

Opportunities to Move Up the Value Chain... an OSAT Perspective

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Overview

- Industry Dynamics and Opportunity
- ASE Overview
- Key Trends
- Growth Opportunities
- Enabling Factors
- Summary

Industry Dynamics

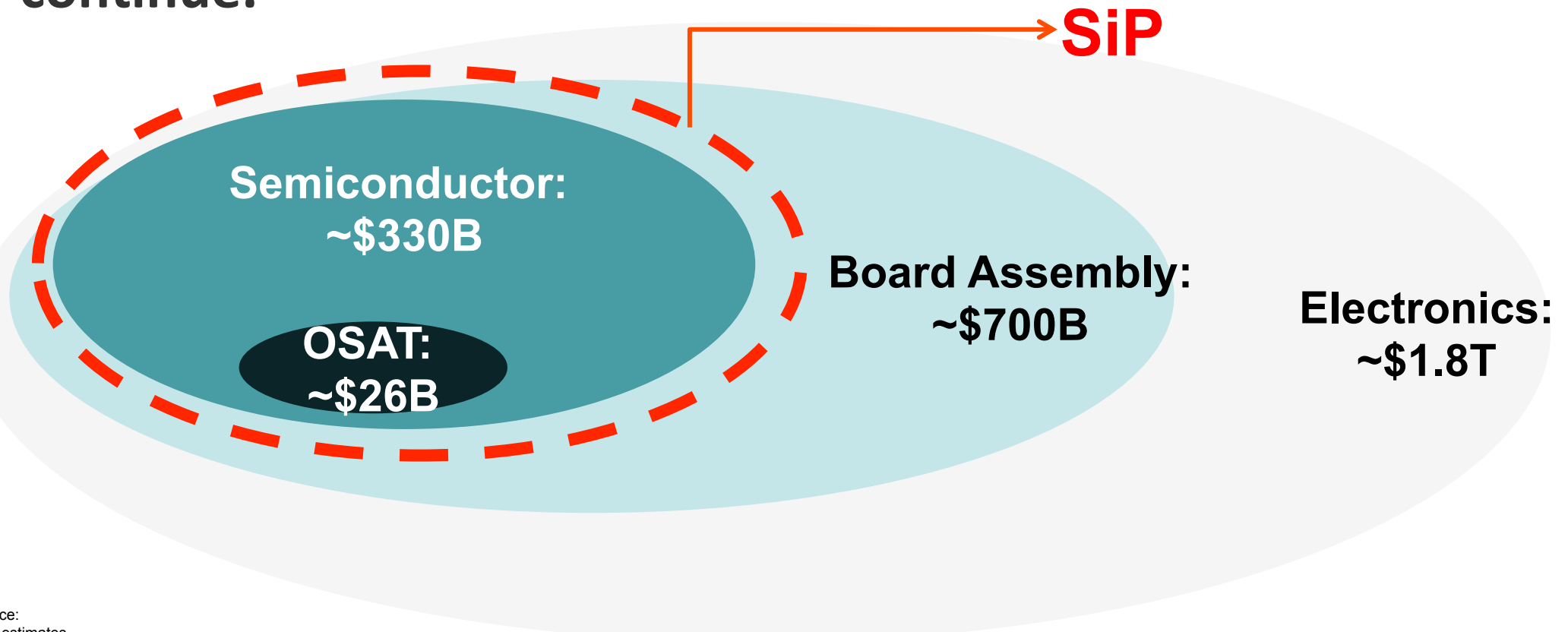
- **Value chain consolidation – supply chain re-verticalization**
 - Software / service providers developing hardware platforms
 - System OEMs & software /service providers establishing IC design capability
 - Creating differentiated platform solutions through system integration and optimization
- **Moore's Law slowing**
 - Cost/transistor increasing for advanced process nodes
 - High development, design and tooling cost
 - Enabling alternative integration paths to SoC
- **Convergence acceleration**
 - Mobile, wearable and IoT system products driving functional integration and miniaturization
 - Functional modules optimized for performance, power and form factor
 - Focus on energy, efficiency, connectivity
 - Reduced time to market / revenue
 - System BOM simplification
- **Growing need for differentiated packaging solutions to facilitate system integration, miniaturization, optimization and cost reduction**

An emerging market – System in Package



A Differentiated Packaging Solution

- System in Package (SiP) will see exponential growth as systems integration, miniaturization & power density trends continue.



Source:
ASE estimates

System in Package/Module (SiP/SiM)



A Differentiated Packaging Solution

- SiP/SiM is a package or module that contains a **functional electronic system** or **sub-system** that is **integrated** and **miniaturized** through **IC assembly technologies**

Miniaturized
Module Package

Electronic
System
Functionality

IC Assembly
Technology

SiP/SiM: Broad range of potential applications

Where Are The Key Growth Focus Areas ?



