University of Chinese Academy of Sciences

Product Chain of SoC Design
Integrated Device Manufacturer (IDM)

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中国科学院大学**2018年夏季**

Product Chain of SoC Design

What is an IDM?

Foundry/Fab Technology

System & Fabless Design Houses

IP Providers & Design Services

## Discussion

AI-Big Data & SoC Design

2018 Semiconductor Sales Leaders

- TOP 15

1Q18 Top 15 Semiconductor Sales Leaders ($M, Including Foundries)

1Q18 Rank	1Q17 Rank	Company	Headquarters	1Q17 Tot IC	1Q17 Tot O-S-D	1Q17 Tot Semi	1Q18 Tot IC	1Q18 Tot O-S-D	1Q18 Tot Semi	1Q18/1Q17 % Change
1	2	Samsung	South Korea	12,811	770	13,581	18,581	820	19,401	43%
2	1	Intel	U.S.	14,220	0	14,220	15,832	0	15,832	11%
3	3	TSMC (1)	Taiwan	7,524	0	7,524	8,473	0	8,473	13%
4	4	SK Hynix	South Korea	5,346	109	5,455	8,016	125	8,141	49%
5	5	Micron	U.S.	4,931	0	4,931	7,360	0	7,360	49%
6	6	Broadcom Ltd. (2)	U.S.	3,740	368	4,108	4,160	430	4,590	12%
7	7	Qualcomm (2)	U.S.	3,676	0	3,676	3,897	0	3,897	6%
8	9	Toshiba	Japan	2,747	265	3,012	3,517	310	3,827	27%
9	8	TI	U.S.	2,960	204	3,164	3,339	227	3,566	13%
10	11	Nvidia (2)	U.S.	1,965	0	1,965	3,110	0	3,110	58%
11	15	WD/SanDisk	U.S.	1,795	0	1,795	2,350	0	2,350	31%
12	10	NXP	Europe	1,965	246	2,211	2,017	252	2,269	3%
13	12	Infineon	Europe	1,130	754	1,884	1,360	907	2,267	20%
14	13	ST	Europe	1,378	440	1,818	1,696	518	2,214	22%
15	17	Apple* (2)	U.S.	1,600	0	1,600	1,830	0	1,830	14%
—	—	Top 10 Total		59,920	1,716	61,636	76,285	1,912	78,197	26.9%
—	—	Top 15 Total		67,788	3,156	70,944	85,538	3,...			

(1) Foundry   (2) Fabless   *Custom devices for internal use.

Source: Company reports, IC Insights' Strategic Reviews database

Semiconductor Manuf. & IC Design Chain
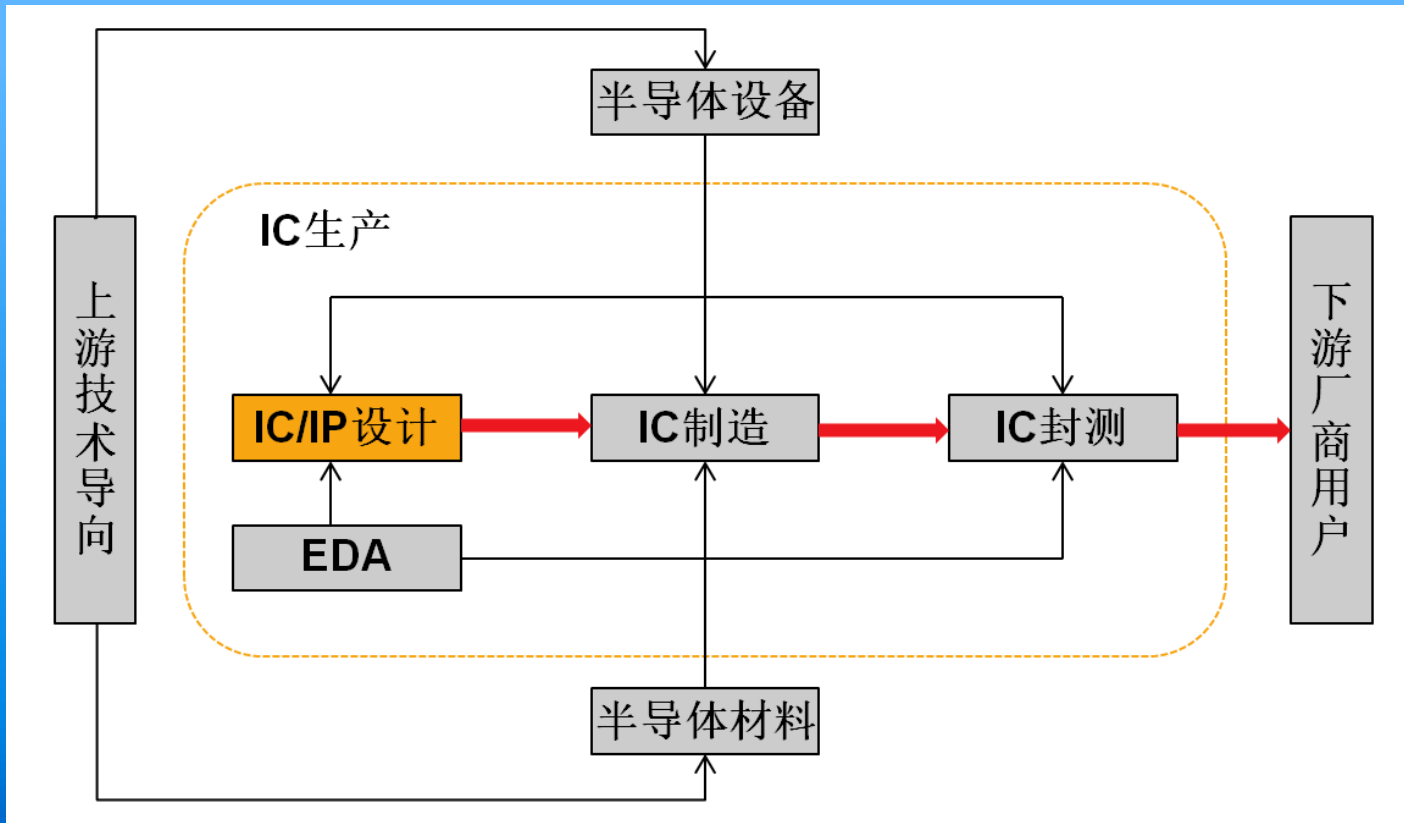
World Semiconductor Growth

Global Semiconductor 3389								
Integrated Circuit 2267						Device, PE, MEMS 622		
Digital 2289					Analog 478	Dev. 194	PE 320	MEMS 108
Memory			Processor		Logic	Gen	Spec	
DRAM	Mem		MPU	MCU	ASIC	Gen		

SRAM MISC   DSP

单位：亿美元 (2016)

IC Talent Needs

- By IC Job Types (2017)

  - R&D, 58%

  - MarCom

  - Manufacturing

  - Packaging & Test

  - Others

- By Education (2017)

  - PhD, 24%

  - MS

  - BS

  - Prof

R&D on System to New Materials

- R&D on IC System
  - SoC & AI-Chip, IIot & MCU/IP Chip, 5G & Comm.
- New Devices, New Processes and New Materials
  - Device: FinFET and …
    - Graphene, CNT, GAA; RRAM, MRAM
    - G1: Ge/Si; G2: GaAs, InP; G3: GaN, SiC
    - GTO, IGBT, ICBT, ETO, MCT
  - Process: 7/5/3/1.5nm, EUV (Smart Manuf.)
  - Graphene-CNT(L:D/1.32×10^8:1), III-V Elements
- Talents and Education
  - Talents needs on IC/Semicon - White Paper (2017-2018)
  - Special Program(s)

IIIA	IVA	VA
5　　　B	6　　　C	7　　　N
硼	碳	氮
10.811(7)	12.0107(8)	14.0067(2)
13　　Al	14　　Si	15　　P
铝	硅	磷
26.981538(2)	28.0855(3)	30.973761(2)
31　　Ga	32　　Ge	33　　As
镓	锗	砷
69.723(1)	72.64(1)	74.92160(2)
49　　In	50　　Sn	51　　Sb
铟	锡	锑
114.818(3)	118.710(7)	121.760(1)
81　　Tl	82　　Pb	83　　Bi
铊	铅	铋
204.3833(2)	207.2(1)	208.98038(2)
113 Uut	114 Uuq	115 Uup
*	*	*
(278)	(289)	(288)

What is an IDM?

