

The Future of Your Career and Company: Avoiding the “Kodak Moment”

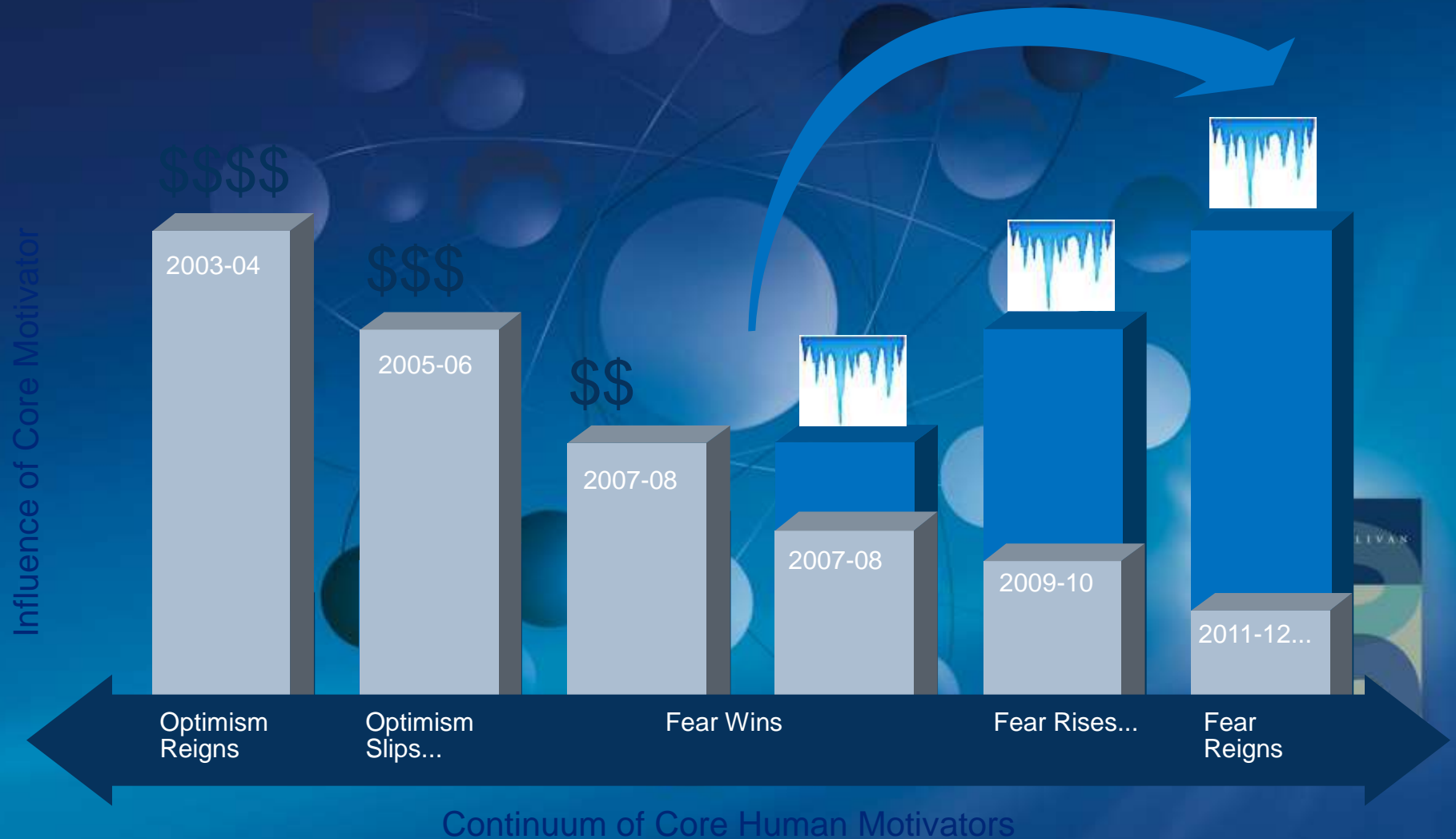
David Frigstad
Chairman
Frost & Sullivan



F R O S T  S U L L I V A N



Fear Supercedes Optimism: Ten Year Retrospective






A Kodak Moment

“If change is happening on the
outside faster than on the inside
the end is in sight.”

– Jack Welch

F R O S T  S U L L I V A N



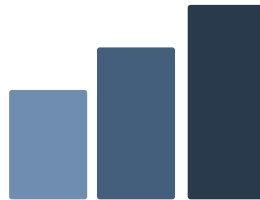
Technology Analysis Dashboard

9 dimensions (cornerstone of technology selection) that eventually influence a technology to be a “market show stopper” rather than a “technology gimmick”

Year of Impact



Market Potential



Global Footprint



IP Intensity



Funding



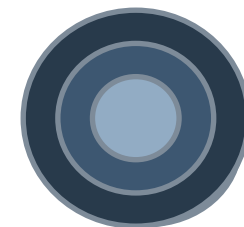
Breadth of Industries



Megatrend Impact

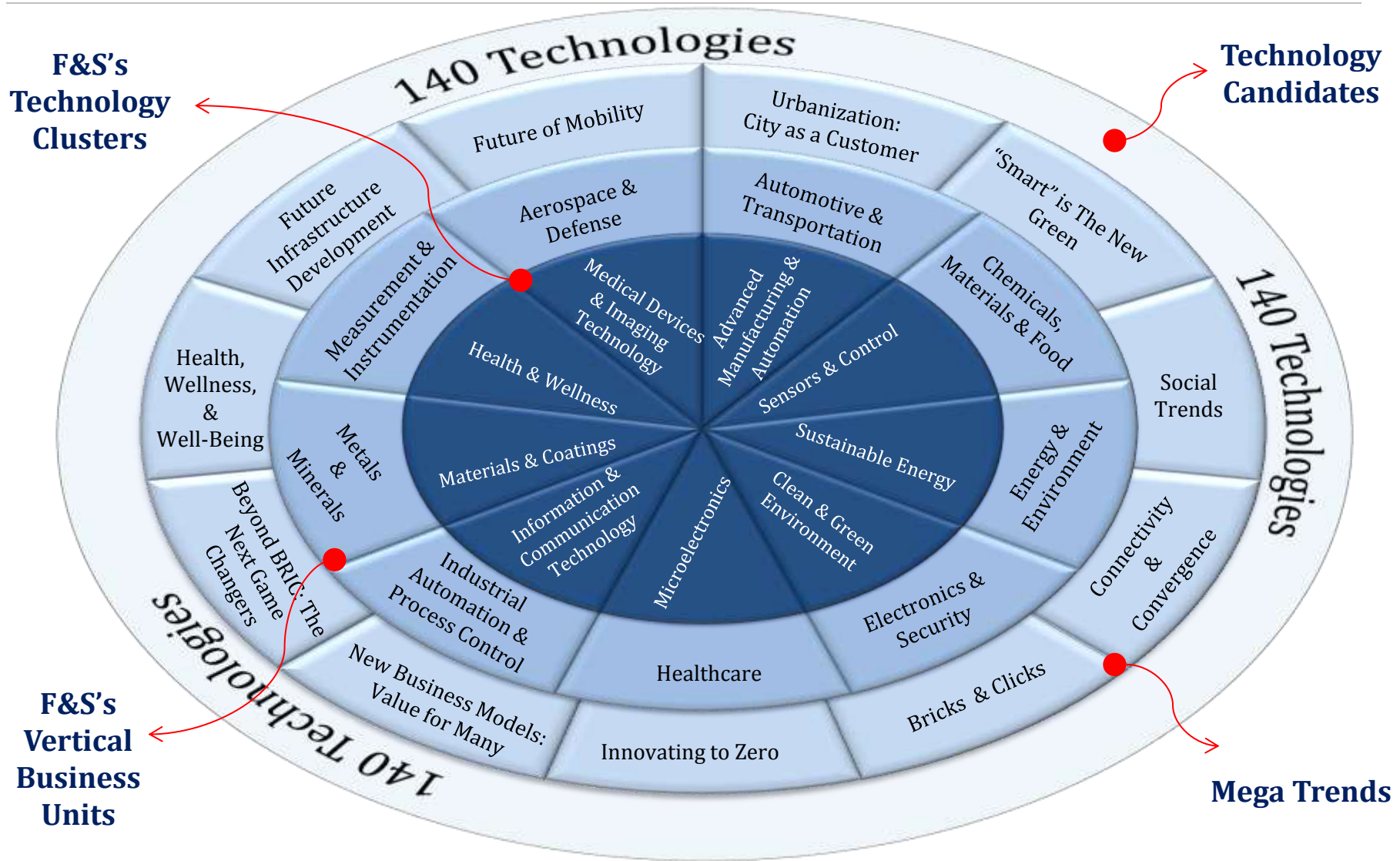


Potential Points of Convergence Size of Innovation Ecosystem



Innovation driven future world!

As part of the TechVision psyche, we look at “technology cluster ↔ market ↔ trend” interplay to evaluate and pick top 50 technologies (for a given year) from a larger pool of 140 or so technology capabilities



Regenerative Medicine
Next-Gen Sequencing
Biomarkers
Personalized Medicine
Targeted Drug Delivery
Genetic Cosmetics

Health & Wellness

Sustainable Energy

Advanced Energy Storage
Concentrated Solar Power
Wind Power
Grid Energy Management
Superconductors

Clean & Green Environment

Waste-to-Energy
Advanced Filtration
Solid Waste Treatment
Biochemicals
Desalination

Information & Communication Technology

Virtualization
Cloud Computing
Big Data Analytics
Semantic Search

Data Visualization
Context-Aware Mobility
Augmented Reality
In-Memory Computing

Medical Device & Imaging Technology

Remote Patient Monitoring
Surgical Robots
Interventional Radiology
Neuromodulation Technologies

Advanced Manufacturing & Automation

Roll-to-Roll Manufacturing
3D Printing
Composites Manufacturing
Micromanufacturing

Sensors & Controls

CBRNE Detection
Energy Harvesting
Nanosensors
Ubiquitous Wireless Sensor

Top 50 Technologies Web

Microelectronics

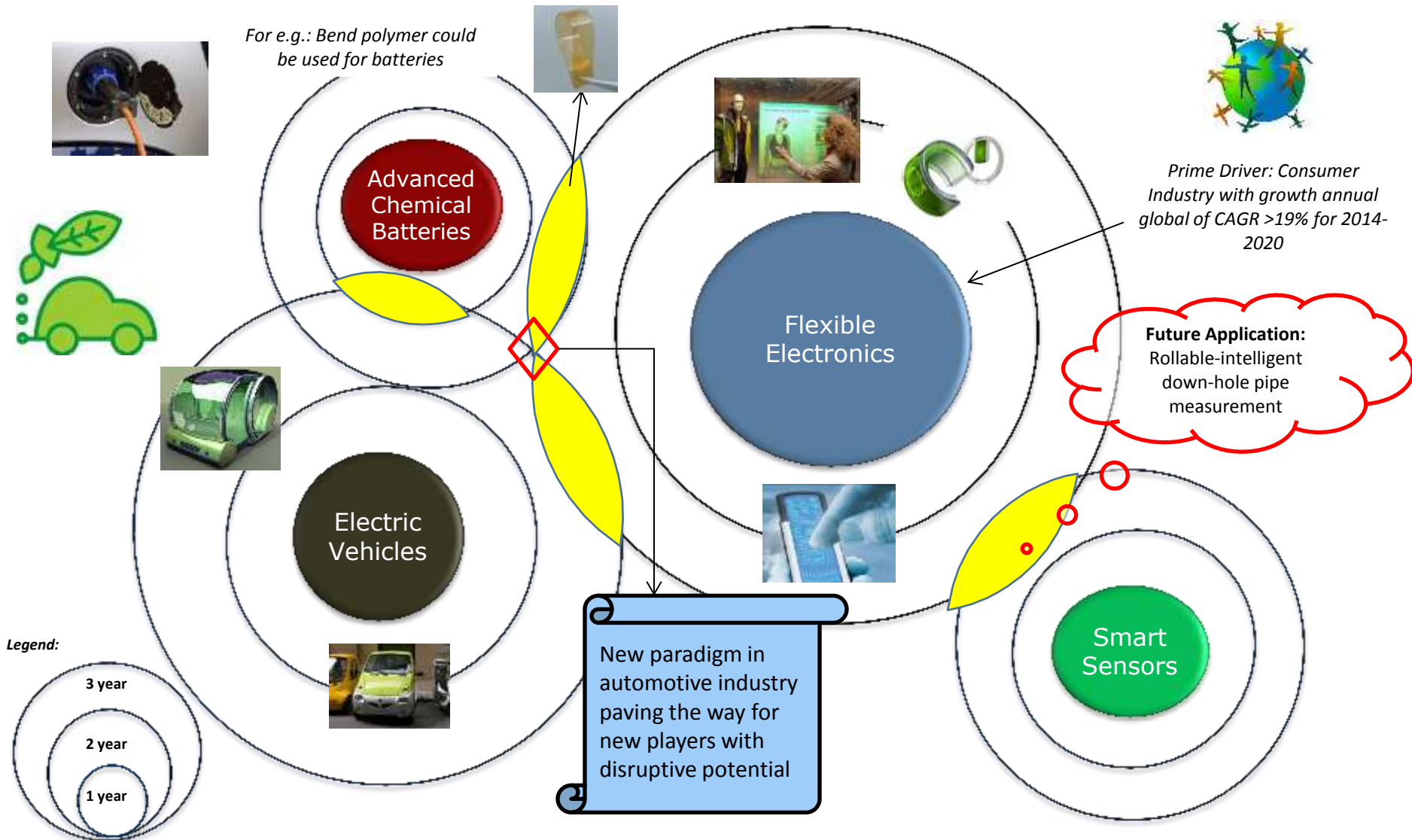
General Illumination LEDs
Energy Efficient Processors
Next-Gen Non-Volatile Memory
Smart Haptics & Touch
Flexible Electronics
OLED Displays

