Semiconductors  
Moore Stress 2.0 – Follow the Money

Key Takeaway
Over the past 10 yrs, Moore’s Law drove profitability to semis from customers and suppliers. Over the next 5 yrs, we believe the stalling transistor cost curve reverses that trend. We expect 1) more vertical integration by customers 2) pricing power by suppliers, and 3) emergence of a low GM business model in semis. We expect a downward bias on growth and margins for semis broadly, but view AMAT, LRCX, INTC, Samsung and AMD as beneficiaries of these trends.

Moore Stress 2.0: In our original Moore Stress note (Sep-'12), we argued that the inflecting transistor cost curve would structurally change the semiconductor industry. In this note we introduce Moore Stress 2.0, and argue that the inflection structurally changes the supply chain as well.

Follow the Money: The rapid pace of technology change in semis described by Moore’s Law has caused both consolidation and a concentration of supply chain power within semis. Consequently, over the past 10 years, EBIT margins for semis have increased to 20%-30% (S&P500 top quintile), while those of its customers and suppliers declined. We think that a deceleration in the transistor cost curve will drive a mean reversion process on those 10-yr EBIT trends that manifests on three dimensions:

1) Customer Vertical Integration: We think a slower transistor cost curve levels the playing field between semiconductor companies and their customers. The internal design teams, and the companies they outsource design work to, have more time to optimize a design using older transistor technology for maximum economic benefit. Apple and Huawei are just two examples of traditional semiconductor customers that are increasingly designing their own chips - we expect to see more.

2) Supplier Pricing Power: We think two things give suppliers pricing power going forward: A) Consolidation: Semi-Cap and EDA companies have consolidated at a faster rate than their customers over the past several years; B) More Value: as it becomes more difficult to climb down the transistor cost curve at historical rates, improvements in supplier products will be considered higher value-add and command higher prices.

3) Lower Gross Margin Business Model: A decelerating transistor cost curve means longer time at a given transistor node, and more time for fast (or slow) followers to develop and amortize development for IP blocks. We think AMD’s semi-custom business model offers a glimpse of what device makers may be up against: gross margins of 25%-30%, customer funded R&D in the form of NREs (non-recurring engineering), nominal inventory risk, and operating margins in the 15%-to-20% range.

Moore Stress 2.0 Beneficiaries: We think suppliers like AMAT and LRCX are poised to benefit from these trends and initiate coverage with a Buy on those stocks concurrent with this note. We continue to believe scale is critical for IDMs to stay on the historical Moore’s Law Transistor cost curve, and view INTC and Samsung as long-term beneficiaries, as their competitors drop off. Finally, we think AMD’s new business model and its unique position as a holder of intellectual property around x86, ARM, Graphics and server fabric technology, position it to benefit from these emerging dynamics.

Moore Stress 2.0 Challenged: We view high-margin, leading edge fabless companies as being potentially challenged by these dynamics, and are incrementally cautious on ALTR, XLRN and NVDA.

Links to Related Reports:
Moore Stress = Structural Industry Shift
Moore Stress - One Year Anniversary Compendium
Moore Stress 2.0: Equipment Supplier Leverage - Initiating Coverage
Moore Stress 2.0: Follow the Money

Moore Stress is Real and Investable. In our original Moore Stress note (Sep ‘12), we argued that the transistor cost curve inflection would structurally change the semiconductor industry. Since that note, MU is up 300%, a memory stock started paying a dividend (SNDK: August, 2013) and Altera shifted its sourcing of leading edge chips to Intel from TSMC. In Moore Stress 2.0, we argue that the inflection structurally changes the supply chain as well.

As Barbie may have said...“Semis are Tough!” Designing chips using the latest, leading edge transistors is not just extremely difficult to do, it is expensive too. IBS estimates that in 2004, it cost about $20 million to design an integrated circuit (IC) using 90nm transistors – that cost has skyrocketed to $170m to design an IC on 20nm transistors today. On the manufacturing side, it can cost upwards of $10 billion and three years to build a new leading edge semiconductor manufacturing facility.

Higher Costs Have Driven Semiconductor Consolidation. Importantly, the semiconductor industry has consolidated at a faster pace than its customers and suppliers, and therefore gained relative power in the supply chain. We think that this increased power shows up in their profitability (EBIT). Over the past 10 years, profitability of semiconductor companies has increased, and profitability of their customers and suppliers has decreased (Charts 3 and 4). Many semiconductor companies have EBIT margins in the 20%-to-30% range, putting them in the top quintile of the S&P500.

