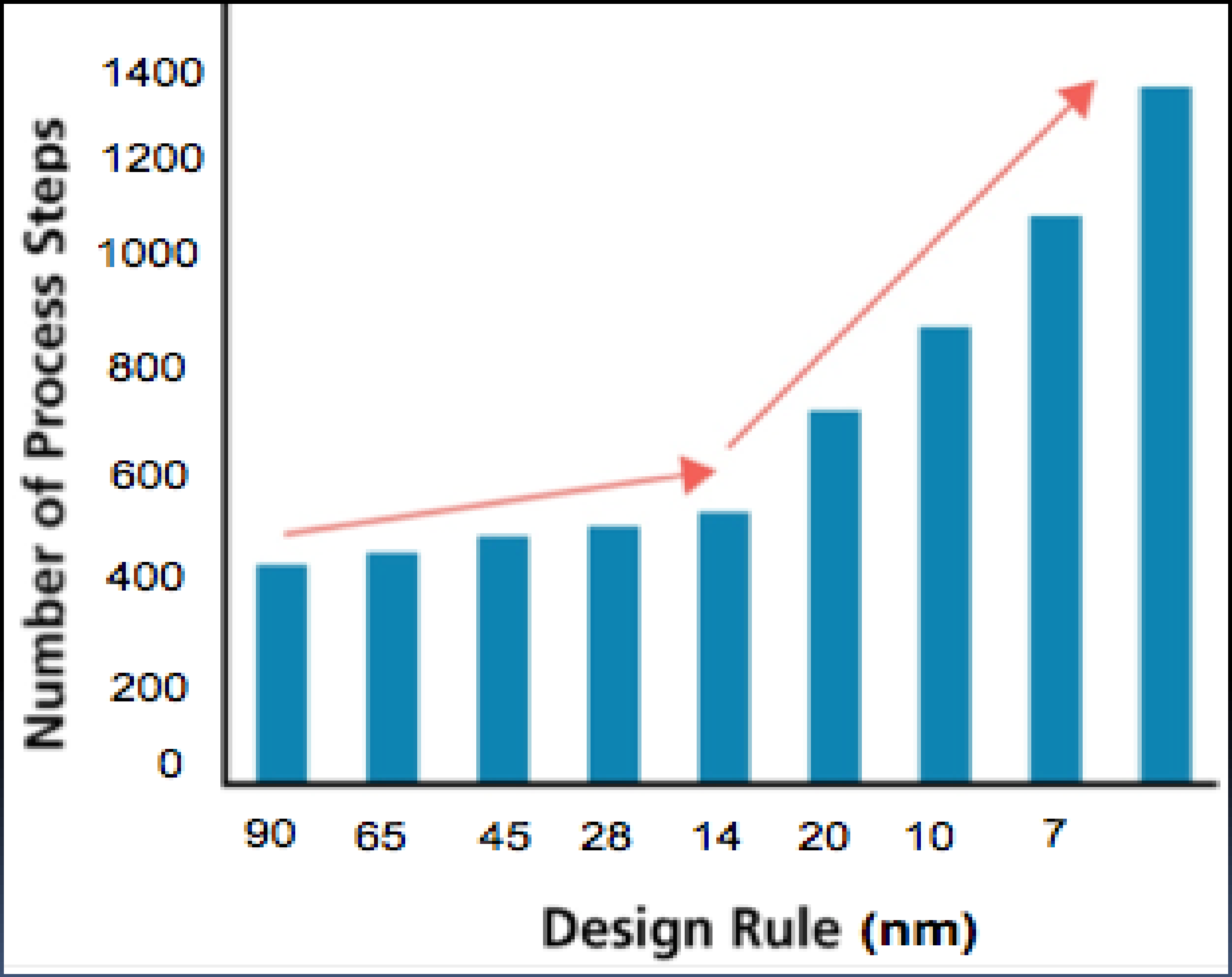
Themes: 2015 CMP Report Research

- Leading Edge Devices
  - New CMP processes
    - 3D transistor: Al and W for High k Gate Electrodes (new materials, removal rate, defectivity, selectivity)
    - 3D NAND: Defectivity for STI, PolySi, W
    - 3D Packaging: High RR Cu slurry for TSV
  - Tailored Consumables (HkMG polymer coated alumina particles; tunable pads for hardness & porosity)
  - Collaboration Across the Supply Chain will continue
  - Key Metrics: Defectivity, Planarization Efficiency, Polish selectivity, Cost

- Legacy Devices
  - CIP programs targeted to reduce cost & improve throughput
- Impact of the IoT?