Materials & Coatings

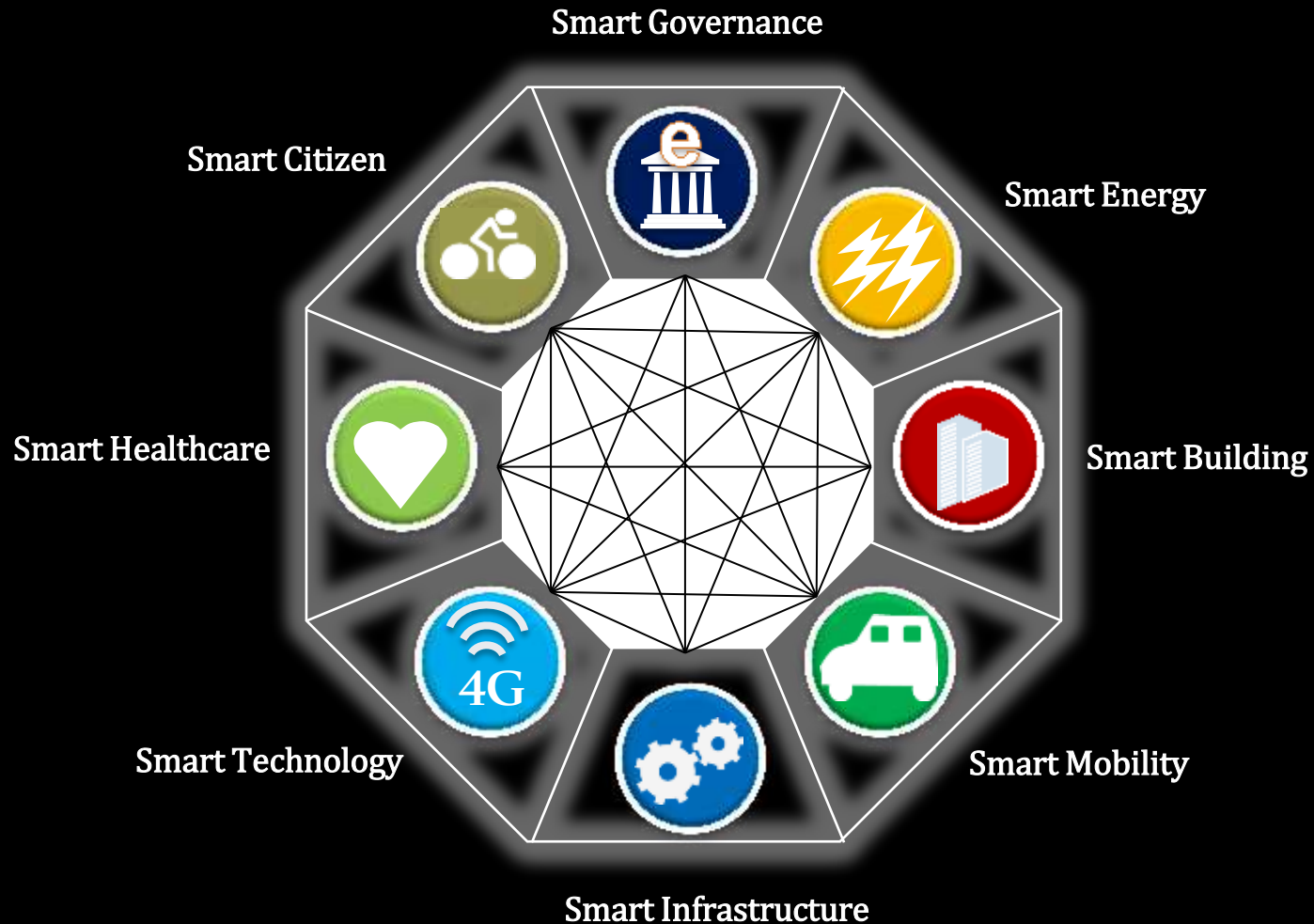
Carbon Fibers
Biocomposites
Superhydrophobic Coatings
Smart Packaging
Lightweight Composites
Polymer Chameleons
Alternative Feedstocks
Nanocoatings

Waves of Convergence!!!

Evolution of technologies at different rates gives rise to various waves of innovation that impact industries and markets at varying times



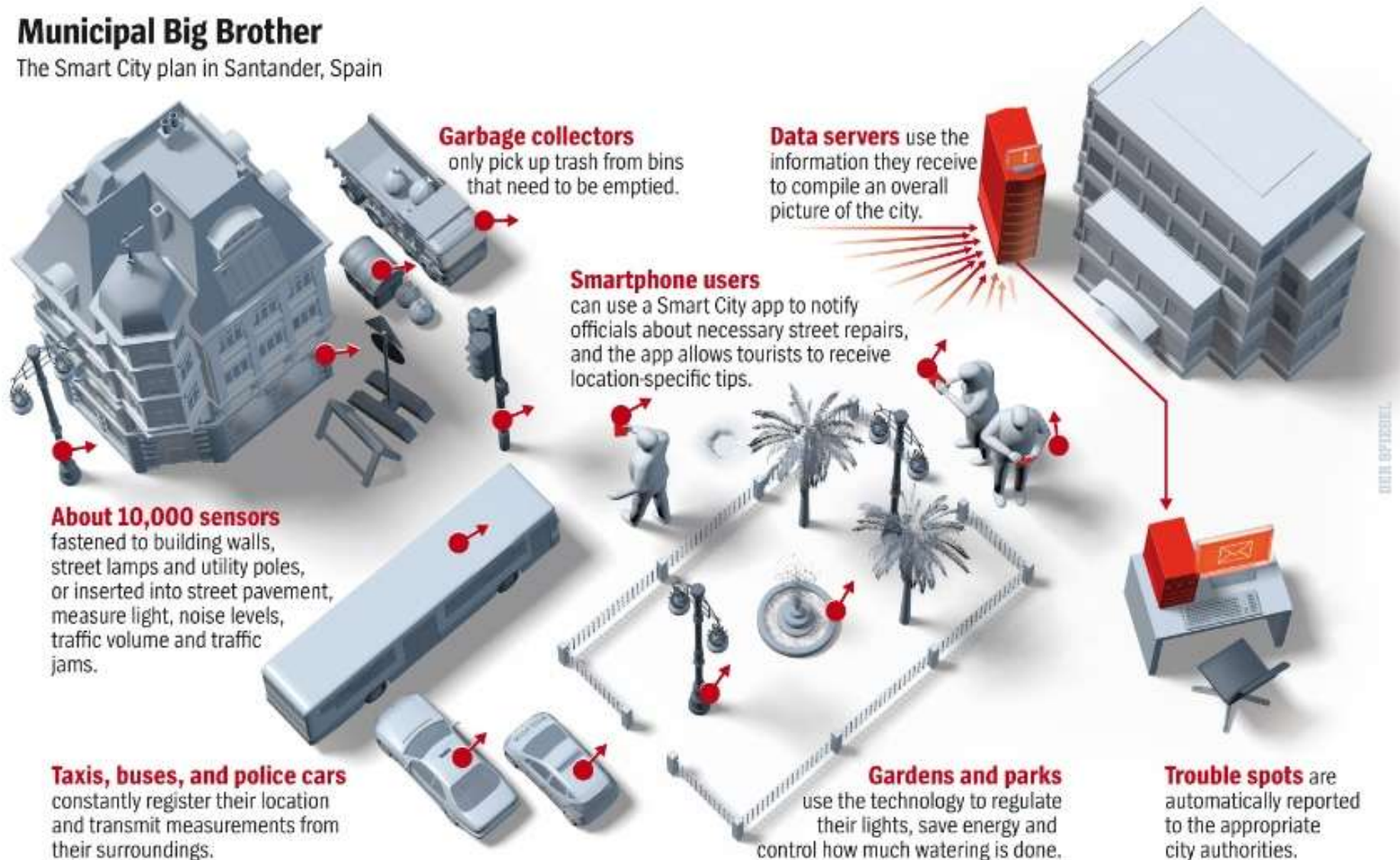
Smart Diamond that Defines a Smart City



Case Study of SMART City Plan: In Santander, Spain **10,000 sensors feed BIG DATA into Data Servers** that Integrates Various Infrastructure

Municipal Big Brother

The Smart City plan in Santander, Spain



SMART is the new Green!!



Photo Credits: Dreamstime and Connected Digital World, Source: Frost & Sullivan Analysis

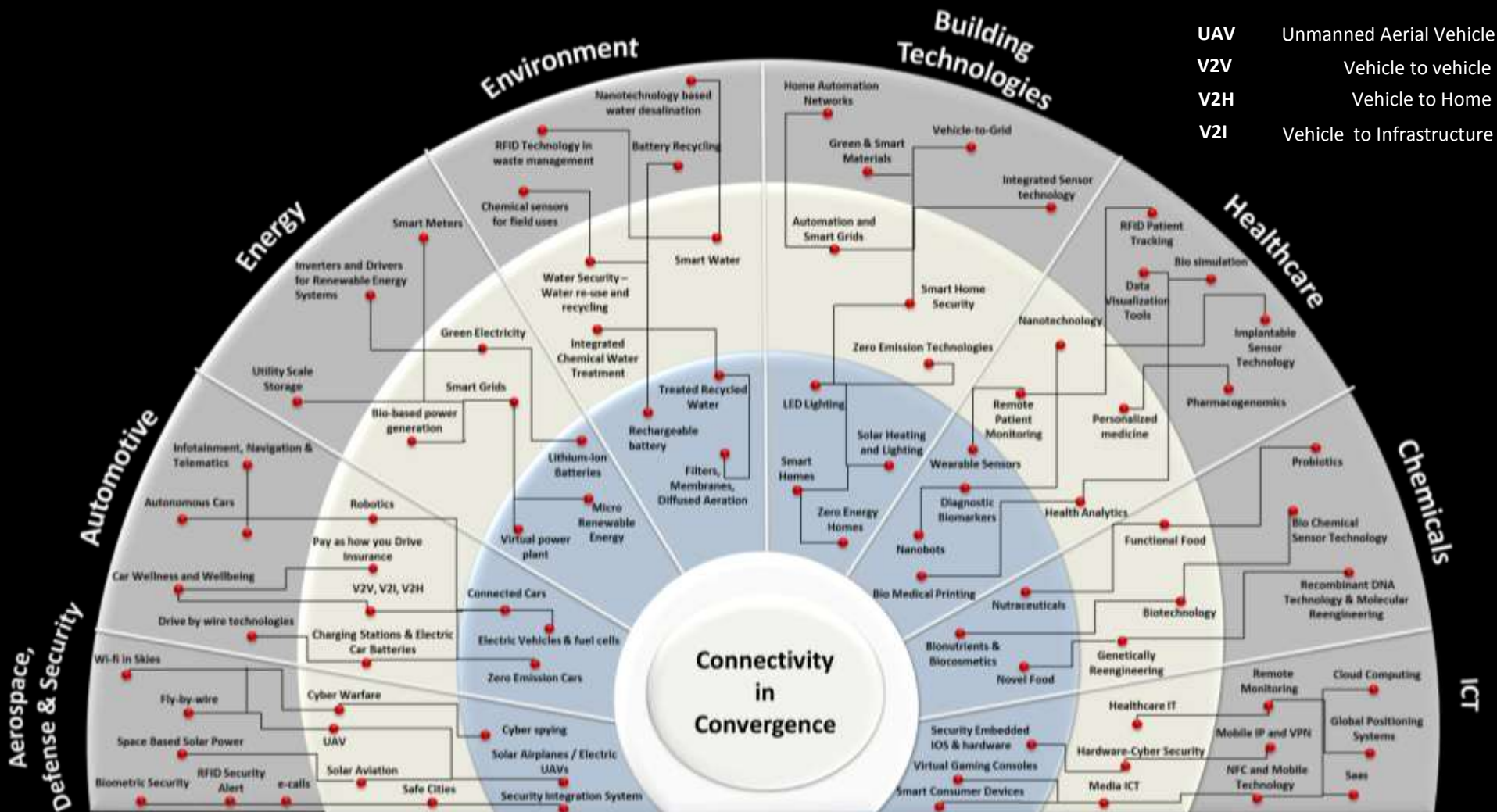


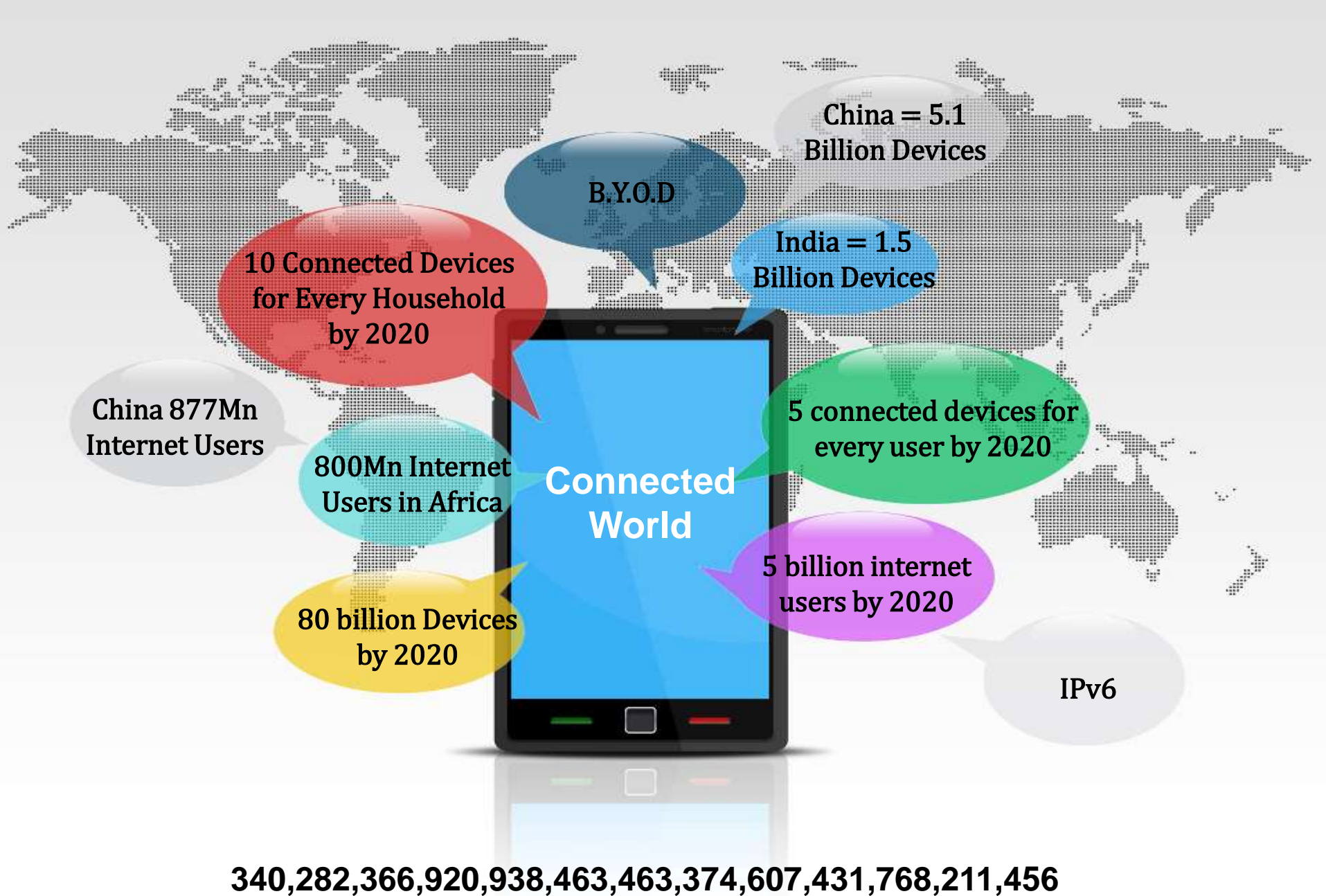
Connectivity will Lead to Convergence of Products, Technologies and Industries