Understanding Fabless IC Technology
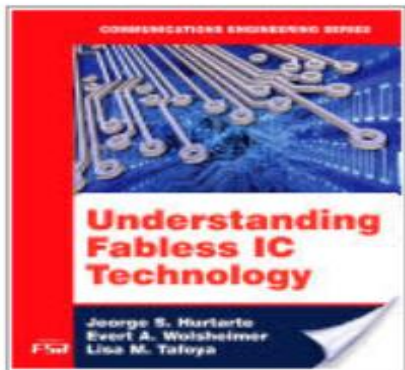
Jeorge S. Hurtarte, Evert A. Wolsheimer, Lisa M. Tafoya

Newnes, Apr 1, 2011 - Technology & Engineering - 296 pages

★★★★★

0 Reviews

G+1 0

Fabless (no fabrication) IC (integrated circuit) techniques are gr
what will soon be required knowledge of the subject. Other book
control of the IC designing company. By contrast, this title reco
are those designed and marketed by one company but actually

More »

LOCAL SUPPLY CHAIN►
LOGISTICS►
GLOBAL SOURCING►
OEM FASTENERS
ENGINEERING►
MANUFACTURING►
QUALITY►

Concept | Design | Prototype | Final Product | Market | Cost Optimization

Product Chain of Electronics

Supplier → Manufacturer → Distributor → Retailer → Shopper

Product · Information · Finances
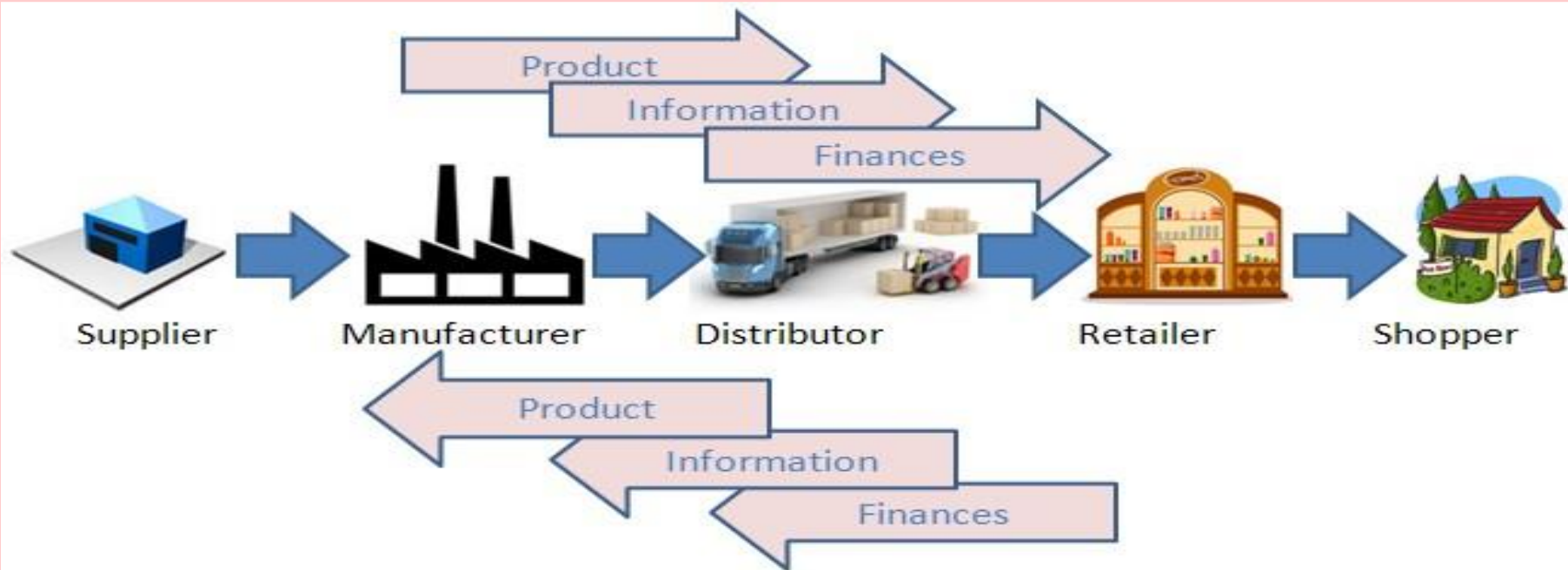
End Market

Fabless, Foundry and IDM

Apple, Cisco, Google, Hisilicon, SpreadTrum

Fabless

Intel/ IBM

IDM

Foundry

Intel, TSMC, SMIC, STM, Samsung

PKG/ATE Vendors

IP – design and verif.
System D&V/FE – archi., algorithm
Phys./BE – IP integration, clock perf., low power implem., reliability

Manuf. – GDSII data
Testing – DFT and ATE

Pkg – selection, analysis
Test – DFT, PCB, ATE

ARM, EDA

MPW, Shuttle

BGA, PCB

PRODUCT NEEDS
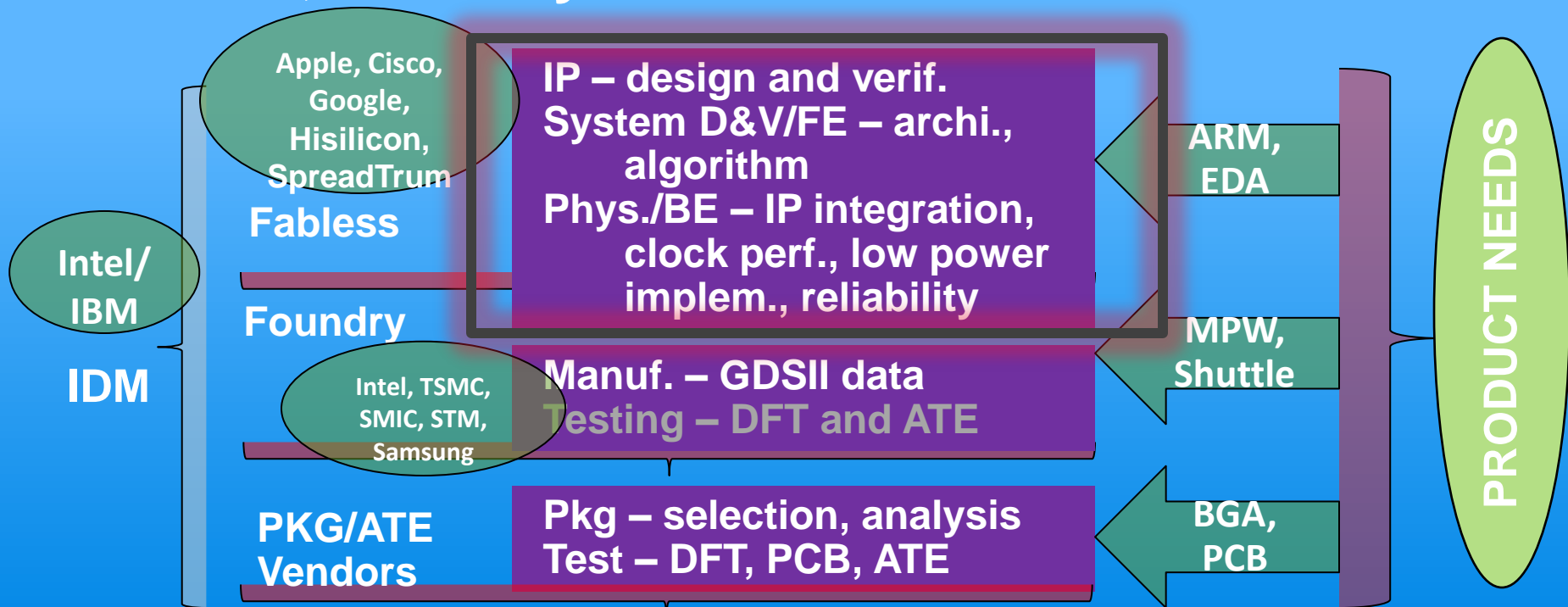
OEM: Original Equipment Manufacturer
ODM: Original Design Manufacturer
EMS: Electronic Manufacturing Services, or
  ECM (Electronic Contract Manufacturing)
IDM: Integrated Device Manufacturing

