Europe’s E&M ‘Got’ 450mm Very Early On

EU strengths to build up its 450mm strategy
Companies involved in EU 450mm programs (closed, running or pending)

Placed on a simplified value chain…
Then The Chip Companies ‘Got’ 450mm Too

The Major Semiconductor Manufactures Realised The Costs Are So High That Collaboration and Cooperation Were Essential

It Must Have Been Serious … Let’s Be Honest, When Was The Last Time This Lot Agreed To Work Together?
New York State Quickly Then ‘Got’ 450mm

An Early Understanding That Public Authority Support Is Nowadays Essential To The Semiconductor Manufacturing Industry
Despite The Three European IDMs Saying There Should Be Absolutely No European Support Funding For 450mm
Following SMART Imec ‘Got’ Its 450mm

Flemish Government to Support imec’s 450mm Clean Room

09/7/2012

SEMICON WEST (San Francisco, USA), July 9, 2012 – The Flemish Minister of Innovation, Ingrid Lieten, has announced to invest in the building of imec’s 450mm clean room facilities. Imec strives to keep playing a world-leading role in research on the most advanced semiconductor processes and technologies. With the combination of a state-of-the-art 300mm clean room and the transition to 450mm, imec will be able to keep on delivering its partners top-notch research on (sub)-10nm devices enabling the future growth of the global nanoelectronics industry.

During Our Research For The SMART2010/62 Project, Imec Constantly Helped Us, Both With Information and Political Support, And We Would Like To Think We Helped Them At Least A Little In Return

“Probably The Best Research Organisation In The World”
The Customers Definitely ‘Get’ 450mm

And Are Now Shouting “Hurry Up!”

John Chen, nVIDIA
Commission VP Neelie Kroes “Gets” 450mm

“I am NOT a politician ... I’m Dutch; I tell it bluntly”

Commission VP Neelie Kroes Lays Down Europe’s Chip Industry’s “Marching Orders”

“The 20% Production Share Goal Requires 450mm High-Volume Production In Europe”
Quote From Her FH IEF2013 Video Speech

THANK YOU Ms Kroes

“If our electronics sector is not competitive, then every other sector suffers, and our entire manufacturing base is at risk. If we don't take this opportunity, if we don't connect our strongholds, then others will leapfrog us. We need this public investment - we need it to be rapid, strategic and coordinated. I will expect great things from the industry; they will have to build on this investment to take the sector to new heights. They will have to find ways to repeat the success of Airbus, but this time in the chip sector, and with its own unique business model”

“Let’s just do it; let’s go for this goal and let’s do it”
Source: Press Conference on launch of European strategy for micro- and nanoelectronic components and systems /Brussels - 23 May 2013

From Humble Beginnings Great ‘10-100:20’ Visions Are Born
EU Commission Bold & Holistic Vision

May 23 - Europe Gets Its ‘Man On The Moon’ Goal*

"I want to double our chip production to around 20% of global production. I want Europe to produce more chips in Europe than the United States produces domestically. It's a realistic goal if we channel our investments properly." Commission VP Neelie Kroes

◆ The Strategy Will Focus On Three Complementary Lines:
  ➢ Making Chips Cheaper (Transitioning To 450mm-sized Silicon Wafers)
  ➢ Making Chips Faster ("More Moore") And
  ➢ Making Chips Smarter ("More Than Moore")

◆ 7-Year Partnership Covering The Whole Value & Innovation Chain In The Electronics Sector, Including Funding Large-Scale Innovation Projects Under The EU's Horizon 2020 Research Programme

European “Airbus Of Chips” aka The “10/100/20 Strategy”

€10b EU Co-Funded Projects / €100b Industry Investment 20% Global Manufacturing Share

* Source: Press Conference on launch of European strategy for micro- and nanoelectronic components and systems /Brussels - 23 May 2013
Has The World Now Got 450mm?
Intel breaks ground on 450mm Fab - D1X Module 2 will open in 2015

