CMP 3020: Digital and Logic Design Automation (aka VLSI Design)

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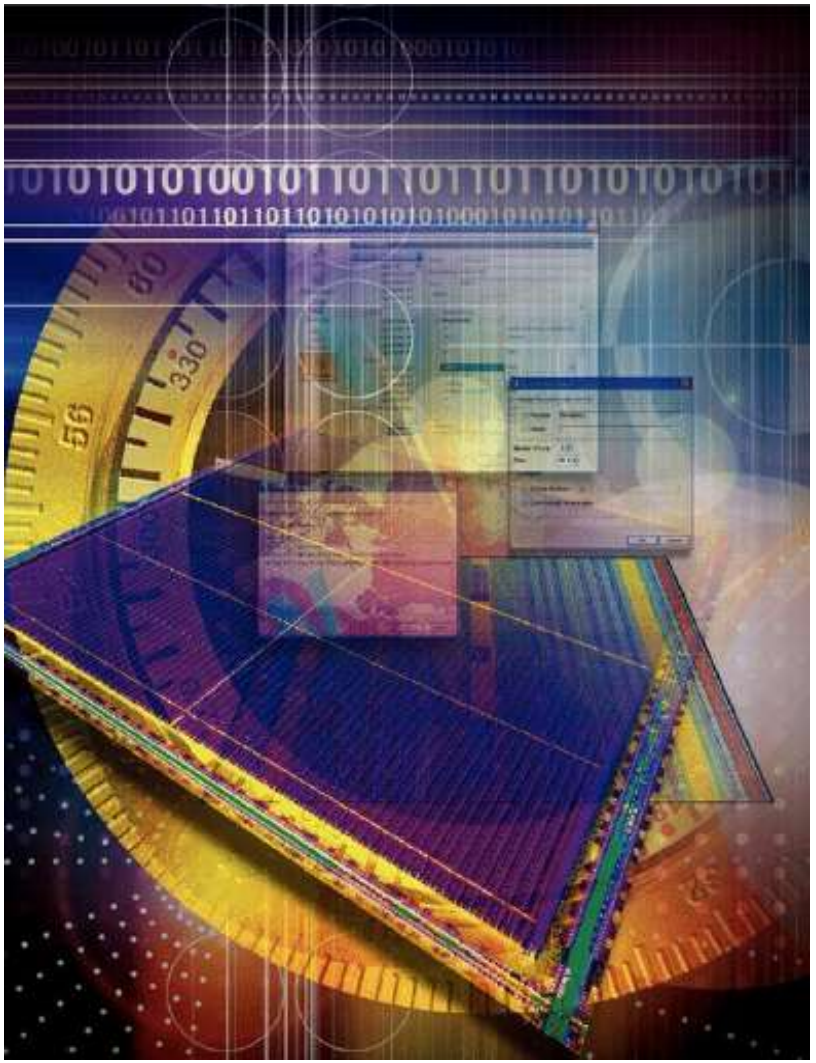
Computer Engineering
Cairo University



Fall 2021

Adapted from
1.Digital Integrated Circuits, Second Edition, ©2003, J. Rabaey, A. Chandrakasan, B. Nikolic
2.Mary Jane Irwin, Vijay Narayanan's slides
3.Synopsys University Courseware , Copyright © 2010 Synopsys, Inc. Developed By:Vazgen Melikyan

Credits & Acknowledgments

- **Slides are adapted from:**

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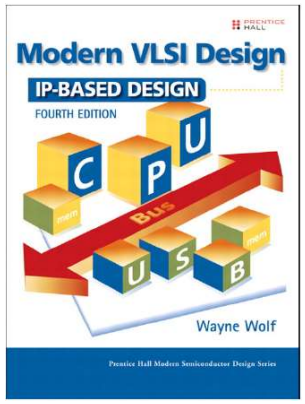
Learning Outcomes

1. Develop an understanding of the VLSI-related industries and their dynamics and economics.
2. Learn about the different technologies for digital design.
3. Acquire the design skills and learn the flow for digital VLSI design.
4. Understand the design metrics and the interplay among design trade-offs, and technology issues.
5. Get introduced to the concept of IP reuse and using it as a means to close the productivity gap.

Suggested References

No Specific Textbook



References

1. "Modern VLSI Design: IP-Based Design," Wayne Wolf, Prentice Hall, 4th Edition, 2008.
2. "Digital Integrated Circuits," J. Rabaey, A. Chandrakasan and B. Nikolic, Prentice Hall, 3rd Edition, 2008.
3. "Application-Specific Integrated Circuits," M. Smith, Addison-Wesley Professional, 2008.

Course Requirements & Grading

Subject to change:

- Tutorials: 5 % - individual effort
- Midterm: 10 % - individual effort
- Final: 60 % - individual effort
- Project: 20 % - group effort
- Lab: 5 % - individual effort

- Office hours:

  by email appointment wassal at eng.cu.eu.eg

  Email subject must start with [CMP3020]

- TAs:

  Eng. Sandra Waheed

Course Outline

- Semiconductor Industry and Technology Overview
- MOS Transistor, IC Design Flows
- Logic Families, Standard Cells
- Timing in Digital Systems
- Front-end Design Flow
- Back-end Design Flow
- Design-for-Testability (DFT)
- Packaging, Interconnection and Signal Integrity
- Low-Power Design

Industry & Technology Overview

- Introduction to the semiconductor industry
- Functional Structure of a Fabless Company
- Manufacturing Process
- Design Rules

Industry & Technology Overview

- **Introduction to the semiconductor industry**
- Functional Structure of a Fabless Company
- Manufacturing Process
- Design Rules

What does the Electronics industry produce?

