

1 July 2018

Fabless silicon photonics operation and design trends



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VLC
PHOTONICS

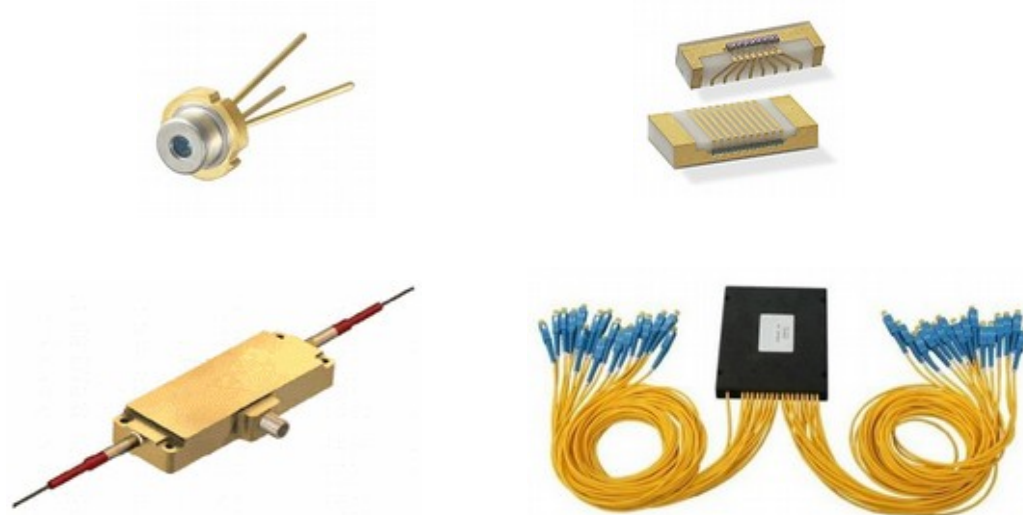
- Vertical vs. Horizontal / fabless business model
- Fabless model in photonic integration
- Fabless silicon photonics operation
- Design trends

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Vertical model



- ✓✓ State-of-the art device
- xx Huge investment



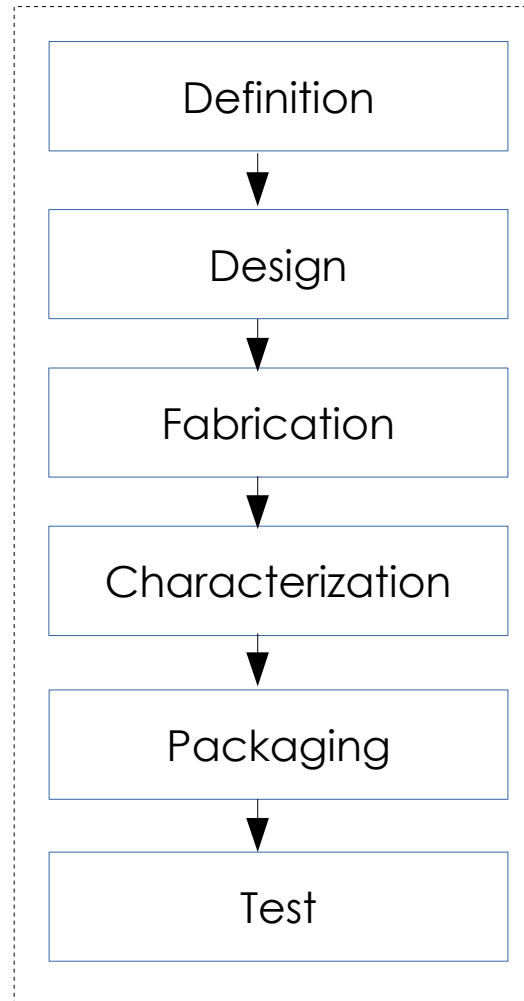
Traditional optical component manufacturers
(lasers, PDs, splitters, AWGs, modulators, etc.)