Touch



Sensor



Wireless



Storage



Power Management



Camera Module



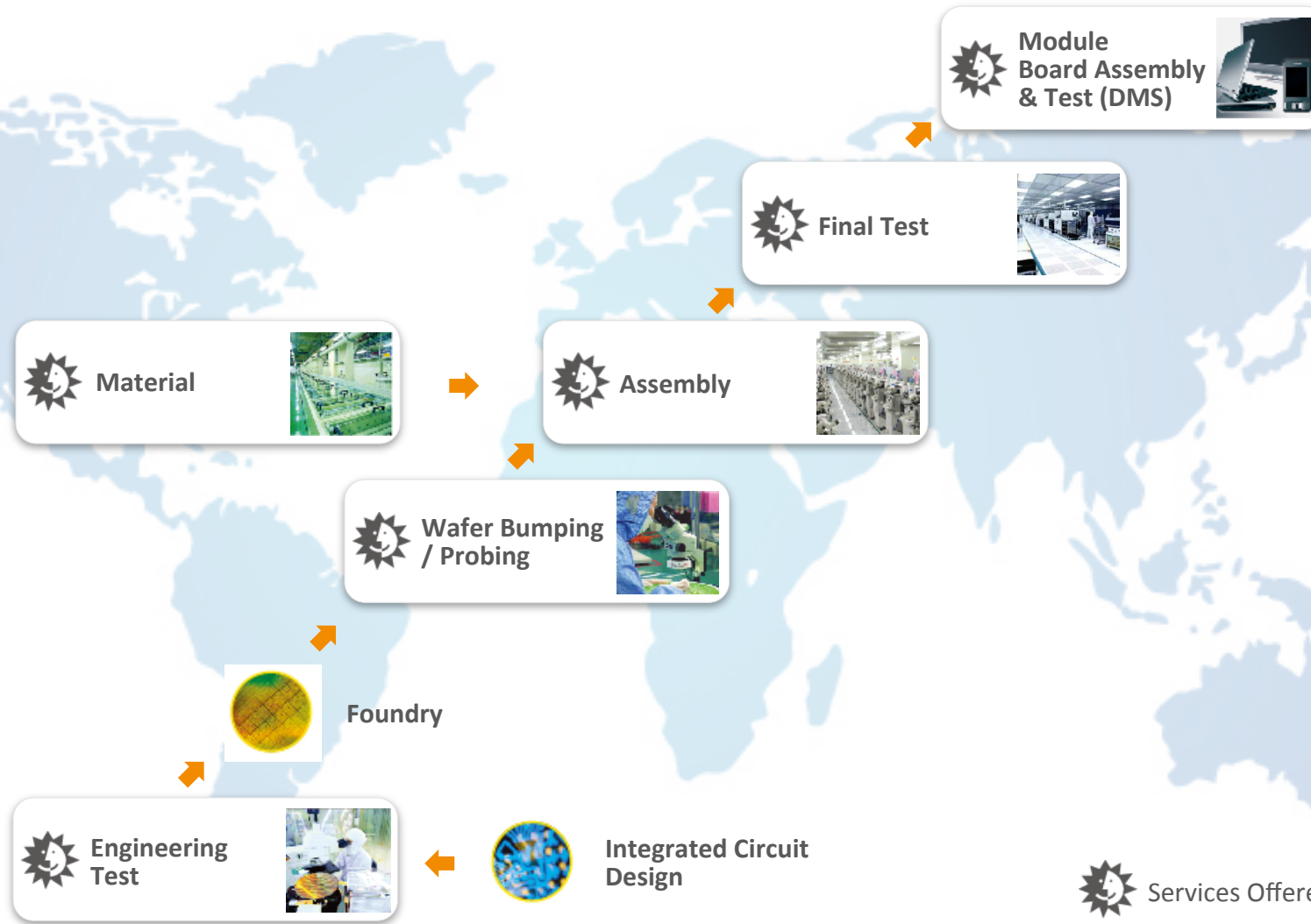
RF Front End



Lighting

ASE's Role in the Manufacturing Value Chain

Vertical Integration Capabilities



 Services Offered by ASE Group

Leverage Capability to Enable OEM Drivers



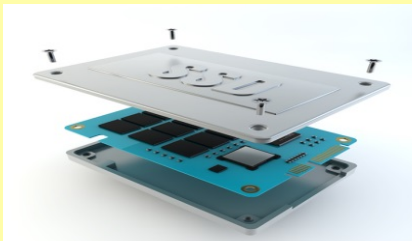
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OEM System Integration