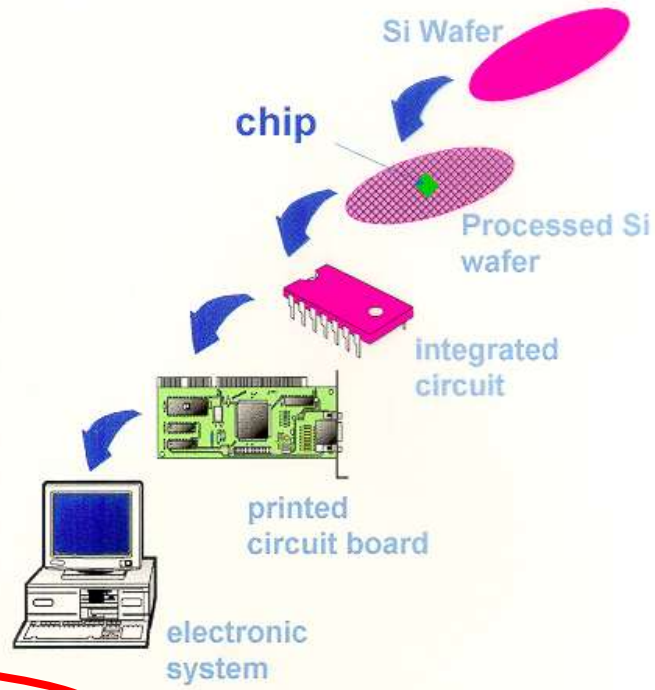
- **System Designs**
- **IC Designs**
- **Physical Products**
  - Integrated Circuits (IC) aka Chips
  - Printed Circuit Boards (PCB)
  - Systems

What does the Electronics industry produce?

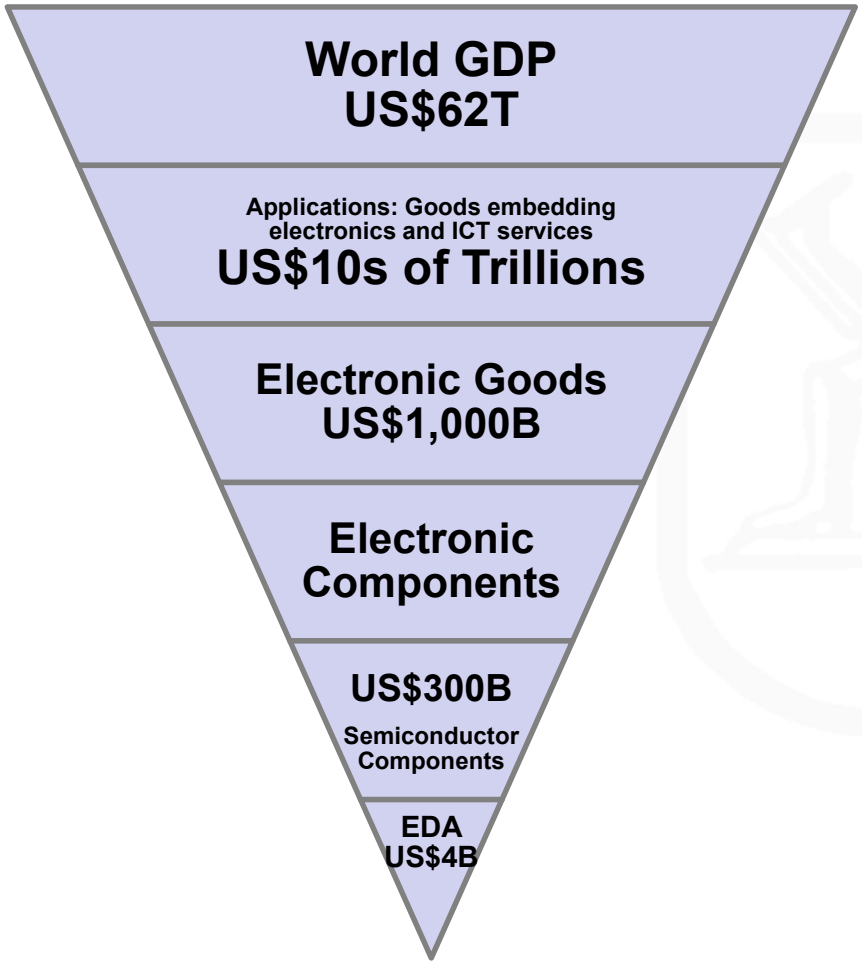
- Silicon Wafers
- IC design
- IC manufacturing
- IC packaging/testing
- PCB design
- EMS
  - PCB manufacturing
  - System assembly
- Product/System definition and design

High added value

Labor intensive



Electronics TAM (Y2010)

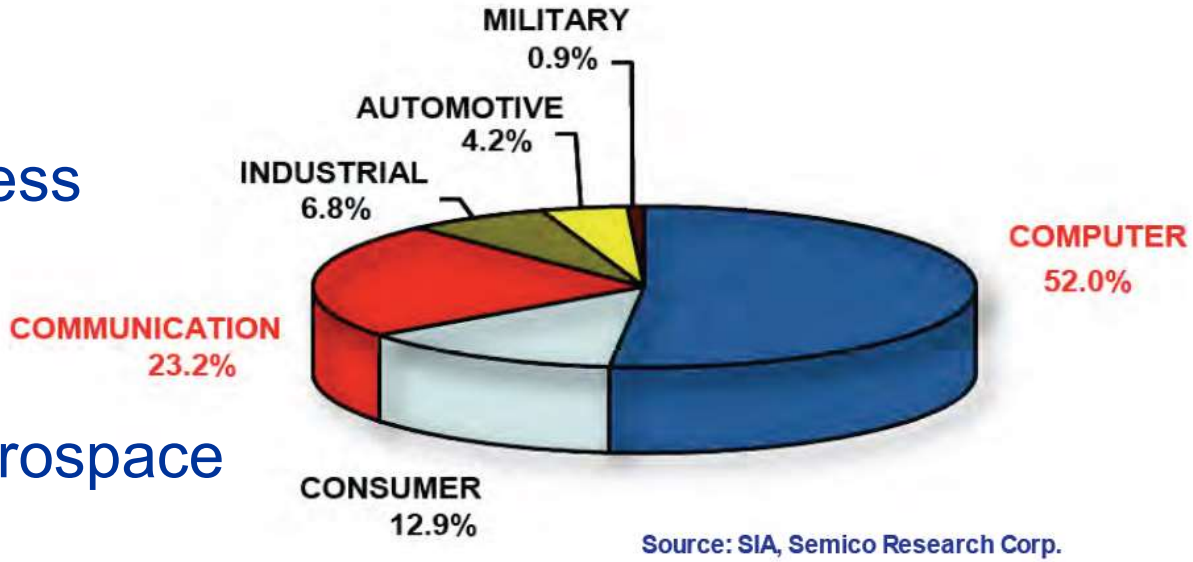


- Per annum size of Electronics Goods market is US$1000B and Semiconductor market is US$300B in Y2010
- Drives the whole world economy
  - Correlation between WW GDP and WW electronics market became very strong starting Y2000
- The locomotive that powered the economy of many tigers