AI-Big Data & SoC Design

GSA/FSA (1994-, FSA➔GSA 2007-)
8 CEO at the 20th Anniversaries

- 40 founding members
- Semiconductor Members
- Supplier Partner Members
- Service Partner Members
- Industry Partner Members
- Organizations / Associations / Government & Educational Partner Members

IDM & IC Chain

- **What is an IDM?** Integrated Device Manufacturer, Fab/IC Manufacturer

- **Foundry/Fab Technology:** **Intel, TSMC, Samsung, STM**

- **System & Fabless House:** Intel, IBM, AMD, Qcom, HiSilicon

- **IP Providers & Design Services:** Arm, MIPS, Ceva

- **Discussion:** IC Product Chain

From Sand to Circuits
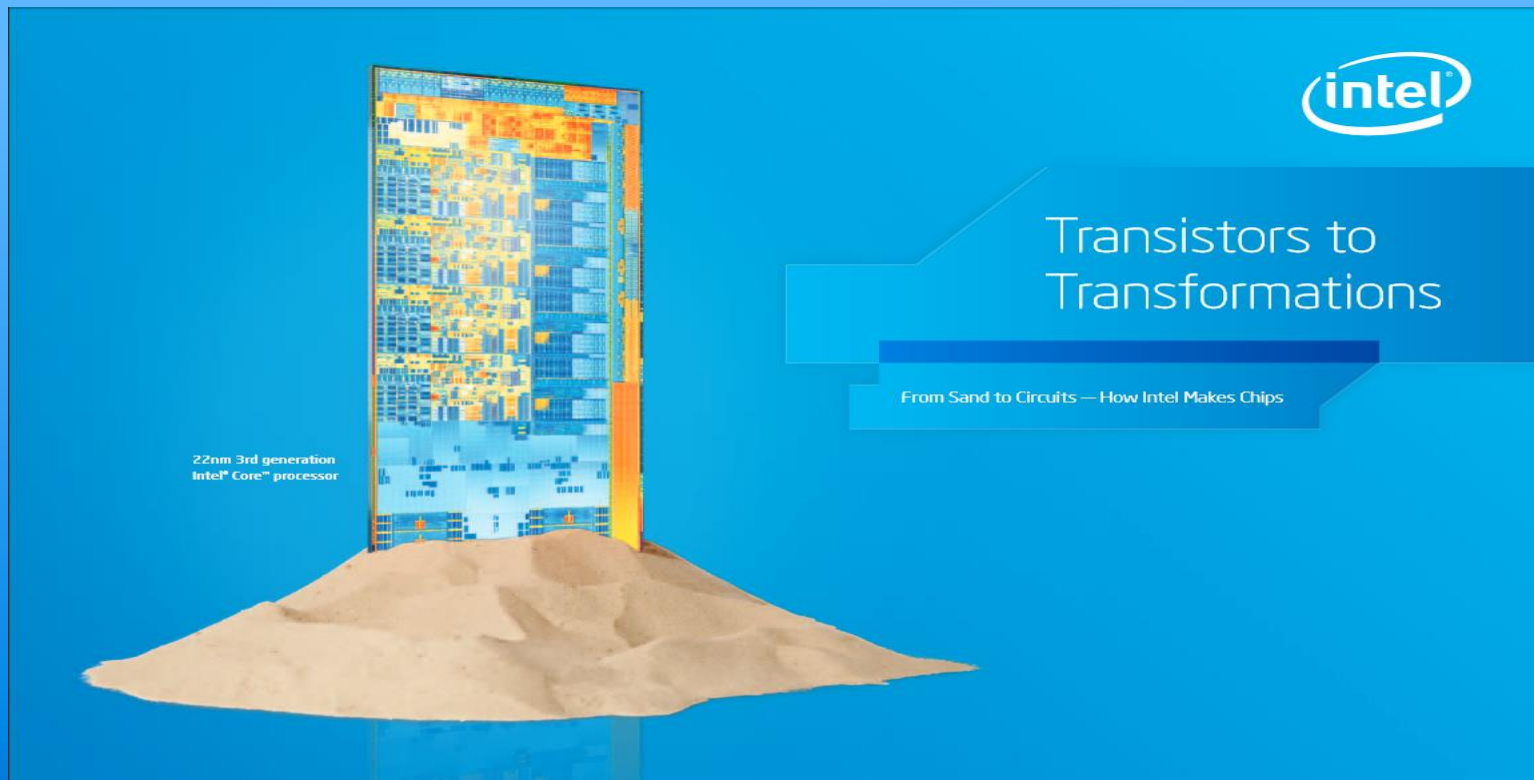
Sand to Circuit.PDF

How is the IC Chip made at the foundry
Six firms dominate 300-mm wafer fab capacity

300mm Wafer Capacity Leaders Forecast
(Installed Monthly Capacity in 300mm Wafers x1000)

2013F Rank	Company	2012 Installed Capacity (K w/m)	2012 % of WW Total	2013F Installed Capacity (K w/m)	2013F % of WW Total
1	Samsung	675	18.8%	717	18.4%
2	Micron-Elpida*	512	14.3%	536	13.8%
3	SK Hynix	420	11.7%	450	11.6%
4	Intel	388	10.8%	441	11.3%
5	TSMC	356	9.9%	414	10.7%
6	Toshiba/SanDisk	320	8.9%	320	8.2%
7	GlobalFoundries	125	3.5%	150	3.9%
8	Nanya	125	3.5%	127	3.3%
9	UMC	97	2.7%	115	3.0%
10	Powerchip**	125	3.5%	90	2.3%
11	TI	51	1.4%	60	1.5%
12	SMIC	51	1.4%	57	1.5%
—	Top 12	3,245	90.4%	3,477	89.5%
—	Others	346	9.6%	410	10.5%
—	TOTAL	3,591	100%	3,887	100%

*Assumes Micron completes acquisition of Elpida in 1H13.
**Assumes Powerchip either sells or tears down its P3 fab as it plans to do.