Various functional devices optimized for SiP

Storage

SSD in
computing



Processor

FPGA/CPU for
data center



Display

Camera in smart
devices



Power Management

PMU in electric
vehicle



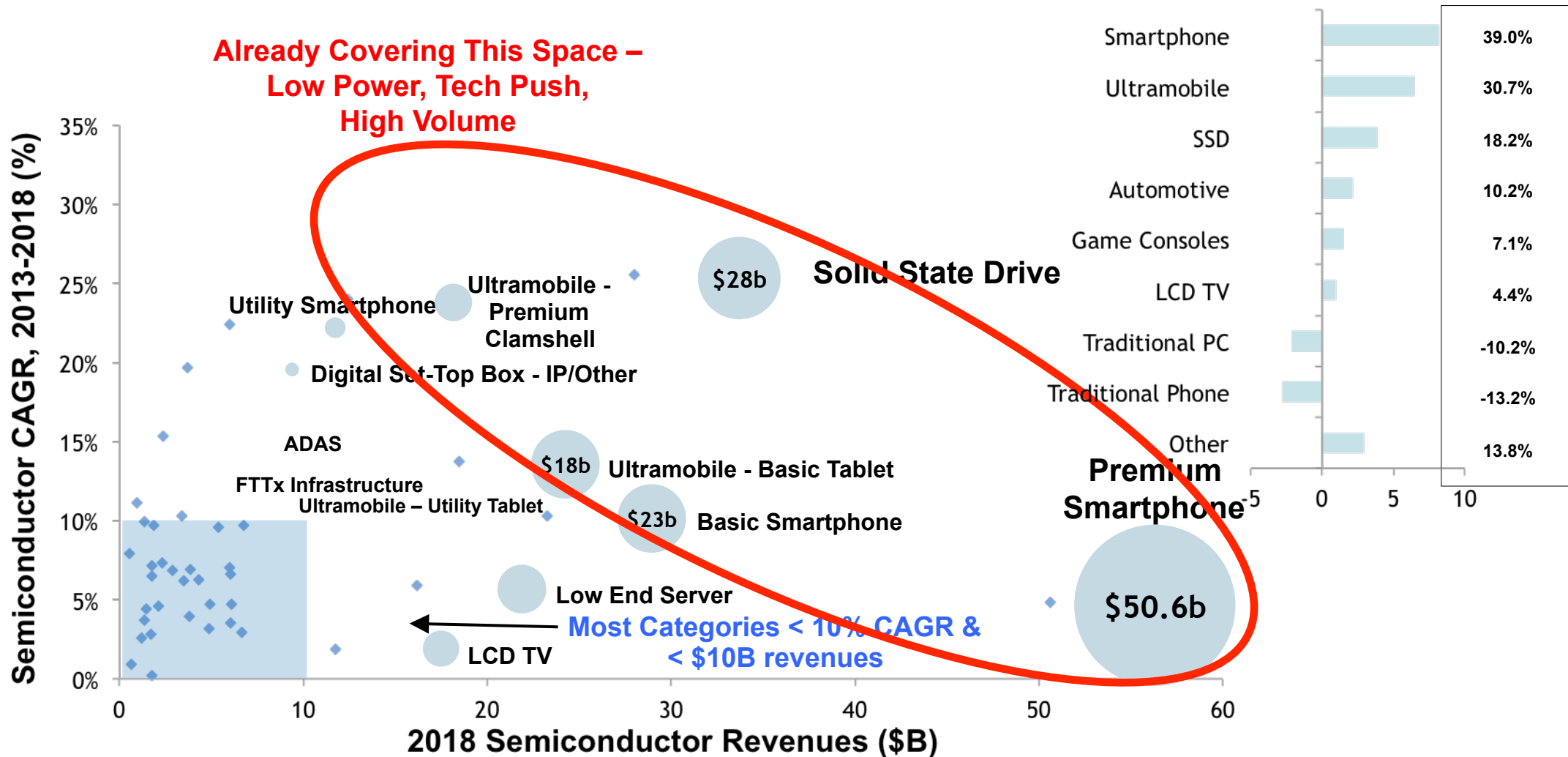
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SiP Manufacturing: OEM's Enabler

Applications Driving Growth Through 2018



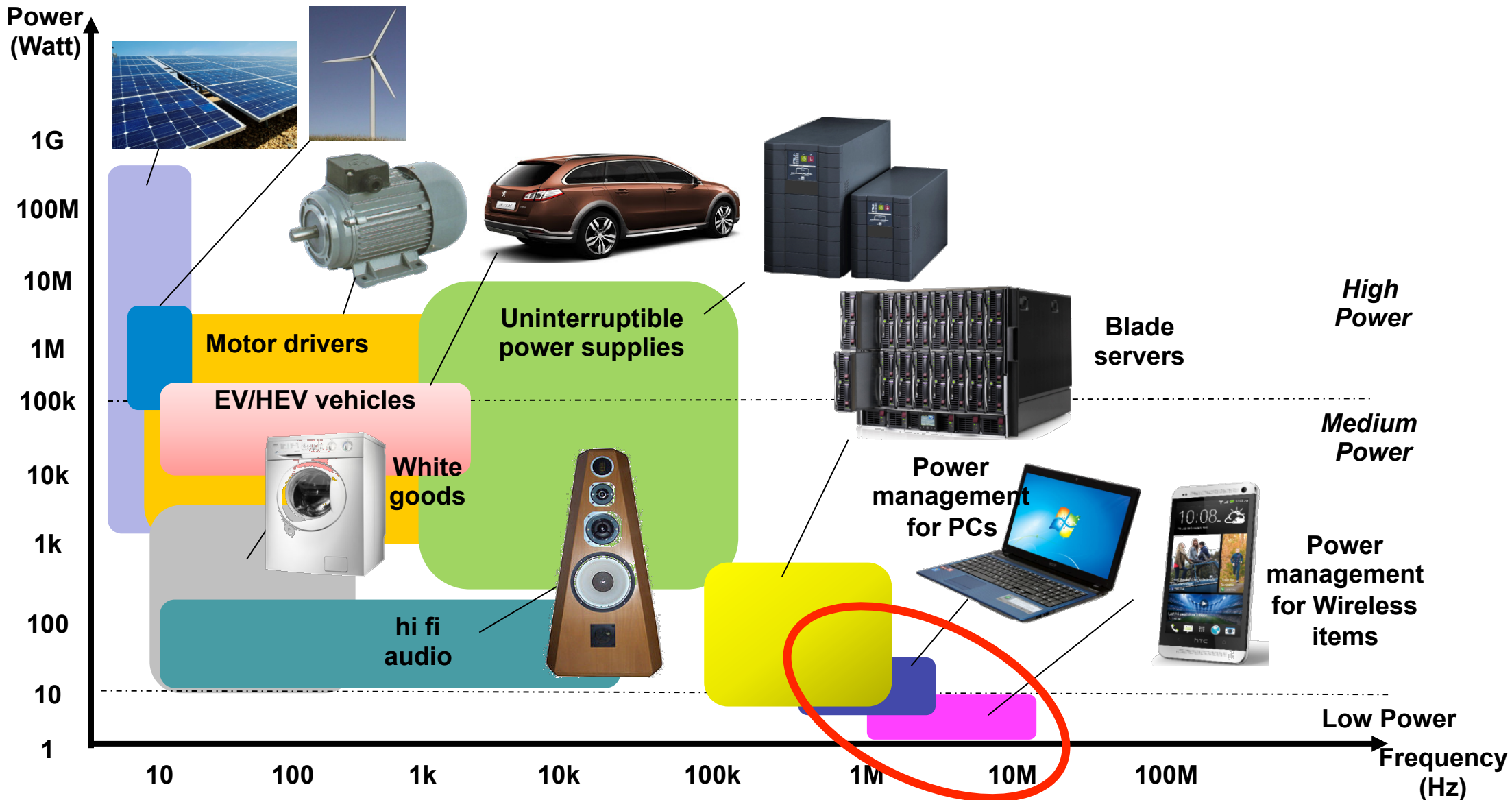
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Source: Gartner, June 2014 "Semiconductor Forecast Database, Worldwide, 2Q14 Update"