Follow the Money. The juicy semiconductor EBIT margins have always been a target for semiconductor customers and suppliers. We think that the inflecting transistor cost curve starts a mean reversion process on those 10-year EBIT trends that manifests on three dimensions:

1) Customer Vertical Integration: We think a slower transistor cost curve levels the playing field between leading edge companies and their customers. If the economic benefit of moving to the next smaller transistor is not as obvious, then why pay semiconductor companies a high margin to do it? The internal design teams at OEMs have more time to optimize an N-1 design for maximum economic benefit. Apple and Huawei are examples of traditional semiconductor customers that are now designing their own chips; we expect to see more (Charts 7 and 8).

2) Supplier Pricing Power: We think two things give suppliers pricing power going forward: A) Consolidation: Semi-Cap and EDA companies have consolidated at a faster rate than their customers over the past several years; B) More Value: as it becomes more difficult to climb down the transistor cost curve at historical rates, improvements in supplier products will be considered higher value-add and command higher prices. The mean reversion process has already started at EDA companies; we think Semiconductor Capital Equipment companies are next.

3) Lower Gross Margin Business Model: A decelerating transistor cost curve means longer time at a given transistor node, and more time for fast (or even slow) followers to develop and amortize IP blocks for different semiconductor manufacturing processes. We think AMD’s semi-custom business model offers a glimpse of what device makers may be up against: gross margins of 25%-30%, customer funded R&D in the form of NREs (non-recurring engineering), nominal inventory risk, and operating margins in the 15%-to-20% range.

Moore Stress 2.0 Beneficiaries: We think suppliers like AMAT and LRCX are best poised to benefit from these trends, and in conjunction with this note, we launch coverage with Buy ratings on both. We continue to believe scale is critical for IDMs to
stay on the historical Moore's Law Transistor cost curve, and view INTC and Samsung as long-term beneficiaries, as their competitors drop off. Finally, we think the power of AMD's new business model and its unique position as a holder of intellectual property around x86, ARM, Graphics and server fabric technology, position it to benefit from these emerging dynamics.

**Moore Stress 2.0 Challenged:** We view high-margin, leading edge fabless companies as being potentially challenged by these dynamics. We expect to see (and may already be seeing) slower growth associated with increased vertical integration by traditional semiconductor customers and increased price pressure as a new lower gross margin business model emerges to take advantage of the slower transistor cost curve. Below the top line, we expect higher R&D intensity as consolidation translates to increased pricing power by suppliers. We are incrementally cautious on ALTR, XLNX and NVDA.
Chart 1: Moore Stress and Moore Stress 2.0 Summary

Moore Stress (Impact on Semis)

- Slower transistor cost reductions = structural industry shift within Semis
- Slower memory supply growth means Memory stocks transition to investment vehicles from trading vehicles
- Slower growth from Leading Edge Fabless and Pure Play Foundry
- Higher growth from Analog Integrators
- Critical mass required to stay on transistor cost curve = Intel and Samsung benefit

Moore Stress 2.0 (Supply Chain)

Semiconductor Suppliers
- SPE EBIT declined over past 10 years
- Slower industry growth has lead to consolidation in EDA and Semi-Cap Equipment
- Moderating transistor cost curve makes EDA and Semi-Cap Equipment upgrades more valuable
- Expect increased pricing power and increased profitability for EDA and Semi-Cap industries

Foundries and Semi Device Makers
- EBIT increased over past 10 years
- Semis OM in top quintile of S&P 500
- Pricing pressure from suppliers = higher R&D intensity
- Vertical integration from customers = slower growth and GM pressure

Semiconductor Customers
- EBIT declined over past 10 years
- Slower transistor cost reductions levels playing field in circuit design
- Expect more vertical integration
- Higher volume chips designed by OEM's

Source: Jefferies
Chart 2: Changing Transistor Cost Curve = Changing Competitive Dynamics in the Supply Chain

Moore’s Law: Transistor Cost Curve 1965-2011

- Over the past 40 years, the number of transistors per chip doubled every 18 months, and the cost / transistor declined at a CAGR of 25-30%

- Leading edge semiconductor companies developed competencies around keeping up with the rapid pace of advancements in transistor technology, and integrating more functionality into chips

- In this environment, semis have extracted value from the supply chain. Semiconductor operating margins have increased over the past 10 years. The margins of many semiconductor device companies are in the 20-30% range, which is in the top quintile of the S&P 500

Moore Stress: Transistor Cost Curve 2012-Future

- Going forward, we think the transistor cost curve will not decline at the same historical rate, at least not broadly for all semiconductor device companies

- We think this will have a “leveling-the-playing-field” effect. Already we see evidence of traditional semiconductor customers vertically integrating into the semiconductor design

- At the same time consolidation at semiconductor companies has put downward pressure on margins and growth rates at their suppliers, which in turn has led to consolidation at EDA and cap equipment makers. We think these suppliers will see increased pricing power which will translate to an upward bias on R&D intensity at device makers