Source: Companies, IC Insights

AI-Big Data & SoC Design

New Materials used in CMOS continuously

Feature Size and Wafer Size
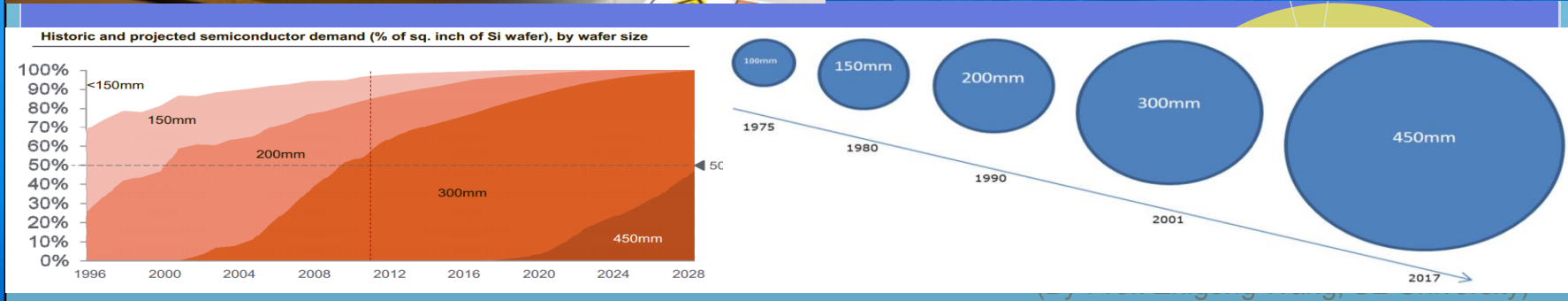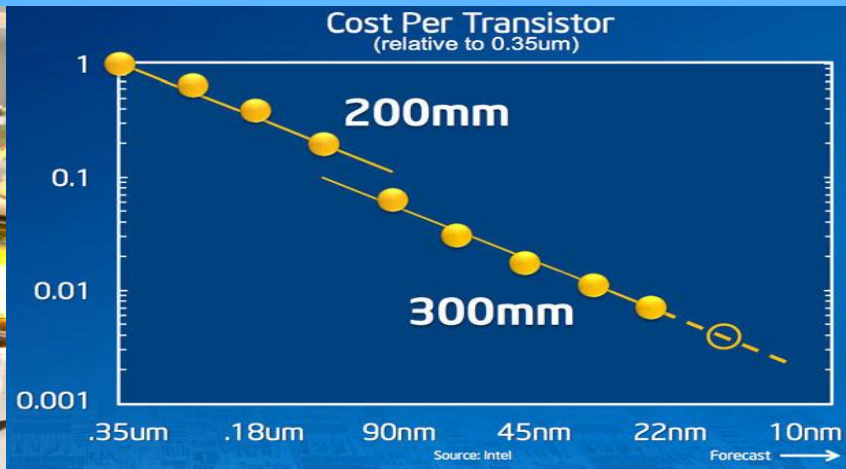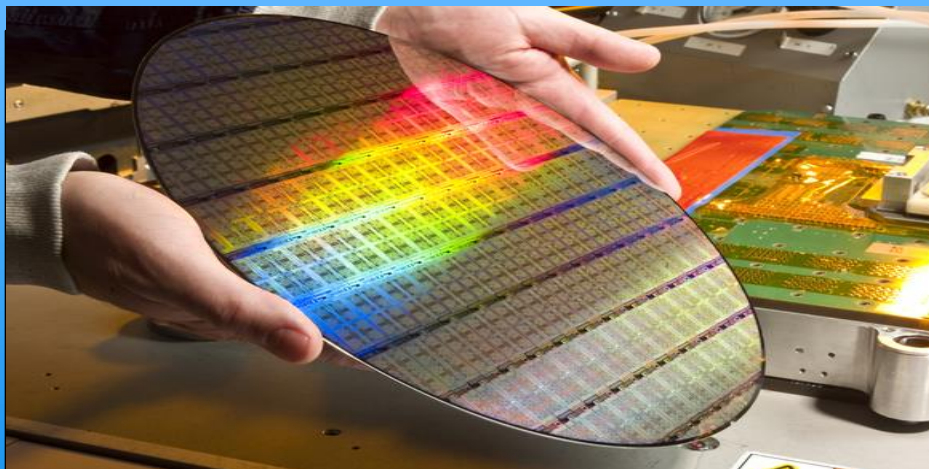
TSMC (1987-)
Fabless/FSA-GSA

- Immersion
- OIP: Open Innovation Platform
- CoWoS
  - Chip-On-Wafer-On-Substrate
- IP/EDA/Ref. Flow
- HKMG; Gate-last
- FinFET: 16FF→16FF+
- IoT
- Morris Zhang

专业技术

专业技术

未来研发计划
尖端技术
先进十二吋晶圆制造技术
超越摩尔定律技术
特殊应用平台解决方案

晶圆制造服务

卓越制造
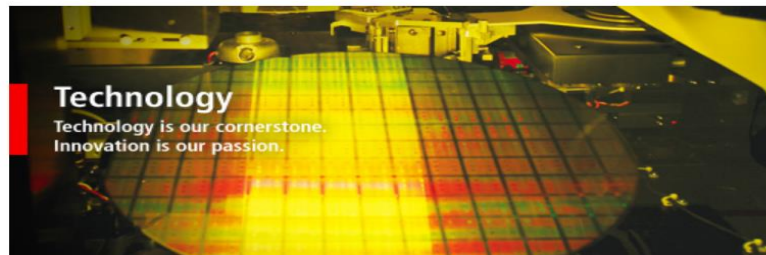
技术是台积公司的基石之一，我们提供专业集成电路制造领域中最完备的技术与服务，为全球半导体业界的客户服务，并期许成为半导体业界坚实的创新基础。此一创新基系以台积公司多样、完备的工艺选择以及各项服务为后盾。透过与合作伙伴的密切协同合作，我们提供最完备并且通过工艺验证的组件数据库、硅知识产权，并构建了全球半导体业界最先进的设计生态环境，期望提供给客户在专业集成电路制造领域中最佳的技术支持服务。

台积公司的技术平台涵盖尖端技术、先进十二吋晶圆制造技术、超越摩尔定律技术以及特殊应用平台解决方案。

AI-Big Data & SoC Design
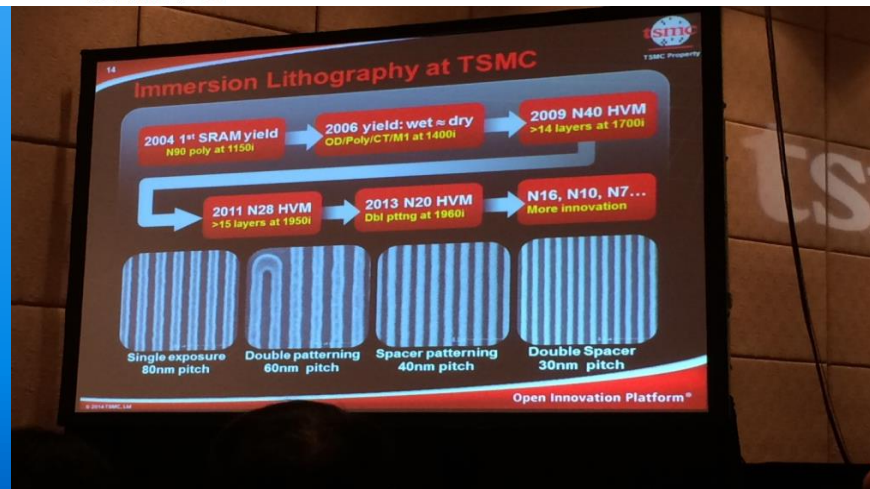
TSMC, UMC, SMIC: Income & Expense