Electronics Industry Segments: By End-User Market

- Computing
- Telecom/Wireless
- Consumer
- Automotive
- Military and Aerospace
- Medical
- Industrial/Process Control/Measurement

and more…

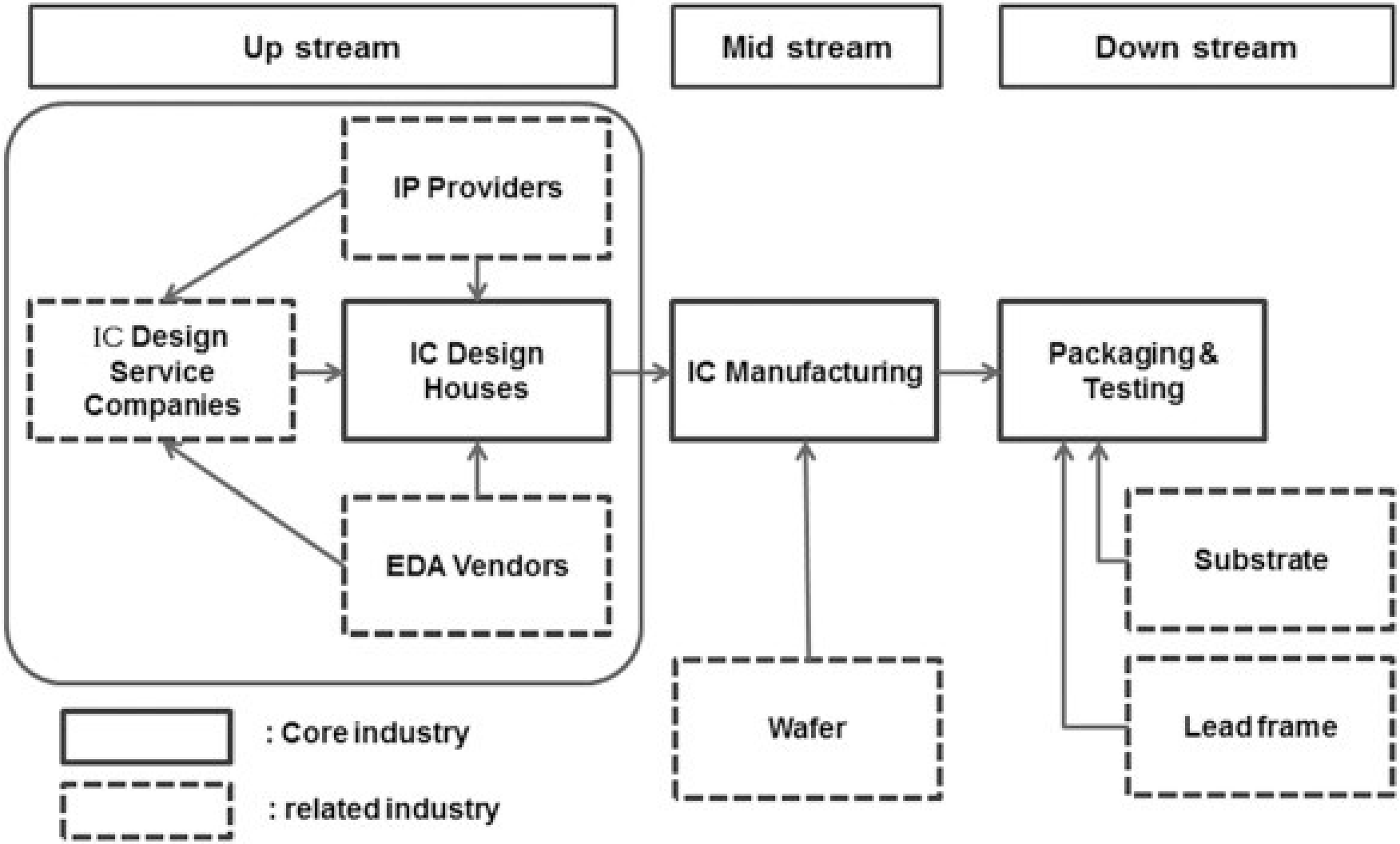


- **Total available market of ~$352 Billions in 2016**

Semiconductors Industry Segments: By Business Model

- **Integrated Device Manufacturer (IDM)**
  - Samsung Semiconductor, IBM, MagnaChip, Intel, TI, Infineon, Toshiba, NEC, Mitsubishi, Motorola,... etc.
  - Has in-house manufacturing using its own Fabs besides its own design capabilities (vertical integration).
- **Fabless**
  - Qualcomm, Broadcom, ON Semiconductor, nVidia, MediaTek, Cirrus Logic,… etc.
  - Outsources manufacturing to (usually) a foundry.
  - Focuses on products, IP, patents and licensing.
- **Merchant Foundry**
  - TSMC, Global Foundries, UMC, SMIC, PowerChip, TowerJazz, Dongbu HiTek, X-Fab,… etc.
  - Finds work from the pool of fabless companies.
  - Requires careful scheduling, pricing and contracting to remain at full utilization.