Intel has started building its first dedicated 106k m² development facility for 450mm wafer production in Hillsboro, Oregon. The new fab module, with the catchy title ‘D1X Module 2’, will come online in 2015 and cost $2 billion. The 450mm facility will set new cost records because of the cost of the new manufacturing equipment, something Intel is banking on. After all - if it is one of the few chip makers that can afford the new generation of gear, it will gain a significant competitive advantage
February 11, 2011 – TSMC’s Morris Chang had some surprisingly specific & bullish comments about the 450mm wafer-size transition, practically as an aside during 4Q10 quarterly results call a couple weeks ago. It seems surprisingly direct and specific — and somewhat counter to what most everyone else has been saying, that the industry downturn (and general lack of supplier enthusiasm) have pushed 450mm well outside the ITRS’ original schedule:

"Our first 450-millimeter pilot line is planned at our Fab12 Phase VI, starting with 20-nanometer technology. The timing of the pilot line will be around 2013, 2014. Our first 450-millimeter production line is planned in around 2015, 2016."

Unrealistic Timescales, of course But Well Within The Normal Chip-Industry Hype Barometer
Full Steam Ahead At ... Samsung?

“I’ll Do If You Do”
“Err ... Hello ... Excuse Me ... Is Anybody Out There ... ? Is Anybody Listening ... ?

Sorry For Being A Party Pooper ... But 

**What’s In It For Me?**

“Trust Me ... You Make It & I’ll Buy It” Just Won’t Hack It Anymore & Frankly Speaking, I Don’t Blame Them!
Full Steam Ahead At ... Europe?

ST, NXP & Infineon Say “Non/No, Nee & Nein”
Research Labs, E&M Firms & EC Say “YES”

Let’s Hope The ELG* Don’t Screw This Decision Up
Hint: Key Words Are ‘Bold’, ‘Holistic’ & ‘Visionary’

* European Leader’s Group (Report Now Due ‘End Jan’ vs Dec 16 Deadline)
NK’s Reins Now Handed Over To The ELG

EUROPEAN COMMISSION

Brussels, 11/10/2013

Electronics Leaders Group

- Ben Verwaeyen, ex-CEO of Alcatel
- Mr. Carlo Bozotti, CEO of STMicroelectronics International NV, Italian
- Dr. Reinhard Ploss, CEO of Infineon, German
- Mr. Rutger Wijburg, CEO of Globalfoundries Dresden, German
- Mr. Rick Clemmer, CEO of NXP, USA
- Dr. Hubert Lakner, Fraunhofer, German
- Mr. Mike Muller, CTO ARM Ltd., English
- Mr. Peter Wennink, CEO ASML, Dutch
- Mr. Aubertin Hervé, CEO SOITEC, French
- Dr. Luc van den Hove, CEO imec, Belgian
- Mr. Jean Therme, Director of Technology of CEA, French
- Mr. Eamonn Sinnott, Intel Vice President Technology & Manufacturing Group and General Manager Intel Ireland, Irish

It’s The ‘M’ Word …

◆ Manufacturing
   As Opposed To ‘Outsourcing’

◆ Also MORE MORE
   Ouch, That Hurts

◆ & MORE THAN MORE
   Now You’re Talking (200mm That Is)

◆ Plus Don’t Forget 450MM
   (% & # $ < ? @ !!)

In All Fairness It’s A Challenging Task Given Their ‘European Vision’ Might (Will) Conflict With Their Corporate Responsibilities …

But … Empowering Another ‘Major’ Foundry For FD-SOI Rather Than Build An In-House European Advanced ‘450mm Ready’ Fab Is Not A Good Omen
(Especially When The Technology Was Developed With Huge EU & French PA Funding)
So Is 450mm Still ‘Doing & Happening’?

