A perspective on the increasingly dynamic semiconductor ecosystem

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March 19, 2014

MEPTEC Luncheon series, Mar 2014
Agenda

- ASE brief
- Market Landscape
- New Dynamics
- SiP
- Summary
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Brief Backgrounder

- Established 1984, production commenced at flagship factory in Kaohsiung, Taiwan.
- Achieved global market leadership in 2004, surpassing all players in OSAT industry.
- Operations now at 12 facilities worldwide, serving multiple markets, applications, & geographies.
- >50K employees: Global team comprises operations, engineering, R&D, sales, & marketing.
- ASE Group overall revenue of $7.4B in 2013, 13% over 2012. ATM* overall revenue of $4.8B in 2013, 10% over 2012.

ATM*: Assembly, Test, Material

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Semiconductor Market Landscape
Global Economy Status
<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
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<tbody>
<tr>
<td>US</td>
<td>2.3%</td>
<td>3.0%</td>
<td>3.2%</td>
<td>2.8%</td>
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<tr>
<td>CN</td>
<td>7.7%</td>
<td>7.5%</td>
<td>7.3%</td>
<td>7.0%</td>
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<tr>
<td>EU</td>
<td>0.1%</td>
<td>1.5%</td>
<td>2.0%</td>
<td></td>
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<tr>
<td>JP</td>
<td>2.7%</td>
<td>1.5%</td>
<td>1.5%</td>
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</tbody>
</table>

Sources:
- 2013/12/18 Federal Reserve (FOMC Meeting Minutes)
- 2014/01/14 IMF World Economic Outlook Databases (WEO)
- 2014/02/25 European Commission (European Economic Forecasts)
- 2013/11/01 Bank of Japan (Outlook for Economic Activity and Prices)

Dow Jones 16422 +1.50% since last report
Gold Price (oz.) 1349 +0.75% since last report
Silver Price (oz.) 21.5 -1.24% since last report
Copper Price (tonne) 7054 -1.07% since last report (LME)
SEMI: A Cyclical Business

Source: SEMI 2013 + Gartner, November 2013
2013 Forecast Contribution

Source: Gartner, October 2013

Share of Dollar Growth

- Smartphone: 67%
- SSD: 28%
- Media Tablet: 17%
- Server: 11%
- LCD TV: 7%
- Automotive: 7%
- Game Consoles: 5%
- PC: -6%
- Other: -36%
Applications Driving Growth Through 2017

Source: Gartner, November 2013

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New Dynamics
New Dynamics

- Consolidation at a global scale
- Moore’s Law
- New markets must be explored and developed
Value Chain Consolidation
Creating Differentiation

IC driven system differentiation

System driven software / service differentiation

Design IP Developer
Semiconductor supplier
System OEM
Software / Service
User

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2013 Semi Industry M&A Activity

- 2013 transactions totaled $19.8 billion, an increase of 48% YoY.

<table>
<thead>
<tr>
<th>Date</th>
<th>Acquirer/Merger</th>
<th>Public/Private</th>
<th>Acquired/Merged</th>
<th>Public/Private</th>
<th>Amount ($US, $M)</th>
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<tbody>
<tr>
<td>Sep-13</td>
<td>Applied Materials Inc.</td>
<td>Public</td>
<td>Tokyo Electron Ltd.</td>
<td>Public</td>
<td>$7,000.0</td>
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<tr>
<td>Dec-13</td>
<td>Avago Technologies</td>
<td>Public</td>
<td>LSI Corporation</td>
<td>Public</td>
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<tr>
<td>Jul-13</td>
<td>Tsinghua Unigroup Ltd.</td>
<td>Private</td>
<td>Spreadtrum Communications Inc.</td>
<td>Public</td>
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<tr>
<td>Nov-13</td>
<td>Tsinghua Unigroup Ltd.</td>
<td>Private</td>
<td>RDA Microelectronics</td>
<td>Public</td>
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<tr>
<td>Aug-13</td>
<td>Maxim Integrated Products Inc.</td>
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<td>Volterra Semiconductor Corporation</td>
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<td>Apr-13</td>
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<td>CyOptics Inc.</td>
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<td>Mar-13</td>
<td>Cadence Design Systems</td>
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<td>Tensilica Inc.</td>
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<td>Nov-13</td>
<td>Apple Inc.</td>
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<td>PrimeSense</td>
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<td>Aug-13</td>
<td>Samsung Group (Cheil Industries Inc.)</td>
<td>Public</td>
<td>Novaled AG</td>
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<td>Jul-13</td>
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<td>Public</td>
<td>iWatt Inc.</td>
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</table>

Includes M&As that involve fabless companies, IDMs, and semi suppliers. Fabless companies and IDMs are in bold. The M&As above were recorded when the companies involved announced a plan to merge/acquire or entered into a definitive agreement, therefore, some M&As may still be pending.

Source: GSA
Changing Landscape - Industry Consolidation

TOP 5 IDMs in 2000: 12%
Share of worldwide installed capacity (without Discrettes)
- Samsung: 3%
- Renesas: 2%
- Hynix: 1%
- Intel: 1%
- Texas Instr: 1%
- Rest of IDMs: 88%

TOP 5 IDMs in 2014: 62%
Share of worldwide installed capacity (without Discrettes)
- Samsung: 19%
- Micron+: 12%
- Toshiba+JV: 12%
- Hynix: 10%
- Intel: 6%

Top 4 Foundries in 2000: 43%
Share of worldwide installed Foundry capacity (without Discrettes)
- UMC: 16%
- TSMC: 16%
- Chartered alone: 8%
- Vanguard: 3%
- Rest of Foundries: 57%