Technology Convergence
Industry Convergence
Product Convergence

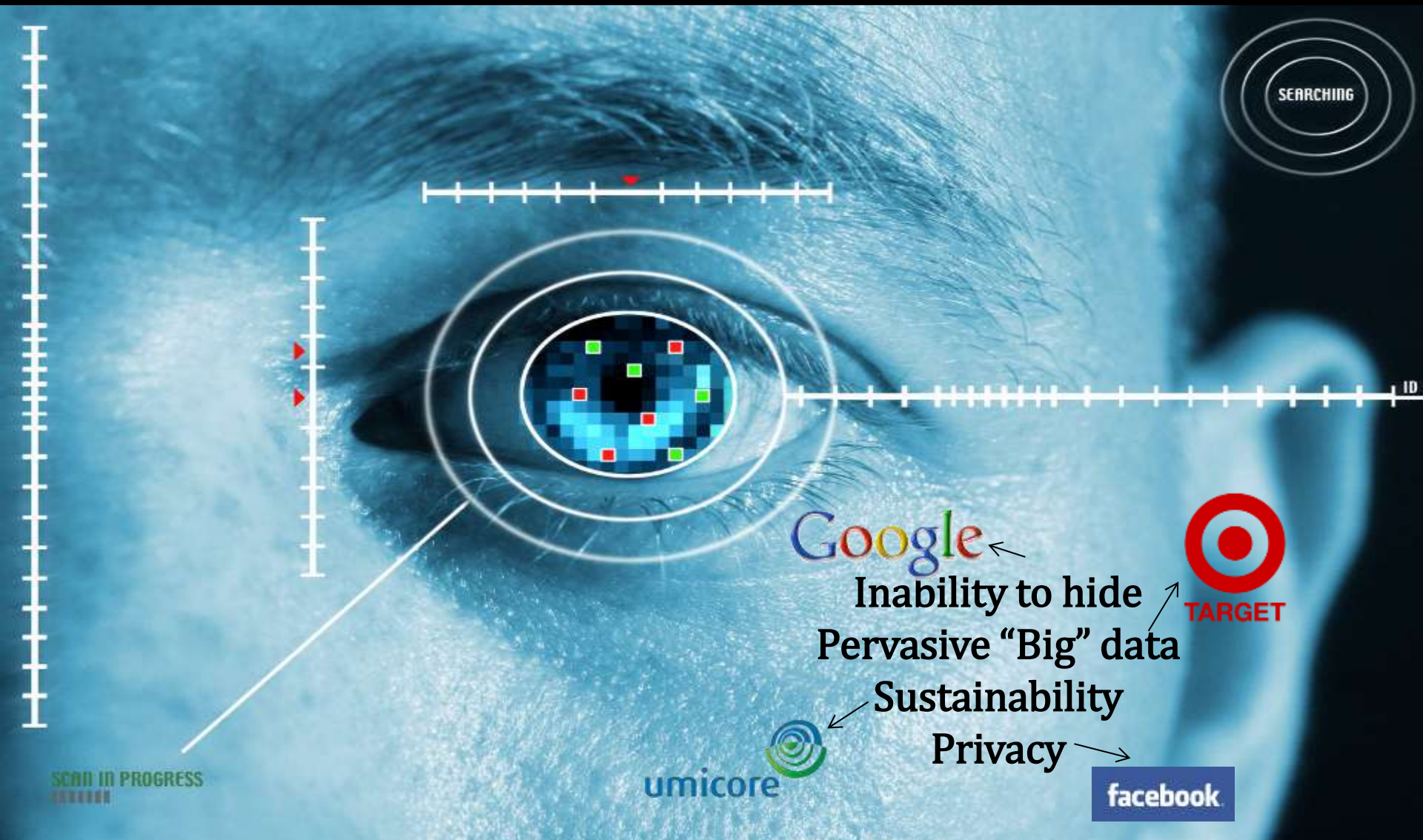


UAV Unmanned Aerial Vehicle
V2V Vehicle to vehicle
V2H Vehicle to Home
V2I Vehicle to Infrastructure

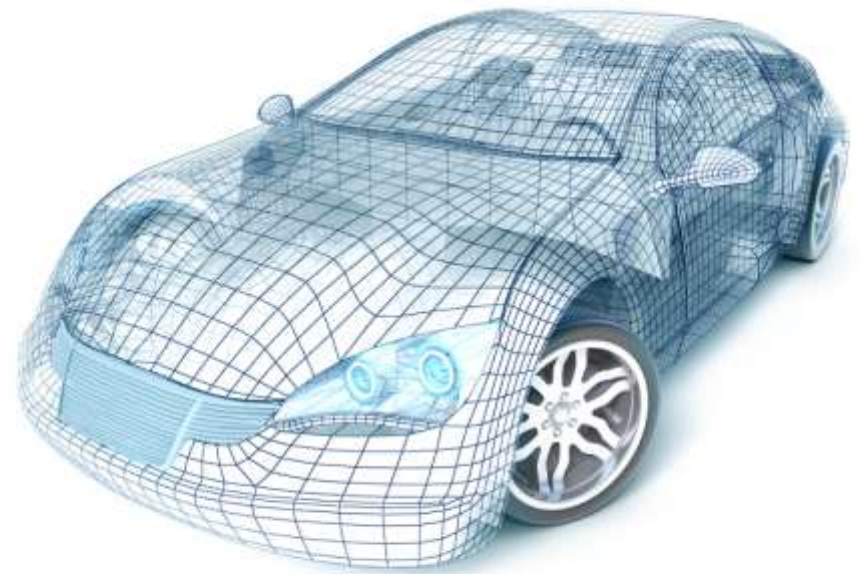




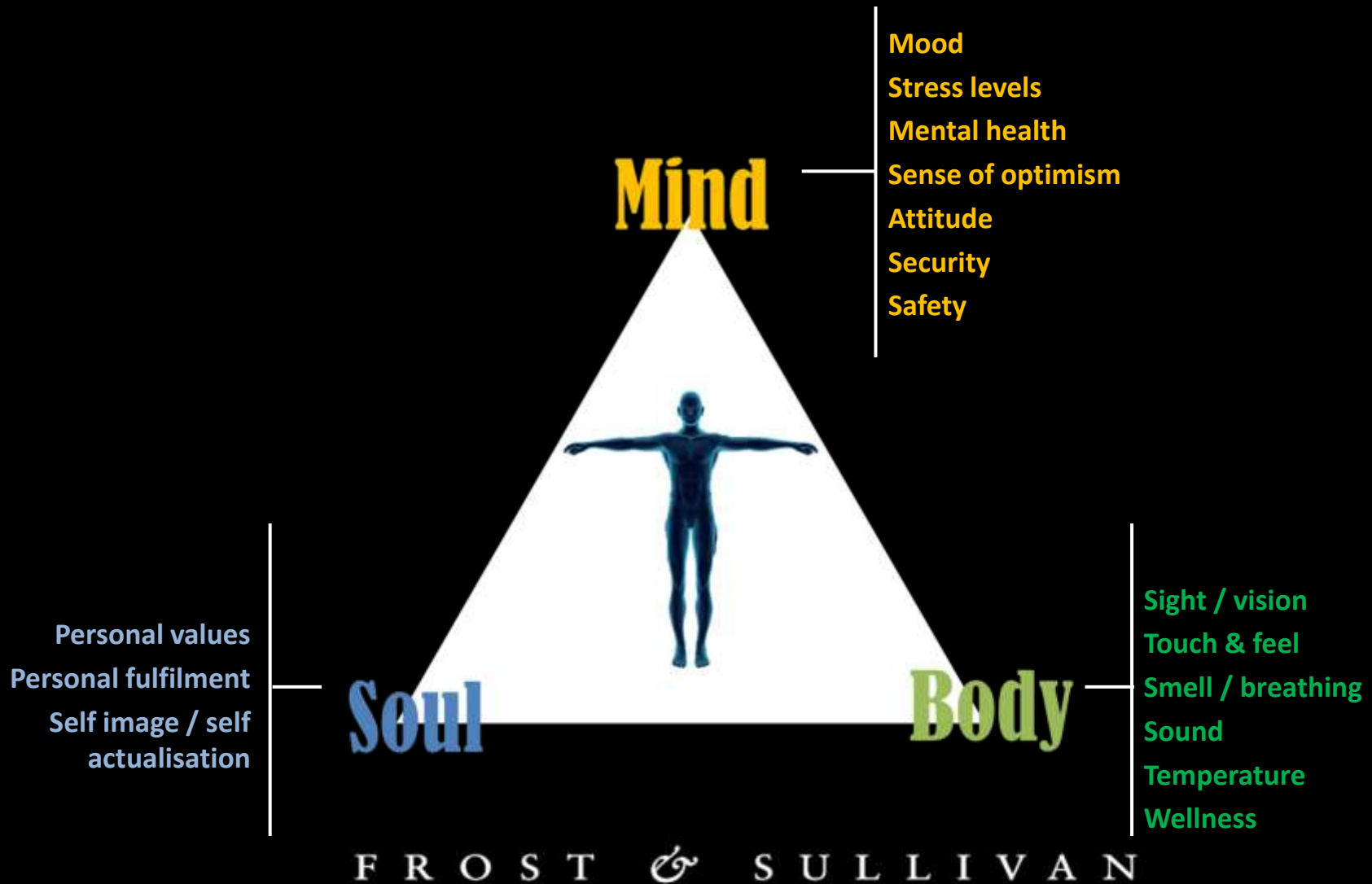
Transparency



Mobility



The 3 Cornerstones - The Body, Mind and Soul -



New Business Models:



Free

+

Premium

=

Freemium

“Value for Many”



Group Buying



**Sharing- What is Yours
is Mine**

Will Replace



Low Cost Products



Affordable Healthcare

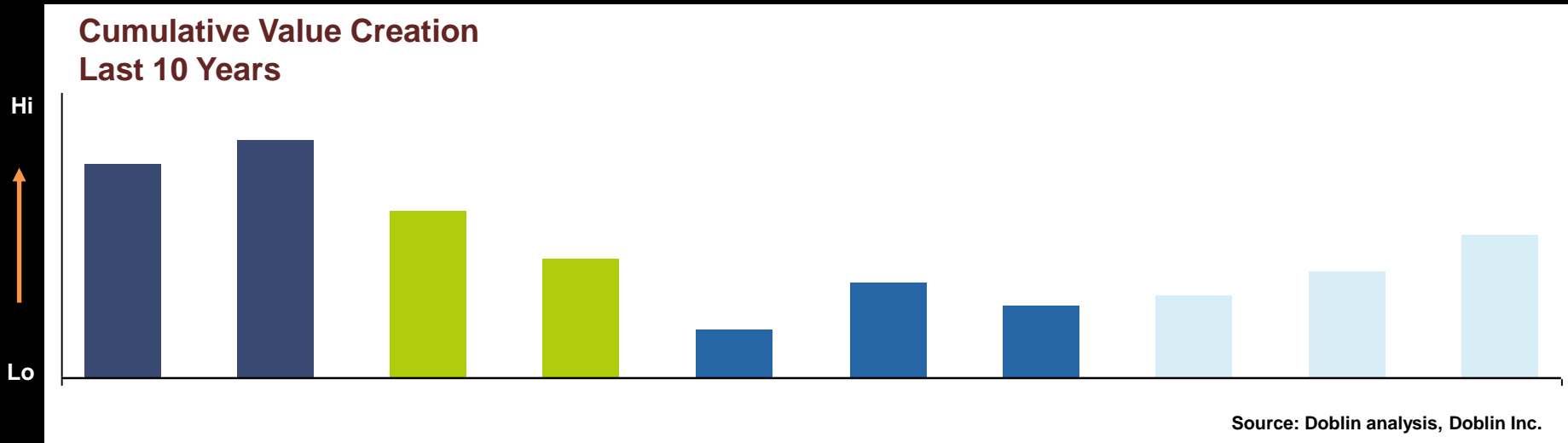
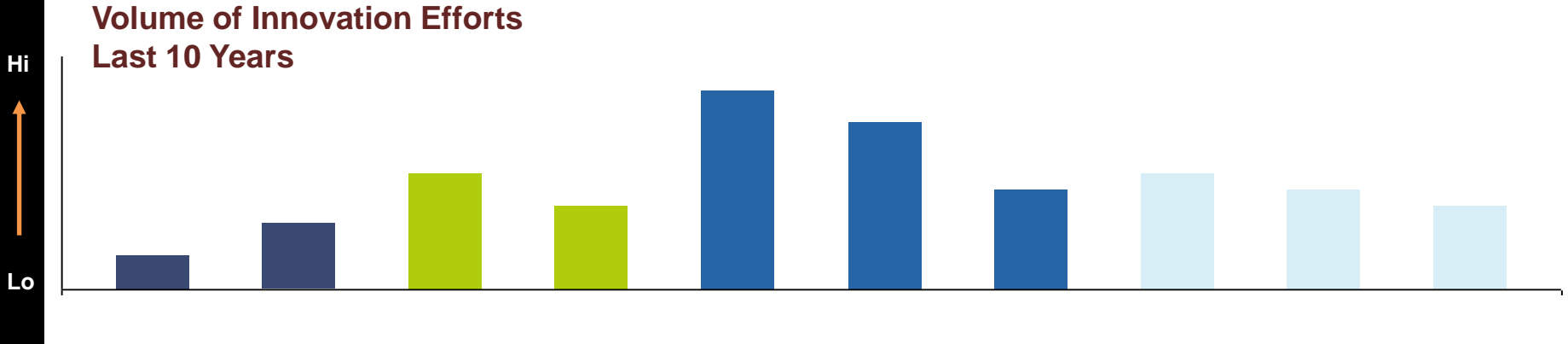
“Value for Money”



Micro Finance

Business Model Focus Creates Higher Rate of Return

Strategy		Process		Product			Delivery		
Business model	Partnering	Enabling process	Core process	Product performance	Product system	Service	Channel	Brand	Customer experience



Source: Doblin analysis, Doblin Inc.