◆ Demand From Advanced Fabs Continuing To Rise
  ➢ 10% IC Unit Growth = 8-9% Silicon Area Increase Per Year

◆ 450mm Fab Cost of US$10b Still Effective vs 2.25 300mm Fabs
  ➢ Build 1x 450mm vs 2.25x 300mm – Fewer Engineers
  ➢ Better Automation, Smart Tools, Faster Ramp
  ➢ Improved Environmental Impact, Ultra-Green Fabs
  ➢ Higher Productivity/Reduced Operating Overheads Similar To A380 vs B747

◆ Node, Wafer Size & Litho Technically Independent
  ➢ But Will Inevitably Be ‘Connected’

◆ 450mm Transition Being Properly Orchestrated (Unlike 300mm)
  ➢ Driven By Intel-Samsung-TSMC … Sort Of!
  ➢ Evaluation Continues In Albany R&D Lab
  ➢ IMEC 450mm Clean Room Under Construction In Leuven

◆ Up To 28% Die Cost Reduction
  ➢ By ‘Target’

◆ Kill The Competition
  ➢ Unspoken but Ever Present & More Apparent
  ➢ Once 450mm Flips, 300mm Node Development WILL Stop
  ➢ Technology Bifurcating Impact On The Industry Will Be Permanent
But The World Has Changed

- Semi Equipment Now Consolidated Around 1-2 Players Per Segment (Even More So With The Prospective Applied-TEL Merger)
- Chip Industry Has Also Defaulted To Fabless (‘Fablite’ sic) Model (Meaning Fewer Semi Equipment Customers & Dwindling Differentiation)
- Equipment Supplier ‘ Monopoly’ Means ‘Chippies’ No Longer Rule OK (& An End To All That 3x Boom/Bust Nonsense …)
- Longer-Term & Meaningful Order Visibility Is On The Cards (As In The Airline Business)
- Future Horizons’ “Brave New World” Seems To Be Coming True (450mm Could Prove The Ideal Business Model Tipping Point)
And So To The 450mm Business Model

◆ Original Justification Rationale Still Stand, 450mm Is Needed (But We Could Live Without It)
◆ But It Remains An **Economic** Not Technical Decision
◆ Waters Are Muddied By The Intense Business Implications (Industry Bifurcation, Competitive Positing, Political Issues)
◆ All Three Proponents Facing Serious Nearer-Term Challenges
  - Intel – x86 PC Era Maturity
  - TSMC – FinFET Transition
  - Samsung – Fragile SoC Model & Memory Saturation
◆ Parallel De-stabilization Of The Fabless Foundry Business Model
◆ Emergence Of The SoC-Centric System OEMs (Apple, Samsung, Microsoft, Amazon, Google …)
◆ BUT … Next Phase Of Makimoto’s Wave ‘On The Horizon’

450mm Risks Becoming The Chip Industry ‘Nuclear Deterrent’ … The Chip Firms Could Do It But Nobody Actually Does
ASML Investment A ‘First Step’ ... ?

How the ASML investments stack up

<table>
<thead>
<tr>
<th>Company</th>
<th>Intel</th>
<th>TSMC</th>
<th>Samsung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment in stock</td>
<td>15% for $3.1 billion</td>
<td>5% for $1.03 billion</td>
<td>3% for $630 million</td>
</tr>
<tr>
<td>Investment in R&amp;D</td>
<td>$1 billion</td>
<td>$345 million</td>
<td>$345 million</td>
</tr>
</tbody>
</table>

“Woops ... We’d Better Have Some Of That As Well !”
Current Status: All Plans Slip A Little

- PC Market Collapse (Intel) & FinFET Transition Problems (Samsung & TSMC) Push 450mm Temporarily Onto The Back-Burner
- Samsung & TSMC Concerns Not To Give Intel A Market Advantage Given Intel’s 2-Year FinFET Lead & Foundry ‘Aspirations’

Bottom Line … At This Point “Cosmetic, Not A Body-Blow”, A ‘9 Month’ Slip To Our 2011 Best Case Roll Out Scenario
Small Slip Turns Into A Slide?

- G450C Representatives first made statements at SEMICON Japan in December 2013.
- Repeated & expanded these at Metro450 meeting in January 2014.
- Message was a weakening of demand for 450mm production by some of the IDMs in collaboration at G450C.
- Outlined a schedule adjustment to take this perceived delay into account.