Note: Y axis cut off at 0% for clarity, so some major markets like Desktop PCs do not appear in the chart as they have negative CAGR

Areas of Growth Potential for SiP – Power Markets



Power Market Trends

- Power applications span a huge space with differing requirements with respect to performance, cost, and size.
- The low power application space is driving form factor reduction, functional integration etc.... in high volumes.
- Higher power densities, faster switching speeds, and higher thermal requirements are pushing packaging technologies such as embedded die package (SiP) and Power Stack.
- These new packaging technology alternatives drive the need for new enabling technologies.

- Interconnects
- Package Construction
- Materials



- Limit performance losses
- Better thermal management
- Smaller form factor
- Enable heterogeneous integration

Power Packaging Focus Areas for Growth

Leveraging the need for SiP/SiM type packaging.....

- **2013 worldwide power semiconductor ~ \$15bn :**
 - ◆ Discrete ~ \$11.5bn , module ~ \$4bn.
- **Discrete market commoditized / limited growth, but module market is projected to grow at 11% CAGR (transportation, renewable energy, EV/HEV & industrial motor drivers)**
- **IGBT is the major power module device type with ~\$3.3Bn. Highest volumes in the 400v – 1300V space.**
 - ◆ IGBT market split by package type: ~20% Discrete, 8% IPM, and 72% Modules

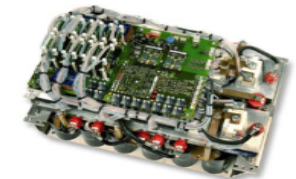
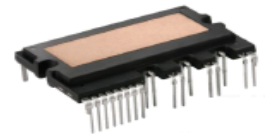
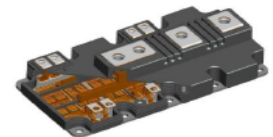
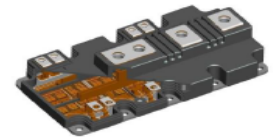
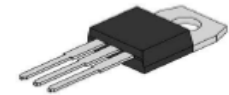
Power Packaging Focus Areas for Growth



Leveraging the need for SiP/SiM type packaging.....

FOCUS

Discrete	Discrete power devices, usually packaged as traditional TO-220, TO-247 pkg
Modules	Modules contain single power circuitry type such as MOSFET, IGBT module
Power Integrated Modules	Power modules contain multiple power circuitry in single housing. Mostly IGBT Based
Intelligent Power Modules	Power modules that combine power transistor with control and protection circuitry in single housing. Mostly IGBT Based
Power Stacks	Multiple power modules mounted on heat sink with driver and protective sensors and external components such as capacitor banks and interface terminals



Enablers for SiP in the Power Market

- Many possible combinations based on diverse market space:
- Business Model
 - » Ownership and Support
 - » Investment strategy – across all areas below
 - » Turnkey Levels and Scale
- Technology
 - » Knowledge Base
 - » IP
 - » Design and Analysis Capabilities
- Collaboration/Partnering
 - » Customers
 - » Supply Chain/Competitors
 - » Industry Consortia / Universities
 - » Standards Organizations
- Services Integration
 - » Vertical and Horizontal across Mfg, Bus, Tech, Support functions

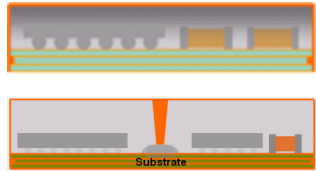
Business Models & Competitive Landscape

- Vertical integration is prevalent for players in the power space.
 - Discrete power semiconductor companies also expand their product portfolio to the module manufacturing
 - There are also specialized power module makers
- The opportunity is to complement existing customers and non-vertically integrated players with technology and services that address power packaging trends while also enabling flex capacity to larger players.