Vertical model



✓✓ State-of-the art device
xx Huge investment

Horizontal model



✓ Performing device

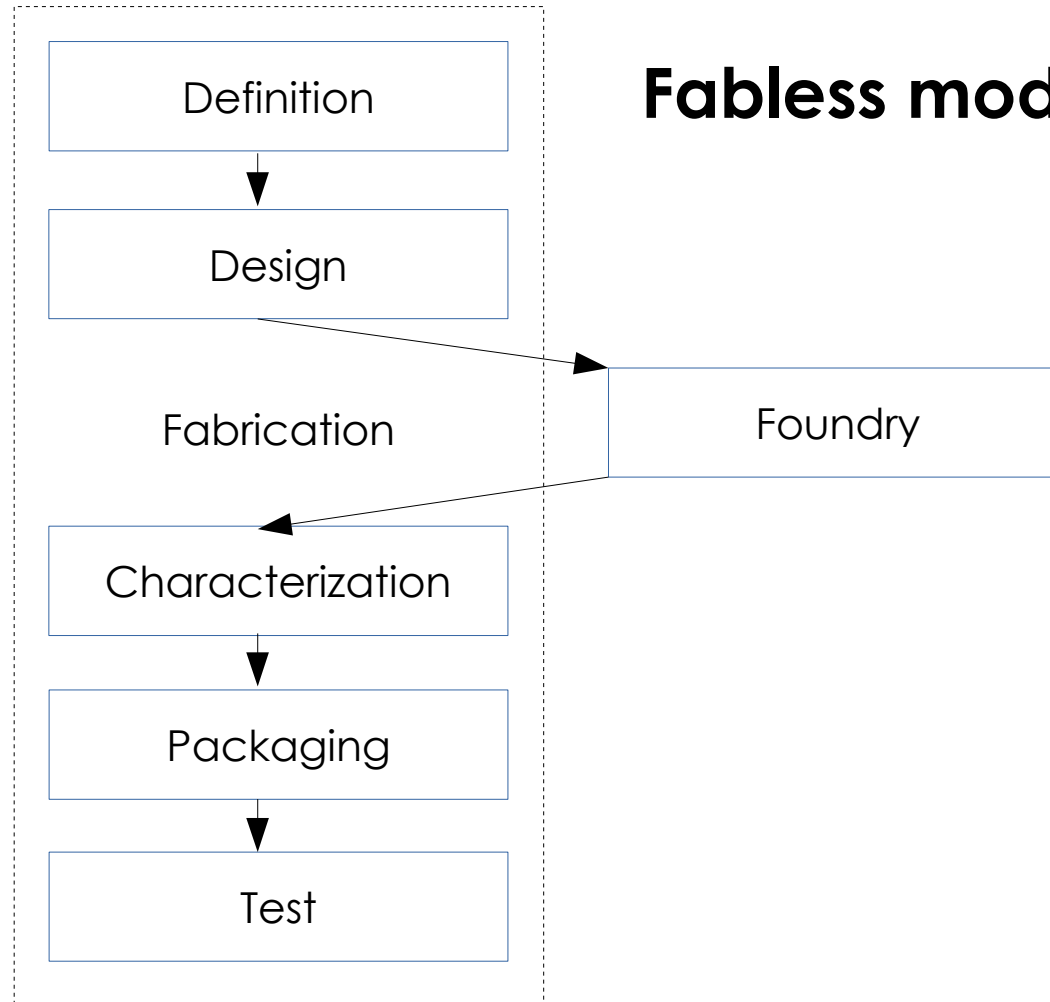
✓✓ Low Investment

Vertical model



- ✓✓ State-of-the art device
- xx Huge investment

Horizontal model



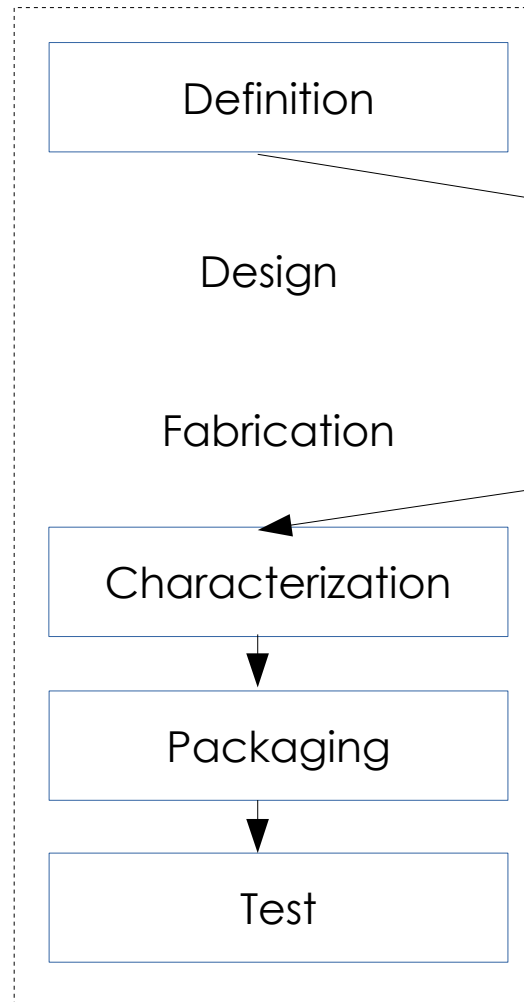
Fabless model

Vertical model

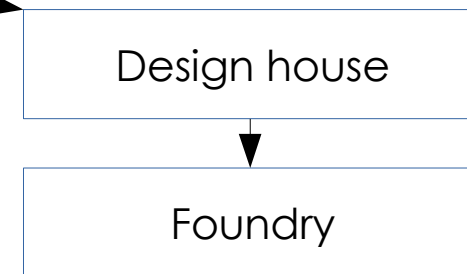


- ✓✓ State-of-the art device
- xx Huge investment

Horizontal model



Fabless model



Vertical model

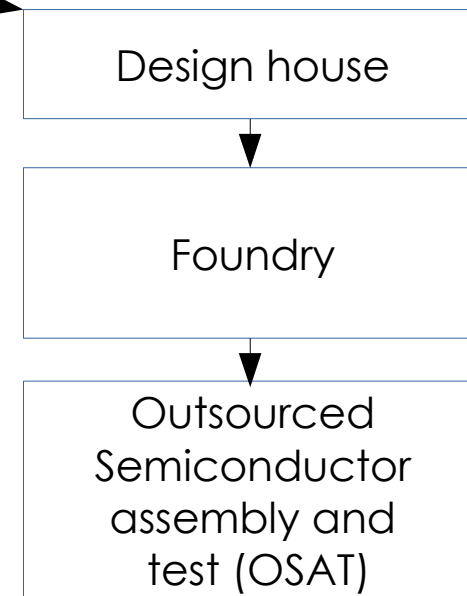


- ✓✓ State-of-the art device
- xx Huge investment

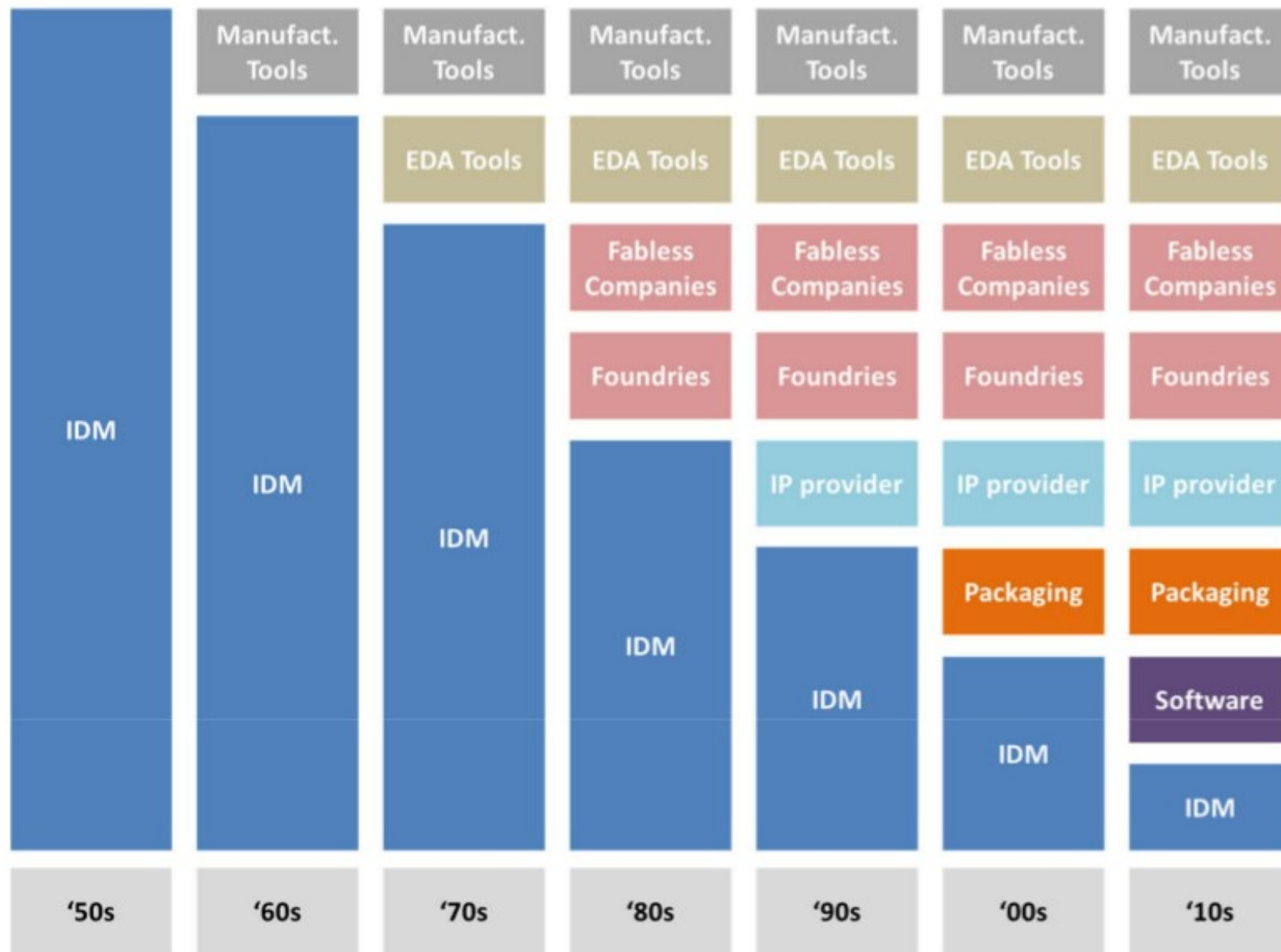
Horizontal model



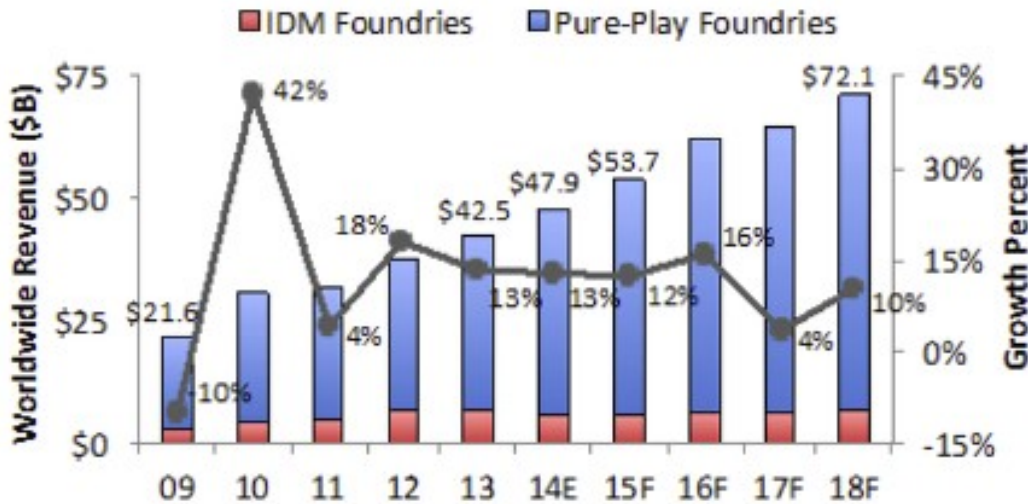
Fabless model



Horizontal business model



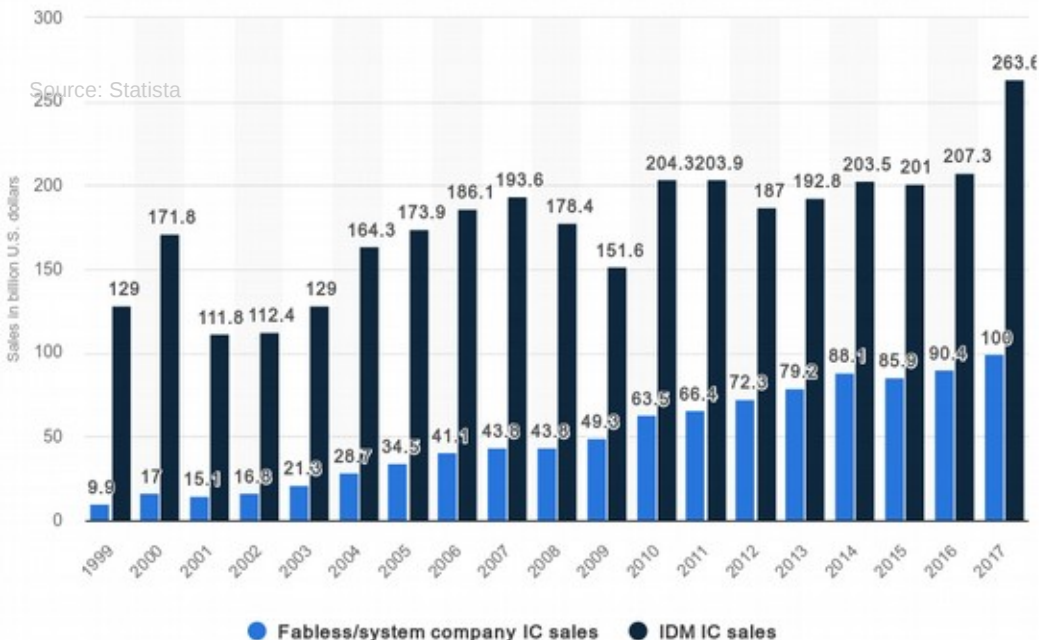
The growth of the fabless model



Source: 2015 Foundry Almanac (IC Insights)

In two decades...

- Pure-play foundry revenues have grown, becoming the predominant manufacturing model.



- While IDM sales are still larger given the large concentration in few players, fabless sales have been growing faster and at a more stable rate over the last two decades.