Semiconductors Industry Segments: By Role in the Supply-Chain



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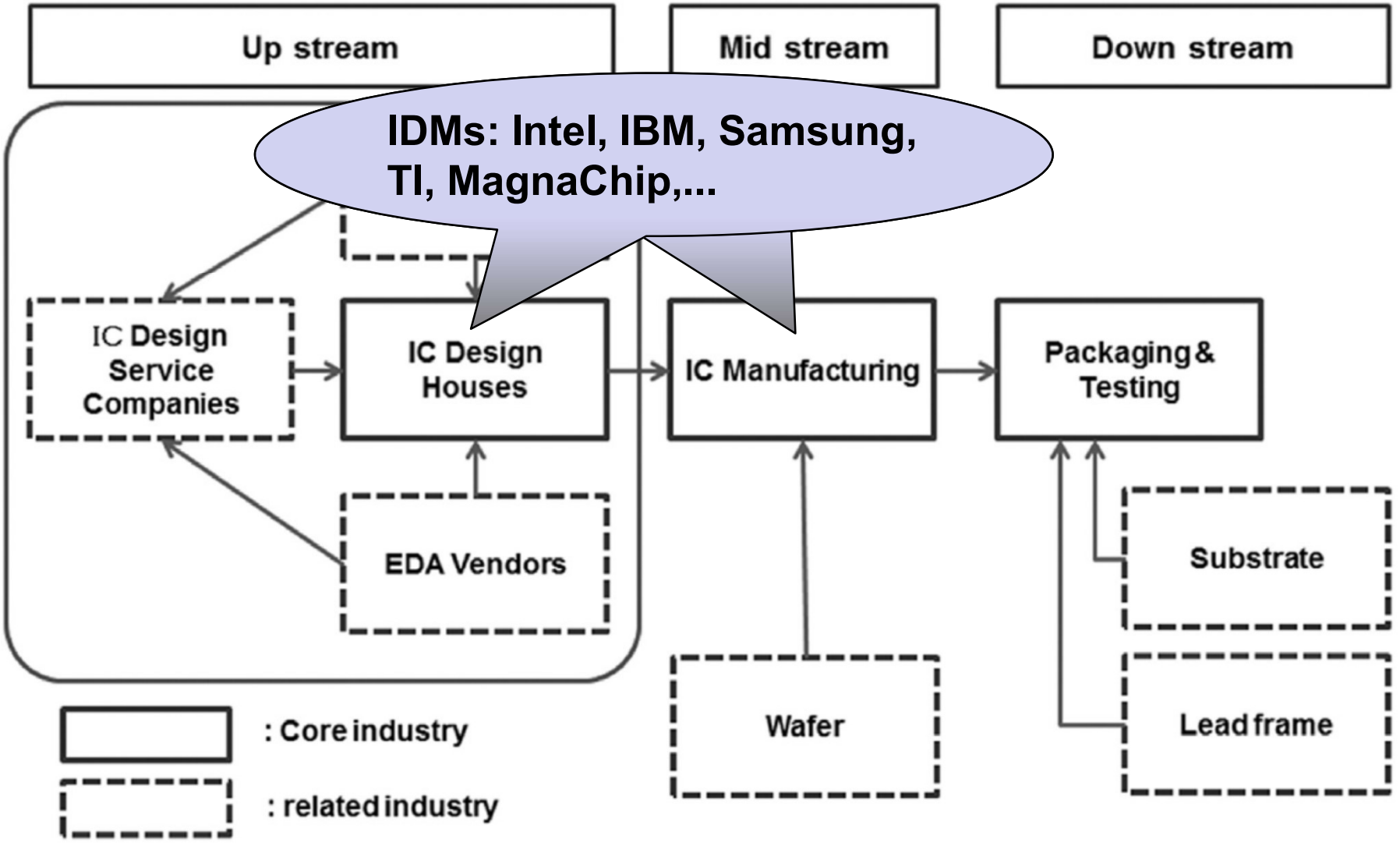

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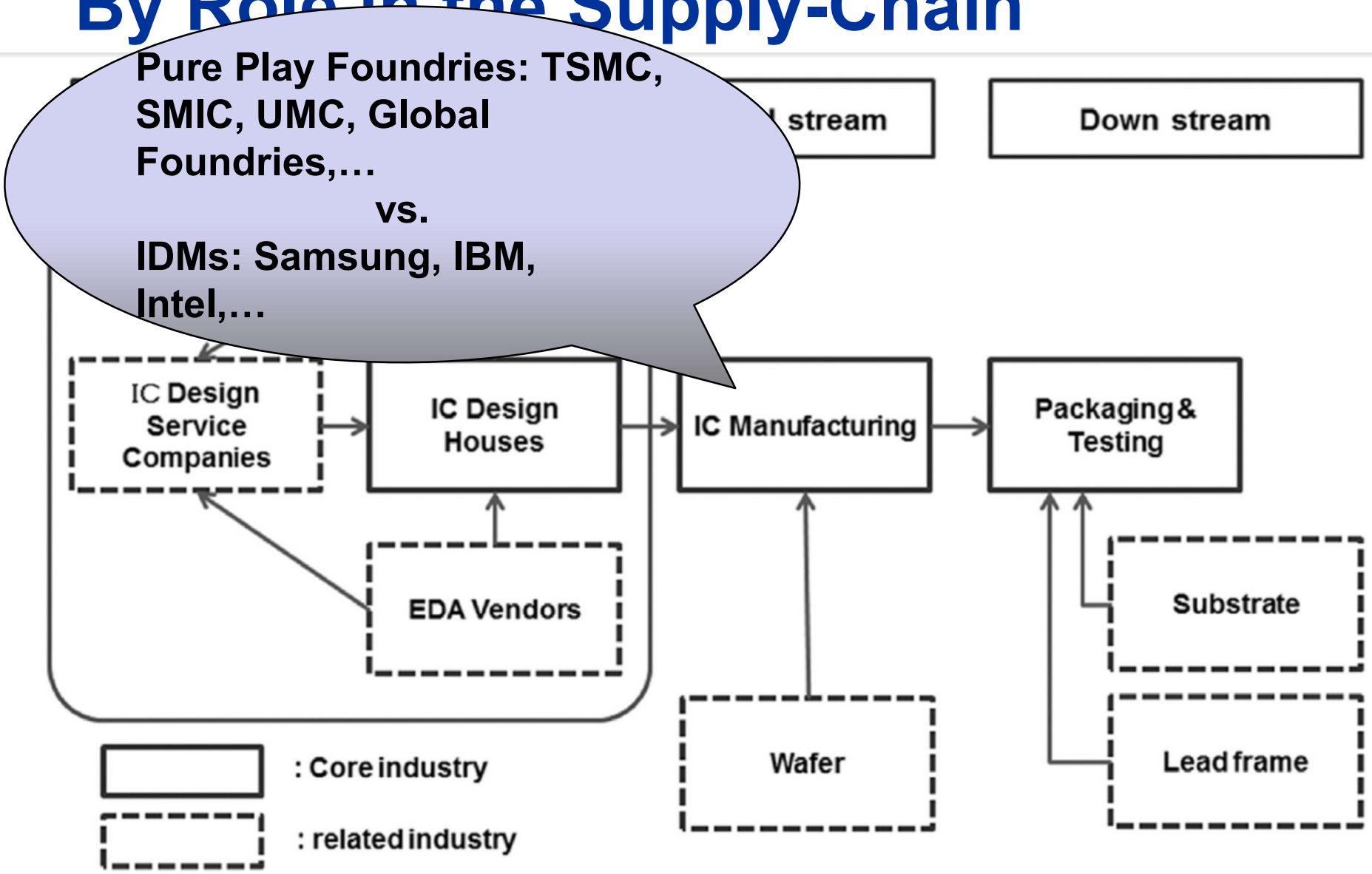