Top 4 Foundries in 2014: 57%
Share of worldwide installed Foundry capacity (without Discrettes)
- UMC: 28%
- TSMC: 28%
- Globalfoundries: 12%
- Samsung: 12%
- Rest of Foundries: 7%

Numbers may not add up due to rounding
Moore’s Law

- Performance
- Costs are skyrocketing
- Fewer companies
- Fewer products
Cost of Scaling is too high

Minimum Lifetime revenue Requirements for SoC

- Requires multi-$B lifetime revenue to be economically feasible per design
- Have to have other solutions

Source: Gartner, November 2013
Volume Paradigm: 10X in 10Y, Accelerating

- **1970s**
  - **Aerospace**
    - Thousands Units

- **1980s**
  - **Mainframe**
    - Millions Units

- **1990s**
  - **PC (PM)**
    - 350M+ Units

- **2000s**
  - **Cell Phone (PP)**
    - 1.8B+ Units

- **2010s**
  - **Smart Computing (PMP)**
    - 10B+ Units
  - **Internet of Things (PMMP)**
    - 100B+ Units

**Long Tail**

We are here

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Trend of Miniaturization

<table>
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<tr>
<th>Scale</th>
<th>$10^{-2}$ meter</th>
<th>$10^{-3}$ meter</th>
<th>$10^{-6}$ meter</th>
<th>$10^{-9}$ meter</th>
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</thead>
<tbody>
<tr>
<td>Example</td>
<td>Fingertip</td>
<td>Pencil Tip</td>
<td>Bacterium</td>
<td>Molecule</td>
</tr>
</tbody>
</table>
SiP
What is System in Package (SiP) ?

SiP is a module package that contains an **electronic system or sub-system** and is **miniaturized** through **IC assembly technologies**.
System Integration – SiP

**OSAT**
- Semiconductor-grade control and R&D

**EMS**
- System design and logistics

**OSAT Profile**
- Value-add & Investment
- Profitability

**EMS Profile**
- Value-add & Investment
- Profitability

**Emerging Business**
- Strong Synergy
- Revenue + Profitability
SiP Applications

- Touch
- Sensor
- Wireless
- Storage
- Power Management
- Camera Module
- RF Front End
- Lighting

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SiP Applications

Touch Controller
Display Driver
Proximity/Finger Print Sensors

Motion Sensors
Micro-controller
Environmental Sensors

WIFI, GPS, BT module
Passive components/IPD
RF Front End Components

Flash Memory
Controller
Passive/SMD Device

Power Management IC
Passive/IPD
Analog IC

CMOS Image Sensor
Image Processor
Gyroscope

Touch
Sensor
Wireless

Storage
Power Management
Camera Module

PA Module
Filter/Tuner/Switch Controller

LED
LED Driver/Dimming Controller
Proximity Sensors/IPD

RF Front End
Lighting

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SiP Module Capability Requirements

- Wafer Grinding
- High Density SMT
- Bumping / Wafer level
- Flip-Chip or W/B
- 3D Die stacking
- Molding
- Saw Singulation

- EVB & Socket Design
  - Design Qualification
  - RF Circuit Design

- Debugging & RF Tuning
  - Simulation
  - Packaging Design

- Design Support

- Assembly

- Testing

- SiP Module
  - Substrate Carrier
    - Substrate Layout Design
    - In-house Laminate Substrate
    - Coreless Substrate

- Adv. SiP Technologies
  - Embedded Passives
    - Embedded Active
  - IPD
  - AoP

- EMI Shielding
  - Metal Lid
  - Conformal Shielding
  - Compartment Shielding
EMI Shielding Solutions

**Dimension**
- Large
- Small

**Cost**
- High
- Low

**Board Level**
- Stamped Metal Shield
- Conductive Coating on plastic housing

**Package Level**
- Metal Shield
- Half-Cut Conformal Shielding
- Full-Cut Conformal Shielding

Other advantages of Package-level shielding solution:
- Performance: More predictable and less influenced by external components
- Design Cycle: Reduce cycle time by eliminating retuning process
- Production: Reduce manufacturing steps

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SiP Challenges

- System Integration of heterogeneous components
- Process and Material Development
- More complex logistics and supply chain ecosystems

Source: ITRS, 2012
2.5D/3D ICs Assembly Implementation

C2C/C2W Bonding
- Thermo-compression bonding
- High precision TC bonding (2um, 12” wafer)

Micro bumps (C2C/C2W)
- Cu pillar/Cu post (40um pitch)
- Micro solder bump (60um height)

Thin Wafer Handling
- 40um chip-to-substrate (Qualified)

Encapsulation
- CUF (10um~25um gap)
- NCP
- NCF

Bump pitch (chip-to-substrate)
- Cu pillar bump – 80um/40um
- Solder bump – 150um

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2.5D IC Ecosystem Models

- Foundry IC → Interposer fab → OSAT MEOL+ASSY
- Foundry IC + Interposer → OSAT MEOL+ASSY
- Foundry IC → Interposer fab → OSAT ASSY
- Foundry IC + Interposer w/MEOL → OSAT ASSY
- IDM / Foundry Captive Turnkey
- **MOST OR ALL FLOWS WILL LIKELY DEPLOY**

![Diagram of 2.5D IC ecosystem models](image-url)

- Logic IC
- Interposer Fab with via formation
- MEOL
- CoW / CoC Assembly
- Final Test
- Memory
- Analog
- Sensors

All components specified by product owner

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Summary
Summary

- Semiconductor outlook – low growth with continued volatility and higher risk
- Consolidation and economics of Moore’s Law is significantly impacting ecosystem
- SiP now, more than ever, provides a viable alternative to SoC for enabling optimization of system cost, performance, size, and fast time-to-market
- Robust technology/service portfolio, investment power and business model flexibility will be key for future success
Thank You

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