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PIC technology evolution



Optical component Manufacturers

Lasers
Photodiodes
Passives

PLC

Splitters
AWGs
VOAs

Infonera
100 Gb/s TX/RX
InP, 2004

LUXTERA
40 Gb/s AOC
SOI, 2007


EU fables
Investment

XiO photonics
Beam combiner
Si₃N₄, 2012

Technobis
tft-fos
FBG interrogator
InP, 2015

MedLumics
Enlightening Healthcare
OCT
SOI, 2015


Global investment

1970 1980 1990 2000 2010 2020

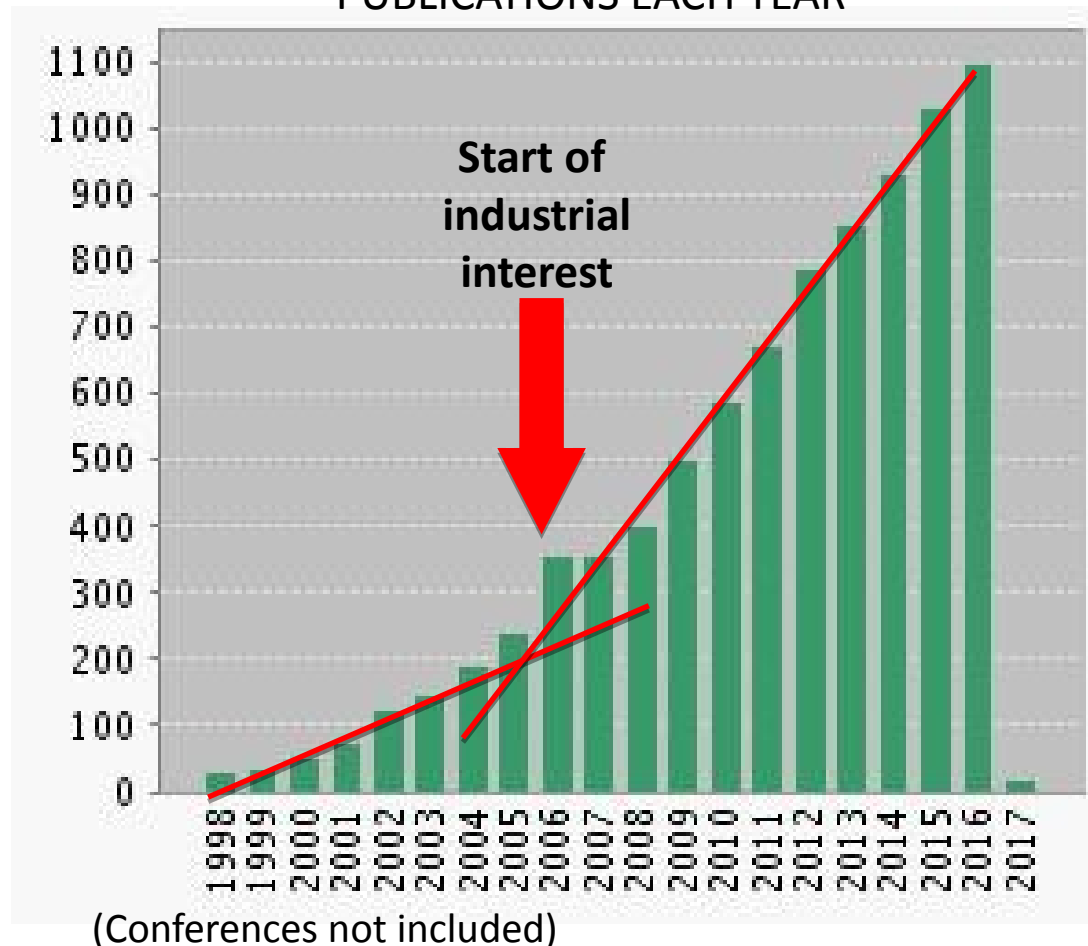
Silicon photonics technology take-up

Citation Report: 8566

(from Web of Science Core Collection)

You searched for: **TOPIC: (silicon) AND TOPIC: (photonic*) AND YEAR PUBLISHED: (1996-2017)**

PUBLICATIONS EACH YEAR



Courtesy Roel Baets,
IMEC/UGhent

PIC market trends

Blog

Data center demand drives silicon photonics to market

6/12/2013 06:38 PM EDT

2 comments post a comment

Like Tweet Share +1

After a decade of research, conversion of electrical signals to light for high speed transmission is edging into production.