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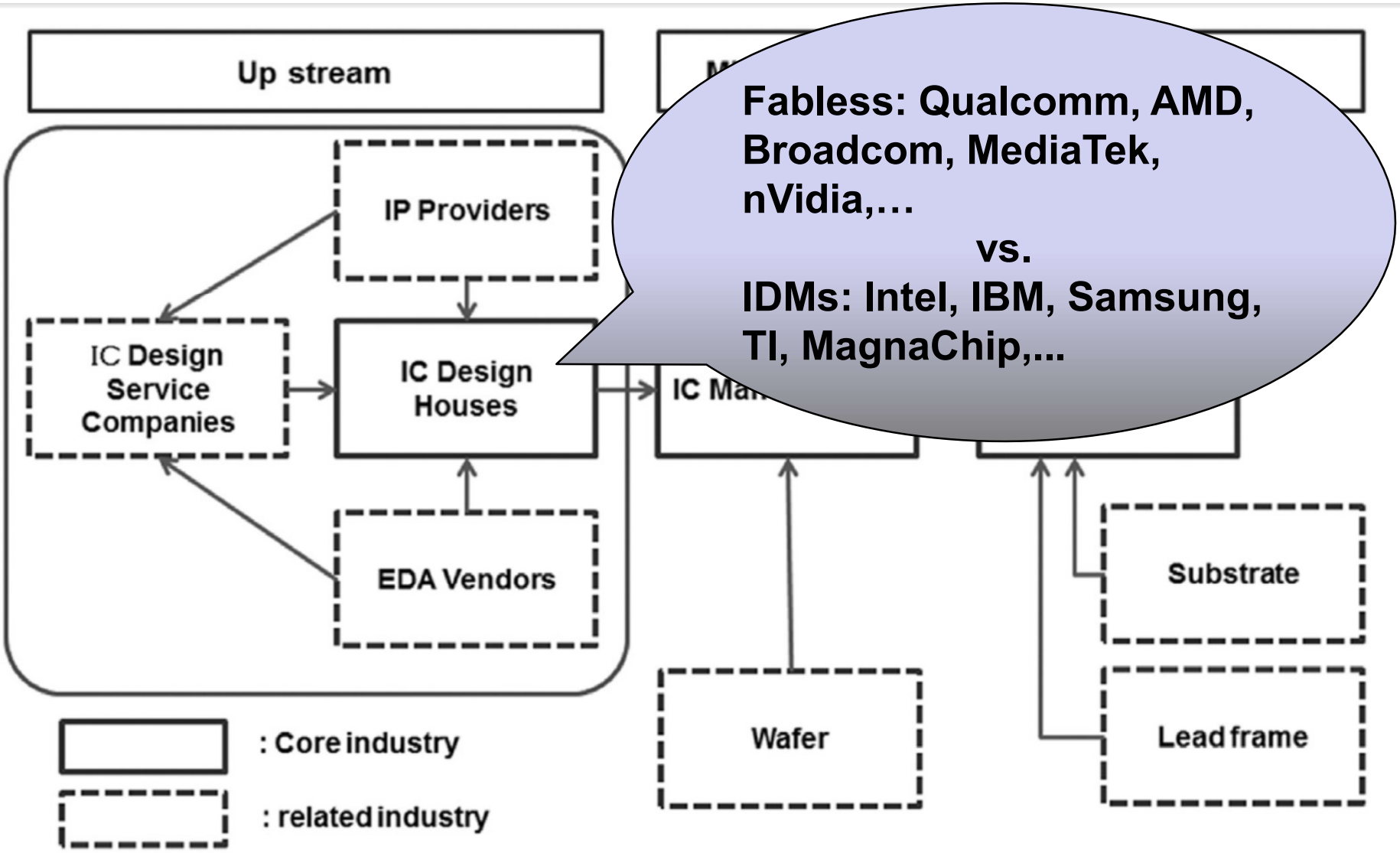

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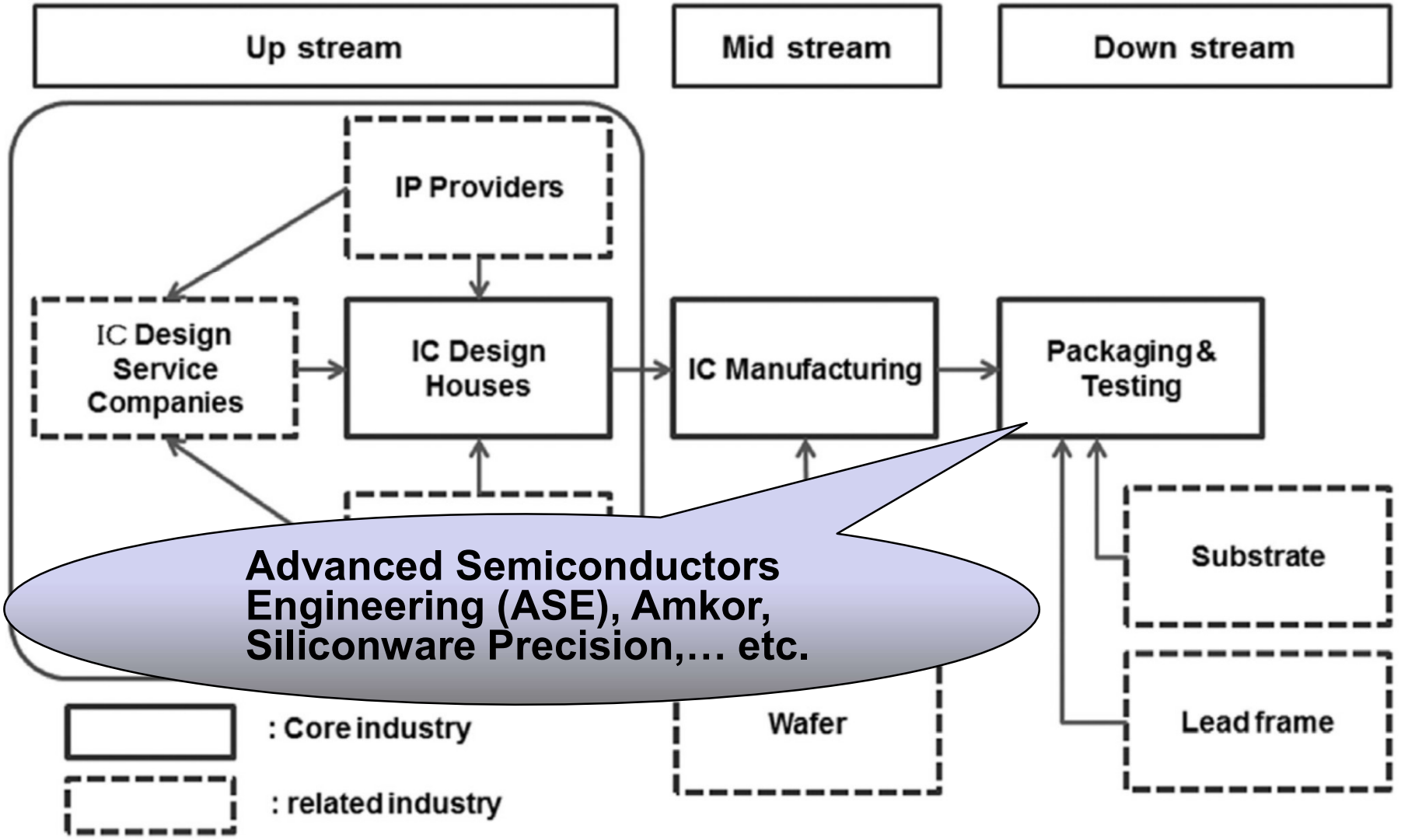