Bottom Line ... No Longer Cosmetic. The OEM rate of development is slowing down & hence the delivery of demonstration toolsets to the Albany Fab (& supplier sites) is being pushed out to 2015 for some toolsets.
‘Slip-Slide’ Ramifications ....

◆ G450C Were To Complete 14nm Tool Demonstrations On ‘The Earliest Available Tools’ …This Is No Longer The Intention
◆ Instead Baseline Assessments Will Proceed But Not Full Marathon Testing
◆ This Will Be Followed By A Period Of Continuous Improvement Between G450C & The OEMs In Order To Develop Production-Capable Toolsets For Marathon Testing In The 2016 Timeframe
◆ Test Wafer Activities Will Remain On Schedule In Order That A Full Complement Of Required Silicon Materials Can Be Available For These Tool Tests.
◆ G450C Will Work In Conjunction With EEMI450 To Define Equipment Performance Metrics (EPM) For Both The 10nm & 7nm Nodes

Bottom Line … By 2016, Marathon Testing Will Have Moved Beyond The Originally Planned Usage Of 14nm Metrics
**So How Bad Is This?**

- Well Obviously It’s Not Good
- But It’s Nowhere Near Fatal
- We Always Said The First Viable Insertion Point For 450mm Was The ‘8nm’ node (whatever that means nowadays)
  - It Takes Two Years For A Production Fab To Go From Starting Construction To Shipping First Silicon (& Another Year To Ramp)
  - It Always Has Done, It Always Will Do!
- Real Question Is Will This Delay The Imec & Intel Pilot Lines?
  - Both Were Supposed To Open In 2015
  - Hans Has Just Detailed Imec’s Plans Showing No Slippage
  - Intel Have Become Masters Of The “No Comment” Routine
- If Either Is Delayed This WILL Delay The Ramp To Full Production
- It Also Raises The Issue “What Will Be The Point Of Albany In The Future?”
Time To Bite The Bullet …

◆ First Some Honest & Realism … Only Intel, TSMC & Samsung Really ‘Wanted’ 450mm

◆ Blaming Other IDMs For ‘Not Showing Commitment’ Simply Does Not Wash
  - GlobalFoundries, SK-Hynix, Toshiba, Micron, STM & Others All Said They Couldn’t Afford It Right From The Start
  - We Never Really Understood What IBM’s Role Was Either

◆ It is Now Up To These Three Companies To Step Up To The Bar & Hit The 450mm ‘Go’ Button With ‘Cash & Commitment’

◆ Chip Firms Cannot Expect The Equipment Industry … From ASML & Applied-TEL, Let Alone The Many Smaller Companies, to “Hurry Up Then Wait” On The Promise “It’ll Be Alright On The Night”

◆ The E&M Firms Have Performed Diligently All The Preparatory R&D (With Some State Support) … Now It’s Time For Some Real Orders & COMMITMENT.
One Possible Reason For The Delays

◆ The Latest Nodes Have Had A Huge Impact On The Chip Design & Production Eco-System - Out With The Old … In With The New
◆ Unprecedented Paradigm Shifts In Transistor Design, EDA Tools & Methodologies At Each Successive Node From 32nm/28nm Down (And It’s Getting Worse At Every Successive Node)

One Type Of Double Patterning Example
(Several Variants Exist)

But Nothing Unexpected In The Way Leakage Caught Us All Out At 90nm
Qu: When Is A Node Not A Node?

Ans: From 65nm & Below!

◆ 90nm Was The Last Node Where The Dimension Referred To The Channel Width
◆ Since Then ‘Node’ Has Come To Mean ‘Generations Of Technology’ Not Necessarily To Shrinking The Design Rules A Linear 70%
◆ This Gave Free Licence For The Marketers To Hijack The Technology Agenda With Gung-ho Gay Abandon … “My Node’s Smaller Than Your Node”
◆ ITRS Roadmap No Longer Acknowledges Or Publishes Node Data
◆ The Transition To FinFET Has Taken This To Hype To New Levels! Most So-Called 14nm/16nm Processes Are Simply The Planar 20nm Layouts With A Decent (Vertical) Transistor In The Same Space As The (Leaky) Planar Device, The Chip Area Hardly Reduces At All!