Silicon Photonics Market worth \$497.53 Million by 2020

According to the new market research report "Silicon Photonics Market Modulators, Optical Interconnects, WDMF, LED, and Others), by Application and Others), and by Geography - Global Trends and Forecasts to 2014 - 2020" to grow to \$497.53 million by 2020, growing at a CAGR of 27.74% from 2014 to 2020.

Silicon photonics market to grow at CAGR of 38% from \$25m in 2013 to \$700m in 2024

Emerging optical data centers of big Internet firms to trigger growth

Beyond all of the hype and tumult, market drivers and technological developments are converging to ensure a bright future for silicon photonics, according to the 'Silicon Photonics 2014' report from Yole Développement. Indeed, although the silicon photonics market has just kicked off, volume production is already close.

Big data is getting bigger by the second, and transporting it with existing technologies will push the limits

As silicon photonics evolves and chips become more sophisticated, Yole expects the technology to be used more often in

Interconnect Market (8%) and Silicon Photonics (27%) Growth Forecasts

CHICAGO, August 11, 2015 /PRNewswire/ --

ReportsnReports.com adds Global Interconnect Market 2015-2019 research that forecasts an 8.6% CAGR to 2019 and Silicon Photonics Market by Product, Application and by Geography - Global Trends and Forecasts to 2014 - 2020 research report that forecasts a 27.74% CAGR to 2020.

Complete report on interconnect supported with 37 data exhibits 2015-2019.html .

One major interconnect market and overall systems, the integral IT intelligence across the shop market is the growing demand for is escalating demand for custom growth in the population world.

Forecast Report on Global Silicon Photonics Market

Published on July 15, 2014 at 8:28 AM

Research and Markets has announced the addition of the "Global Silicon Photonics 2014 Report: US\$1B Spent in the Past 3 years on Si Photonics Companies' Acquisitions" report to their offering.

Silicon photonics is an exciting field that mixes optics, CMOS, MEMS and 3D stacking technologies. Over the past several years, it's become clear that some technical choices will be better than others for successful commercial development:

- Light source is a big integration challenge. As silicon laser is probably years away from realization, the different approaches are likely to be either attached laser (i.e. Luxtera) or (InP) wafer-to-wafer/die-to-wafer bonding, followed by post-processing (i.e. Intel or Lett).
- there has also been a shift from monolithic integration for integration, since critical dimensions are very different. To seem to be two-chip hybrid integration (the Cu-pillar for example), since semiconductors' and photonics' critical dimensions are at least one order of magnitude different.
- The fiber choice: multi-mode versus single mode is also

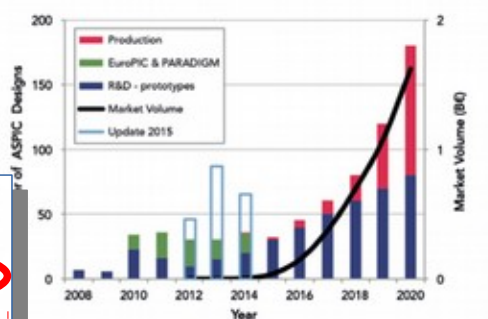


Figure 7 Development of the applications market enabled by ASPICs. The bars from 2012 indicate our predictions, made in 2011. The bars labelled 'update 2015' indicate the actual development.

Global Photonic Integrated Circuit (IC) Market to Reach US\$996.2 Million by 2019: Transparency Market Research

Global Photonic Integrated Circuit (IC) Market to Reach US\$996.2 Million by 2019: Transparency Market Research

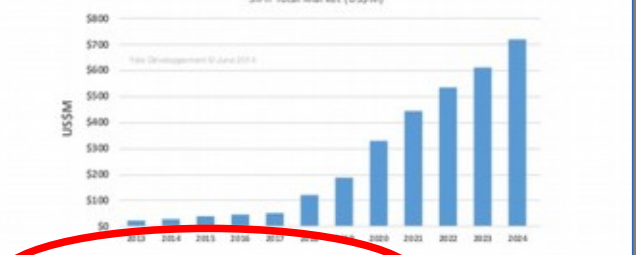
Transparency Market Research has announced the release of a report titled "Photonic Integrated Circuit (IC) Market - Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2013 - 2019".

Browse Report: <http://www.transparencymarketresearch.com/photonic-integrated-circuit.html>

The report states that the global photonic integrated circuit (IC) market will grow at a 31.3% CAGR from 2013 to 2019. The report also includes a detailed analysis of the market's growth drivers and challenges.

Subscription Press Releases Customer Support

Photonic Integrated Circuit Market worth \$1,547.6 Million by 2022



Silicon photonics devices market will grow from less than US\$25M in 2013 to more than US\$700M in 2024 with a 38% CAGR.