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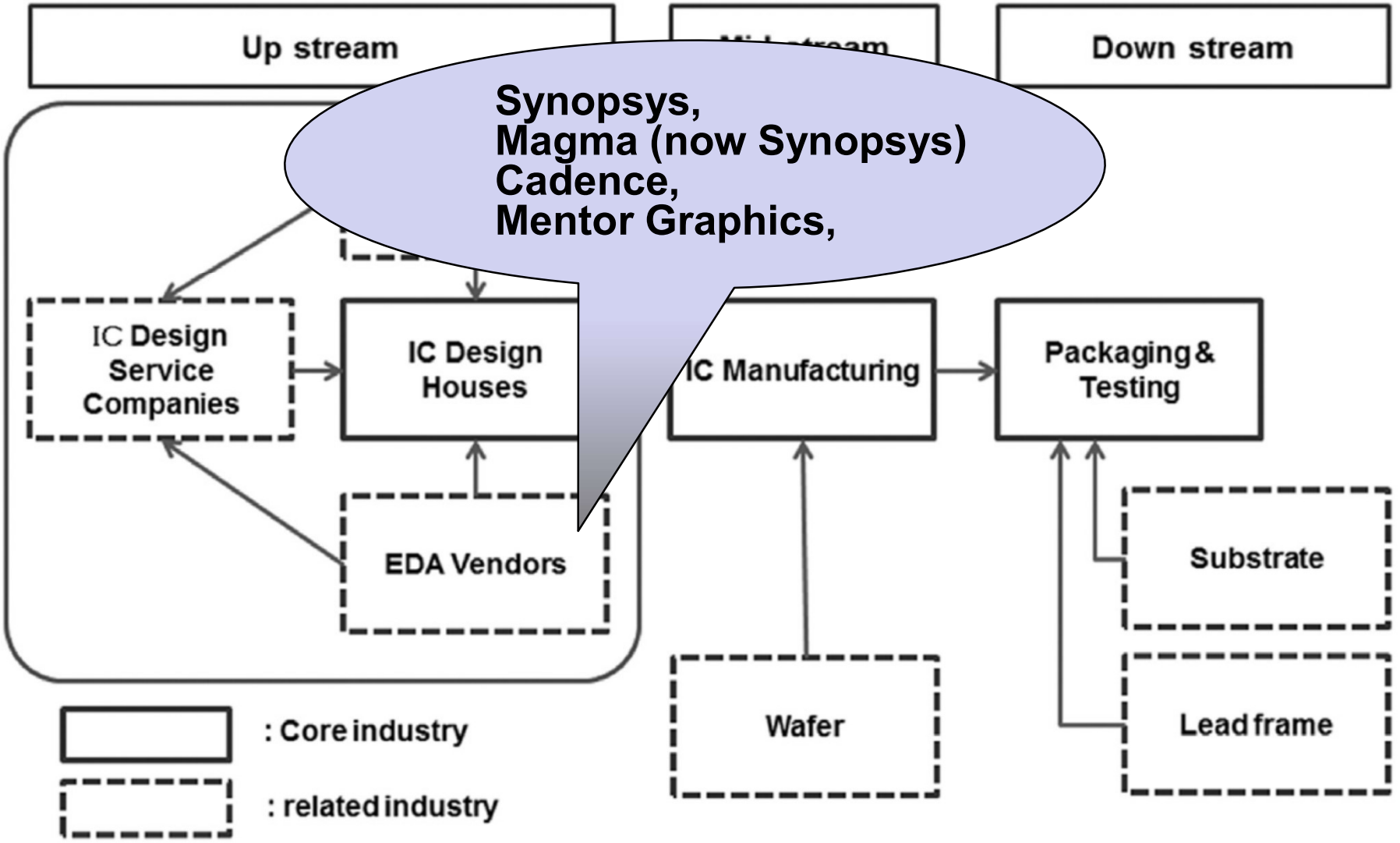