The Current Spin & Hype Is Out Of Control!!

What we would call the ’14nm’ nodes:

◆ Intel – 16nm
◆ Samsung – 18nm
◆ TSMC – 19nm
◆ GF – 20nm
◆ STM – 21nm
So What Next For 450mm Intel?

◆ To Be Fair Intel Have Started D1X Module 2 – 450mm Pilot Line (But We Have Not Heard Of Any Equipment Order Placing Yet)
  ➢ We Normally Hear Something Through The Grapevine
  ➢ The ASML Statements To The Press Mentioned This Morning Would Tend To Indicate The Same Thing
◆ Fab 42 At Chandler, Arizona Is Unfitted So Why Not Announce This Will Be the Location Of The First Production 450mm Fab
  ➢ This Sort Of Statement Will Calm Many Jitters
  ➢ It Will Also Give Some Longer Term Focus For The Irish & Israeli Governments On When Their Support Will Realistically Be Needed
So What Next TSMC?

- TSMC Should Confirm What Their New Plans Are For 450mm
- We realise that if the equipment had been ready they would now have a 450mm fab
- However since the 300mm transition their size & hence responsibilities to the E&M industry have grown massively
- This is the first node transition they have participated in as a leading player

TSMC’s endorsement & commitment to 450mm is crucial to 450mm’s success
So What Next Samsung?

- Samsung’s Situation Is Actually A Little More Understandable
- They Have Never Vocalised A Desire For 450mm
- But They Realise They Must Also Never Be Left Behind Either
- If They Build A 450mm Flash Memory Fab They Will Quickly Have A Monopoly With All The Political Headaches That Would Raise
- They Have Also Never Had Aspirations To Be A Mainstream Foundry Like TSMC
- Building Application Processors For Apple Is The Nearest Thing To a Memory Operation That SoC Logic Gets
- Combine That With Their Internal Usage & No Other Business Available To Them Comes Anywhere Close
So What Next For Europe?

Embrace The Goals Of 10/100/20
Finally Some Market Forecasts
(As Without A Market, Who Needs 450mm or sub-10nm !)

◆ 8% Growth Rate For 2014
  (Downside Risk 4% … Upside Potential 14%)
◆ Balance Of Probabilities Favours Sustained SC Market Recovery
◆ Confidence Should Start To Improve By Mid-Year
◆ 18% Potential For 2015 If Current Recovery Trends Sustain
  (Could Be Even Higher)
◆ Plenty Of New Products & Market Opportunities
  (Don’t Hold Your Breath For Wearables & IoT Though ! )
◆ Plenty Of Political & Economic Minefields Yet To Traverse
◆ Masses Of Technological Hurdles To Jump Over Also
◆ Moore’s Law Will Continue But Not Just Through Scaling
PC Market Update

- If It Ain’t Broke Don’t Replace It
  (Especially In A Downturn With Squeezed Discretionary Spending)
- For Consumers … PCs Just Aren’t Cool Or Sexy Anymore
- For Enterprise … Windows XP Works & Does All That’s Needed
- Few New ‘Must Have’ Software Applications Since Netscape!!!
- Prices Still Way Too High (Thanks To Intel’s $100/cm²)
- Software Still Far Too Boring & Bloated (Thanks Microsoft)
- User Experience Still Far Too Frustrating (Thanks Wintel)
- Little Wonder The PC’s Lost Its Glamour
- Endless (Unwanted) Windows Updates Are Simply Unappealing
- Market By Numbers (Units)

<table>
<thead>
<tr>
<th>PCs</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units (m)</td>
<td>340</td>
<td>300</td>
<td>280</td>
<td>270</td>
<td>265</td>
</tr>
<tr>
<td>Growth</td>
<td>-11.8%</td>
<td>-6.7%</td>
<td>-3.6%</td>
<td>-1.9%</td>
<td></td>
</tr>
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</table>
### Smartphone Shipments