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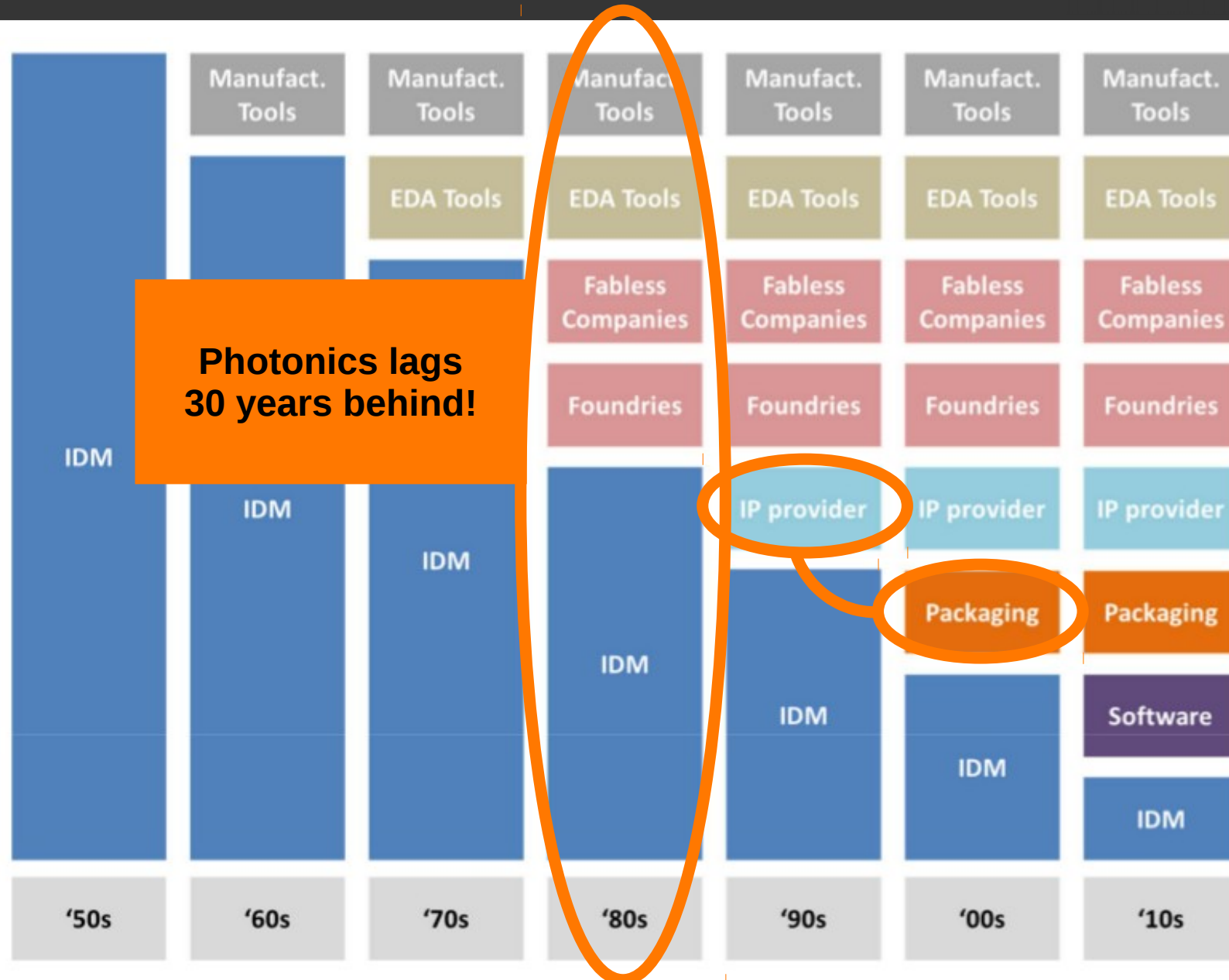
Photonic Integrated Circuits: Technologies and Global Markets
Published: March 2014 | Report Code: PH0007A

Highlights Scope & Analyst Related Materials TOC & Pricing

REPORT HIGHLIGHTS
The global photonic integrated circuit (PIC) market reached \$165.3 million in 2012. This market is expected to grow to \$206.5 million in 2013 and \$866 million in 2018, with a compound annual growth rate (CAGR) of 33.2% over the five-year period, 2013 to 2018.