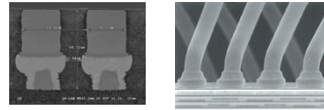
	Die	Module	System
Vertical Integration	Mitsubishi, Fuji, ABB, Hitachi, Toshiba		
Die + Module	Fairchild, IR, IFX, STM, Vishay		
Modules + System		Danfoss, Electroviprymitel	
Module Maker		Semikron, Powerex, IXYS, Vincotech	
System Maker			Schneider, Yaskawa, Siemens, Alstom
source: Yole, 2013			

Enabling Technologies for SiP/SiM



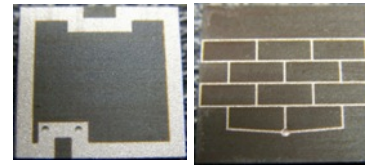
Shielding

- Board or package level
- Compartmental



Interconnection

- Flip chip (MR & TCB)
- Wire Bond



Antenna

- Package integration for 2.4G/5G/60GHz



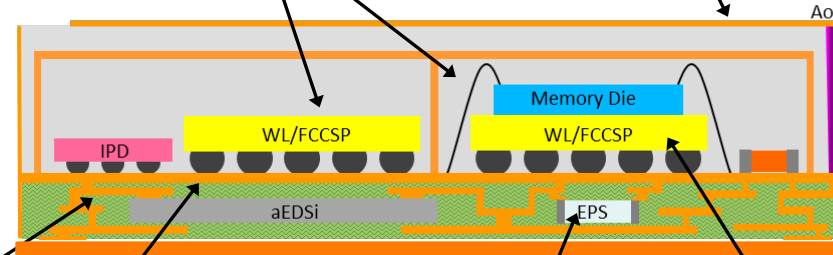
Molding

- MUF
- Exposed die



SMT

- Passives
- Components
- Connectors



Thermal Management

- Board or package level
- Compartmental



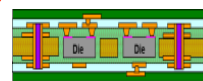
Passives / IPD

- Integrated Passive Devices



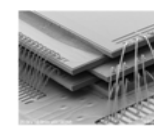
Wafer Bumping / WLP

- Leadfree / Cu Pillar
- Bare die package



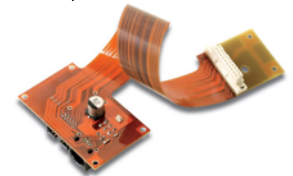
Embedded Technology

- Passive component
- Active device



Die / Pkg Stacking

- Die thinning
- Die interconnect
- Die attach



Mechanical Assy

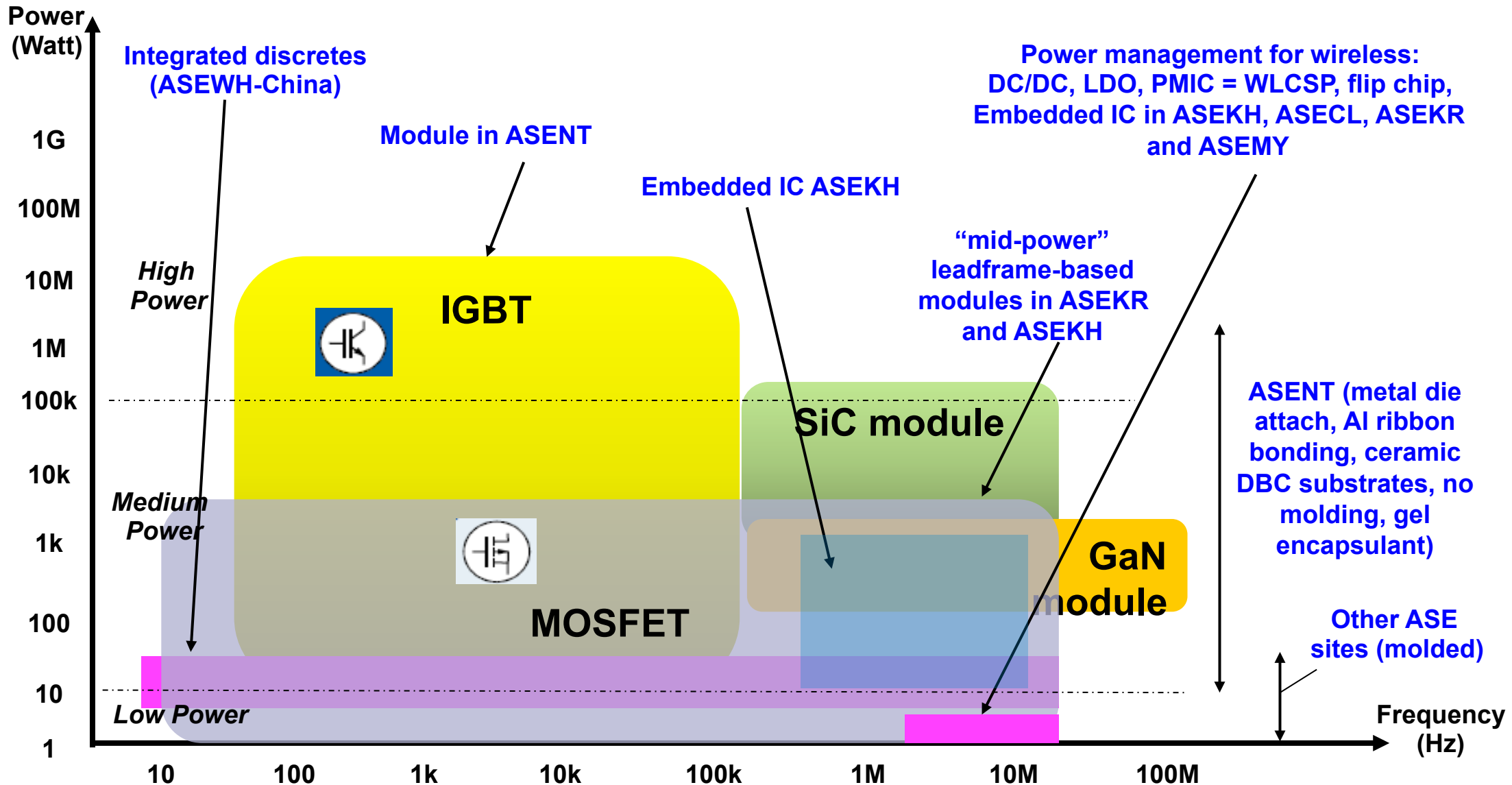
- Laser welding
- Flex bending

ASE Technology Capability Mapping

Coverage in the Power Space



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Collaboration



- **Customer Road Map & Requirements Early Involvement**