CMP Materials & Processes

Growing Number of Process Steps



Source: IC Insights, KLA-Tencor

Changes to Shrink Logic & RAM

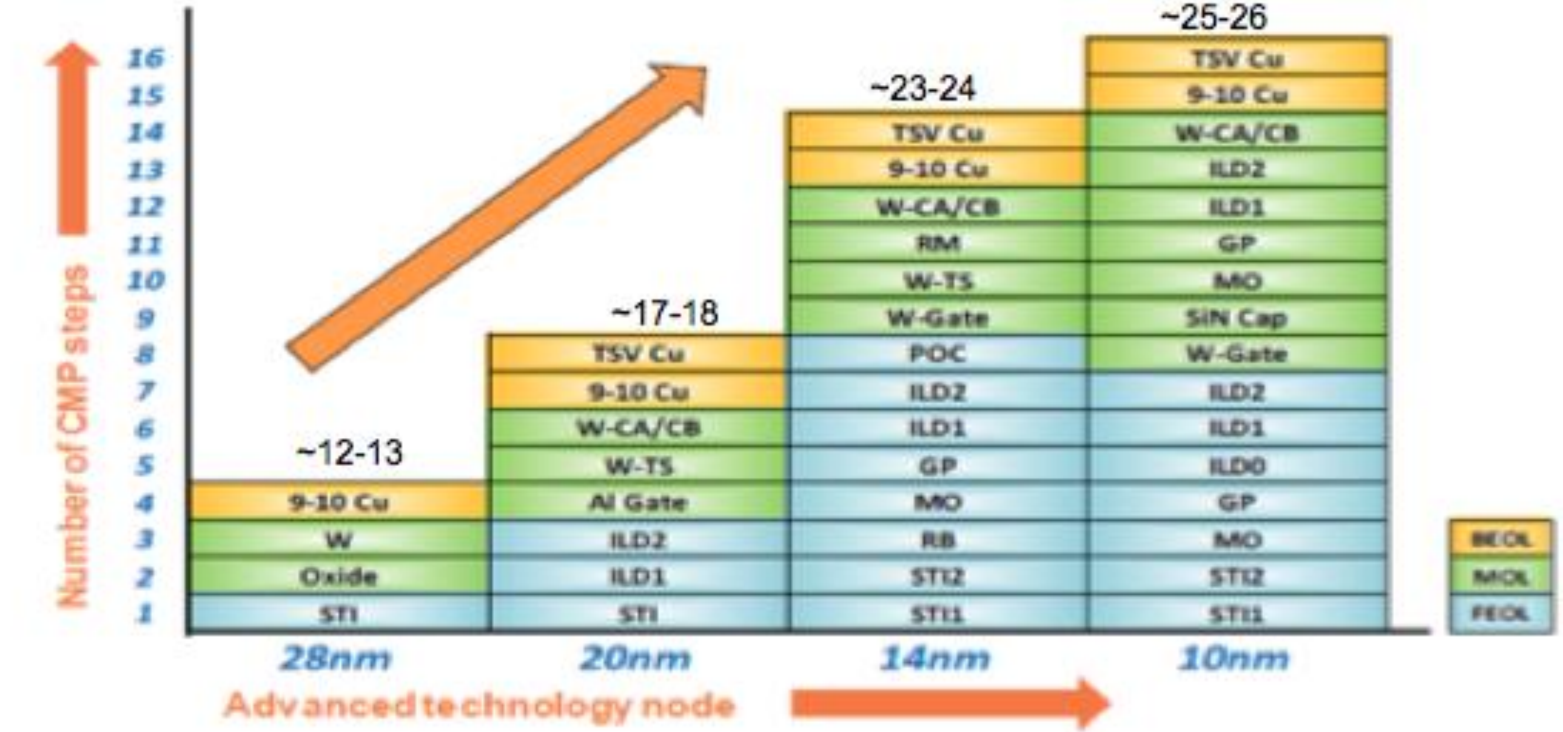
65-45nm
- STI & CMP Strained Si Gate
- Co, Ni, W Gate Electrodes
- W Contact Cu wiring 8-10 (layers)
- Low k dielectric (SiOF, SiOC)
- 193nm Litho

28/20nm Planar
- STI & CMP Strained Si Gate
- HkMG HfO_2 ALD TiN & Al Gate
- W Contact Cu Wiring 9-11 (layers)
- Low k & ULK dielectrics

22/20/16/14nm FinFET
- 2 STI for Fin Isolation
- HkMG HfO_2 ALD TiN TiAl W Gate
- 2 W Contact Cu wiring (12-14 layers)
- Co barrier, Ta @ larger Cu (12-14 layers)
- Low k & porous low k
- Multi Pattern Litho