台积电、联电、中芯国际收入（亿美元）

■台积电　■台联电　■中芯国际

台积电、联电、中芯国际资本开支（亿美元）

■台积电　■台联电　■中芯国际
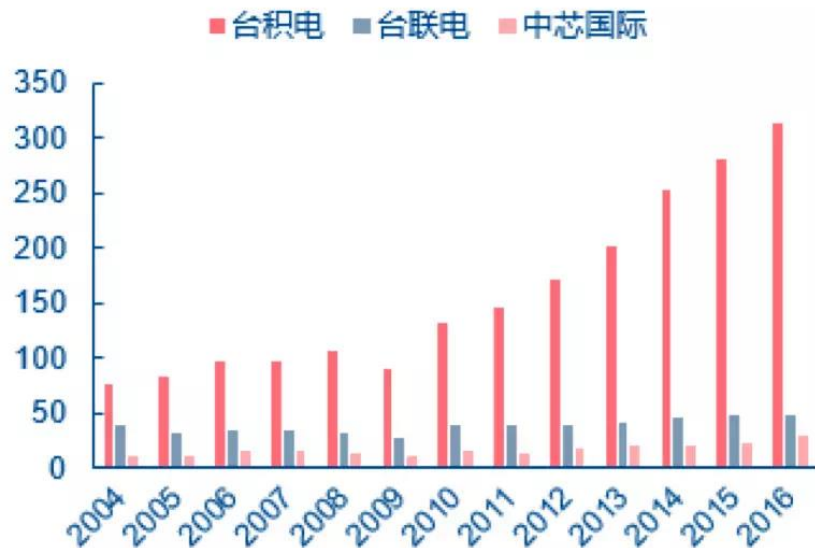
资料来源：Bloomberg，中信证券研光部整理
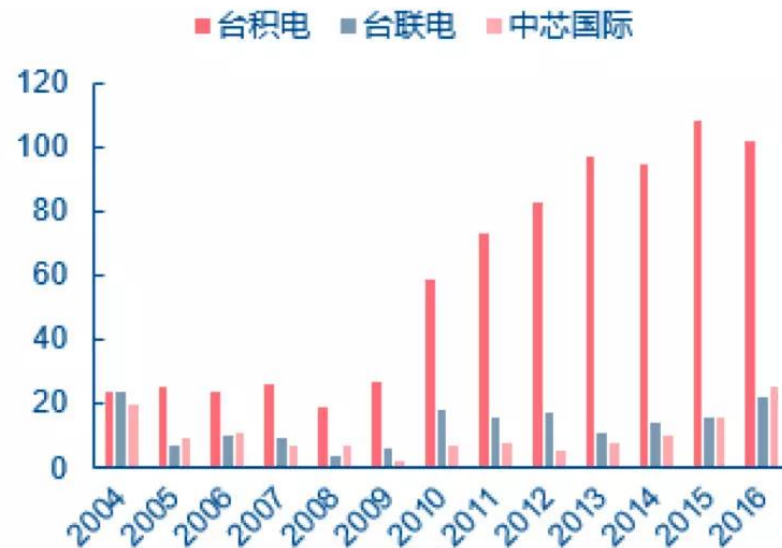
资料来源：Bloomberg，中芯国际，中信证券研光部整理

AI-Big Data & SoC Design

Samsung

- **1974-1979:** 1974, Samsung Electronics acquires Hankook Semiconductor

- **1980-1989:** 1983, VLSI, 64Kb DRAM; 1988, 4Mb DRAM

- **1990-1999:** 1992, Industry's first 64Mb DRAM; 1998, 128Mb Flash

- **2000-2009:** 2005, DDR3; 2009, 40nm 2Gb DRAM

- **2010-:** 2010, Industry's 32nm HKMG; 2016, 10nm FinFET SoC & 10nm DRAM

STM

- FD-SOI vs Bulk CMOS (planar)

- FD-SOI vs FinFET

Limited body bias capability
Weak process compensation
Low process/design co-optimization

Complex channel architecture
High cost process flow (yield, cycle time, capex)
Source of variability (multiple steps)
Source of leakages currents

Heavily Doped Wells
High variability due to dopant fluctuation
Longer minimum gate length (less speed, less density)
Severe layout effects (wells proximity)

Gate

Source   Drain

Gate oxide stack
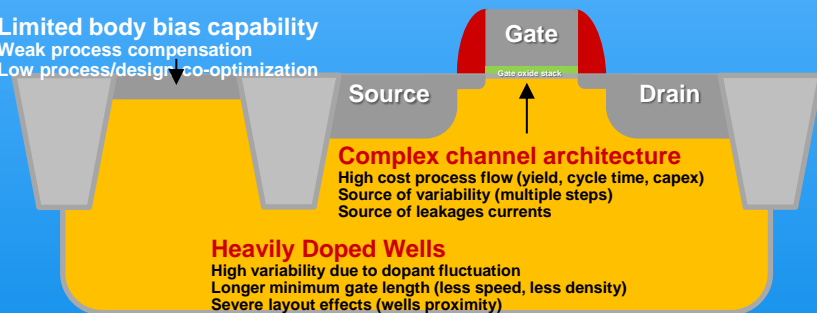
Depleted devices deliver improved electrostatic control and device scalability

Gate

Source   Drain

L_{eff}
28nm

Bulk Transistor

Gate

Source   Drain
Buried Oxide

Shorter L_{eff}
24nm

FD-SOI Transistor

FD-SOI = 2D

source   gate
                    drain
Thin Silicon film   width

FinFET = 3D

drain
gate
height   source
Thin Silicon film
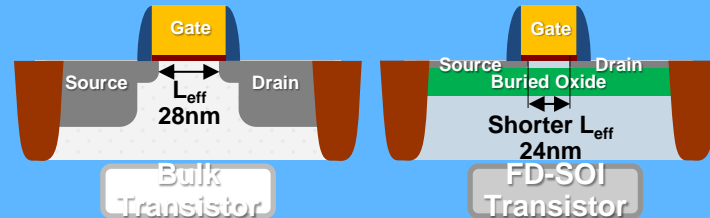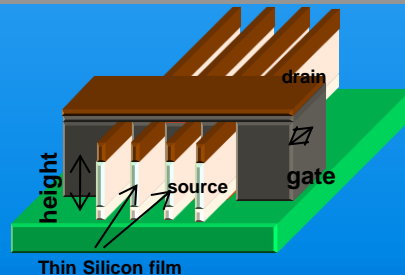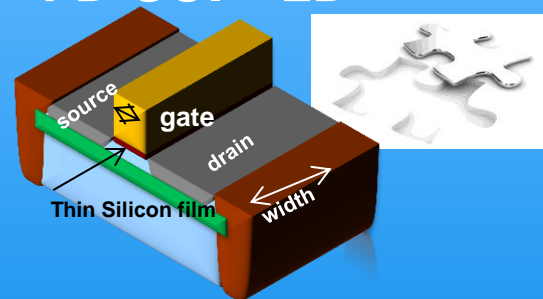
GLOBALFOUNDRIES

- 2009 span of AMD, ATIC of Abu Dhabi in UAE

- 2010, acquired Chartered Semiconductor, S'pore

- 22nm FD-SOI [w/ Samsung and STM]

- 14nm FinFET [Samsung]

- 2015: Microelectronics + $1.5B from IBM + 16,000 patents

12" Foundries in China

- SMIC-Shanghai; SMIC-Beijing 28nm in 2015
- Wuhan XMC: Flash Memory
- Intel Dalian: Internal Processors/Chips
- SK Hynix Wuxi: DRAM, NAND Flash
- Samsung Xi'an: 3D NAND
- UMC Xiamen: 2017
- Lijing (GF?) Hefei: 2017
- TSMC Nanajing: 28nm 2018

Foundry and Fabless
Competition at 22/14/10/7 nm

The Electronics Value-Chain

What's it all about
The roadmap for European electronics is about having stronger European involvement in the global electronics "value chain", benefiting our economic competitiveness and ability to innovate. So what is the electronics value chain?

A chip
...Is the "brains" of every computing device. It is made up of active devices like transistors and diodes; passive devices like capacitors and resistors; and their interconnections.

Did you know?
A state-of-the-art chip today has about 200 million transistors, each measuring just 32 nanometres (about 1/3000th the thickness of a sheet of paper).

Applications
Chips are used in virtually all electronic equipment today: from computers, smartphones and tablets, to domestic appliances, cars and factories.

Did you know?
Your car may soon be able to prevent accidents by "talking" to other cars – and to the road itself. v

Architecture
A chip's architecture depends on its purpose: what will it be used for? Its functions and behavioral features are based on that – iteratively until the "final" chip is designed.