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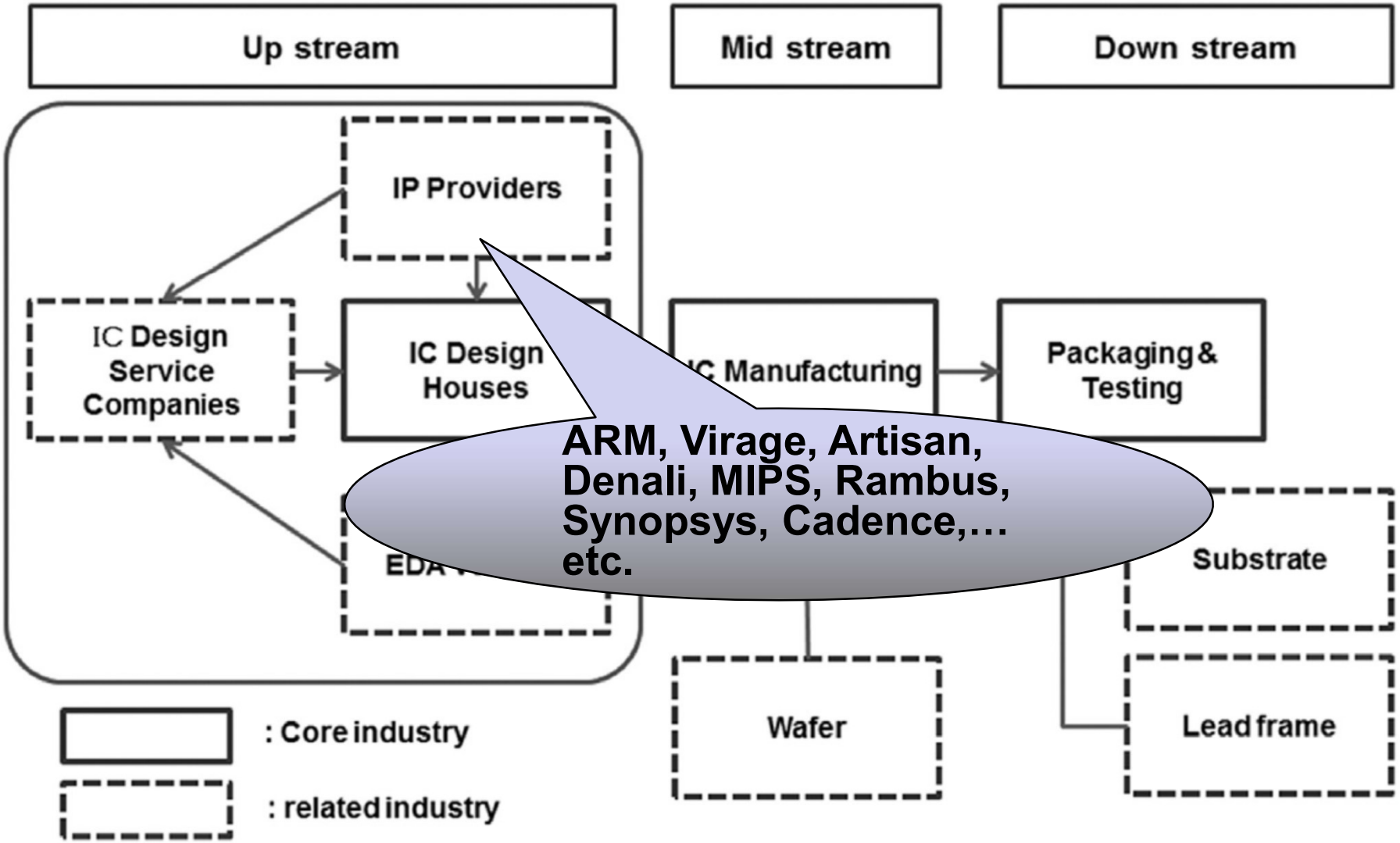

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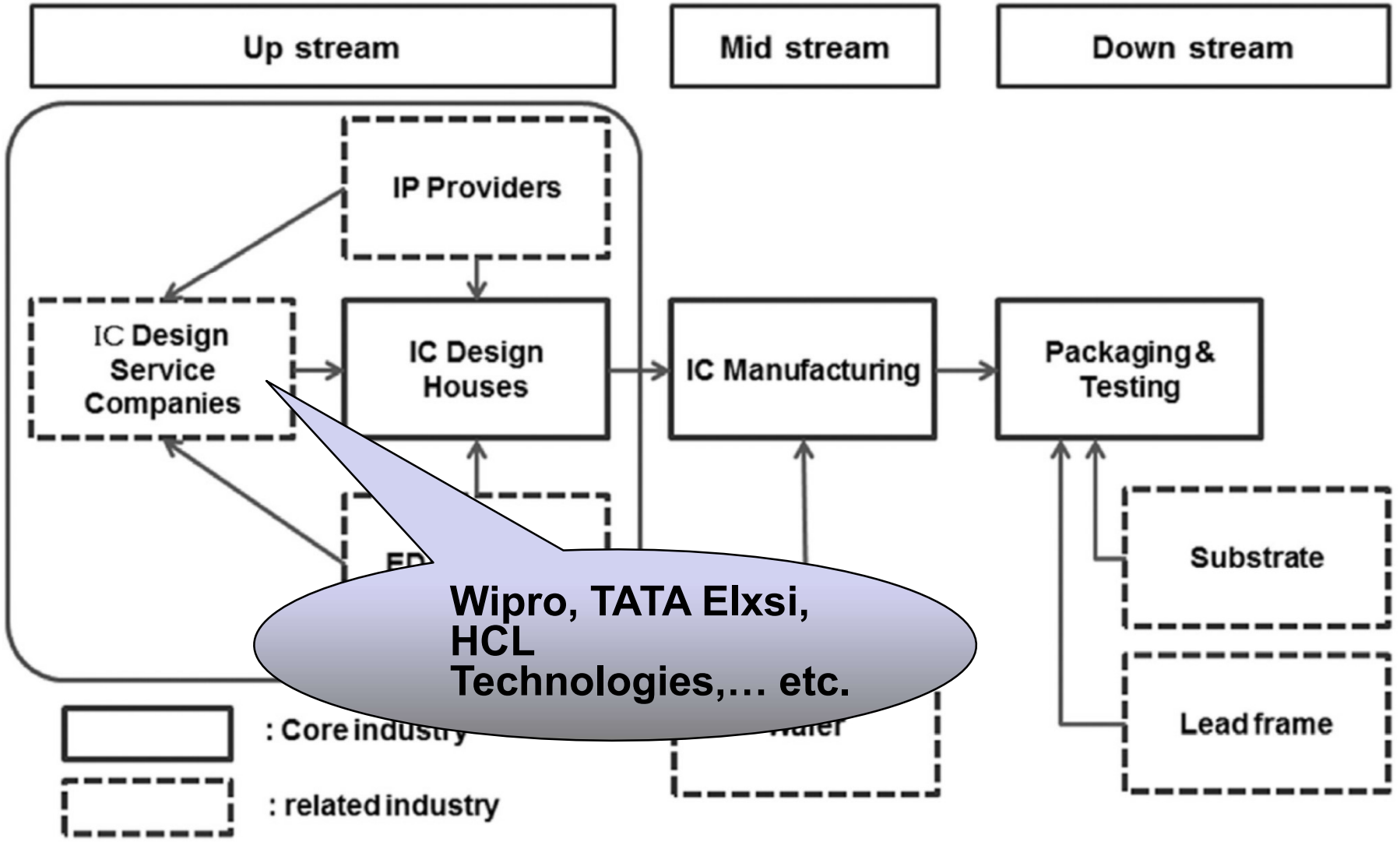