↑ # metal levels

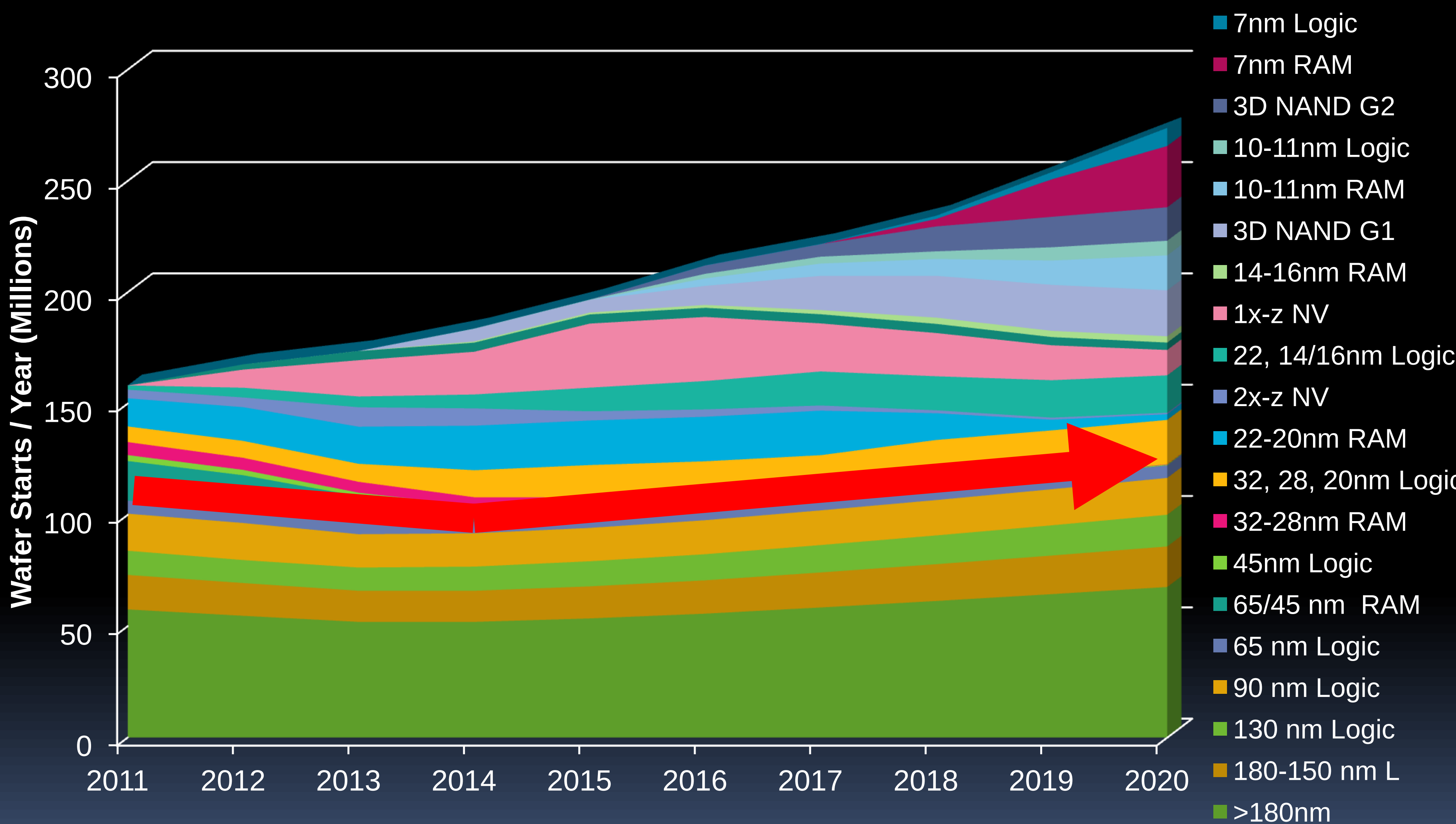
CMP Process Layers



- # CMP steps doubled from 28nm to 10nm
- # of FEOL/MOL CMP steps exceeded BEOL CMP steps starting at 14nm/FinFET
- 75% increase in MOL CMP steps from 14nm

Impact on Wafer Forecast

Wafer Starts per Year (200mm equivalent)



The Internet of Things

IoT Perception: Industry Executives

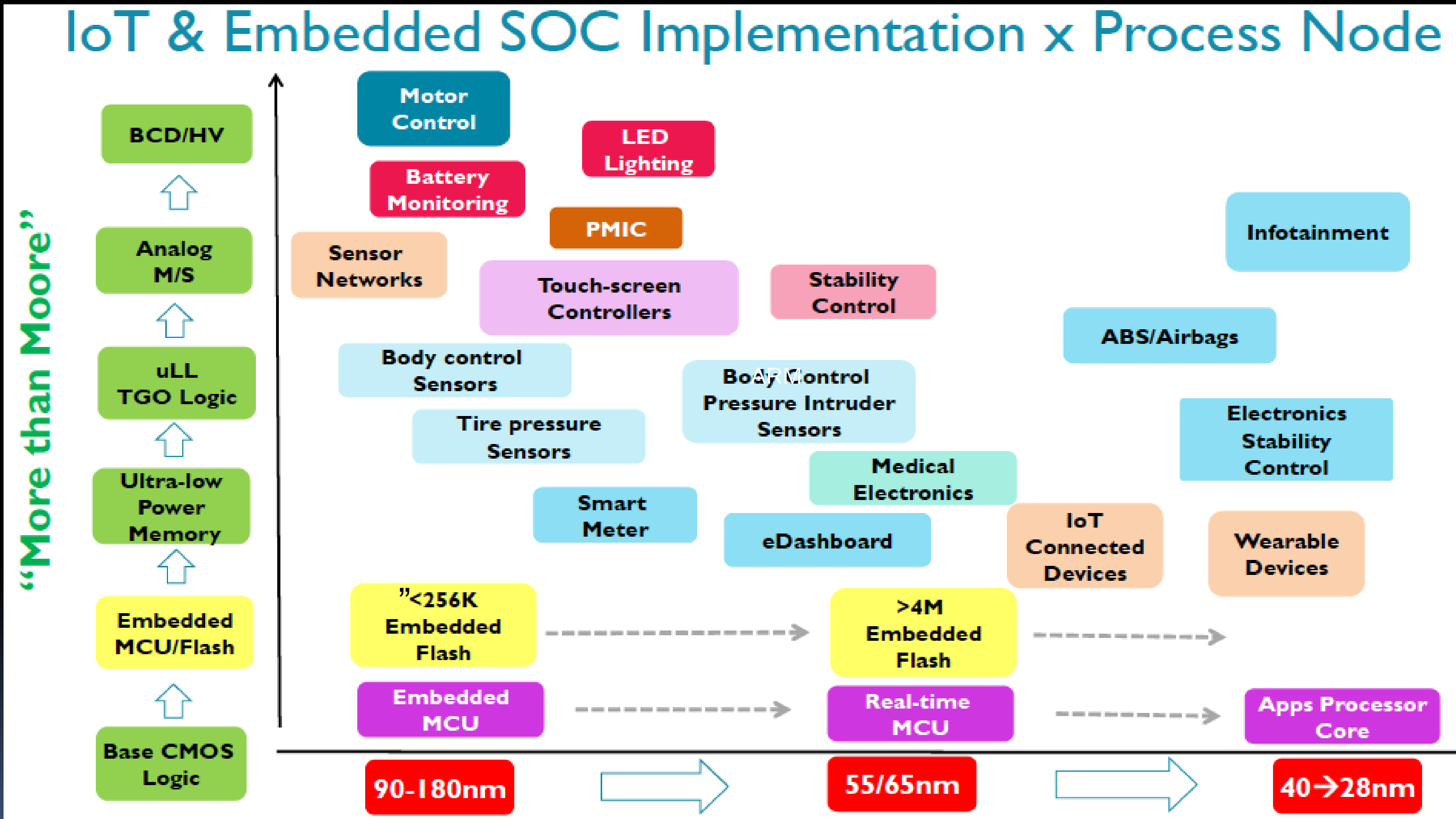
McKinsey GSA Alliance IoT Implications Survey

- 30 Sr executives across IoT ecosystem interviewed
- 229 semiconductor executives interviewed