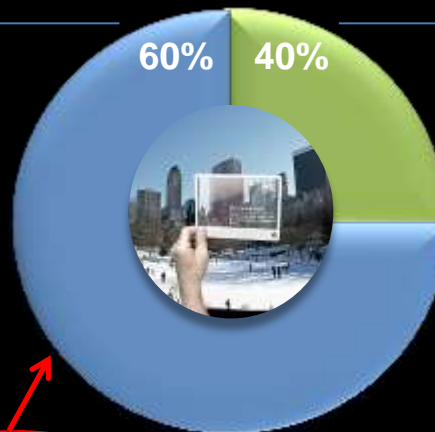


Total Augmented Reality Market to Hit \$75.2 Billion in 2020,

Augmented Reality, Global Revenue, 2020

Total AR Market: \$75.2 Billion

Mobile AR
Augmented reality embedded
mobile apps
\$45 Billion



Others
Heads Up Displays & Head
Mounted Displays
\$30.2 Billion



Reality



Augmented Reality



Augmented Virtuality



Virtual World

Photocredits: : Dreamstime

Source: : Frost & Sullivan, 2012

Your Next Step



The Convergence of 450mm, 22/14nm, EUV, and 3D (FinFET - NAND) Structures and its Impact on the Semiconductor Equipment Industry

AROOP ZUTSHI

FROST & SULLIVAN

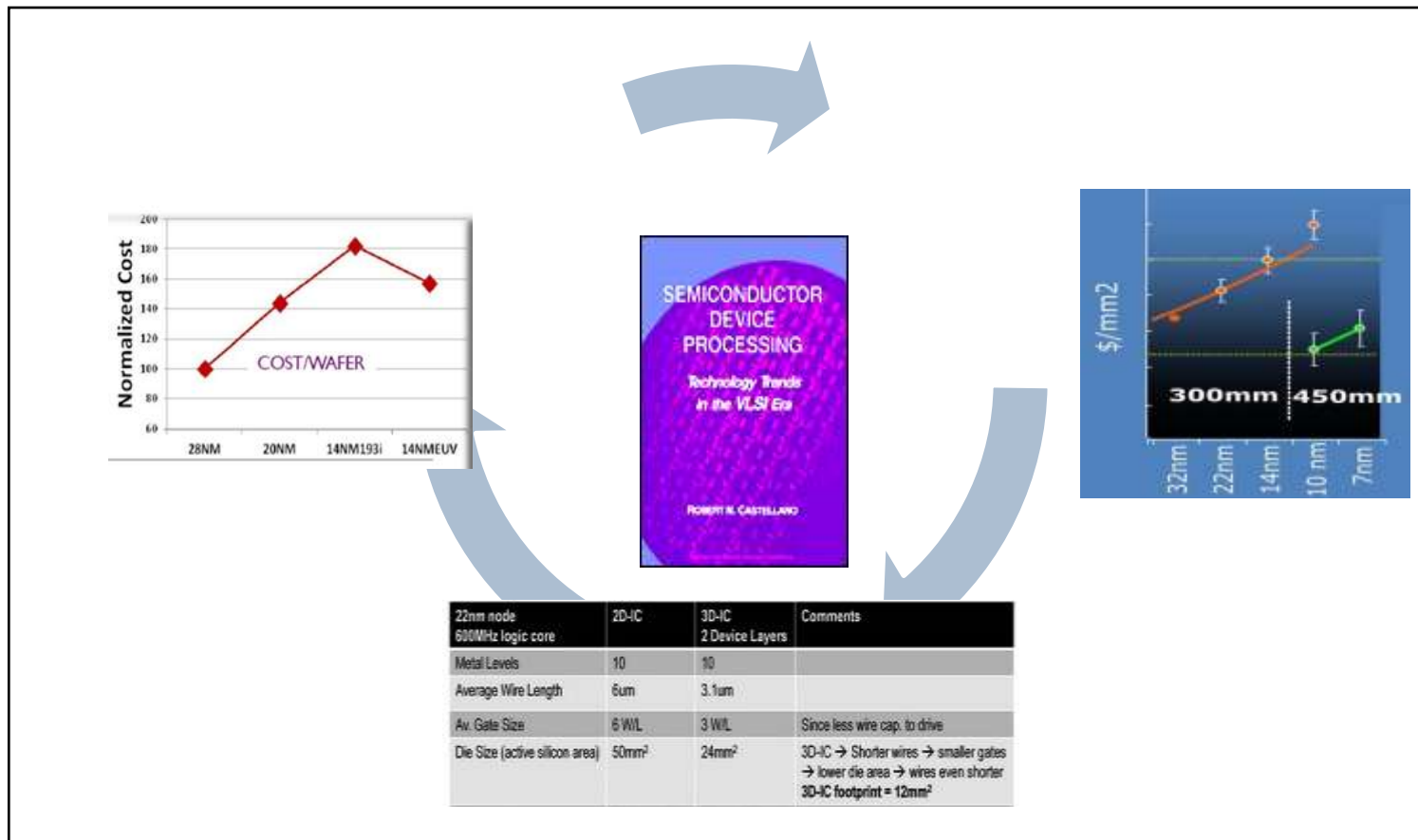
November 2013



Convergent and disruptive

We are entering the most dynamic period that, I have witnessed in the 30 years of analyzing the semiconductor industry !!!!

It's all about timing

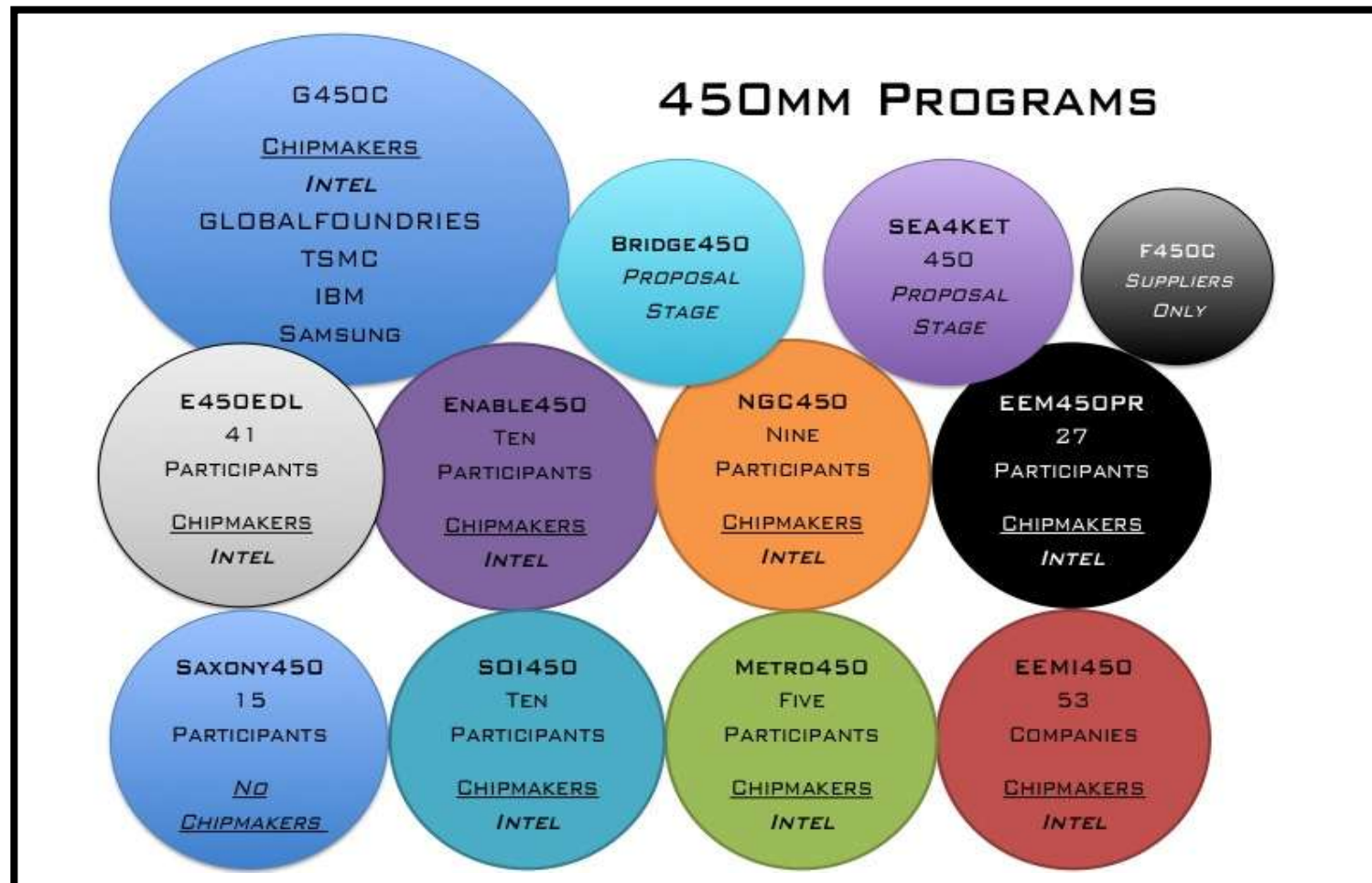


Why?

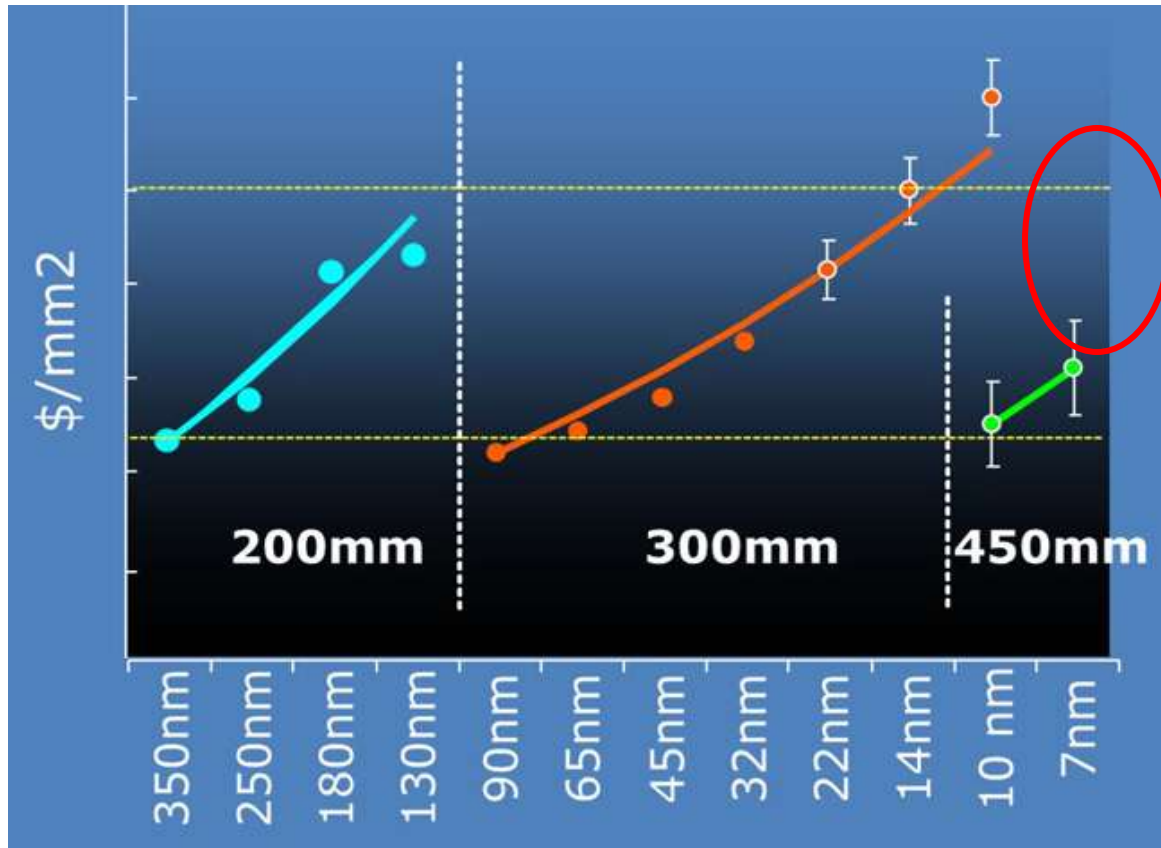
When?

What are the Implications?

