FOUNDORY-DRIVEN INNOVATION IN THE MOBILITY ERA

AJIT MANOCHA, CEO, GLOBALFOUNDRIES
First, a quick poll...

What is the biggest challenge facing our industry today?

A. Technology (141672)
B. Talent (141689)
C. Economic (141752)

Text your response to 22333 now
Agenda

- The Impact of Mobile Era
- Technology Challenges
- Economic Realities
- Evolving the Business Model
- Foundry 2.0℠ at Work
Agenda

The Impact of Mobile Era
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The Mobile Impact on Silicon Consumption

IC Market for PCs vs. Cellphones

PC and Cellphone IC Markets ($B)

$120

$118.9B
$102.0B

$77.6B

$70

$64.7B

$62.2B

$35.9B

$0

08 09 10 11 12 13F 14F 15F 16F

STANDARD PC ICs

TABLET & OTHER PC ICs

Cellphone ICs

Source: IC Insights
Mobile Drives New Requirements: Power, Performance and Features

- Higher data rates
- High resolution screens
- Multicore processors
- Thinner form factors

The Convergence is Here

- Communication
- Computing
- Consumer
- Navigation
- Imaging
- Video

Performance*

Power

Area

A4
A5
A5X
# Mobile Device System-Level Integration Requirements Driving Advanced Technology

<table>
<thead>
<tr>
<th>Devices</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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<tr>
<td>Application Processor</td>
<td>45NM</td>
<td>45NM</td>
<td>28nm</td>
<td>28nm</td>
<td>&lt;=20nm</td>
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<tr>
<td>(Dual Core)</td>
<td>(Dual</td>
<td>(Quad</td>
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<td>Baseband Processor</td>
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<td>(Dual</td>
<td>(Quad</td>
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<td>BT/FM</td>
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<td>15nm</td>
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<td>RF / Transceiver</td>
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<td>NAND Flash</td>
<td></td>
<td>19nm</td>
<td>15nm</td>
<td>13nm</td>
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<tr>
<td>Audio / Video Codec</td>
<td>180nm</td>
<td>130nm</td>
<td>130nm</td>
<td>90nm</td>
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<td>Power Management IC</td>
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<td>Noise Cancellation IC</td>
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<td>90nm</td>
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<td>Touchscreen Controller</td>
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<td>Gesture Recognition</td>
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<td>e-Compass / e-Gyroscope</td>
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<td>Total Devices</td>
<td>8</td>
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<td>9</td>
<td>7</td>
<td>5</td>
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</tbody>
</table>

SOURCE: Gartner
Cost of Ownership Driving New Dynamics
(For high-volume manufacturers...>50K wpm)

SOURCE: Handel Jones, IBS Consulting
Agenda

The Impact of Mobile Era
Technology Challenges
Economic Realities
Evolving the Business Model
Foundry 2.0℠ at Work
The “Big Five” Challenges

Device Architectures/Materials
- FDSOI
- FinFETs
- NanoWires
- III-V

Litho/EUV
- Cost
- Multi-pattern immersion
- EUV Source power
- Tool availability

Packaging
- ‘Normal economics’ are dead
- Value proposition shifting toward PPC
- Alternative scaling opportunities (2.5/3D)

450mm
- Pilot lines and HVM timing driven by 193i and EUV lithography
- G450C

COST – Time to Everything, Moore’s Law, SCM Security, Talent, IP Security
Range of Application Optimized Technology Solutions

### Speed @ ISO Power*

- **28HPP**: +17%
- **28LPP**: +27%
- **28SLP/HPP**: +53%
- **28LPS**: +58%
- **20LPM**: +20%

### Power @ ISO Speed*

- **28LPS**: -60%
- **28SLP**: -56%
- **28LPH**: -40%
- **28HPP**: -32%
- **20LPM**: -38%

### Area Reduction

- **28LPS/LPH**: -50%
- **28SLP/HPP** (smaller 28nm area with more competitive gate first DR): -45%
- **20LPM**: -38%

*Based on RO1 benchmark circuit simulation results*
14XM FinFET – Total Solution

- Full Suite PDK
- Power and Performance Optimized CPU Solutions
- Mobile SoC Platform
- Multicore GPU Solutions
- High Performance Platform
- 2.5D and 3D Packaging

“Other companies will follow GLOBALFOUNDRIES’ lead. I expect everyone to do it.”

Dr. Chemning Hu, Wall Street Journal interview
The “Big Five” Challenges

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Cost – Time to Everything, Moore’s Law, SCM Security, Talent, IP Security
At advanced nodes, Litho starts to dominate the wafer cost.

Source: IMEC, GLOBALFOUNDRIES
Is EUV Ready for 10nm?
The “Big Five” Challenges

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Packaging Will Evolve to New Dimensions

Silicon Partitioning with Interposers
Market: FPGA
2011

Memory Cube
Market: Server and Computing
2013

Logic + Memory on Interposer
Market: GPU, CPU, Network Processors
2013-14

Wide I/O Memory on Apps Processor
Market: Mobile, Tablet
2014

Heterogeneous Stacking
Market: Mobile, CPU
2017?
Agenda

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Advanced Technologies
Driving Complexity / Cost

Mask Layer Growth
Per Technology Node

180nm
130nm
65nm
28nm
20/14nm

Technology Node
Technology Complexity Makes Equipment a Greater Proportion of Overall Fab Costs