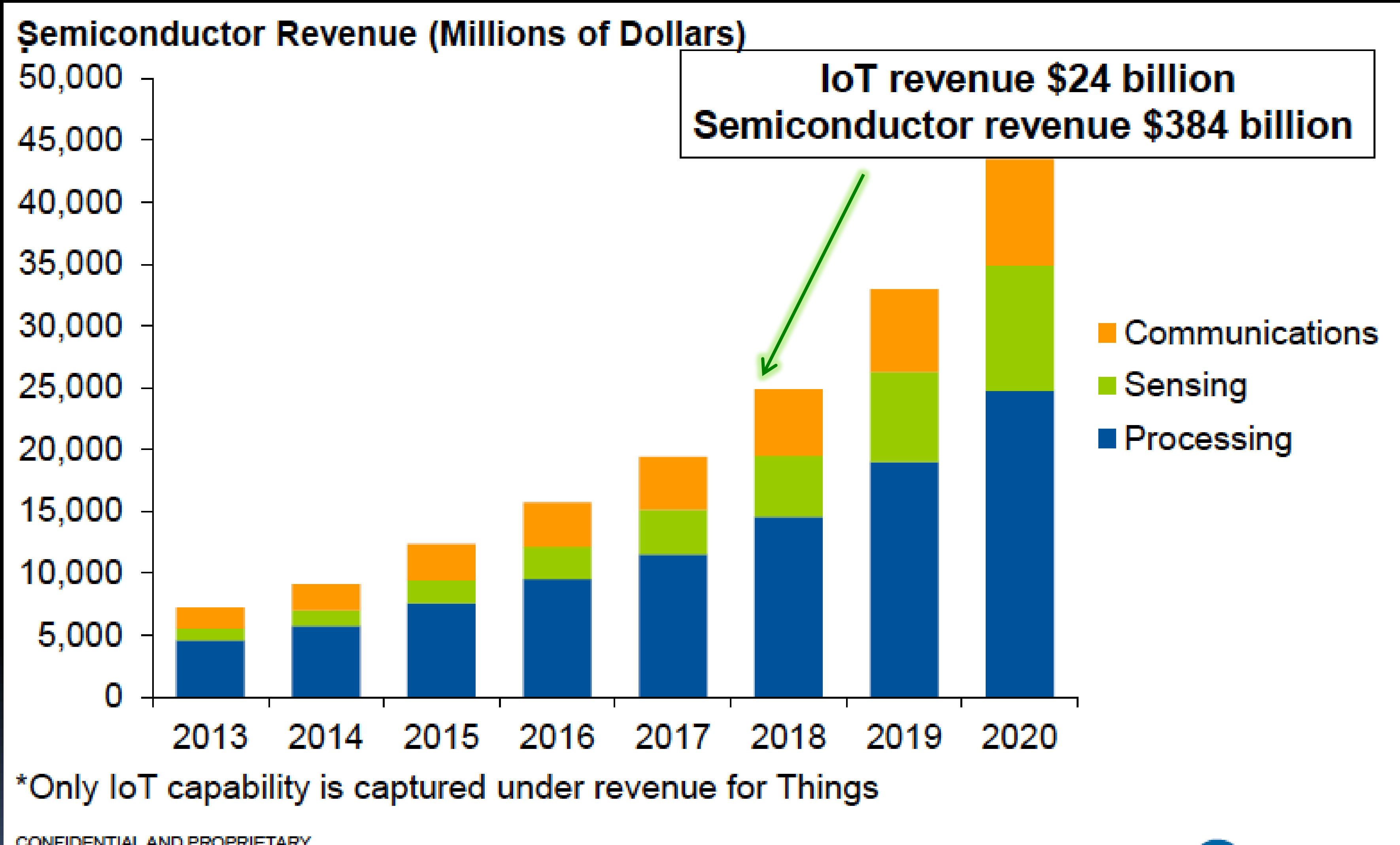
Survey Results

- Some “ambiguity” if IoT will be a key growth driver
- 48% interviewed stated IoT would be a top 3 growth driver for the industry; with 17% ranking it as #1
- Cloud, software, security & systems integration viewed as best opportunities