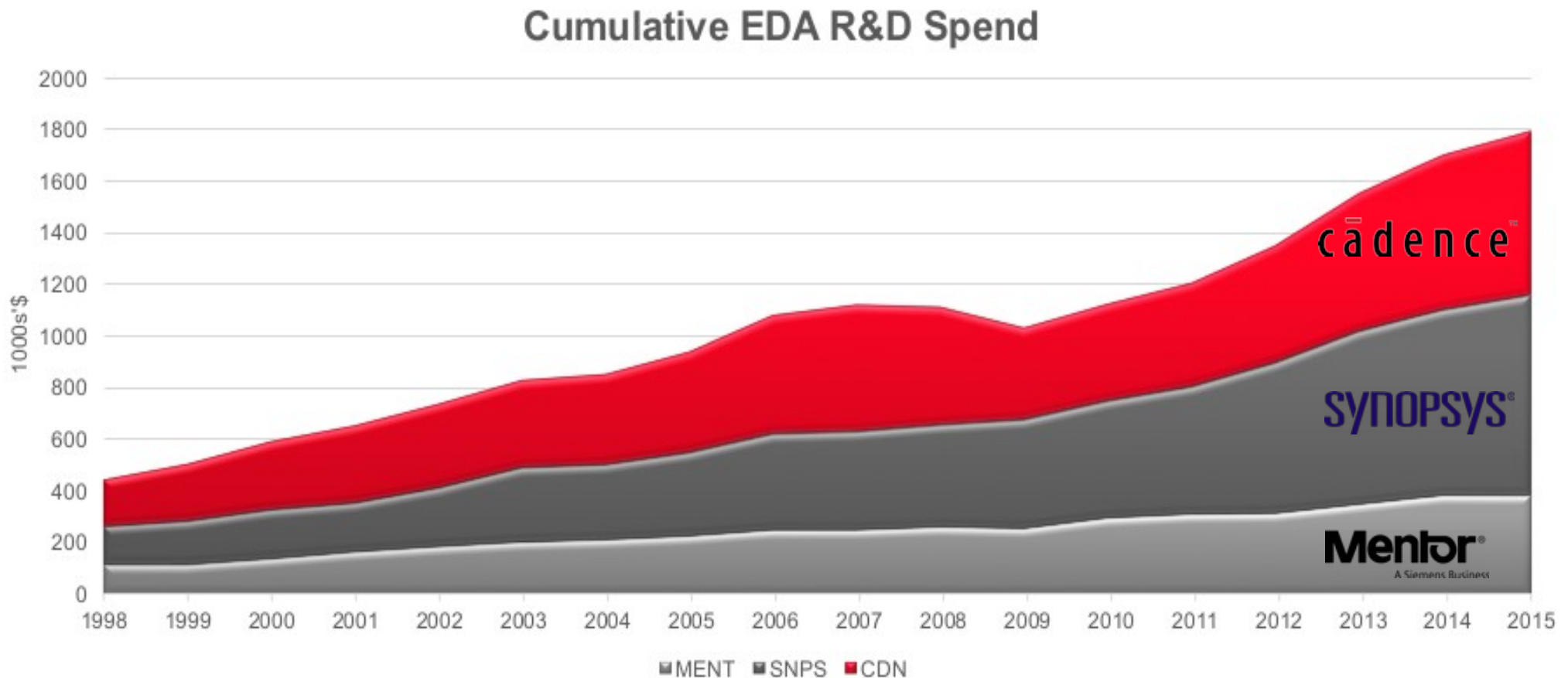
\$866M

Horizontal business model

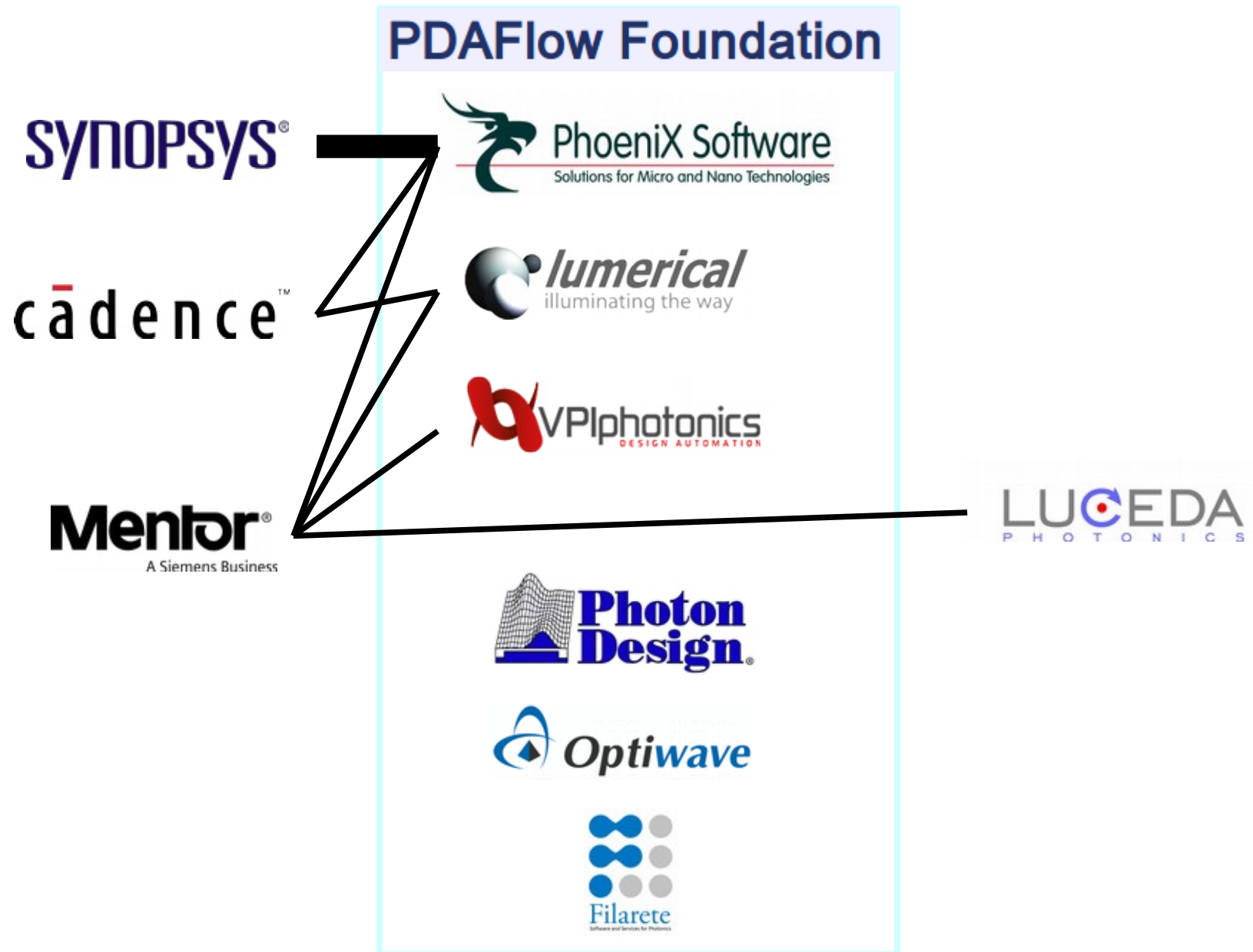


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- Traditional Electronic Design Automation (EDA) tool vendors are heavily investing and partnering with smaller photonic design tool vendors.

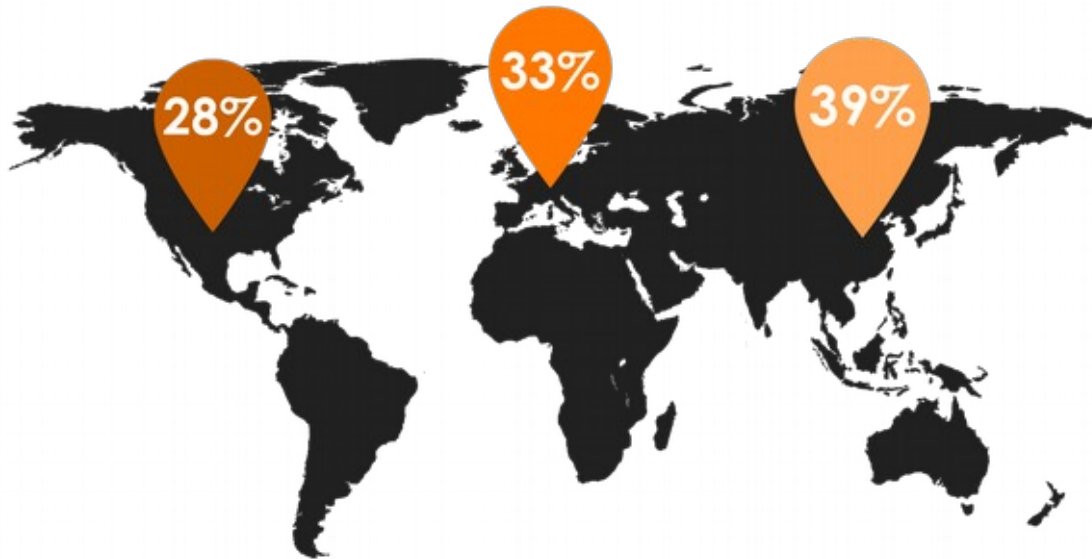


Photonic EDA tools (II)



Fabless Si photonics manufacturing

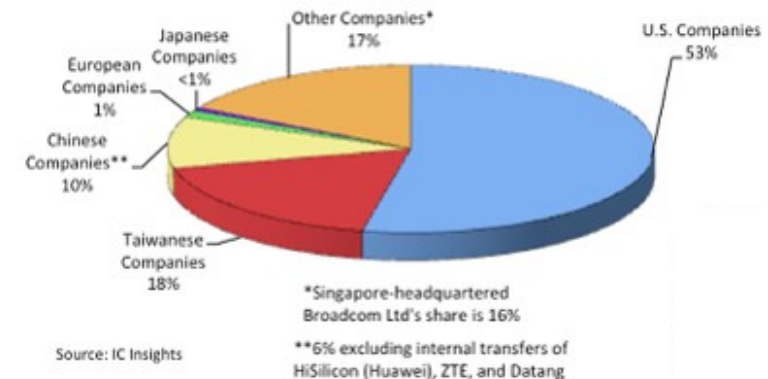
GEOGRAPHIC DISTRIBUTION OF SILICON PHOTONICS FOUNDRIES



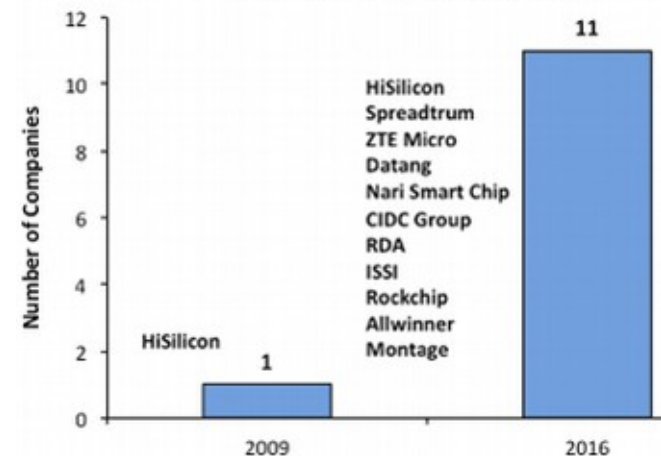
- All major CMOS foundries investing, specially in Asia following IC trends.
- Proprietary generic processes: passives, actives (heaters, Ge PDs, Modulators, heterogeneous InP)
- Extra FEOL modules (SiN, SSC, etc.)
- BEOL options (Al/Cu, multilayer routing, TSV, pillars, etc.)
- Electronic-Photonic co-design