- We think this will necessarily put downward pressure on semiconductor growth rates, and profitability

Source: Jefferies, company data, IBS
Chart 3: Semiconductor 10-yr Review – Operating Margin Growth – Net Extractors of Value

- Semiconductor device component and Foundries have been net extractors of value from the supply chain
- Over the past 10 years, their operating margins have increased
- With operating margins in the 20%-to-30% range, many semiconductor companies are amongst the most profitable in the S&P500

Source: Jefferies, company data, (Leading Edge Fabless = NVDA, ALTR, XLNX), (Foundry = TSMC, SMIC, UMC), (Analog = TXN, MXIM, ADI, MCHP, LLTC)
Chart 4: Semiconductor Customer and Supplier 10-yr Review – Operating Margin Decline – Net Losers of Value

- At the same time that Semi-Device and Foundries have seen increasing profitability, their customers and suppliers have seen profitability decline
- Over the past 10 years, OEM and Cloud profitability has declined
- Semi-Cap Equipment margins have also declined over the past 10 years
- EDA margins declined up until 2008, but have rebounded after the industry consolidated

Source: Jefferies, company data, (Semi Cap = ASML, AMAT, LRCX, KLAC, TEL), (EDA = CDNS, SNPS, MENT), (OEM = DELL, HP, CSCO, ALU, ERIC), (Cloud = AMZN, GOOG, FB)
**Chart 5: Herfindahl Index for Semi-Cap Equipment Segments**

**Etch HHI**

- Concentrated: >25% (Less Competitive)
- Moderate: 15% to 25%
- Unconcentrated: <15% (More Competitive)

**Deposition HHI**

- Concentrated: >25% (Less Competitive)
- Moderate: 15% to 25%
- Unconcentrated: <15% (More Competitive)

Looking forward, we think combination of:

1) Consolidation
2) Moore Stress
3) Increasing Foundry Competition

will translate to pricing power for Semi-Cap Equipment players...
...and increasing R&D expenses for semis

*Source: Jefferies, company data, Gartner*
Chart 6: Acquisition and Op Margins for EDA Companies

- We think Semi Cap profitability will follow consolidation similar to EDA names

Source: Jefferies, company data, (EDA = CDNS, SNPS, MENT)
Chart 7: Vertical Integration by Semiconductor Customers

- Cisco, ALU, design their own ASICs
- Apple designed its AP, potentially baseband modem
- Huawei reclaimed high volume sockets with internal ASICs from ALTR
- AMD designed semi-custom chips for game consoles from MSFT and Sony
- Amazon hired Caldexa ARM server chip engineers

- We think a slower transistor cost curve is having a “leveling-the-playing-field” effect between Semi companies and some of their customers
- Already we are seeing examples of vertical integration by customers of Semiconductor companies
- We expect more Semiconductor companies to embrace the AMD semi-custom chip design model: Semi-Custom ASIC Design, gross margins of 25-35%, low R&D expense as R&D is funded by customers, low inventory risk, operating margins in the 15-20% range

Source: Jefferies, company data
### Chart 8: Data Points on OEMs Moving to Chip Design (click underlined text for link to article)

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<tr>
<th>OEM</th>
<th>Key Actions/Designs</th>
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<tr>
<td><strong>Microsoft &amp; Sony</strong></td>
<td>• Engaged AMD to design custom chips for Xbox One and PS4</td>
<td>Moor Insights: The Real Reasons Microsoft, Sony Chose AMD For The Xbox One And PS4</td>
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| **Apple** | • Acquired SoC designer PA Semi (April 2008)  
• Acquired core accelerator chip designer Intrinsity (April 2010) | Wired: Four Reasons Apple Bought PA Semi  
The New York Times: Apple Buys Intrinsity, a Maker of Fast Chips |
| **Amazon** | • Hired former Calxeda engineers  
• Posted job openings for CPU Architects (April 2014) | GigaOm: Amazon joins other web giants trying to design its own chips |
| **Google** | • Acquired Agnilux (April 2010)  
• Designed data center switches | Ars Technica: Google Buys Secret Chip Startup  
Wired: Mystery Google Device Appears in Small-Town Iowa |
| **Huawei** | • Huawei’s internal ASIC design team, HiSilicon, licensed ARM (2011)  
• Captured high-volume design wins from Altera (2H12) | ARM: HiSilicon Licenses ARM Technology for use in Innovative 3G/4G Base Station, Networking Infrastructure and Mobile Computing Applications  
eetimes: Huawei Using ASICs for First Time |
| **Facebook** | • Collaborates with Intel on server chip designs | Wired: The Facebook Special: How Intel Builds Custom Chips for Giants of the Web |
| **ZTE** | • Licenses CEVA DSP cores in internal ASIC designs | eetimes: Ceva-ZTE Deal Hints Home-Grown ASIC Is Back |
| **Cisco** | • Large internal team engaged in ASIC design | Seeking Alpha: Cisco announces new network processor, EZchip tumbles |
| **Alcatel-Lucent** | • Also has an internal ASIC design team | Itweb: Alcatel-Lucent Enterprise to address network application challenge with new access switch, added analytics, SDN capabilities |

*Source: Jefferies, company data, media reports*
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*Covered by Mark Lipacis  **Covered by Sundeep Bajikar

Source: Jefferies, company data

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Underperform - Describes stocks that we expect to provide a total negative return (price appreciation plus yield) of 10% or more within a 12-month period.