IoT Process Node Breadth

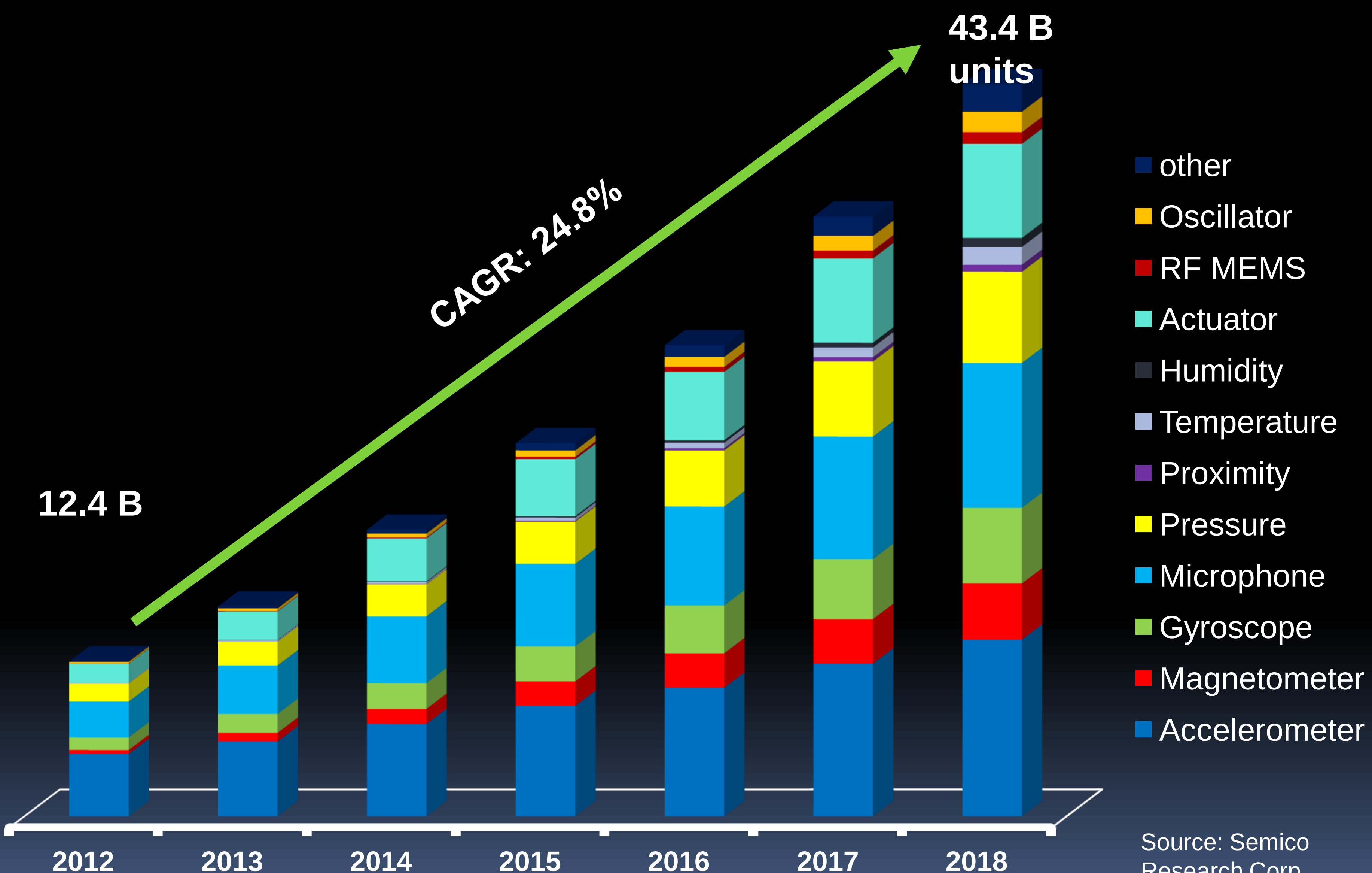


Semiconductor Opportunity – IoT



Permission granted by Gartner

MEMs Total Units Forecast



Source: Semico Research Corp

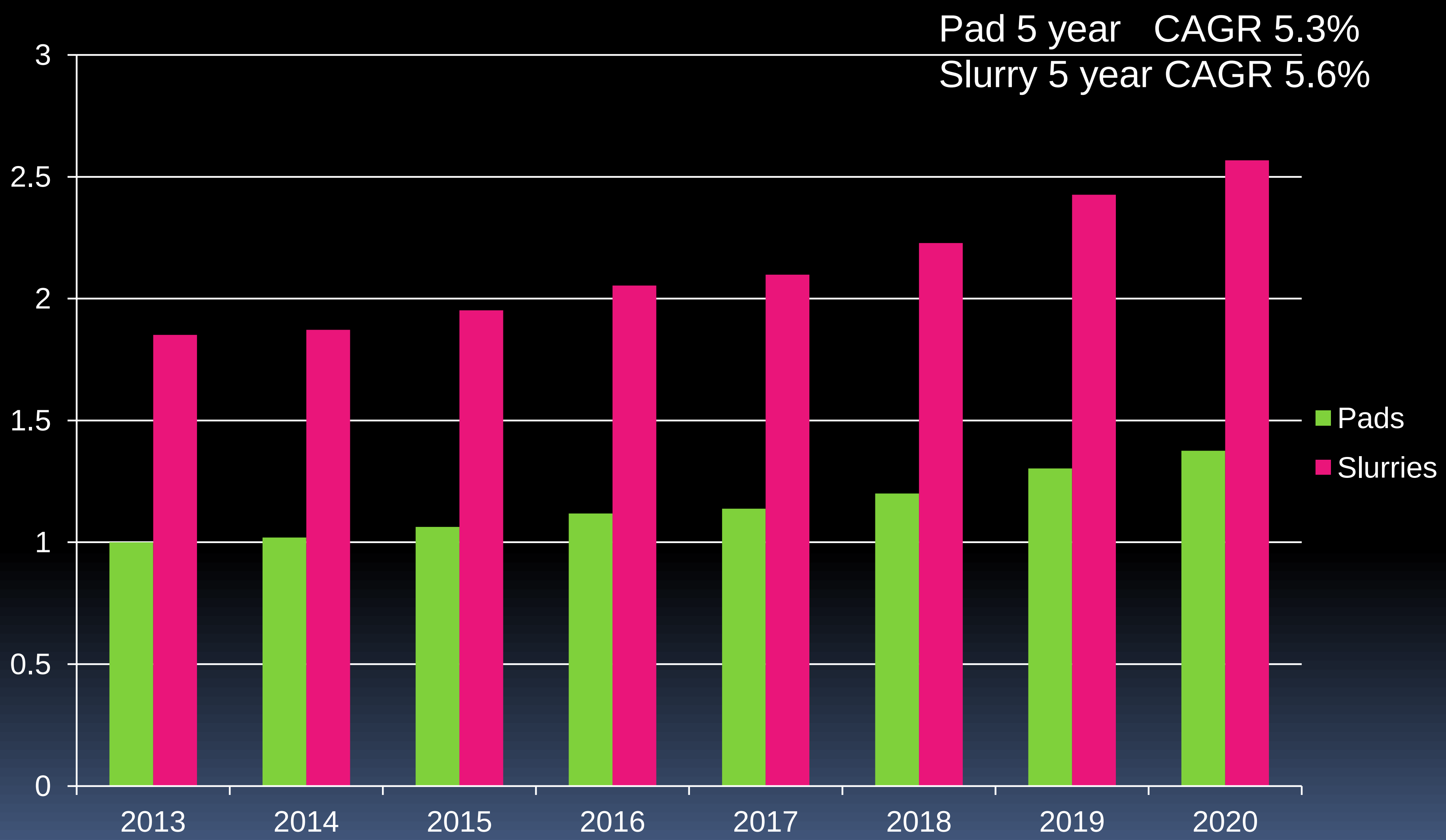
Changes to Shrink Logic & RAM

> 180nm	180nm	130nm	90nm
STI & CMP	STI & CMP	STI & CMP	STI & CMP Strained Silicon Gate
PolySi & silicides Gate Electrodes	Co, Ni, W Gate Electrodes	Co, Ni, W Gate Electrodes	Co, Ni, W Gate Electrodes
W Plugs/Al wiring (4-6 layers)	W Plugs/Al Wiring (4-6 layers)	W Contact Cu wiring (6-8 layers)	W Contact Cu wiring (6-8 layers)
TEOS	TEOS	Low k dielectric	Low k dielectric (SiOF)
248nm litho	248nm litho	Phase Shift Litho	Phase Shift Litho
			300 mm wafers