Did you know?
Hundreds of people work to design, test, fine-tune and make a chip.

Systems
Electronic systems can be intelligent, miniaturised, and with advanced functionality – even integrating with biological systems.

Did you know?
You could soon be able to wear medical instruments 24/7: as bio-electronic systems take your vital signs for you.

Materials
Chips are built up on a thin "wafer" of semiconductor, usually silicon. The EU is investing €1 bn over 10 years on research to substitute silicon with graphene – perhaps the thinnest, lightest and strongest material in the world.

Did you know?
Silicon is among the most common elements on Earth, and the key ingredient in sand.

Design tools
Computers are themselves used to design chips, from defining specifications, to testing and production.

Did you know?
While chips look flat, they are in fact three-dimensional, with as many as 30 layers of complex circuitry.

Equipment
Making chips takes many complex precise steps, layering many different materials on top of each other. A typical "fabrication plant" needs many hundred costly items of equipment.

Did you know?
The rooms where microchips are made are 100,000 times cleaner than the cleanest hospital operating room.

Applications
Systems
Chips
Architecture
Equipment
Materials
Design tools

European Commission
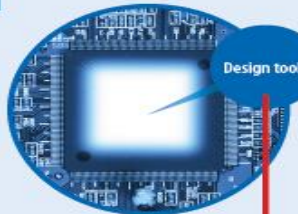
MP & GP in 10nm and Below

Source: IMEC
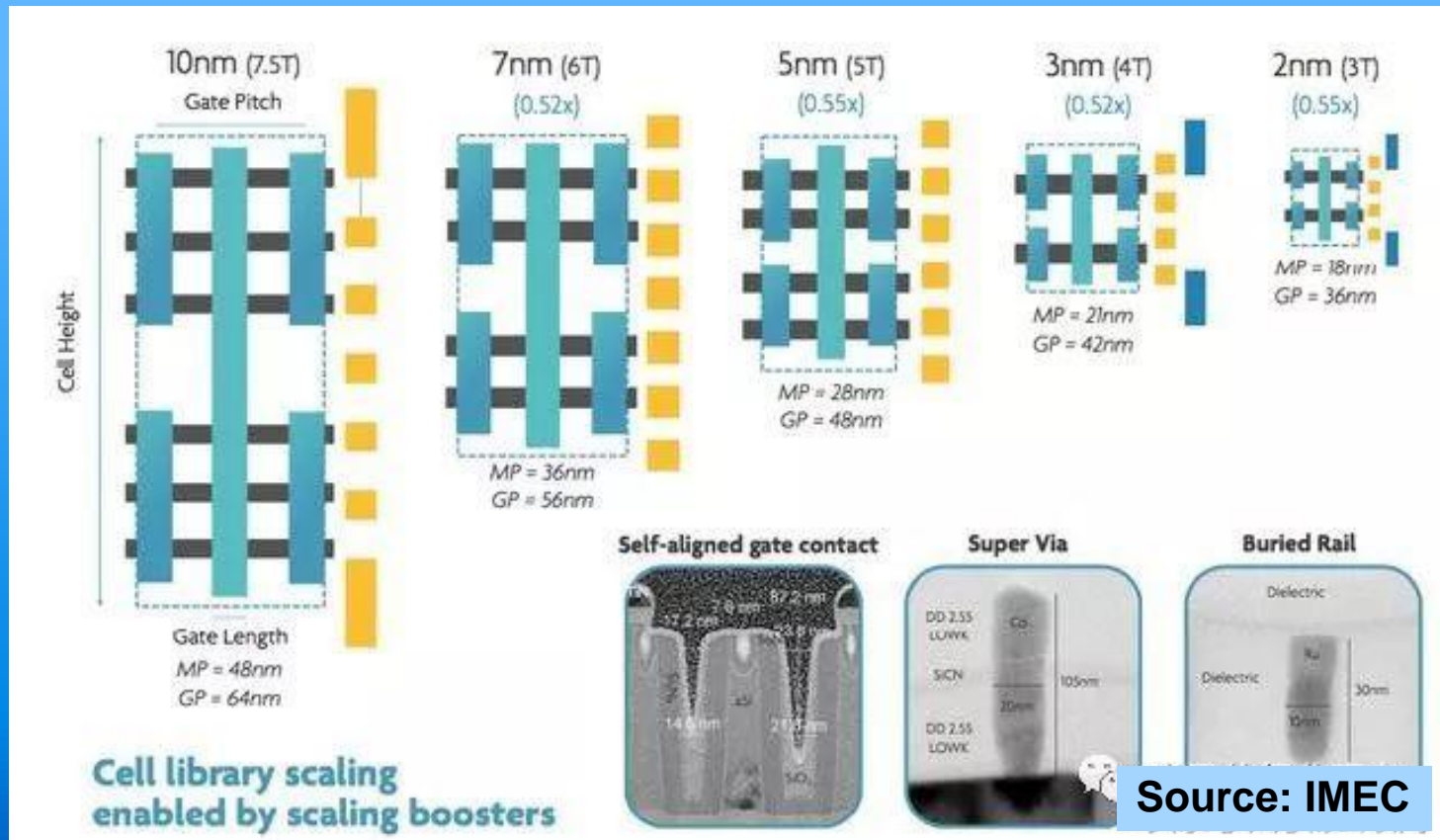
Transistor Density and Moore's Law

Logic Transistor Density

60/40 NAND+SFF Density Metric
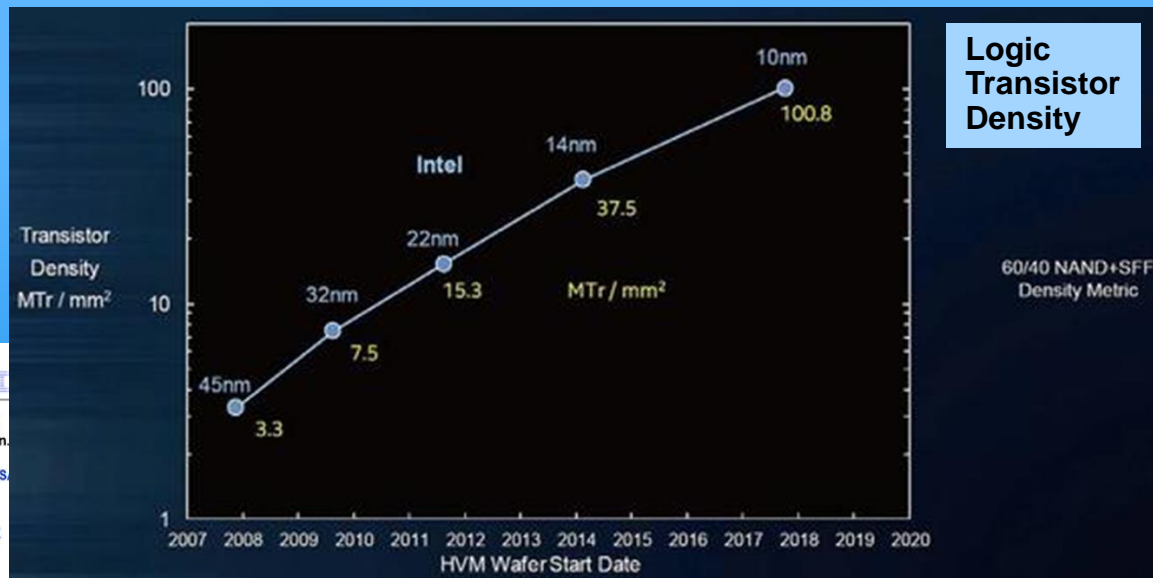
At 10nm, Transistor Density >100MTr/mm^2