 - **Identify Needs, Timing, and Potential Areas of Partnering**
 - ◆ Business Requirements
 - ◆ Development activities
 - ◆ Infrastructure Requirements
 - ◆ Process/Equipment/Material Capabilities
 - ◆ Qualification Requirements
- **Supply Chain**
 - **Materials**
 - **Equipment**
 - **Piece Parts/BOM materials**
 - **Assurance of Supply (Sourcing, Disaster Recovery, other risk mitigation strategies)**

Collaboration

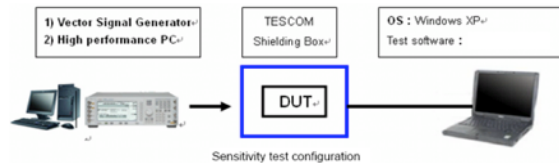


• Others

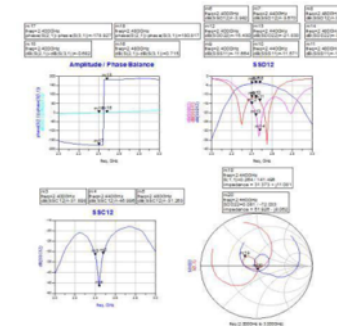
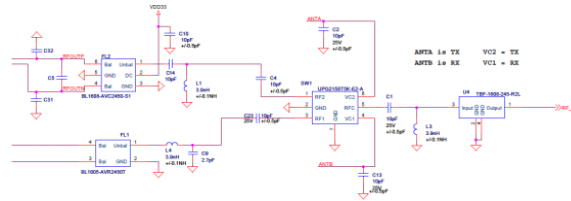
- Leverage involvement in Standards organizations, Consortia, University and 3rd Party driven efforts

<i>Packaging Challenges</i>	<i>Key Factors</i>	<i>Current Solution</i>	<i>Emerging</i>	<i>Potential Breakthru</i>
Die Interconnect	Resistivity	<i>Al wire bonding</i>	<i>Al ribbon/ Cu wire bonding</i>	<i>Sintering Joint</i>
	Thermal Conductivity			
	Lifetime			
Die attache	Thermal cycling capability	<i>Eutectic/Lead free Solder</i>	<i>Ag u-powder sintering</i>	<i>Nano powder sintering</i>
	Themperature of operation			
	Manufacturability			
Substrate attach	Thermal performance	<i>DBC + Substrate</i>	<i>DBC to heat sink only</i>	<i>Micro-channel cooling</i>
	Size / Volume reduction			
source: Yole 2013				

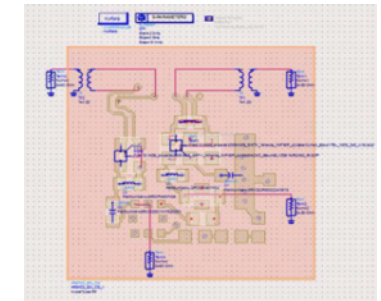
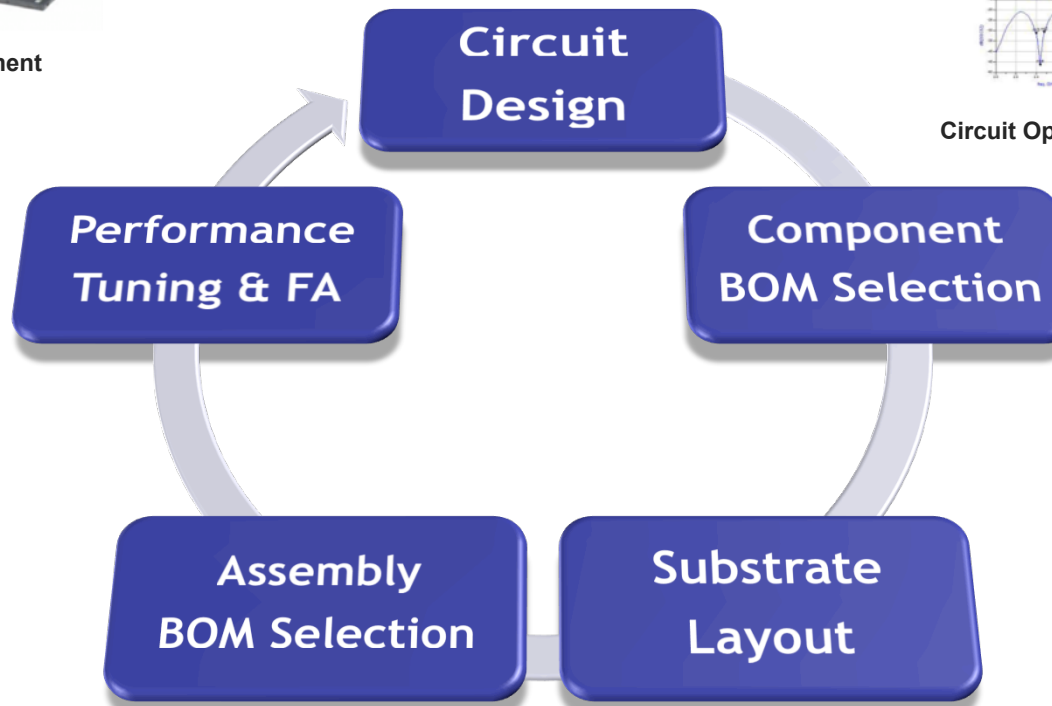
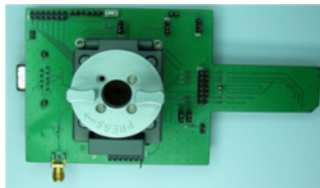
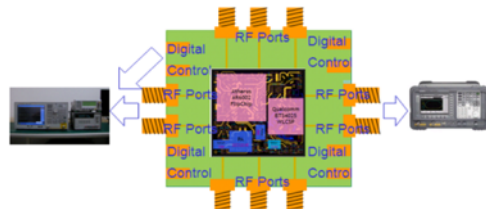
Collaboration: SiP/SiM Design Flow