The expected total return (price appreciation plus yield) for Buy rated stocks with an average stock price consistently below $10 is 20% or more within a 12-month period as these companies are typically more volatile than the overall stock market. For Hold rated stocks with an average stock price consistently below $10, the expected total return (price appreciation plus yield) is plus or minus 20% within a 12-month period. For Underperform rated stocks with an average stock price consistently below $10, the expected total return (price appreciation plus yield) is minus 20% within a 12-month period.

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CS - Coverage Suspended. Jefferies has suspended coverage of this company.

NC - Not covered. Jefferies does not cover this company.

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Jefferies Franchise Picks include stock selections from among the best stock ideas from our equity analysts over a 12 month period. Stock selection is based on fundamental analysis and may take into account other factors such as analyst conviction, differentiated analysis, a favorable risk/reward ratio and investment themes that Jefferies analysts are recommending. Jefferies Franchise Picks will include only Buy rated stocks and the number can vary depending on analyst recommendations for inclusion. Stocks will be added as new opportunities arise and removed when the reason for inclusion changes, the stock has met its desired return, if it is no longer rated Buy and/or if it underperforms the S&P 500 by 15% or more since inclusion. Franchise Picks are not intended to represent a recommended portfolio of stocks and is not sector based, but we may note where we believe a Pick falls within an investment style such as growth or value.
Risk which may impede the achievement of our Price Target

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Other Companies Mentioned in This Report

- Advanced Micro Devices, Inc. (AMD: $3.97, BUY)
- Altera Corp (ALTR: $33.11, HOLD)
- Analog Devices, Inc. (ADI: $52.37, BUY)
- Applied Materials, Inc. (AMAT: $20.52, BUY)
- Avago Technologies (AVGO: $71.64, HOLD)
- Broadcom Corporation (BRCM: $34.84, BUY)
- Cavium Inc. (CAVM: $48.41, BUY)
- EZchip Semiconductor Ltd. (EZCH: $24.57, HOLD)
- Inphi Corporation (IPHI: $14.93, BUY)
- Intel Corporation (INTC: $27.26, BUY)
- KLA-Tencor Corporation (KLAC: $65.58, HOLD)
- LAM Research Corporation (LRCX: $62.31, BUY)
- Lattice Semiconductor Corporation (LSCC: $7.77, BUY)
- Linear Technology (LLTC: $45.99, BUY)
- M/A-COM Technology Solutions Holdings, Inc. (MTSI: $18.63, BUY)
- Marvell Technology Group Ltd. (MRVL: $15.92, HOLD)
- Maxim Integrated Products, Inc. (MXIM: $34.20, BUY)
- Microchip Technology Inc. (MCHP: $47.25, BUY)
- Micron Technology, Inc. (MU: $28.66, BUY)
- NVIDIA Corporation (NVDA: $18.94, HOLD)
- NXP Semiconductors NV (NXPI: $62.40, BUY)
- ON Semiconductor Corporation (ON: $8.66, HOLD)
- PMC-Sierra, Inc. (PMCS: $7.01, HOLD)
- Rambus, Inc. (RMBS: $11.77, HOLD)
- Samsung Electronics Co. Ltd. (005930 KS: KRW1,470,000, BUY)
- SanDisk Corporation (SNDK: $97.15, BUY)
- Spansion, Inc. (CODE: $19.80, HOLD)
- Texas Instruments Incorporated (TXN: $46.99, BUY)
- Xilinx Corp (XLNX: $46.37, HOLD)

Distribution of Ratings

<table>
<thead>
<tr>
<th>Rating</th>
<th>Count</th>
<th>Percent</th>
<th>IB Serv./Past 12 Mos.</th>
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<tbody>
<tr>
<td>BUY</td>
<td>900</td>
<td>50.48%</td>
<td>241</td>
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<tr>
<td>HOLD</td>
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<tr>
<td>UNDERPERFORM</td>
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<td>8.02%</td>
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</tbody>
</table>

Mark Lipacis, Equity Analyst, (415) 229-1438, mlipacis@jefferies.com
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