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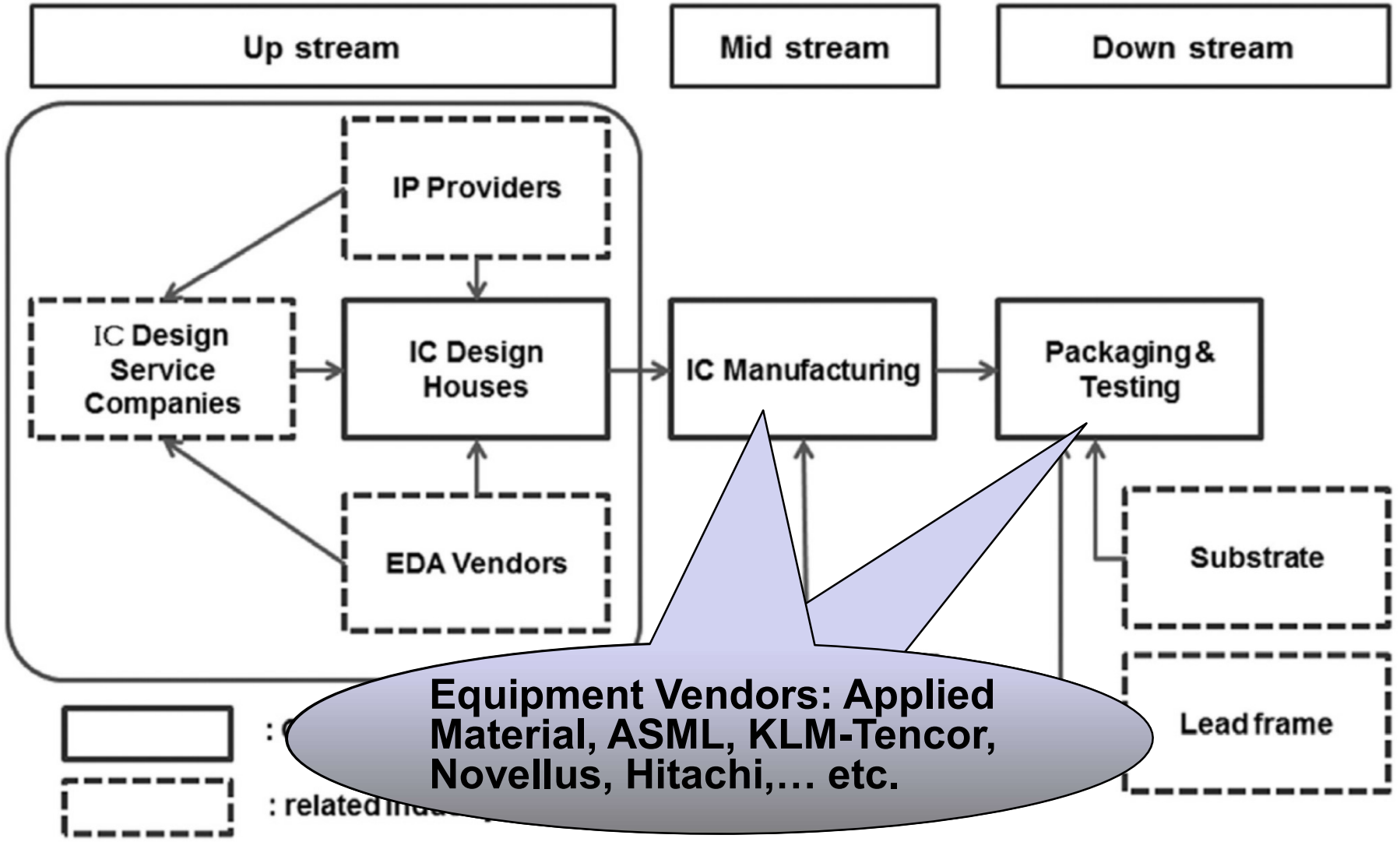

Semiconductors Industry Segments: 1Q14 Top Performers (Sales)

1Q14 Top 20 Semiconductor Sales Leaders
($M, Including Foundries)

1Q14 Rank	1Q13 Rank	Company	Headquarters	1Q13 Tot Semi	1Q14 Tot Semi	1Q14/1Q13 % Change	1Q14/1Q13 Ranking Change
1	1	Intel	U.S.	11,555	11,666	1%	0
2	2	Samsung	South Korea	7,946	8,797	11%	0
3	3	TSMC*	Taiwan	4,470	4,852	9%	0
4	4	Qualcomm**	U.S.	3,916	4,243	8%	0
5	5	Micron + Elpida	U.S.	3,300	4,175	27%	0
6	8	SK Hynix	South Korea	2,577	3,507	36%	2
7	6	Toshiba	Japan	2,939	2,793	-5%	-1
8	7	TI	U.S.	2,717	2,792	3%	-1
9	10	Broadcom**	U.S.	1,962	1,984	1%	1
10	11	Renesas	Japan	1,886	1,865	-1%	1
11	9	ST	Europe	1,994	1,801	-10%	-2
12	16	MediaTek + MStar**	Taiwan	1,083	1,608	48%	4
13	12	Infineon	Europe	1,208	1,440	19%	-1
14	14	AMD**	U.S.	1,088	1,397	28%	0
15	13	Avago + LSI**	Singapore	1,136	1,305	15%	-2
16	15	NXP	Europe	1,085	1,246	15%	-1
17	19	Nvidia**	U.S.	940	1,072	14%	2
18	20	Freescale	U.S.	931	1,071	15%	2
19	18	GlobalFoundries*	U.S.	946	1,010	7%	-1
20	21	UMC*	Taiwan	899	1,006	12%	1
—	—	Top 20 Total		54,578	59,630	9%	—

*Foundry **Fabless

Source: Company reports, IC Insights' *Strategic Reviews* database