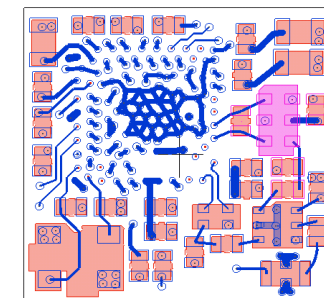
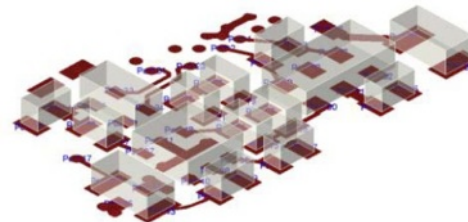
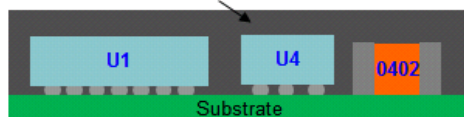
Fine tune for performance improvement
& BOM reduction



Circuit Optimization & BOM reduction

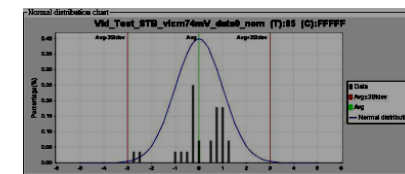
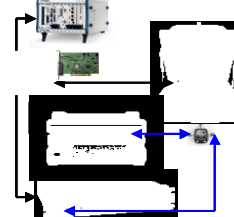
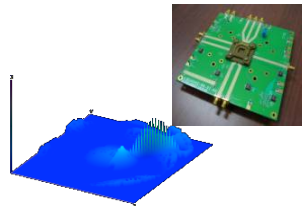
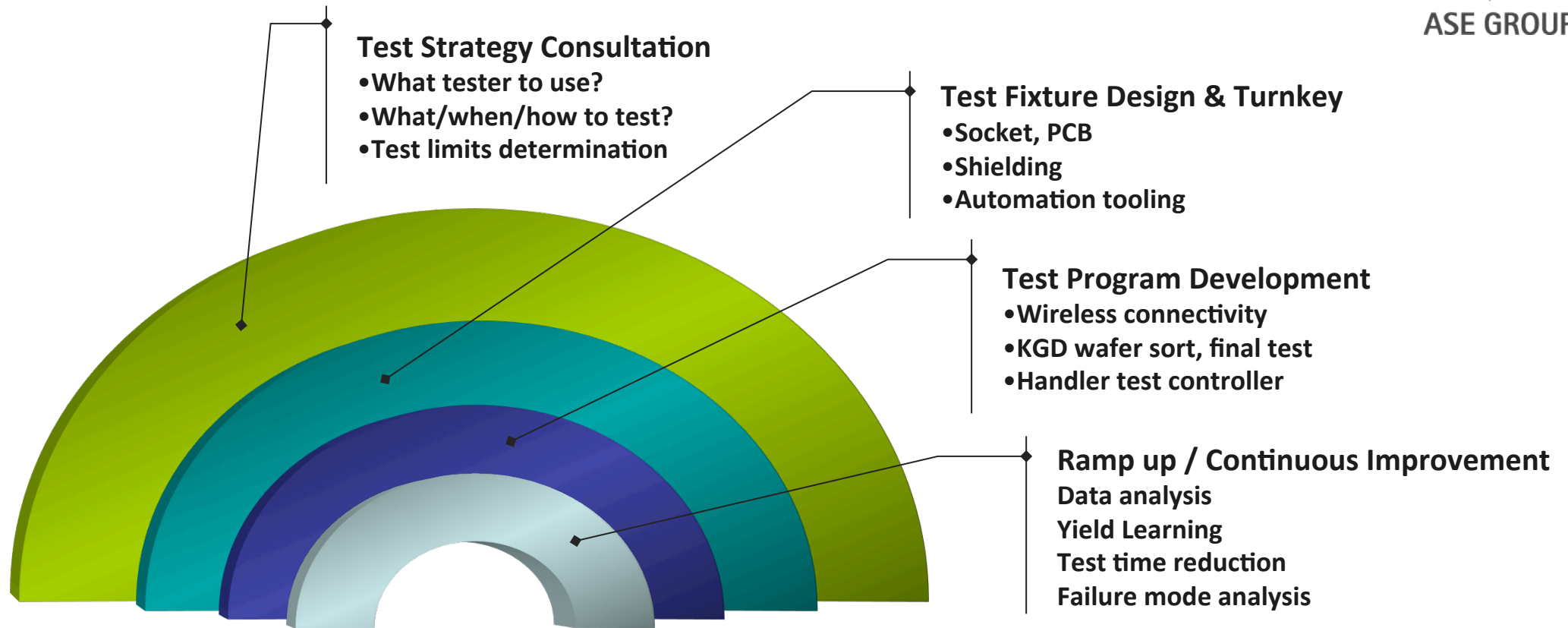