Intel is the catalyst behind 450mm through several consortia

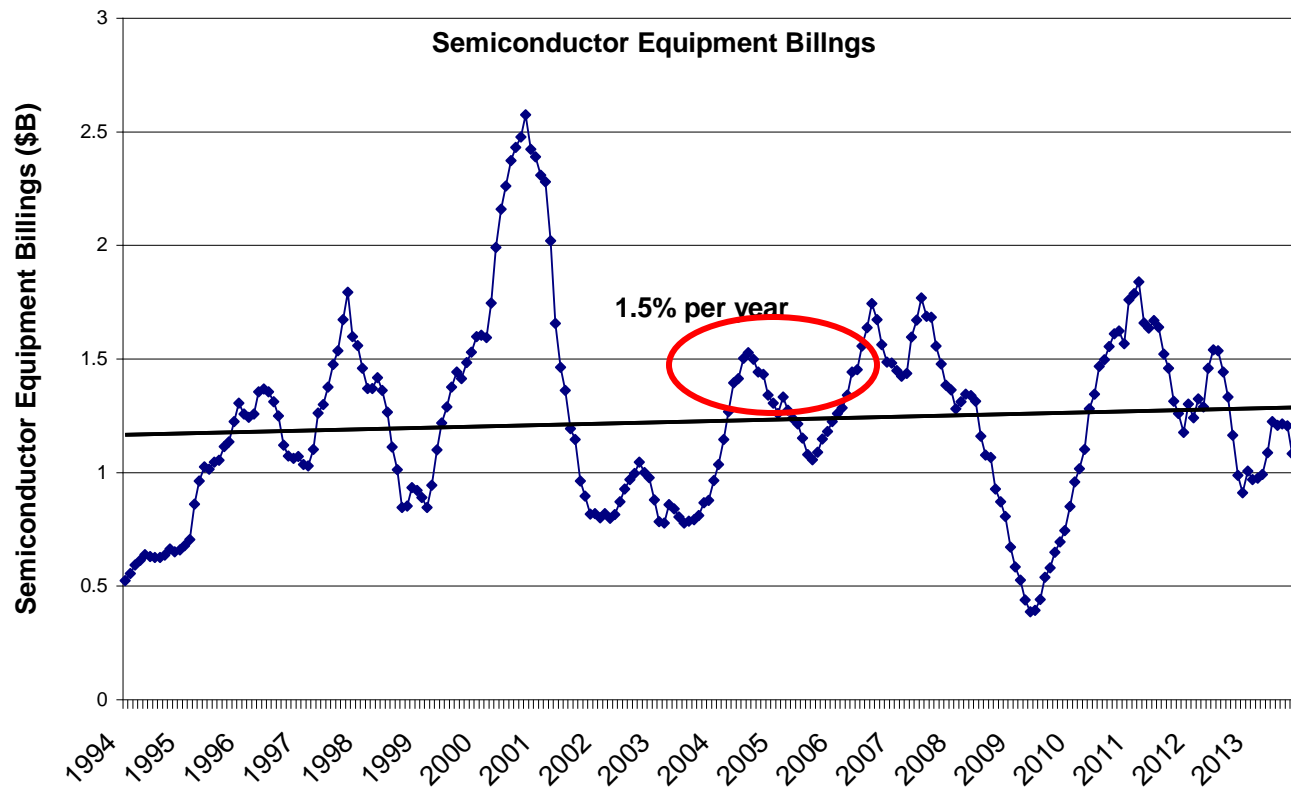


Why? Reduced costs entering the sub 14nm node

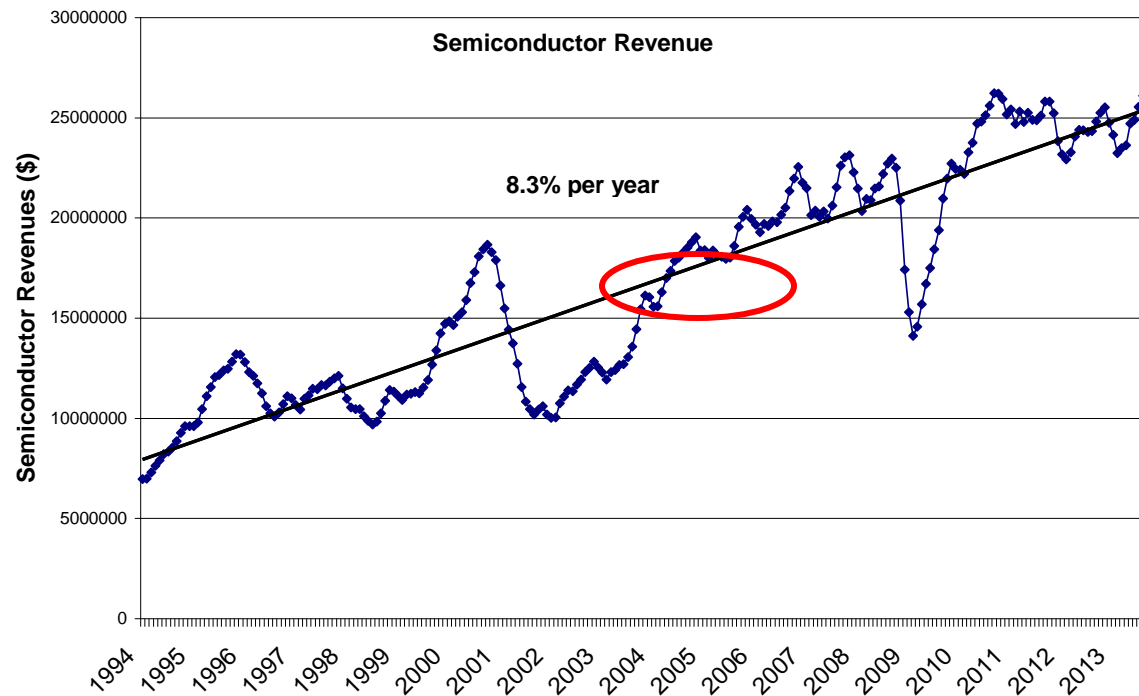


Source: Intel

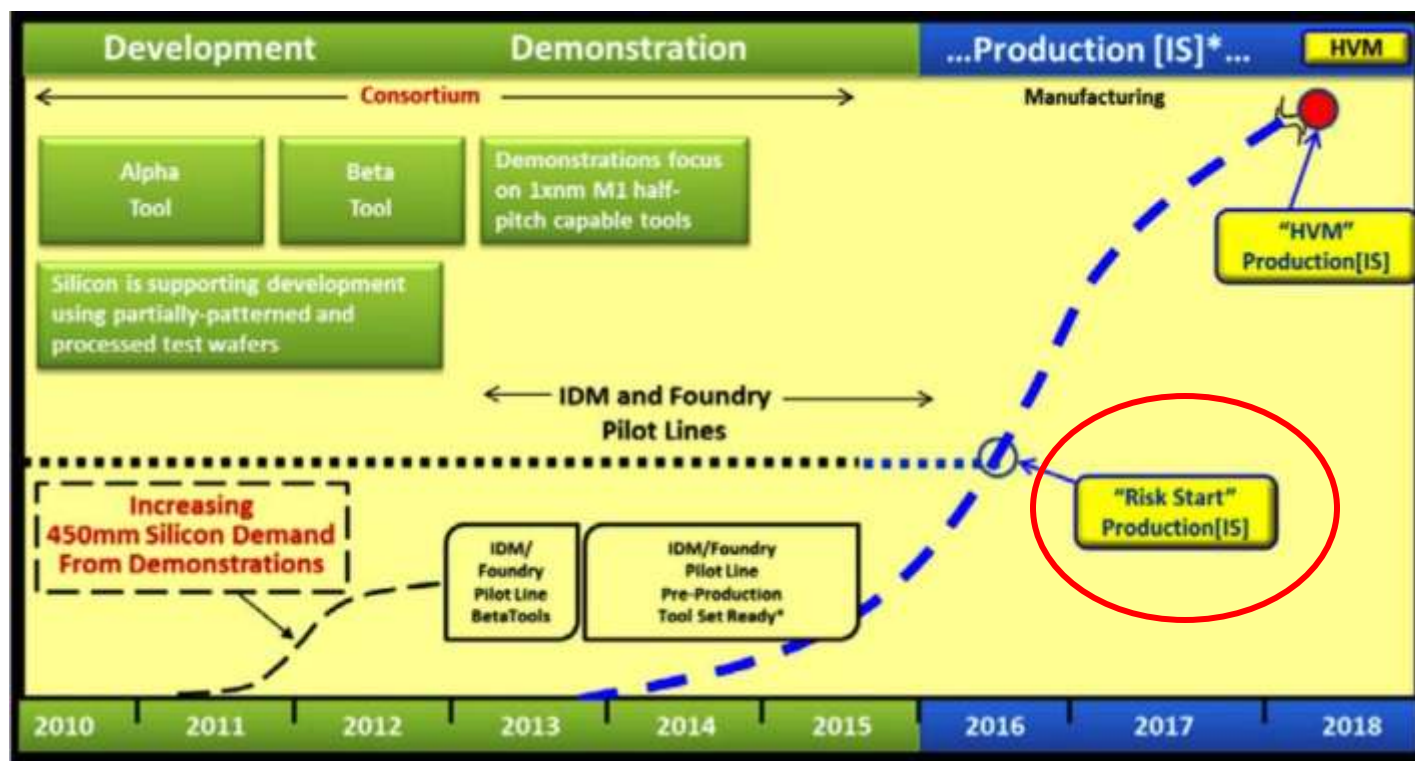
And reduced equipment purchases – 1.5% per year growth since 300mm equipment was introduced



Compared to 8.3% growth per year for semiconductors



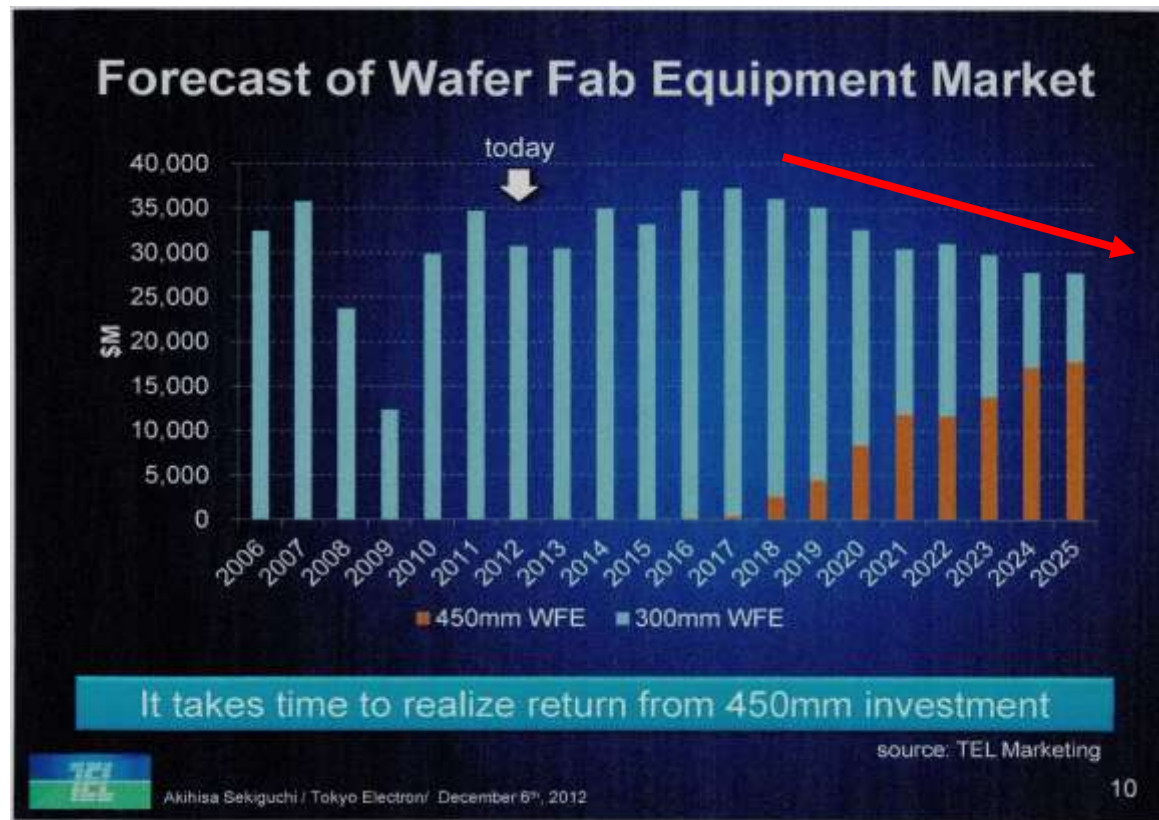
When? ITRS has its roadmap for 450mm wafers - 2016



Implication 1 - Not many fabs will be built with a >\$10B price tag – only the largest will benefit



Implication 2 – While 450mm equipment will be up overall equipment revenues down



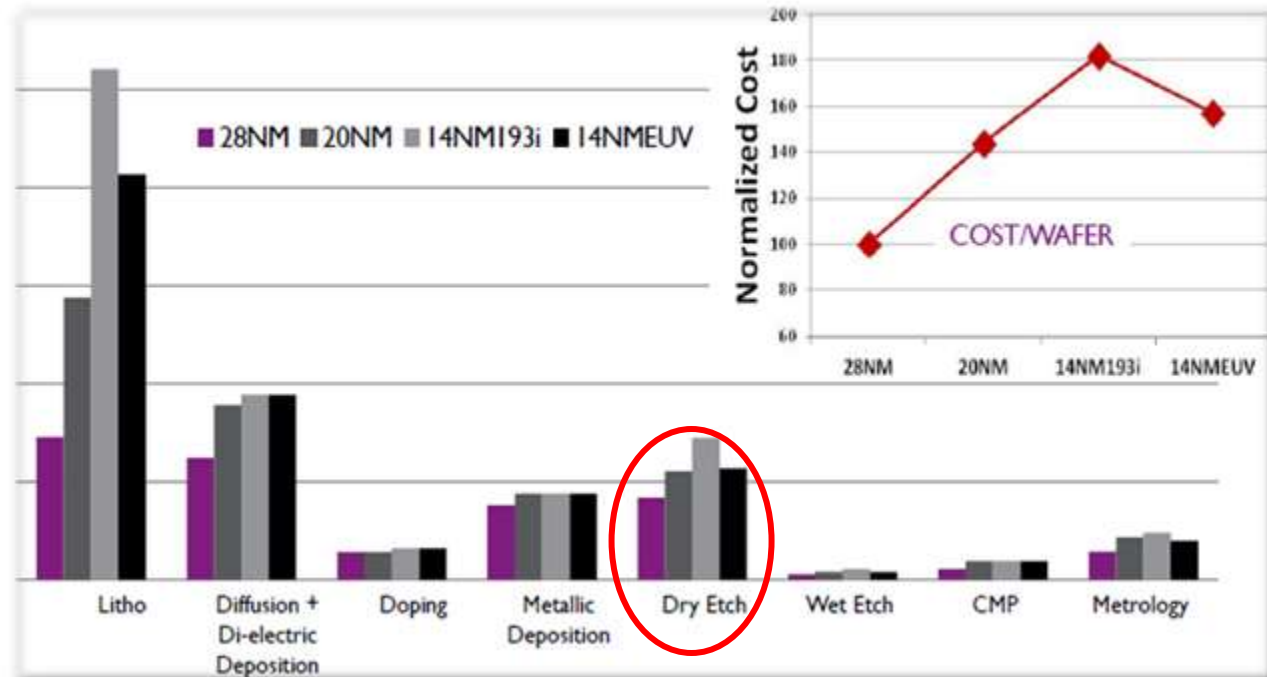
EUV Lithography

Why?