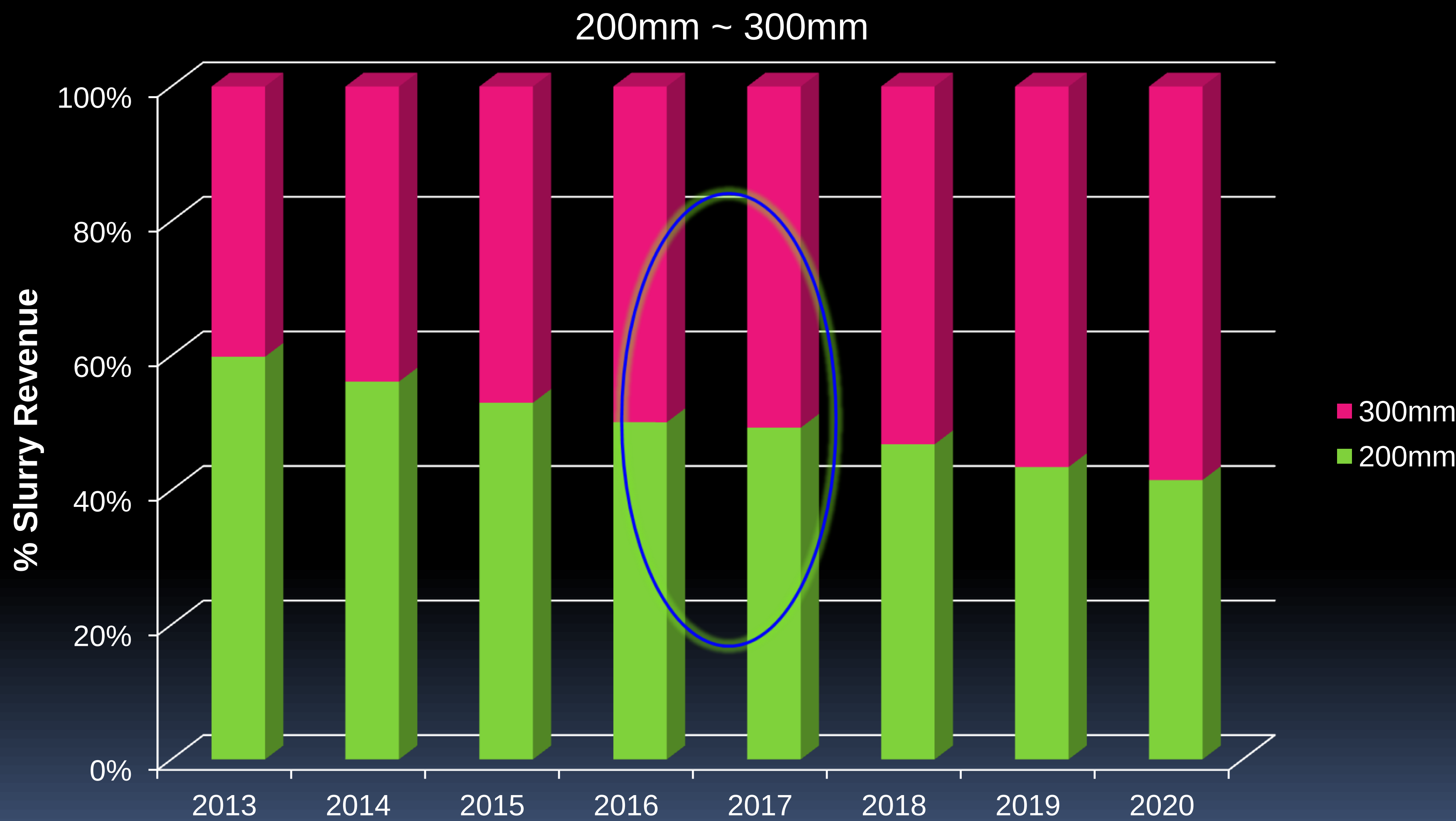
↑ # metal levels

CMP Market Update

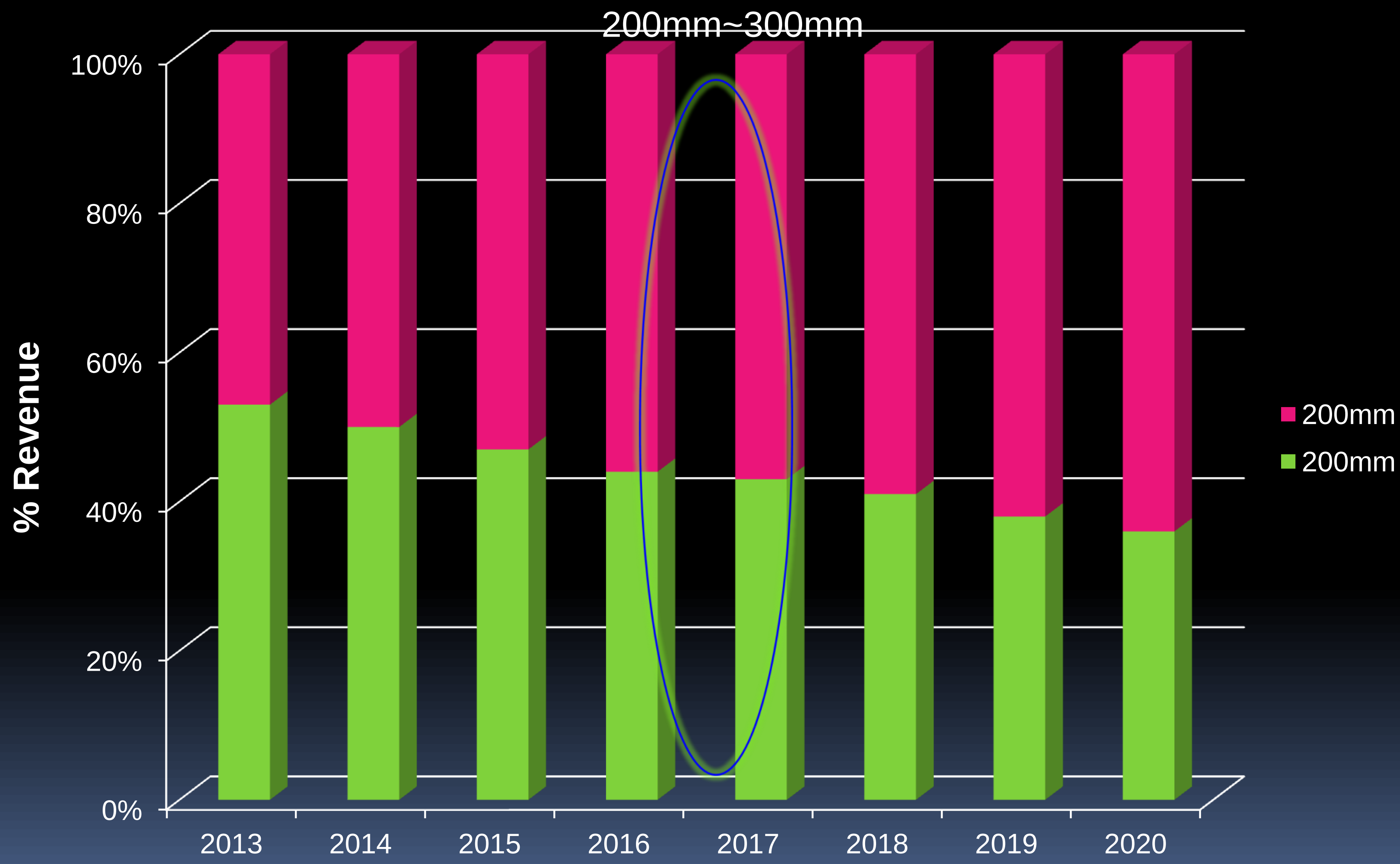
Normalized Pad & Slurry Revenue



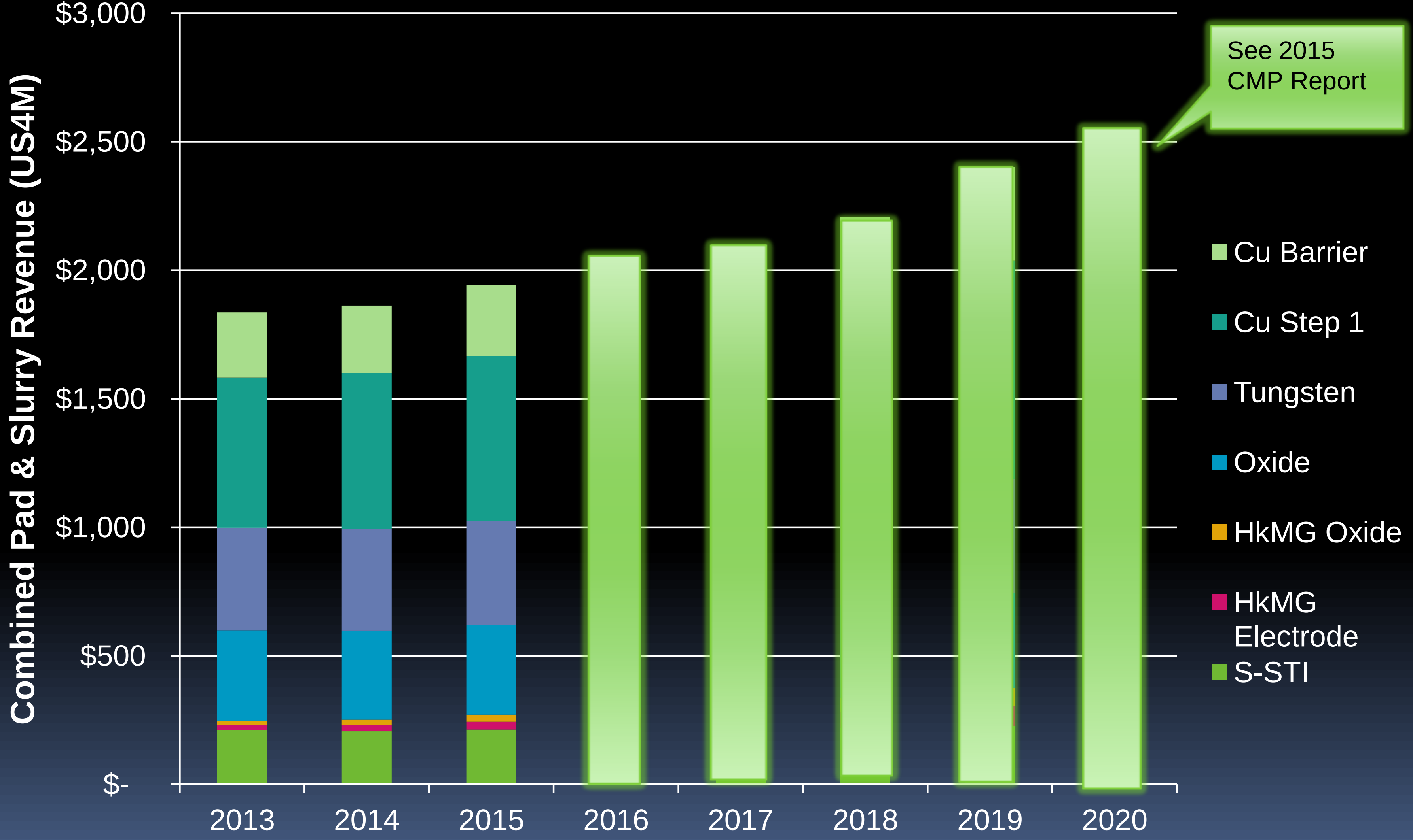
CMP Slurry Revenue 200mm & 300mm



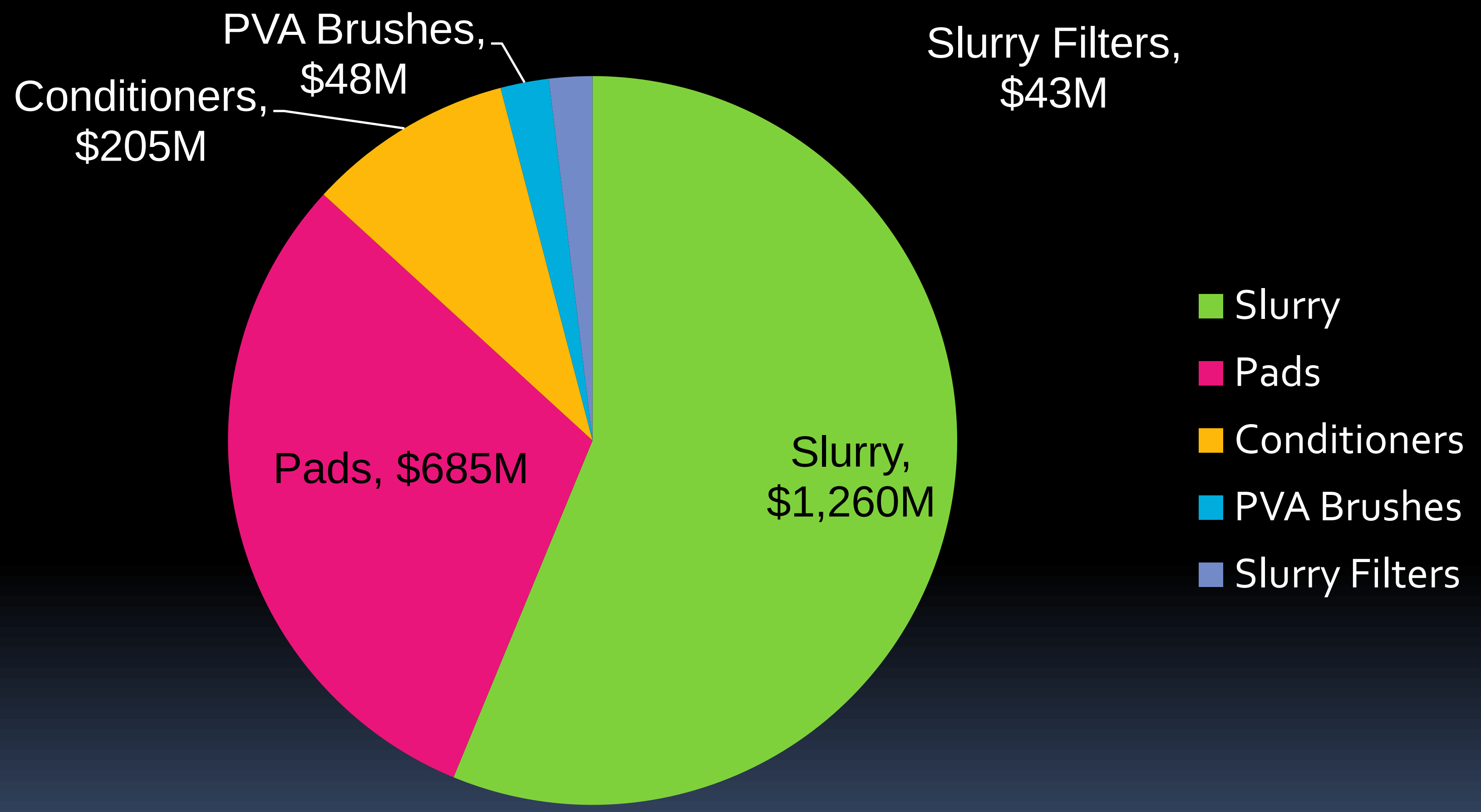
Pad Revenue 200mm & 300mm



Pad and Slurry Revenue by Application



2015 CMP Consumables Market Shares
Total TAM $2.24B



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CMP Supply Chain Impacted by IoT

- “Significant – extreme” pricing pressure
- Legacy slurries are being used → and will grow very slightly (STI/oxide/W/Cu)
- Competition in both pad and slurry market
- Crowded ceria slurry market
- CIP programs continue; changes to POR when CoO/tpt gain > cost of requalification
- Supply chain capacity well positioned

Techcet Materials Coverage includes:

- ALD Hi K Precursors
- CMP Consumables
- Dielectric Precursors
- 3D/TSV Packaging
- Gases
- Graphites
- Photoresist & Ancillaries
- Quartz
- Silicon Carbide
- Silicon Wafers
- Sputtering Targets
- Si Equipment Components
- Wafer Level Packaging (WLP) Polymers
- Wet Chemicals

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Techcet's 2015 CMP Critical Materials Report

- Available as Full Report or by Individual Consumable
  - 11 Sections
  - 7 Markets Segments
  - >170 Supplier Profiles
  - Process Flows

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THANK YOU !