Molding Underfill (MUF)



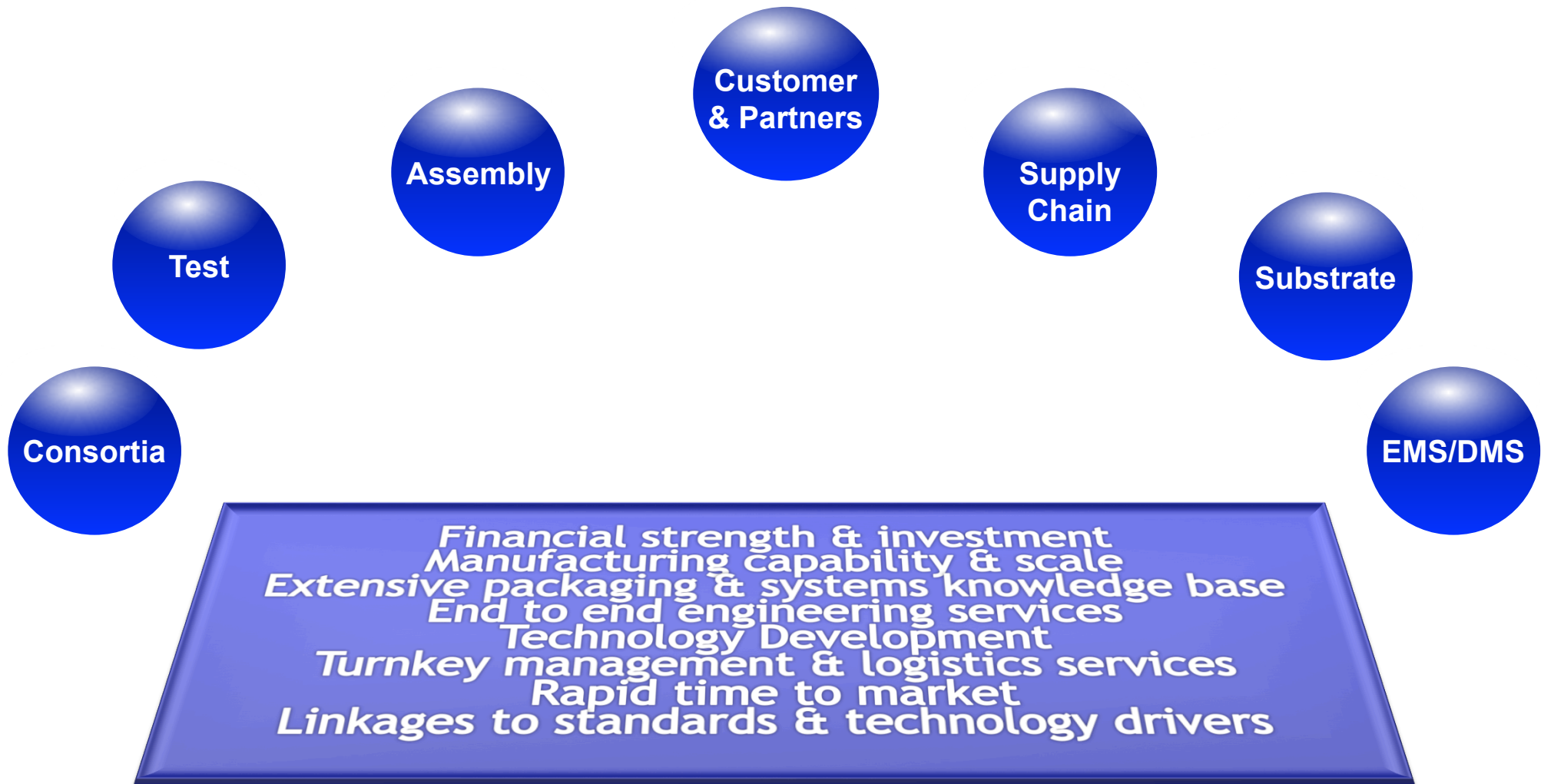
High Density SMT

Collaboration: SiP/SiM Test Services



Leverage Enablers and Value Chain

Enable electronic systems developers to achieve higher levels of functional integration and miniaturization



Changing Industry Landscape



- Value Chain Consolidation is changing the industry:
 - Innovation, investment approaches as well as supply chain models.
- Specialized solutions for varying market spaces are driving complexity in terms of the number of approaches and choices needed to get an appropriate solution that satisfies both business and technical drivers.
- Need for Collaboration in the form of standards, IP, and strategic partnerships (investment and sourcing) that are necessary for transitions to new markets.
- Opportunities in the space between traditional OSATs and EMS providers will allow for further growth through leveraging capabilities and knowledge from both ends. Having the right capabilities, scale, flexibility and financial wherewithal to make it happen will be key.

Thank You

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