When?

What are the Implications?

Cost - Without EUV manufacturing cost would escalate 80% at 14nm – overall and for plasma etch

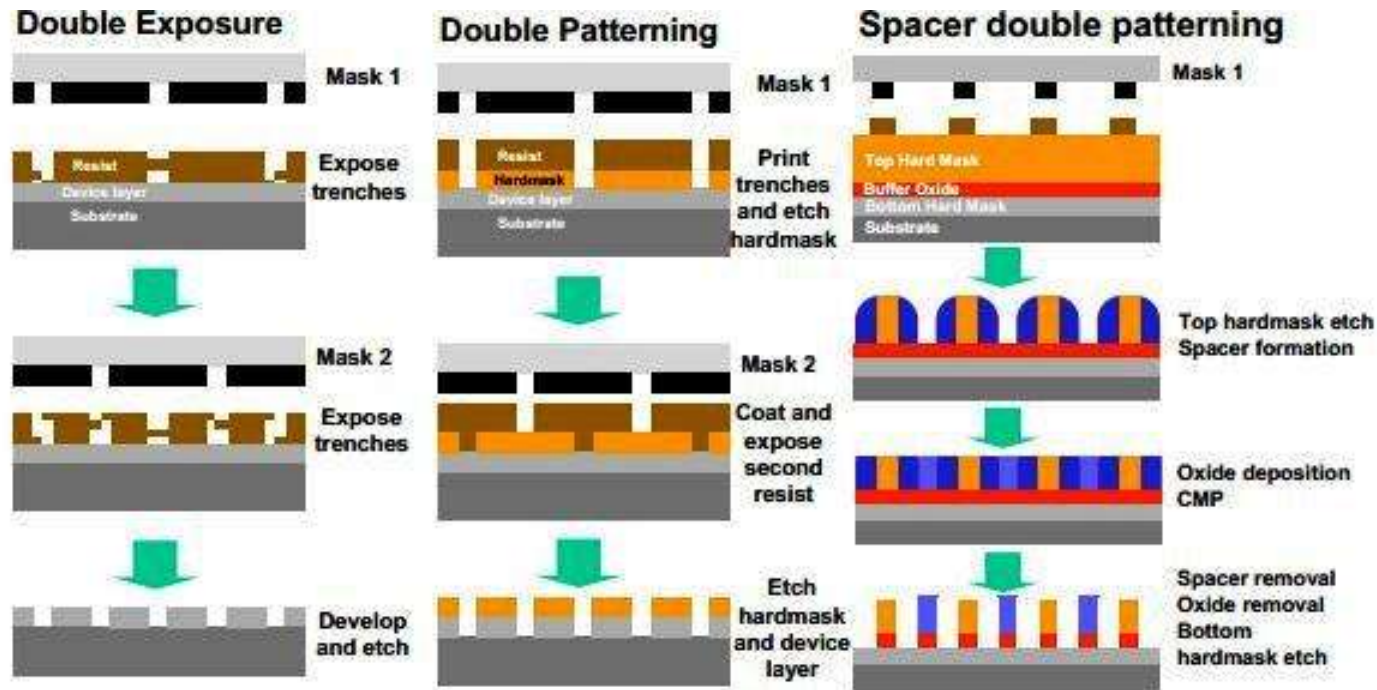


Source: IMEC

Some Pushouts in EUV until 2014 but still ready for 450mm wafers at 10nm in 2016



Implication – EUV eliminates need for multiple patterning that extends DUV - Etch processes are also eliminated



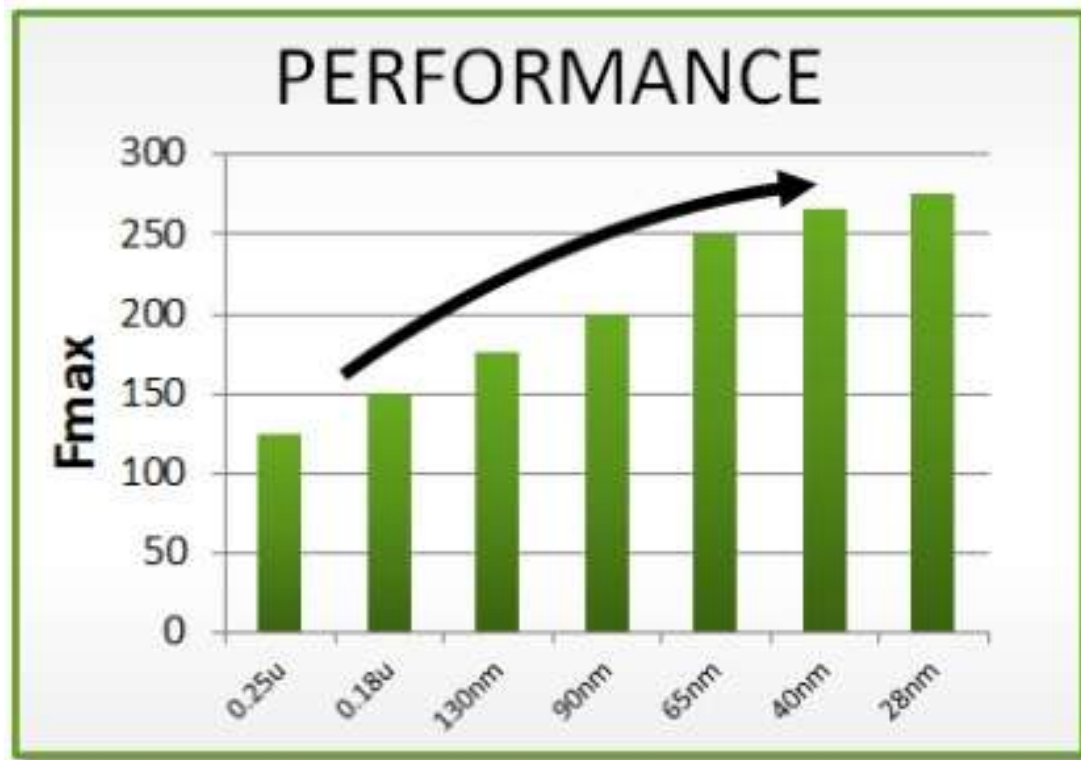
22/14nm

Why?

When?

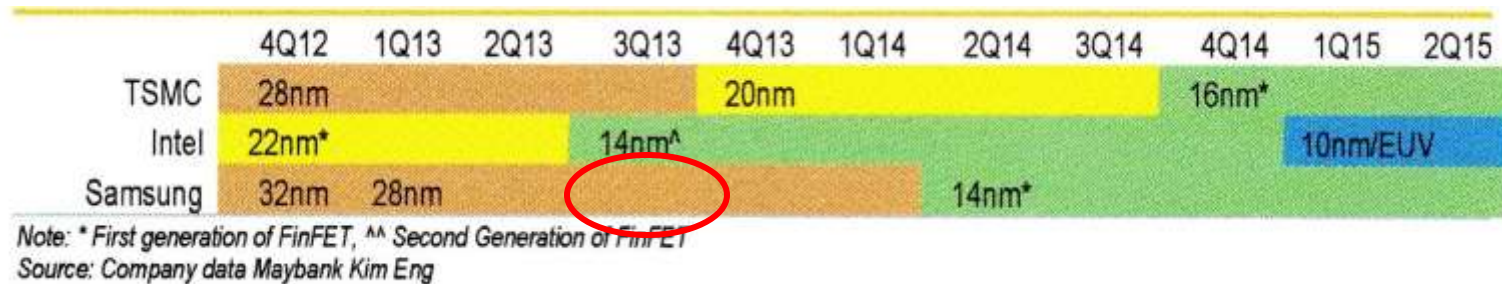
What are the Implications?

Smaller features give improved performance and extends Moore's Law

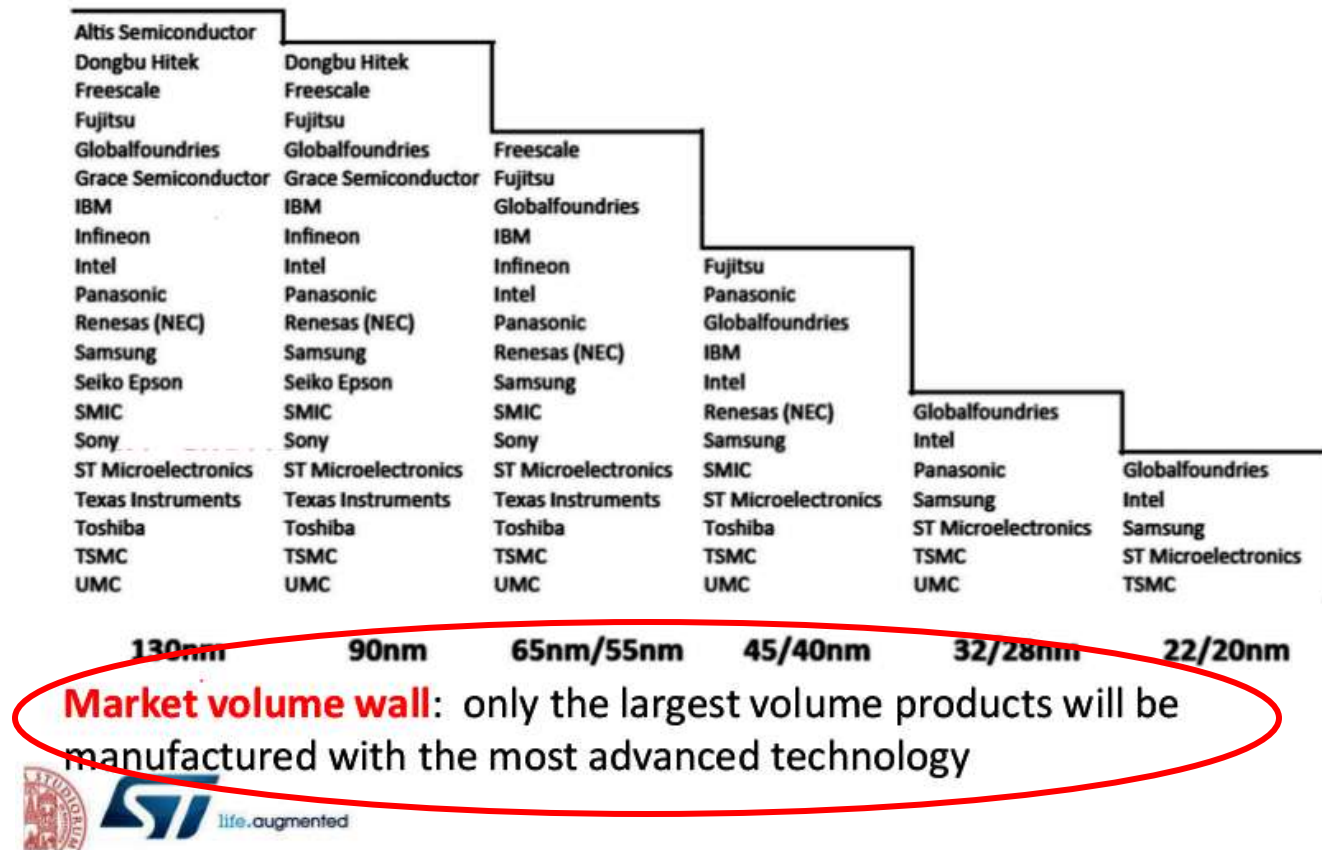


Source: Achronix

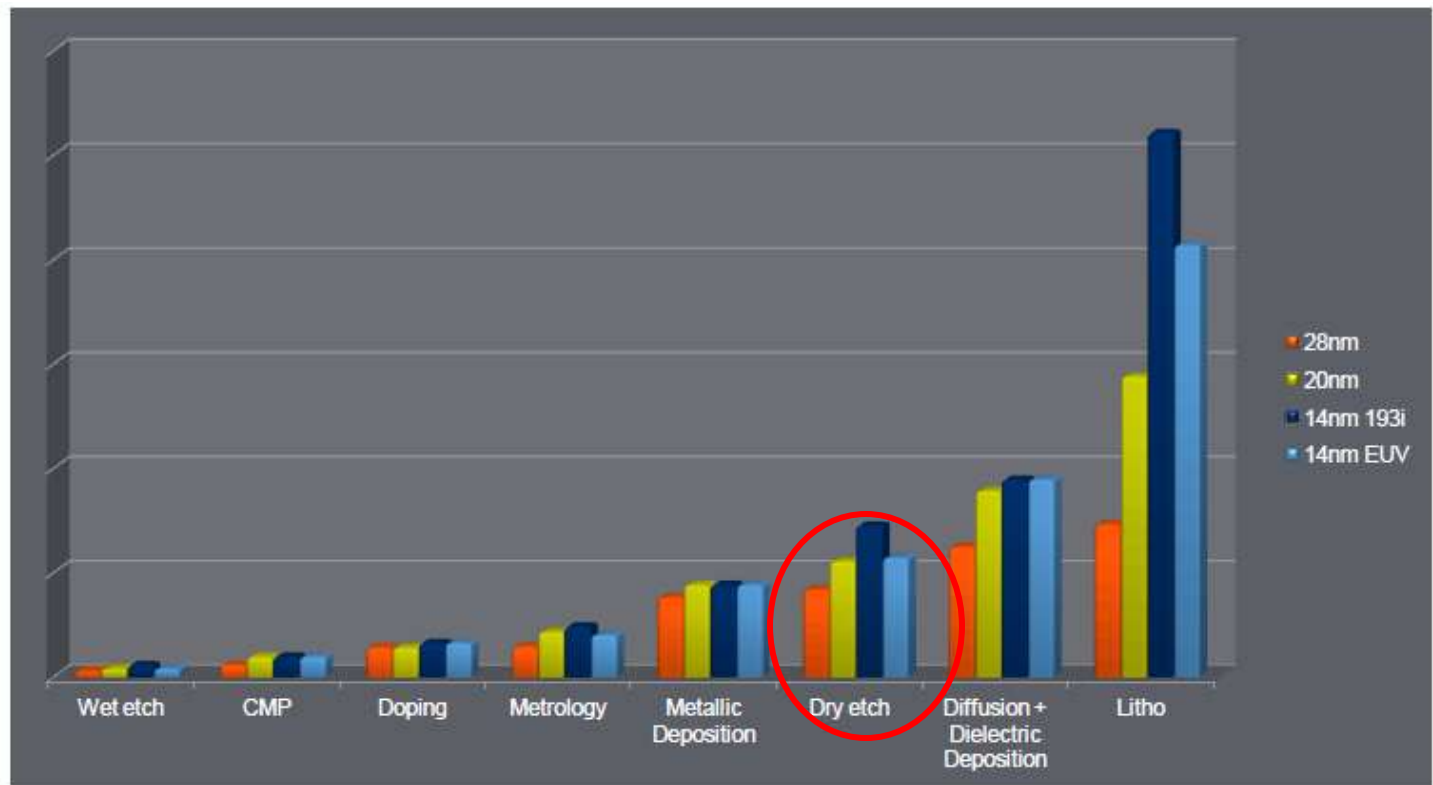
Intel is ahead at 14nm but defects have pushed out start until 2014