Source: IC Insights

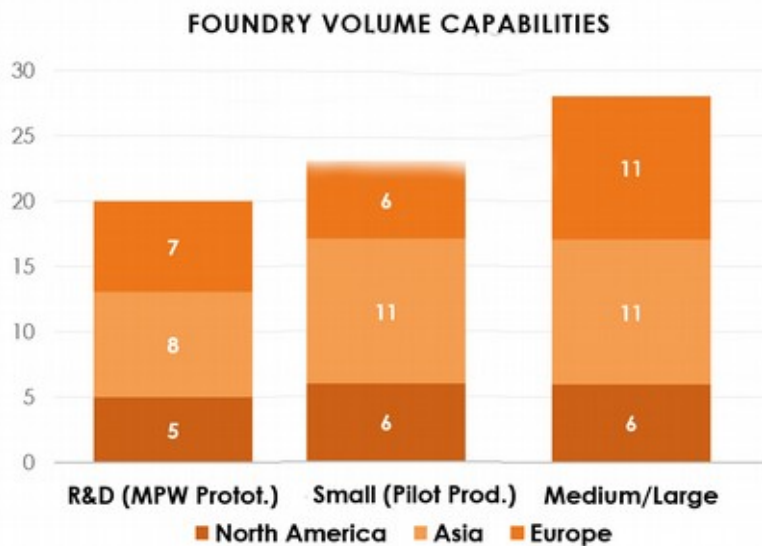
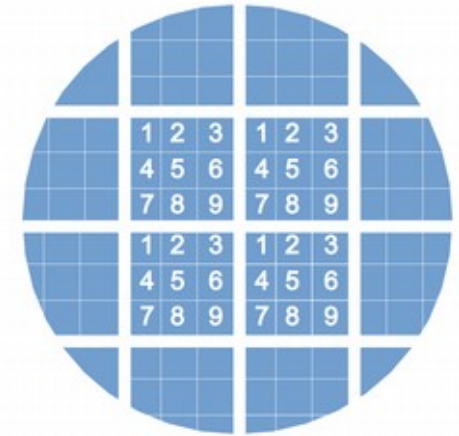
2016 Fabless Company IC Sales by Company Headquarters Location (\$90.4B)



Chinese Companies in the Top 50 Fabless IC Supplier Ranking



- Different software versions of Process Design Kits (PDKs) in place at most foundries, compiling design libraries with many mature building blocks for several processes.
- Multi-Project Wafer (MPW) runs available directly or through brokers for low-cost prototyping.
- R&D foundries setting up strategic agreements to transfer process and allow to scale-up production.



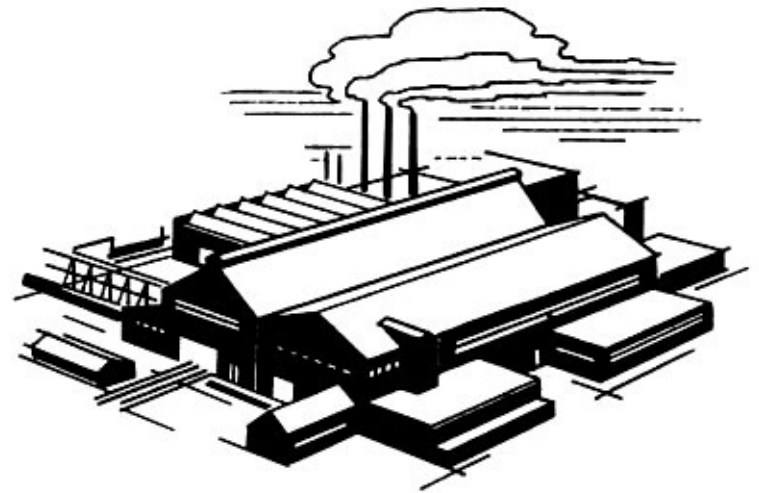
VLC Photonics technical foundries report:

- **35 silicon photonic foundries, 6 brokers**
- **Contact info, capabilities, & PIC developments**
- **180 pages & +650 references**



[BUY ONLINE NOW](#)

- Lack of updated information & roadmaps
- PDK availability & BB validation
- Turn around (cycle) time & delays
- Fabrication reporting
- Performance and delivery guarantees
- Wavelength range

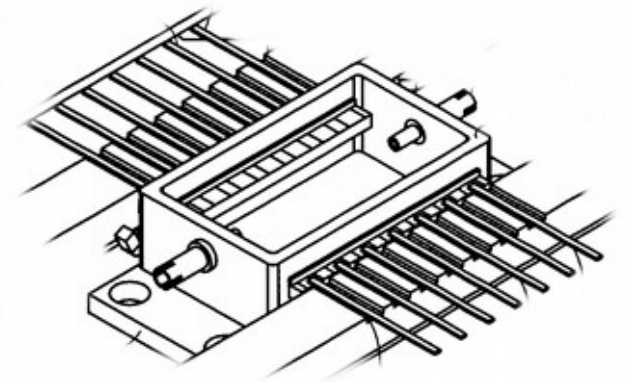


Back-end (post fab) processes comprise:

- Wafer metrology and probing
- Wafer back grinding (thinning) and dicing/cleaving
- Bare die characterization
- Packaging into component
- Component testing
- Assembly into module

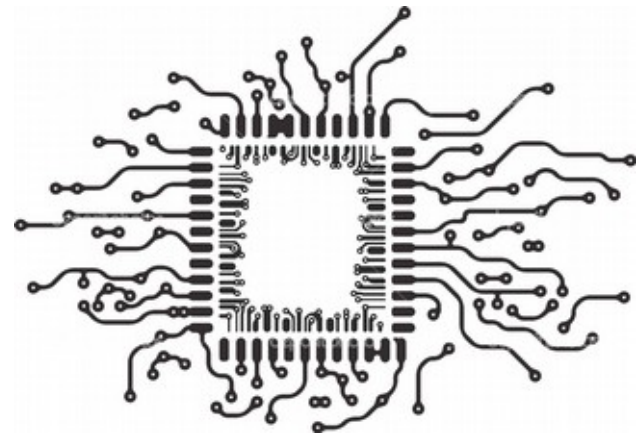
Challenges in photonics still remain:

- High cost contribution at the back-end
- On wafer electrical+optical testing
- Package & assembly scalability
- Lack or fragmentation of standards
- DC+RF+optical package design & multiphysics
- Small pool of expertise and providers



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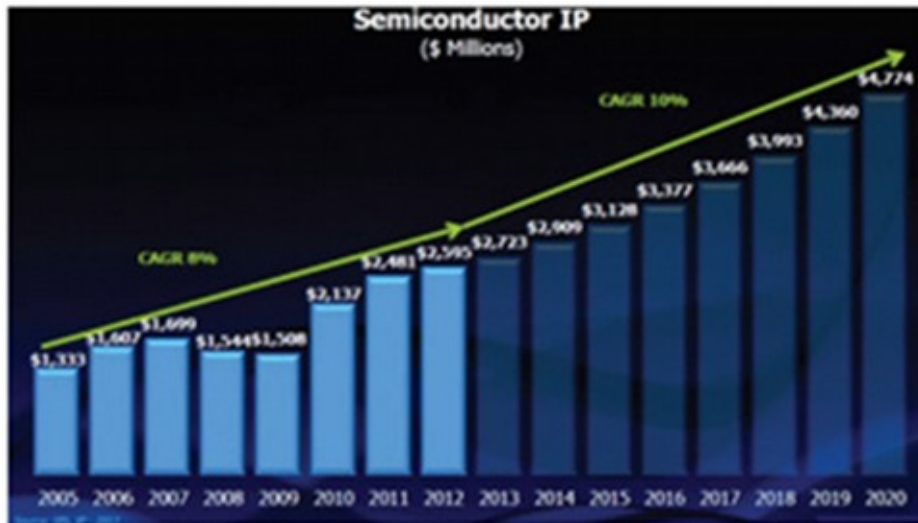
- IP on building blocks / PDKs
- DRC validation & routing automatization
- Workflow standardization & tool interfacing
- Software licensing models and incumbent pricing
- Training & documentation
- Skilled workforce



