

International Technology Roadmap for Semiconductors

The **International Technology Roadmap for Semiconductors (ITRS)** is a set of documents produced by a group of semiconductor industry experts. These experts are representative of the sponsoring organisations which include the Semiconductor Industry Associations of the United States, Europe, Japan, China, South Korea and Taiwan.

The documents produced carry this disclaimer: "The ITRS is devised and intended for technology assessment only and is without regard to any commercial considerations pertaining to individual products or equipment".

The documents represent best opinion on the directions of research and time-lines up to about 15 years into the future for the following areas of technology:

- System drivers/design
- Test & test equipment
- Front-end processes
- Process integration, devices and structures
- Radio frequency and analog/mixed-signal technologies
- Microelectromechanical systems (MEMS)
- Photolithography
- IC interconnects
- Factory integration
- Assembly & packaging
- Environment, safety & health
- Yield enhancement
- Metrology
- Modeling & simulation
- Emerging research devices
- Emerging research materials

As of 2017, ITRS is no longer being updated. Its successor is the International Roadmap for Devices and Systems.

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History

Constructing an integrated circuit, or any semiconductor device, requires a series of operations—photolithography, etching, metal deposition, and so on. As the industry evolved, each of these operations were typically performed by specialized machines built by a variety of commercial companies. This specialization may potentially make it difficult for the industry to advance, since in many cases it does no good for one company to introduce a new product if the other needed steps are not available around the same time. A technology roadmap can help this by giving an idea when a certain capability will be needed. Then each supplier can target this date for their piece of the puzzle.^{[1][2][3]}

With the progressive externalization of production tools to the suppliers of specialized equipment, the need arose for a clear roadmap to anticipate the evolution of the market and to plan and control the technological needs of IC production. For several years, the Semiconductor Industry Association (SIA) gave this responsibility of coordination to the United States,

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Ex. 2080, p. 1

which led to the creation of an American style roadmap, the **National Technology Roadmap for Semiconductors** (NTRS).^[4]

Characteristic	1992	1995	1998	2001	2004	2007
Feature size (microns)	0.50	0.35	0.25	0.18	0.12	0.10
Gates per chip (millions)	0.3	0.8	2.0	5.0	10.0	20.0
Bits per chip						
DRAM	16M	64M	256M	1G	4G	16G
SRAM	4M	16M	64M	256M	1G	4G
Wafer processing cost (\$/cm ²)	\$4.00	3.90	3.80	3.70	3.60	3.50
Chip size (mm ²)						
logic	250	400	600	800	1,000	1,250
memory	132	200	320	500	700	1,000
Wafer diameter (mm)	200	200	200-400	200-400	200-400	200-400
Defect density (defects/cm ²)	0.10	0.05	0.03	0.01	0.004	0.002
Levels of interconnect (for logic)	3	4-5	5	5-6	6	6-7
Maximum power (watts/die)						
high performance	10	15	30	40	40-120	40-200
portable	3	4	4	4	4	4
Power supply voltage						
desktop	5	3.3	2.2	2.2	1.5	1.5
portable	3.3	2.2	2.2	1.5	1.5	1.5

The first semiconductor roadmap, published by the SIA in 1993.

In 1998, the SIA became closer to its European, Japanese, Korean, and Taiwanese counterparts by creating the first global roadmap: The International Technology Roadmap for Semiconductors (ITRS). This international group has (as of the 2003 edition) 936 companies which were affiliated with working groups within the ITRS.^[5] The organization was divided into Technical Working Groups (TWGs) which eventually grew in number to 17, each focusing on a key element of the technology and associated supply chain. Traditionally, the ITRS roadmap was updated in even years, and completely revised in odd years.^[6]

The last revision of the ITRS Roadmap was published in 2013 (<http://www.itrs2.net/itrs-reports.html>). The methodology and the physics behind the scaling results for 2013 tables is described in transistor roadmap projection using predictive full-band atomistic modeling (<http://scitation.aip.org/content/aip/journal/apl/105/8/10.1063/1.4894217>) which covers double gate MOSFETs over the 15 years to 2028.

With the generally acknowledged sunseting of Moore's law and, ITRS issuing in 2016 its final roadmap, a new initiative for a more generalized roadmapping was started through the IEEE's Rebooting Computing initiative, named the International Roadmap for Devices and Systems (IRDS).^[7]

ITRS 2.0

In April 2014, the ITRS committee announced it would be reorganizing the ITRS roadmap to better suit the needs of the industry. The plan was to take all the elements included in the 17 technical working groups and map them into seven focus topics:^[6]

- **System integration**

This is a design-focused topic that examines architectures, and how to integrate heterogeneous blocks.

- **Outside system connectivity**

Focuses on wireless technologies, how they work, and how to choose the best solution.

- **Heterogeneous integration**

The focus will be on integration of separately manufactured technologies into a new unit so that they function better than the individual pieces do separately - whilst allowing for components such as cameras and microphones.

- **Heterogeneous components**

Focuses on different devices that form heterogeneous systems, such as MEMS, power generation, and sensing devices.

- **Beyond CMOS**

The focus is on devices that provide electronics but aren't CMOS based, such as spintronics, memristors, and others.

More Moore

Because there is still work to be done, this group will take on the continued shrinking of CMOS.

Factory integration

Focus will be on the new tools and processes to produce heterogeneous integration of all these things.

Chapters on each topic were published in 2015.^{[8][9]}

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8. ITRS 2.0 reports (<http://www.itrs2.net/itsr-reports.html>)
9. ITRS 2.0 chapters (<https://www.dropbox.com/sh/3jfh5fq634b5yqu/AADYT8V2Nj5bX6C5q764kUg4a?dl=0>)

Further reading

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- Esmaeilzadeh, Hadi, Emily R. Blem, Renée St. Amant, Karthikeyan Sankaralingam, Doug Burger (2011). "Dark silicon and the end of multicore scaling" (<ftp://ftp.cs.utexas.edu/pub/dburger/papers/ISCA11.pdf>) (PDF). *Proceedings of ISCA'2011*: 365–376.

External links

- Official itrs2 website (<http://www.itrs2.net/>)
- Mirror of the original website (<https://web.archive.org/web/20151228041321/http://www.itrs.net/>) at Archive.org
- Yearly ITRS reports (<https://web.archive.org/web/20090207001203/http://www.itrs.net/reports.html>)

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