**Units (m)**

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
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</thead>
<tbody>
<tr>
<td><strong>Units (m)</strong></td>
<td>630</td>
<td>950</td>
<td>1210</td>
<td>1420</td>
<td>1550</td>
</tr>
<tr>
<td><strong>Growth</strong></td>
<td>50.8%</td>
<td>27.4%</td>
<td>17.4%</td>
<td>9.2%</td>
<td></td>
</tr>
</tbody>
</table>
Tablet Market Update

- PCs They Are NOT!!! It’s Not Cannibalisation Per Se
- Great For Many Things e.g. E-Mail, Photos, Videos & Web Surfing (Exactly What Most People Use Their Laptops/Smartphones For!)
- They Are NOT Good At ‘Road Warrior’ Stuff (Word Processing, Presentations & Spreadsheets)
- iPad Is Starting To Loose It’s ‘Must Have’ Kudos
- Kindle (Especially) & Galaxy Are Cool
- Still No Product Out There That Will Let Me Dump My Laptop!
- Market By Numbers (Units)

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</tr>
</thead>
<tbody>
<tr>
<td>Units (m)</td>
<td>155</td>
<td>240</td>
<td>290</td>
<td>345</td>
<td>400</td>
</tr>
<tr>
<td>Growth</td>
<td>54.8%</td>
<td>20.8%</td>
<td>19.0%</td>
<td>15.9%</td>
<td></td>
</tr>
</tbody>
</table>
Just A Few “Trillion Transistor” Applications

BRAIN-DERIVED COMPUTING
- Consistent concept for a non-von Neumann, non-Turing computer architecture
- Accessible to available technologies (CMOS) and attractive application for future component technologies (nanoelectronics)
- Key features: Universality, scalability, fault tolerance, power efficiency, speed, learning
- Accelerated operation: Only known approach to bridge all timescales relevant for circuit dynamics

A New Revolution: Into the Wild

University of Edinburgh
Wearable Electronics & Other IOT (IOB) Brouhaha

“$10 billion industry by 2016” ... In Your Dreams & Hype!!

“Breaker 1-9, This Here’s Rubber Duck ... Looks Like We’ve Got Us A Convoy”

- Sony "SmartBand" (LifeLog)" captures quantifiable information about your activities
- Netatmo "smart jewellery" monitors your skin's UV exposure and sends it to an app
- Wellograph smartwatch with a heart monitor that also tracks your movement
- Runphones sweatband which tracks performance when running
- Pebble Steel smartwatch with a multicoloured screen and metal surround
- Kolibree Bluetooth toothbrush that tells your phone how well you brush your teeth
- Bendable TVs with little practical application in a housing that is larger than a typical TV
- Internet fridges you can text to find out what you need to buy
- Washing machines you text to ask what they are you doing and how they’re getting on
- Ovens you can text to find out what you need for a recipe
- T-shirt that tracks your heartbeat
- Microsoft bra that tells you if you are eating too much
- Google Contact Lenses That Measure Your Glucose Level
- Graphene Condoms ...
Outlook For 2015-18?

If 2014 Recovery Holds 2015 Will See 18% Minimum Growth

Economy Can Still Derail (Delay) Things, Lot’s Of ‘Stuff’ Unresolved
Sharp Market Recovery When Economic Confidence Recovers
Chip Market Will Explode ... A Coiled Spring Waiting To Unravel
No Slack In The Global Semiconductor Ecosystem Anywhere
The Boom, When It Happens, Will Take ‘2 Years’ To Unwind
Even Cap Ex Is Finally Beginning To Rise

This Means Net New Capacity Starting 3Q-2014

Source: SEMI/Future Horizons
Makimoto’s Wave … What’s Next?

This Could Solve Intel’s (& 450mm’s) Current Dilemma

Source: Dr Tsugio Makimoto
Long Term Outlook ... Hang On In There !!!

“The Semiconductor Business Can Be Hazardous To Your Health”

But If You Wanted An Easy Life You Wouldn’t Be In The Semiconductor Industry, Would You 😊

Thank You

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Affiliates In Europe, India, Israel, Japan, Russia & USA

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