Implication 1 - Only a few companies will implement 22/14nm initially



Implication 2 – Etch cost jumps at 14nm without EUV because of multiple patterning



Source: IMEC INSITE program in collaboration with partners

3D

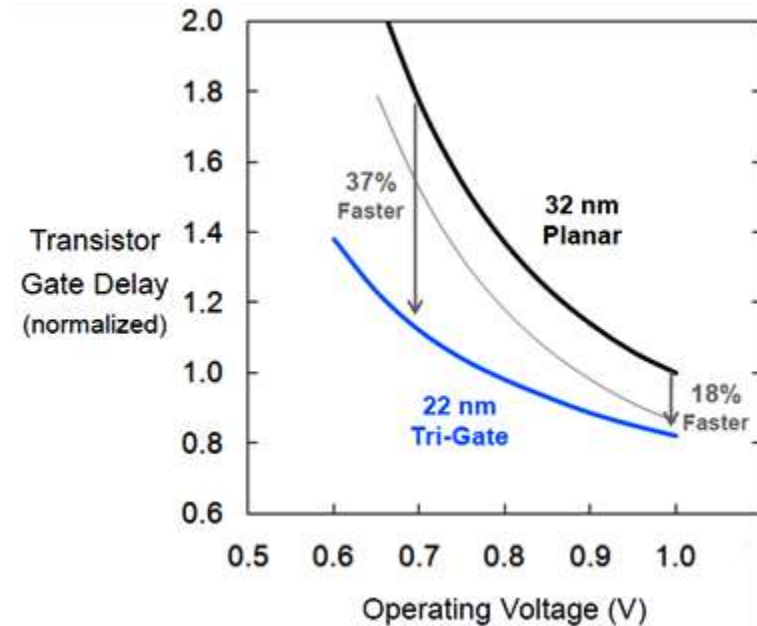
Why?

When?

What are the Implications?

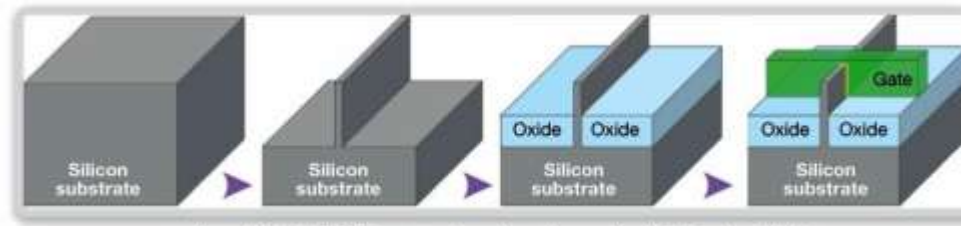
Why 3D?

- Excellent short channel control in FinFET leads to improved performance
 - Lower leakage (lower DIBL and lower SS)
 - Low V_t variability due to low channel doping
 - Less variability caused by random dopant fluctuations
 - Lower operating voltage -> 50% dynamic power savings

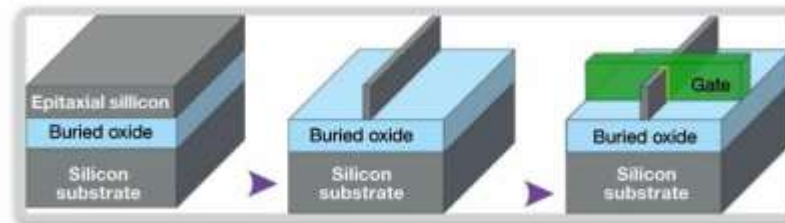


Source: Intel

Intel's FinFETs took an early lead but FD-SOI has benefits



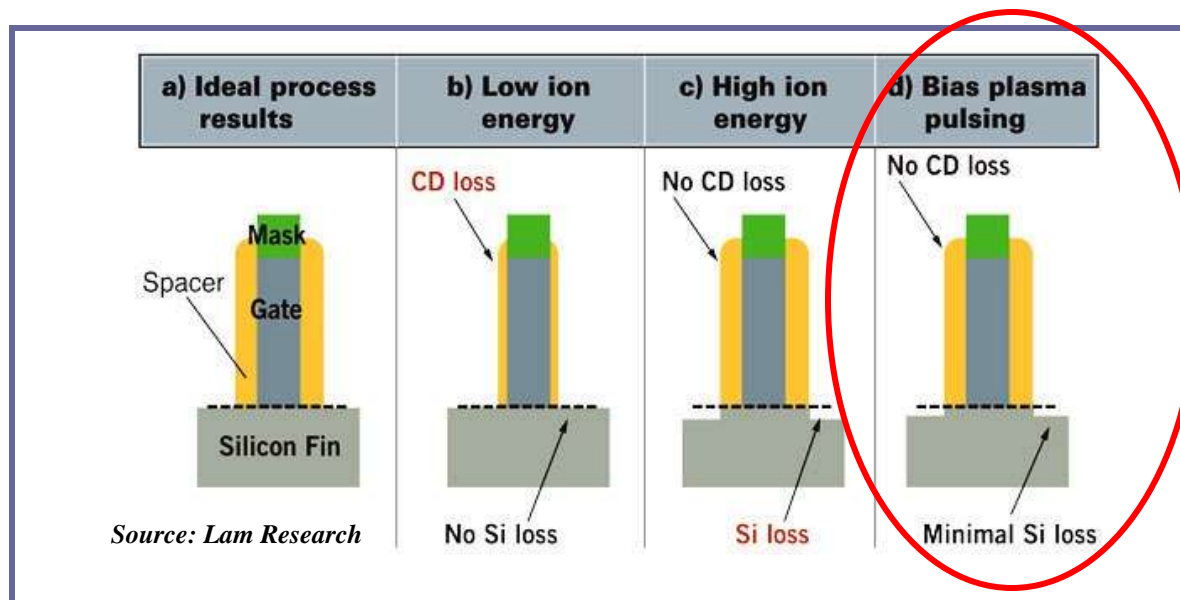
Normal Wafer: FinFETs on regular wafers rely on a timed etch to form the fins



Silicon-on-Insulator Wafer: FinFETs on SOI wafers rely on the buried oxide layer to stop the fin etch

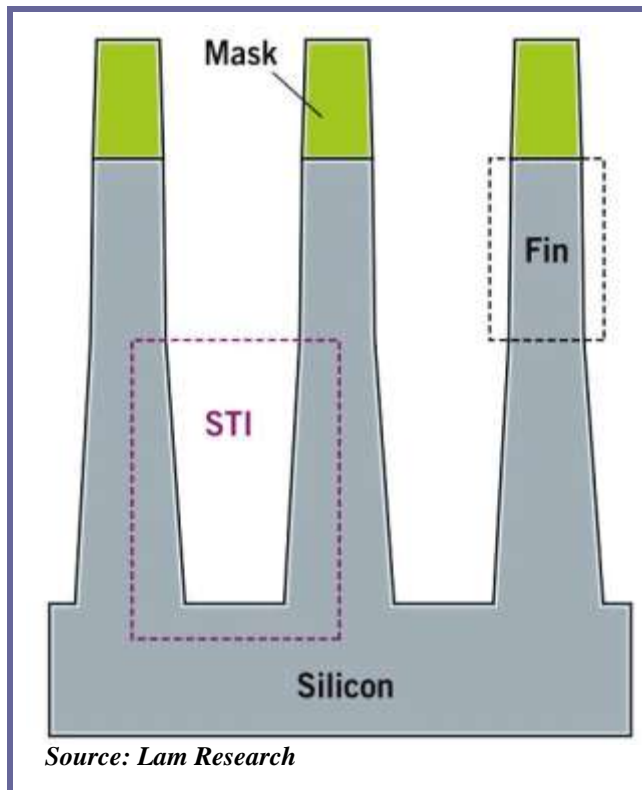
- **Cheaper: Lower overall cost**
- **Faster time to market, up to one year earlier**
- **Simplified manufacturability with fewer process modules to develop**
- **Better: Improved variability and electrical characteristics**

What does all this mean for plasma Etch equipment?



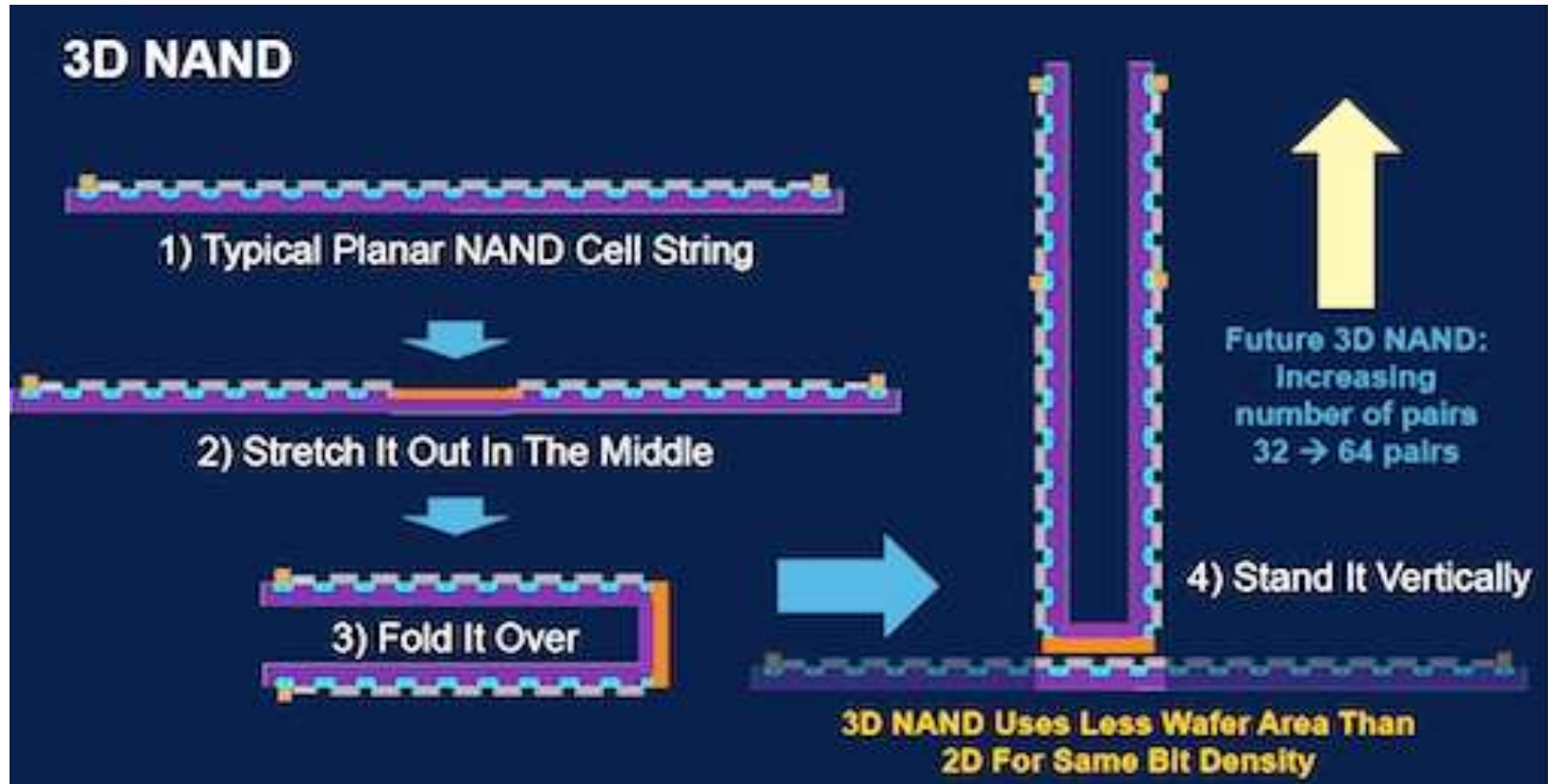
Bias pulsing offers a viable approach to achieve directional etching with minimal structural damage that will be needed for manufacturing FinFET devices according to Lam Research

Implication– Greater need for advanced plasma Etch



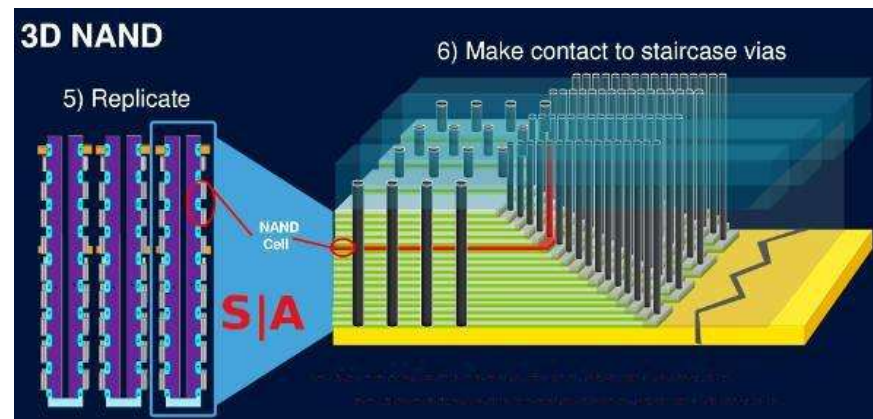
- For a FinFET Fin
 - STI structure and fin are etched simultaneously
 - Etch process creates the actual channel (the fin), so producing a precisely vertical fin with low surface state density is critical.