**Breakdown of Equipment Costs**

- Lithography: 30%
- Etch: 20%
- PVD: 15%
- CVD: 10%
- Metrology: 10%
- Implant: 5%
- CMP: 5%
- Diffusion: 5%

**Historical Breakdown of Fab Costs**

- 90nm: Facilities 70%, Equipment 30%
- 65nm: Facilities 70%, Equipment 30%
- 45nm: Facilities 75%, Equipment 25%
- 32nm: Facilities 80%, Equipment 20%
- 20nm: Facilities 85%, Equipment 15%

*Source: VLSI*
Advanced Technology Costs are Rapidly Escalating…

- **Fab Cost**
  - 130nm: 1,450
  - 90nm: 2,000
  - 65nm: 2,500
  - 40nm: 4,000
  - 28nm: 4,850
  - 20/14nm: 6,700

- **Process Development Cost**
  - 130nm: 250
  - 90nm: 310
  - 65nm: 400
  - 40nm: 600
  - 28nm: 900
  - 20/14nm: 1,300

- **Chip Design Cost**
  - 130nm: 15
  - 90nm: 24
  - 65nm: 34
  - 40nm: 60
  - 28nm: 100
  - 20/14nm: 150
Cost of Building a New Leading Edge Fab is Rapidly Escalating

Rising capital costs are increasing investment risk

SOURCE: World Fab Watch/GLOBALFOUNDRIES
Agenda

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Evolution of Foundry Model

1990
Foundry 1.0
Customer-funded contract manufacturing
No transparency needed
Fab cost-savings focus

2000
Foundry 1.0
Wafer price competition
Less transparency
Technology challenges
Transaction focus
Zero-sum orientation

Today
Foundry 2.0℠
Virtual IDM
Partnering for success
Product/Market collaboration
Time to Everything

Source: VLSI Technology Research
Why the Traditional Model No Longer Works

**IDM and Foundry 1.0 Model Will No Longer Work**

- Slower rate of change
- Solutions optimized to one product
- Systems and methods become inflexible
- Best solutions rarely originate from insulated team

- Not tapping global R&D talent
- Lack of flexibility and transparency
- Single source supply adding geographical risks
- Lack of collaborative innovation
It Takes an Ecosystem

- System Company
- O/S Provider
- Embedded Software
- Fab-Lite Company
- Fabless IC Company
- Foundry
- EDA tools
- SoC Subsystem
- Assembly and Test
- IP cores
Engaging early, deeply, openly, and comprehensively

Collaborative Innovation

Tapping global talent

Jointly develop new technologies and manufacturing solutions

Focused on shared success

Time to Everything!
Agenda

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GLOBALFOUNDRIES and ARM enable early POP IP in 28SLP for Cortex-A12
Artisan® Core-optimized Physical IP
ARM Implementation Knowledge
ARM Certified Benchmarking

ARM’s Cortex-A12 architecture, POP IP combined with GLOBALFOUNDRIES 28SLP process projected to yield significant improvement over Cortex-A9 in 40LP:

1.7X higher performance
1.5X – 2X better power efficiency
Similar area and leakage.
Foundry 2.0@Work: Enabling a New Approach to Collaborative Development

Technology Development Center

$2B investment in collaborative space to help close the gap between lab and fab

Located on Fab 8 campus in Saratoga County, NY

Strengthens R&D ecosystem from mask to silicon to packaging
Foundry 2.0@Work: Pushing the Leading-Edge… And Accelerating the Process Roadmap

- **2003**: Single CESL
- **2005**: 130nm, 90nm
- **2007**: 65nm
- **2009**: 45/40nm
- **2011**: 32SOI
- **2013**: 28nm
- **2015**: 20nm
- **2017**: 7nm

**Production**
- DSL Stressors In Production
- <100> Wafer Orientation For Low Cost Enhancement
- HKMG For Leakage Reduction

**Development**
- Esige For PFET Enhancement
- Fully depleted device
- In collaboration with ST

**Path-Finding**
- TPEN
- Ge
- InP
Foundry 2.0@Work: 10nm Development Model
The Future Today…Enabled by Collaboration

Lab to Fab
- CNSE
- JDA
- IMEC
- SRC
-IME

Ecosystem Collaboration
- Embedded
- Memory
- 3D-IC
- EDA

Shared Tooling, Common Evaluations
- Litho / EUV
- Etch
- Metrology

Process Integration / Characterization
- PDF
- Intermolecular
Rockchip’s RK3188 and RK3168 next generation mobile processors

China’s 1st 28nm HKMG Multicore tablet SoCs in production

Delivers high performance AND low power

ARM Cortex-9 based

Manufactured exclusively by GLOBALFOUNDRIES

Early close collaboration between design and process technology teams

1.8 GHz performance and ultra-low leakage

28SLP HKMG process

"This partnership is a true demonstration of GLOBALFOUNDRIES’ unique approach to Collaborative Device Manufacturing. Rockchip is fortunate to have a partner like GLOBALFOUNDRIES."

Chen Feng, Rockchip Executive
Addressing Technology, Talent and Economic Challenges...Were you correct?

Supply Chain Challenges

Operational Excellence

Supply Continuity / Global Footprint

FOUNDRY 2.0
Fully Optimized for Mobile Era
Time to Everything!

Open Fab Concept / Collaboration

IP Security

Technology and Innovation Leadership
Join the Elite on Today’s Playing Field

Device Architecture / Materials

450mm

Litho / EUV

Advanced Packaging

FOUNDRY 2.0

Time to Everything!

Challenge your teams to play in the big leagues of Foundry 2.0