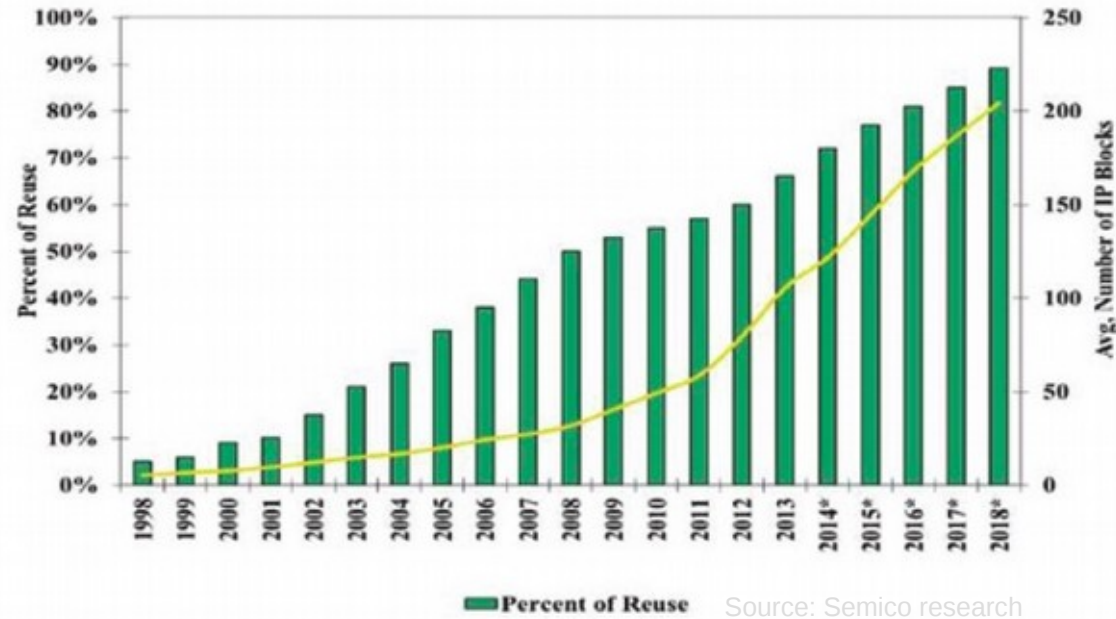
Design company trends

Company Type	Characteristics	Typical size
ID design consultants	1-2 person operation focusing on consulting on particular specialties	0.2 to 0.5M €
PIC design house	Always fabless, 3-25 people, sometimes also brokers fabrication or other services	0.5 to 2M €
IP / Technology licensing company	Usually focused on one technology or product area, engineering oriented management	2 to 15M €
Fabless chip firm	Growing fast to a niche product or market; usually fabless, strong marketing, product development and distribution departments, 20-200 people	< 200M €

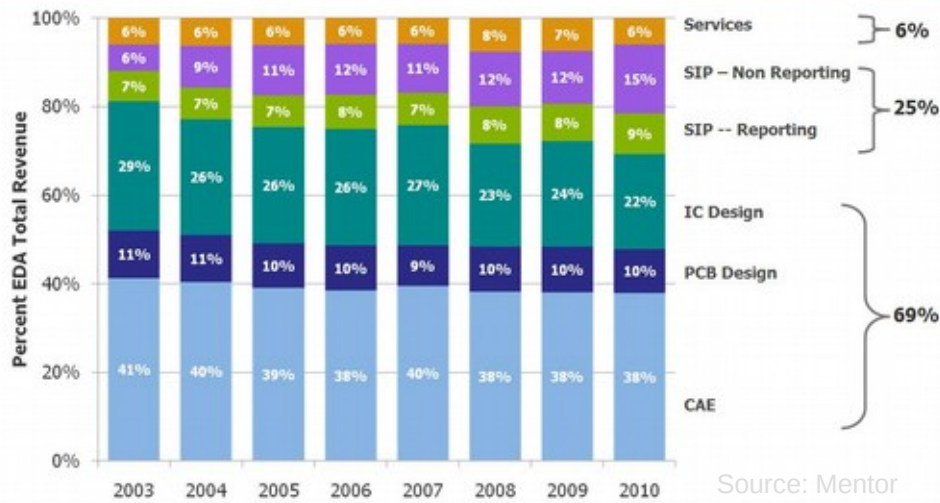
IP approach in photonic integration



Source: IBS



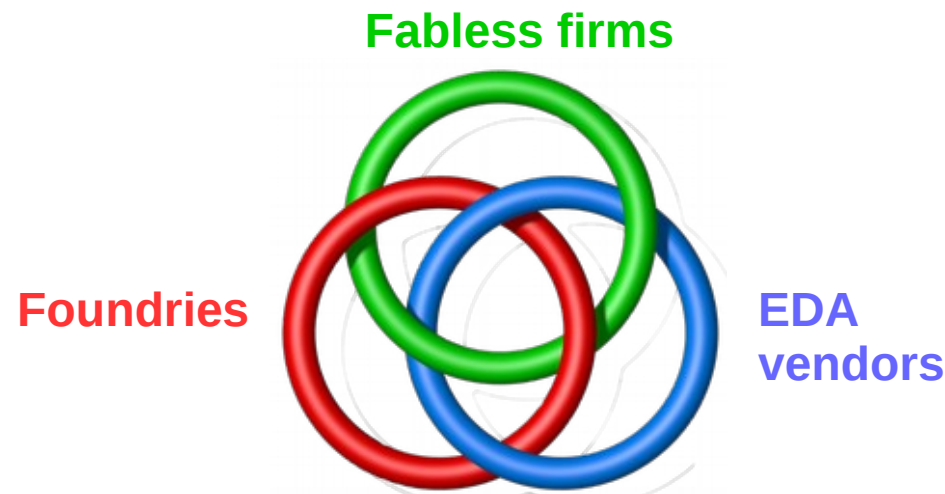
Source: Semico research



Source: Mentor

- **Design IP is a large business in semiconductor markets.**
- **IP owned by:**
 - Foundries
 - Fabless firms
 - EDA vendors

- **Photonics still lacks such business model, mainly due to:**
 - Lack of market volume and enough licensee base,
 - Low maturity of fabrication processes, risky and expensive IP development,
 - IP usually limited to building blocks, not circuits,
 - Difficult IP usage, checking and enforcing,
 - Expensive patent/semiconductor topography registration, maintenance and defence, specially for SMEs.



- Photonic integration is maturing very quickly due to growing market demands, and silicon photonics is profiting from all experience of the CMOS world.
- The fabless model is being successfully replicated in the photonic integration field.
- Main technical and business challenges remain on the back-end processes.
- On the design side, the photonics EDA market is quickly consolidating, while design IP will take longer to become a market reality.

**Thank you for
your attention!**

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