Ten Generations of IBM SOI Technology

Sustained innovation in IBM technology

Node	Technology
7 nm	EUV + 3rd Gen.
10nm	2nd Gen. FinFET + SA + SIT BEOL
14nm	SOI FinFET with 3rd Gen.HiK + Hi-K e-DRAM with FIN
22 nm	2nd Gen. HiK Gate + SOI Hi-K eDRAM w/ Epi Plate
32 nm	High-K gate dielectric on SOI + SOI eDRAM with Hi-K trench
45 nm	SOI eDRAM + Immersion litho + Ultra Low-k metal dielectrics
65 nm	Advanced Strained Silicon (DSL + SOI e-SiGe)
90 nm	Low-k dielectrics + DSL
130/180 nm	Gen 1&2 H/S PDSOI

Generations of Technology Leadership

Shrinkage of Gate Length

Tech Node, nm	Intel	Samsung	TSMC	GF	UMC	ST	SMIC
Bulk 32/28	2010, 32nm, Core i7 980x	2011, 32nm, Exynos 4212	28nm Bulk CMOS	28nm	2010, 28nm HPC+	FD-SOI 28nm	28nm Bulk CMOS
22 G1 *Tri-Gate*	2011, Atom, First FinFET	N/A	N/A	22nm FD-SOI (22FDX)	N/A	FD-SOI 22nm (22FDX)	N/A
16 FinFET	N/A	N/A	201?, GTX 1000	N/A	N/A	?FD-SOI 16nm	N/A
14 G2 FinFET	37.3M/mm^2 XMM 7560	2016, Exynos8890, Snapdrogon820	N/A	2015, Apple A9	CPU/GPU		Planned
10 G3 FinFET	100.8 MTr/mm^2 Core i3	55.1 MTr/mm^2 Exynos 9810	?55 MTr/mm^2 Apple A11, 1H17	N/A			
7	Plan 2020	101.2 MTr/mm^2 2H18	<101.2 MTr/mm^2 2H18	<101.2 MTr/mm^2			
5	Planned 2017	2017, Test	Plan 1H19				

MTr: millian transistor

Can people still make 450mm wafer possible?

Litho costs back to normal with EUV >100 W/hr
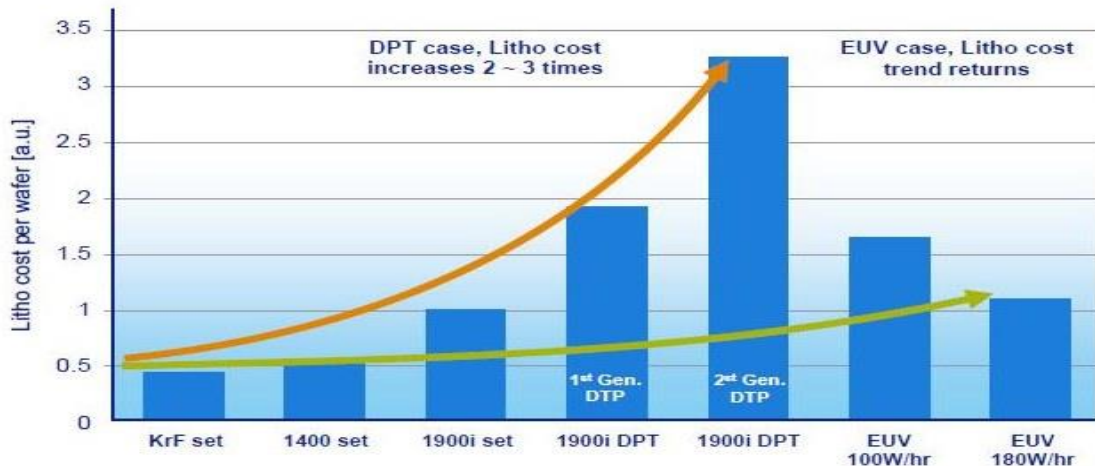
IDM & IC Chain

- What is an IDM? Integrated Device Manufacturer, Fab/IC Manufacturer

- Foundry/Fab Technology: Intel, TSMC, Samsung, STM

- **System & Fabless House: Intel, IBM, AMD, Qcom, HiSilicon**

- IP Providers & Design Services: Arm, MIPS, Ceva

- Discussion: IC Product Chain

Apple iPhone
an Integration of Digital and Analog SOC

Analog
Mixed
Signal
RF
MEMS

**SST
SST25VF080B
1 MB Serial Flash**

**SAMSUNG
Application
Processor and
DDR SDRAM**

**ST MICRO
LIS331 DL
Accelerometer**

**INFINEON
SMP3i
SMARTi Power
Management IC**

**SKYWORKS
SKY77340
Power Amp. Module**

**INFINEON
UMTS Transceiver**

**NATIONAL
SEMICONDUCTOR
LM2512AA
Display Interface**

**TRIQUINT
TQM666032
WCDMA/HSUPA
Power Amp.**

**BROADCOM
BCM5974
Touchscreen
Controller**

**TRIQUINT
TQM676031
WCDMA/HSUPA
Power Amp.**

**TRIQUINT
TQM616035
WCDMA/HSUPA
Power Amp.**

**INFINON
Digital Baseband
Processor**

**WOLFSON
WM6180C
Audio Codec**

Semiconductor
insights

**INFINEON
PMB2525
Hammerhead II GPS**

**LINEAR TECH
LTC4088-2
Battery Charger/
USB Controller**

**NXP
Power
Management**

**NUMONYX
PF38F3050M0Y0CE
16 MB NOR + 8 MB
Pseudo - SRAM**

Source: Dr. Alberto Sangiovanni-Vincentelli

IBM/Lenovo

M= MACHINES

AIX Version 7.1

IBM POWER processor roadmap

~ 3 Year Revolution
~ 18 month "+" Evolution

POWER8

POWER7/7+

POWER6/6+
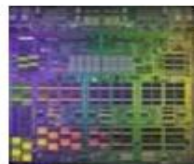
POWER5/5+

POWER4/4+

First Dual Core in Industry
- Dual Core
- Chip Multi Processing
- Distributed Switch
- Shared L2
- Dynamic LPARs (32)
- 180nm, 130nm

Hardware Virtualization for Unix & Linux
- Dual Core & Quad Core Md
- Enhanced Scaling
- 2 Thread SMT
- Distributed Switch +
- Core Parallelism +
- FP Performance +
- Memory bandwidth +
- 130nm, 90nm

Fastest Processor In Industry
- Dual Core
- High Frequencies
- Virtualization +
- Memory Subsystem +
- Altivec
- Instruction Retry
- Dyn Energy Mgmt
- 2 Thread SMT +
- Protection Keys
- 65nm

Most POWERful & Scalable Processor in Industry
- 4,6,8 Core
- 32MB On-Chip eDRAM
- Power Optimized Cores
- Mem Subsystem ++
- 4 Thread SMT++
- Reliability +
- VSM & VSX
- Protection Keys+
- 45nm

Power 7+ 32nm
- Faster
- Very large cache
- Accelerators
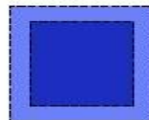
Most POWERful, Scalable and Exclusive Performance
- More Cores
- Larger Cache
- 4th Gen SMT
- Reliability ++
- Accelerators +
- more...
- 22nm
High Level design complete and in implementation phase

IBM is the leader in Processor and Server design

2001   2004   2007   2010

Binary Compatible & Increased Core Performance

10

SoC vs. CPU
The battle for the future of computing

- After more than 50 years at the top of the heap, the CPU finally has some competition from an upstart called the SoC. For decades, you could walk into a shop and confidently pick out a new computer based on its CPU — and now, everywhere you look, from smartphones to tablets and even some laptops, there are SoCs.

- Don't worry, though, CPUs and SoCs are actually rather similar, and almost everything you know about CPUs can also be applied to SoCs.

- What is a CPU?

- What is an SoC?