3D NAND - Instead of one transistor layer then metal layers above it (Dep/Etch), you lay wown 32+ layers of mixed transistor and metal



Source: Applied Materials

3D NAND – Extremely complex processing but 3D means relaxed linewidths – 19nm planar node is ~50nm rule



Source: Applied Materials

Staircase etching - Put down as many layers as you need with horizontal traces then etch them out layer by layer forming a staircase pattern. Then you put in vertical vias down to these exposed horizontal traces

The advantage of 3D NAND is that it doesn't require leading-edge lithography...the burden will shift from lithography to deposition and Etch

PLANAR

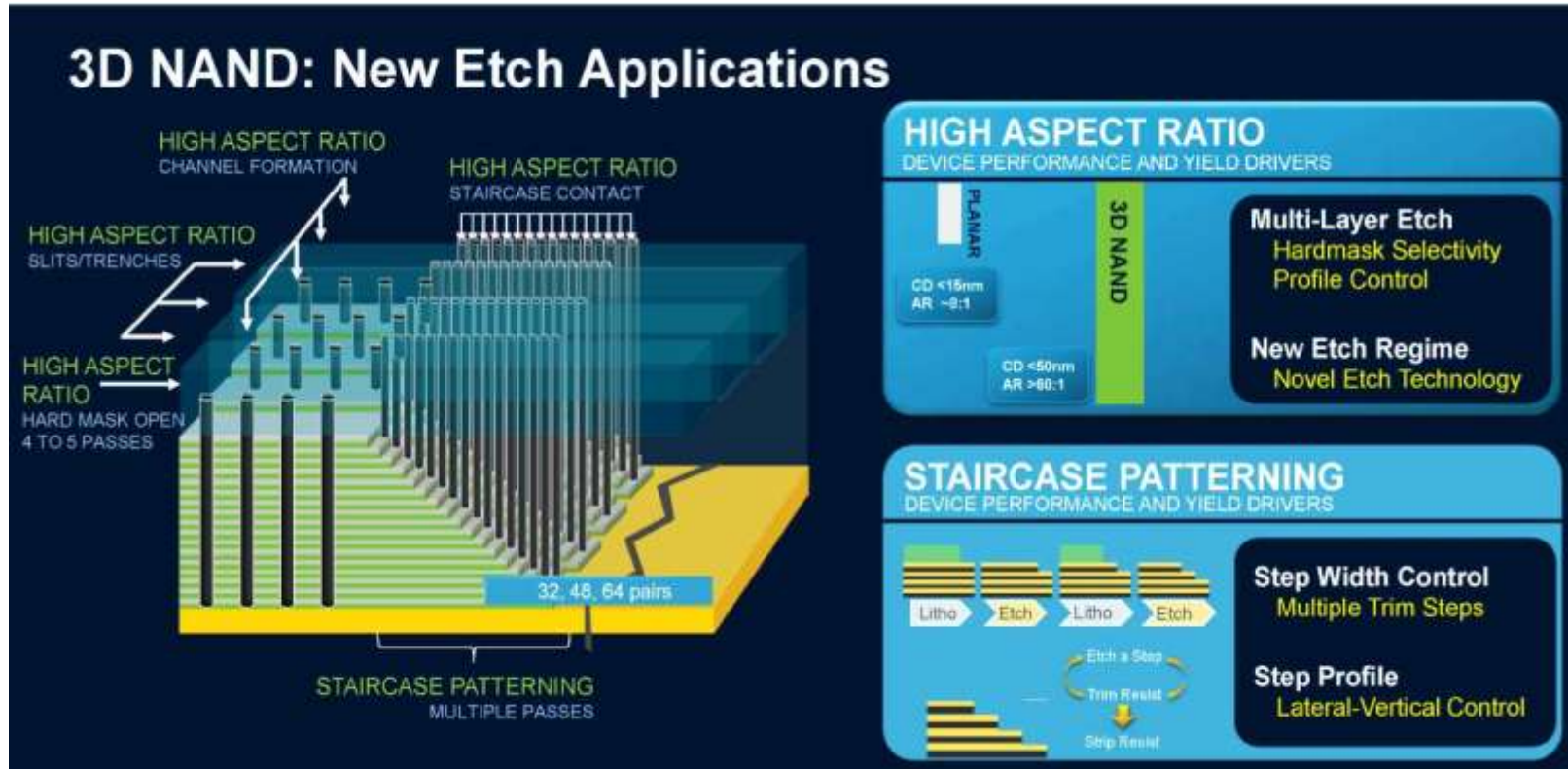
- CD DEFINITION AND SCALING (<15nm)
 - Lithography
- ETCH
 - Lower aspect ratios
 - Multi-patterning (SATP, SAQP)
- DEPOSITION
 - Single layer
 - Thinner films

Source: Applied Materials

3D NAND

- CD DEFINITION AND SCALING (~50nm)
 - Etch and Deposition Grows
 - Lithography drops
- ETCH (+30 to +40%)
 - High aspect ratios
 - Staircase patterning (trim and etch)
- DEPOSITION (+50 to +60%)
 - Multi-layer stacks
 - Thick films (active and hardmask)

3D NAND introduces many new Etch applications

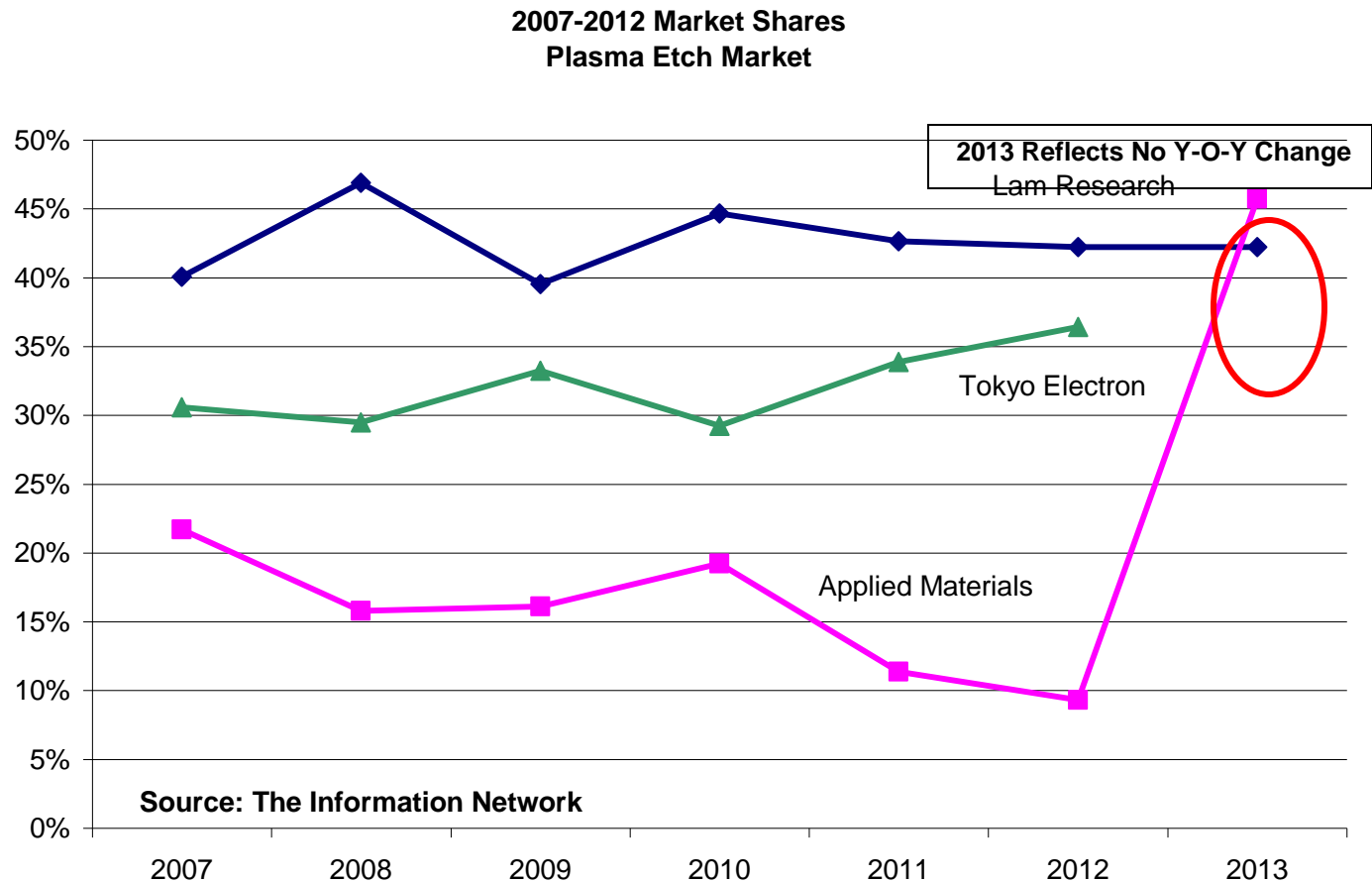


Source: Applied Materials

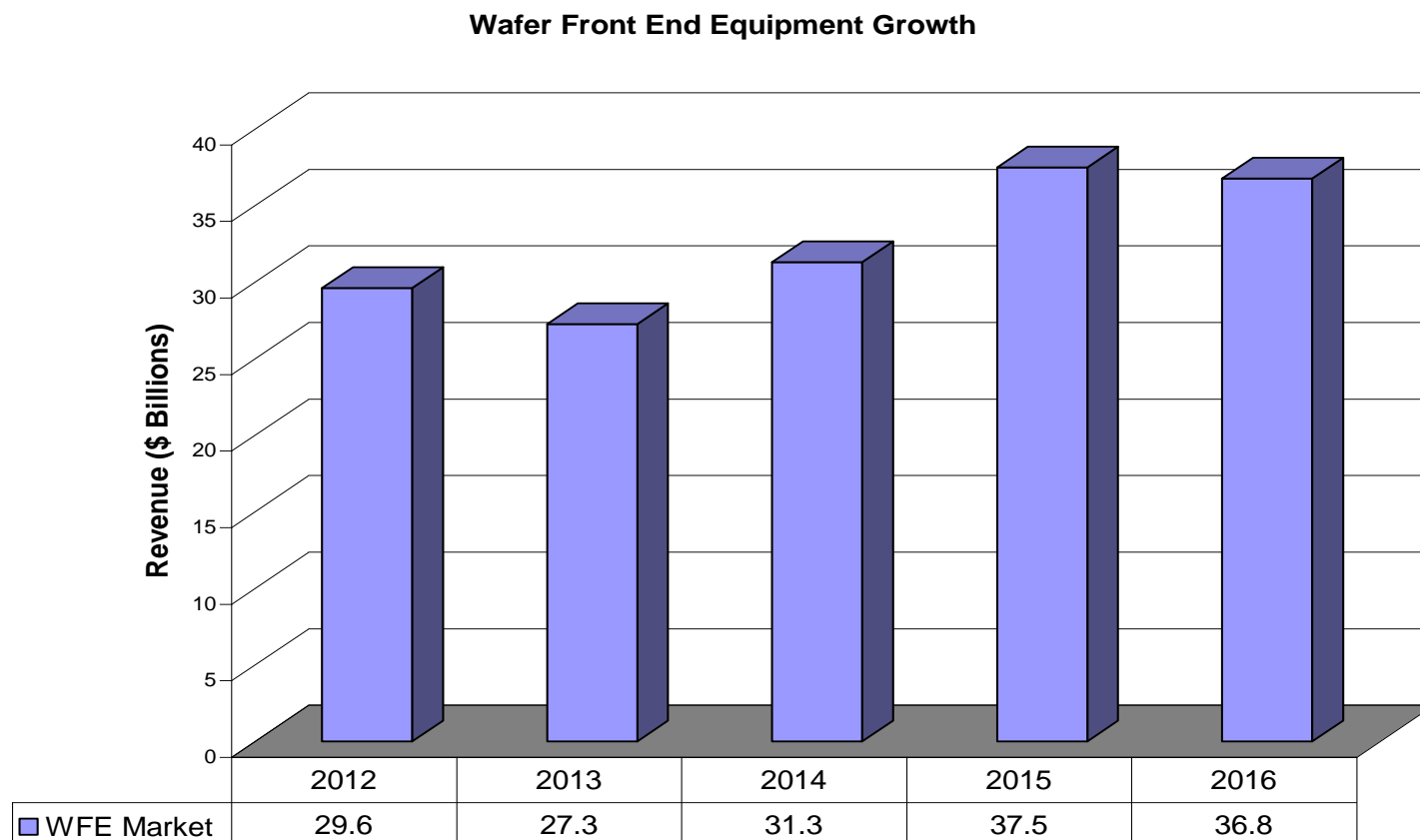
And new revenue opportunities in Etch



Applied Materials key beneficiary of merger for Etch



Positive growth for overall equipment in 2014 and 2015 – plasma etch market represents about 14% of overall market



Source: The Information Network

Thank You