IDM & IC Chain

- What is an IDM? Integrated Device Manufacturer, Fab/IC Manufacturer

- Foundry/Fab Technology: Intel, TSMC, Samsung, STM

- System & Fabless House: Intel, IBM, AMD, Qcom, HiSilicon

- **IP Providers & Design Services: Arm, MIPS, Ceva**

- Discussion: IC Product Chain
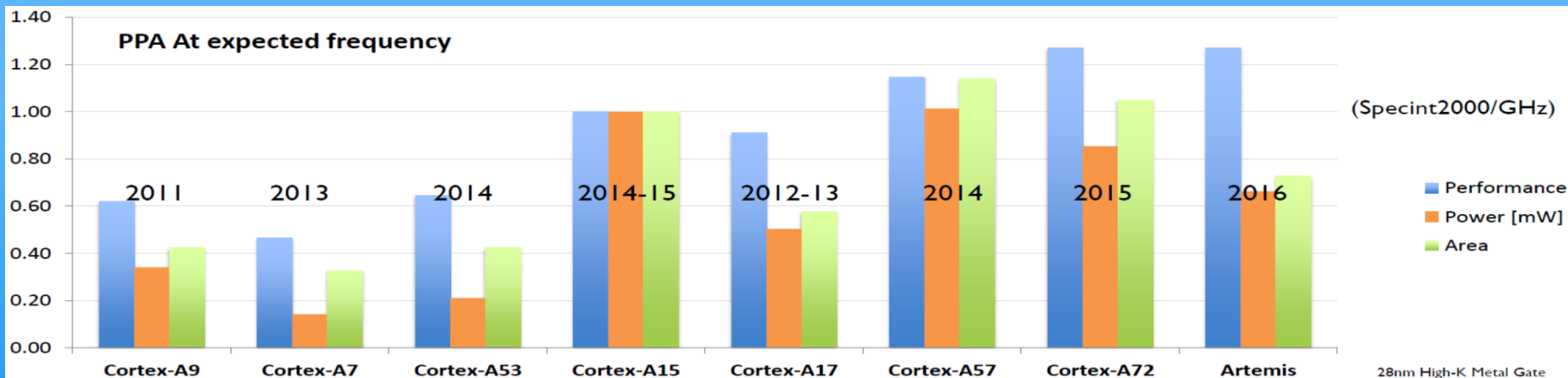
Types of IP

- Design type
  - Digital, Analog, MS
  - PLL/DLL
- Function type
  - Library
  - Memory storage
  - Connectivity
  - MCU (IoT)
 - DSP (data)
  - CPU/GPU etc

ARM Holdings (1990-)

PPA At expected frequency

(Specint2000/GHz)

- Performance
- Power [mW]
- Area

28nm High-K Metal Gate

		Cortex-A53 MP4	Cortex-A17 MP4	Cortex-A57 MP4	Cortex-A72 MP4 mixed Vt	Artemis MP4 – uLVT
Perf	L2 Cache Size [Area]	2MB	2MB	2MB	2MB	2MB
	Frequency [GHz] **SSG** **TT/V$_{OD}$**	1.7 2.15	1.6~1.75 2.0~2.1	1.95 2.25	2.0 2.3	1.9~2.0 2.3
Power	Performance [SpecInt2k/GHz] [Specint2006/GHz]	500 3.8	640	780 6.0	816 6.7	820~840
	P$_{dynamic}$ (1 Core) [mW/GHz]	73	~163	306	245	210~222
Area	P$_{static}$ CPU / non-CPU L2 [mW]	29 / 22	51/ 37	89/ 77	65 / 45	65/ 47
	Core [mm^2]	0.5	0.74	1.51	1.34	1.1~1.15
	Total Cluster [mm^2]	4.8 (L2 ECC)	5.8 (no ECC) 6.4 (L2 ECC)	9.7 (L2 ECC)	7.6 (no ECC) 8.0 (L2 ECC)	7.0~7.2 (no L2 ECC)

16nm FF, Performance Tuned 9T uLVT20

AI-Big Data & SoC Design

IDM & IC Chain

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- **Discussion: IC Product Chain**

Amkor and ChangDian
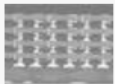
3D/3DIC - Through Silicon Via (TSV)
Through Silicon Via (TSV) interconnects have emerged to serve a wide range of 2.5D & 3D packaging applications & architectures that demand very high performance and functionality at the lowest energy/performance metric.

Fine Pitch Copper Pillar Flip Chip
Copper pillar bump is a next generation flip chip interconnect which offers advantages in many designs while meeting current and future ROHS requirements. It is an excellent interconnect choice for applications where some combination of fine pitch, ROHS / Green compliance, low cost and electromigration performance are required.

Flip Chip BGA (fcBGA)
Amkor Flip Chip BGA (fcBGA) packages are assembled around state-of-the-art, single unit laminate or ceramic substrates. Utilizing multiple high density routing layers, laser drilled blind, buried, and stacked vias, and ultra fine line/space metallization, fcBGA substrates have the highest routing density available.

Flip Chip Packaging Technology Solutions
Since being the first OSAT to provide FCiP solutions in 1999, Amkor has continued to introduce innovative packaging solutions utilizing Flip Chip interconnect, and offers the broadest range of FCiP solutions on the market. SuperFC®, FCBGA, FlipStack CSP, fcLBGA, fcLGA and fcCSP are qualified and are in production.

Flip Chip CSP (fcCSP) | Flip Chip LGA (fcLGA)
Amkor Technology is now offering the Flip Chip CSP (fcCSP) package -- a flip chip solution in a CSP package format. This package construction utilizes Pb-Free (or Eut. SnPb) flip chip interconnect technology, in either area array or peripheral bump layout, replacing standard wire-bond interconnect.
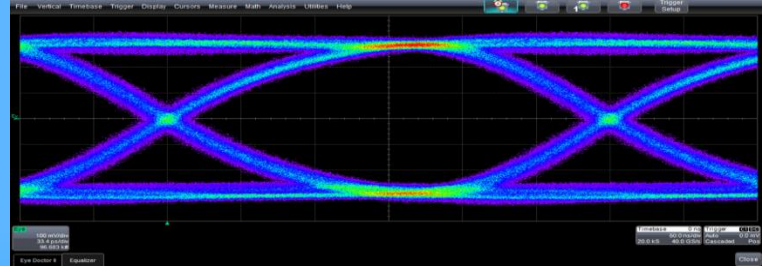

Silver Wire Bonding
Ag-Alloy offers properties similar to those of Gold while its cost is similar to that of Palladium Coated Copper (PCC).

ATE

- Analyzing Equipment

  - Teledyne Lecroy WaveMaster

    - SDA 830Zi-B: bandwidth 30 GHz, sample rate 80GS/s

- Automatic Test Equipment

Introducing V93000 Smart Scale Generation

- Broadest Scalability by Compatible Tester Classes
- New Level of Integration and Performance
- New Standard for Performance Test at Wafer Level
- Smarter Test Methodologies

V93000-L
V93000-S
V93000-C
V93000-A

EDA Vendors

- Cadence
- Mentor
- Synopsys

- Calypto
- SpyGlass
- ATopTech

EDA CONSORTIUM

Where Electronics Begins™

DESIGN AUTOMATION CONFERENCE 52

Sunday Jun 7th, 2015
to
Thursday Jun 11th, 2015

DATE 16

Monday Mar 14th, 2016
to
Friday Mar 18th, 2016

I♥DAC 2015

ATopTech CALYPTO
SPYGLASS

Summary

- **Equipment Manufacturer:**
  - ASML
- **IC Manufacturer:**
  - TSMC, SMIC, ST
- **System Design House:**
  - Huawei,
- **IC Design House:**
  - SpreadTrum
- **Supply Partners:**
- **EDA Vendors:**

Summary

- Industrial Chain & Product Segments

- IDM, Foundry and GSA

- Sand to Silicon and 45/32 to 10/7 nm

- System & Fab, IP/DS and EDA