Nothing on the Extrapolation in the Chip Industry

GSA / SEMATECH Memory Conference, April 16, 2012

Invited Speech

Commentary

GSA (Global Semiconductor Alliance) is an organization that changed its name and expanded its mission in 2004 as a successor to FSA (Fabless Semiconductor Association) established in 1994. Currently, more than 400 companies in the world are the members. This speech is an invited talk at the conference co-hosted by GSA and SEMATECH in Tokyo in 2012. The content is intended for semiconductor managers.

What the title of the speech really means is that it is very difficult to predict the future in the semiconductor industry and that we must be prepared for the situation which may change unexpectedly.

Moore's Law is an exceptional case which has allowed future prediction in one aspect of the industry, or the integration level of a transistor on a chip, for a long time since 1960's. But there are cases in which the future is quite unpredictable, and these are the subject of this speech.

The topics covered here include changes in the trend of standardization and customization, changes in market drivers, diversification of technology, and market forecasts. The important lesson to be remembered is named "95 mentality" which includes "there will be no more silicon cycle because of solid state pervasiveness" (P. 17). The silicon cycle has not disappeared since then.

I also mentioned that the long time dreams are coming true such as the nonvolatile RAM technology and the business related to the language technology.

In our industry, tomorrow is not a simple extension of yesterday and today. It is important to catch the turning point and ride on the new wave bravely.

GSA / SEMATECH
Memory+ Conference
April 16, 2012

Nothing on the Extrapolation In the Chip Industry

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President of SSIS

(Society of Semiconductor Industry Specialists)

Dr. T. Makimoto (TechnoVision)

It is extremely difficult to predict the future of semiconductors. Especially market forecast can vastly deviate from the reality even one to two years ahead. Also, from the technical point of view, past trends will not simply last long, and the left and right may be reversed. Those who are engaged in semiconductor business must always be prepared for such situations.

Outline

★ Impact of Chip Innovation

★Nothing is on the Extrapolation

★ Longtime Dreams Coming True

Mobile Phone in 1970's

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This picture was taken at the War Museum in Ho Chi Minh City when I visited Vietnam in 2006. These are three sets of mobile phones in the era of Vietnam War in the 1970s. The weight of a set is about 10 Kg, which is about 100 times that of a current mobile phone (about 100 grams, shown in the middle). The background to such impressive progress is semiconductor innovation.

Supercomputer vs iPod

★ Cray-1A Introduced in 1976

- Speed: 160MFLOPS
- Weight: 5.5tons
- Price: $6M
- 5u Bipolar Technology

"Cray-1A specs are comparable to those of 2006 iPod shuffle" (Wikipedia)

- 90nm CMOS Technology

Courtesy of Computer History Museum

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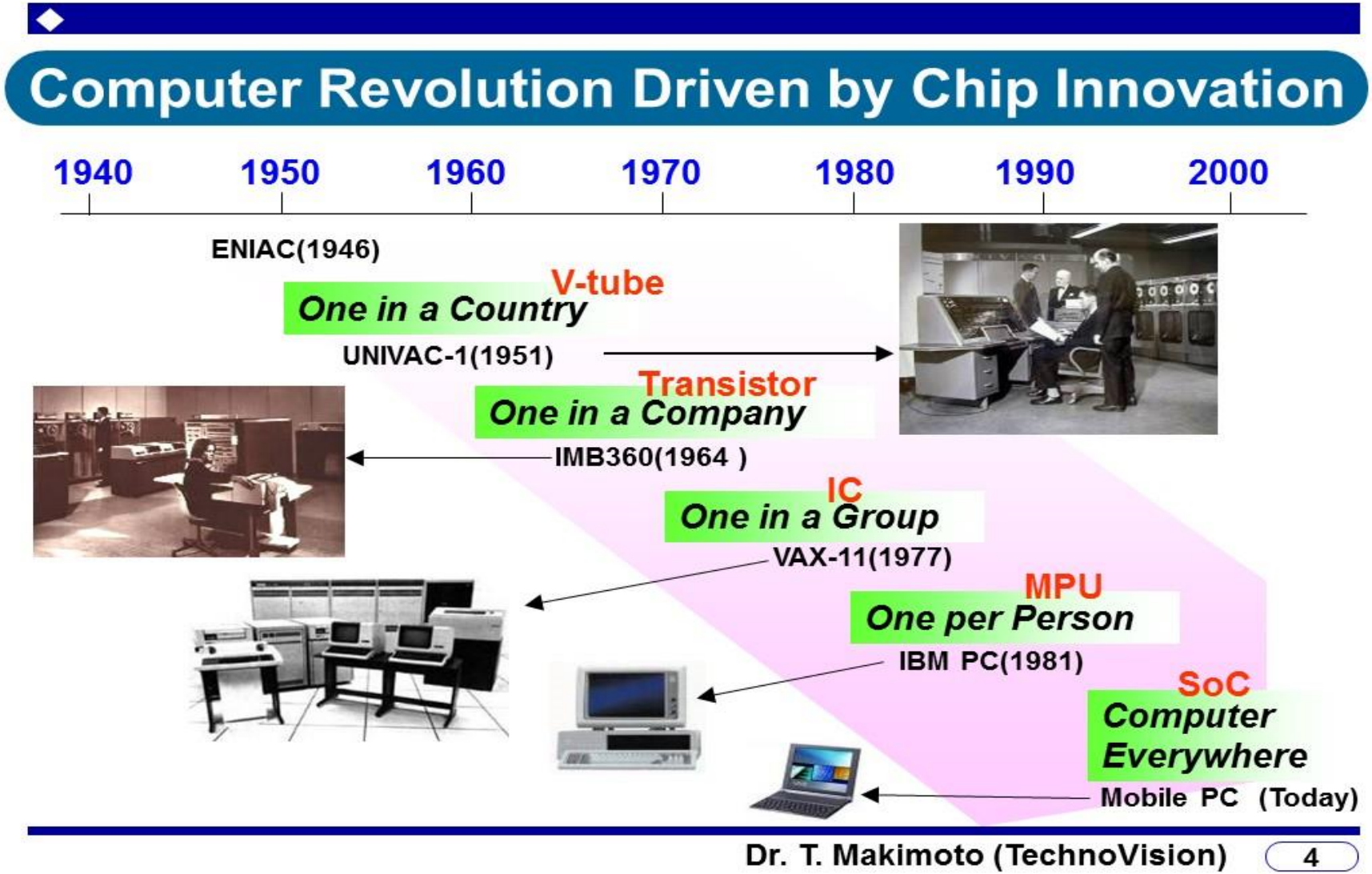
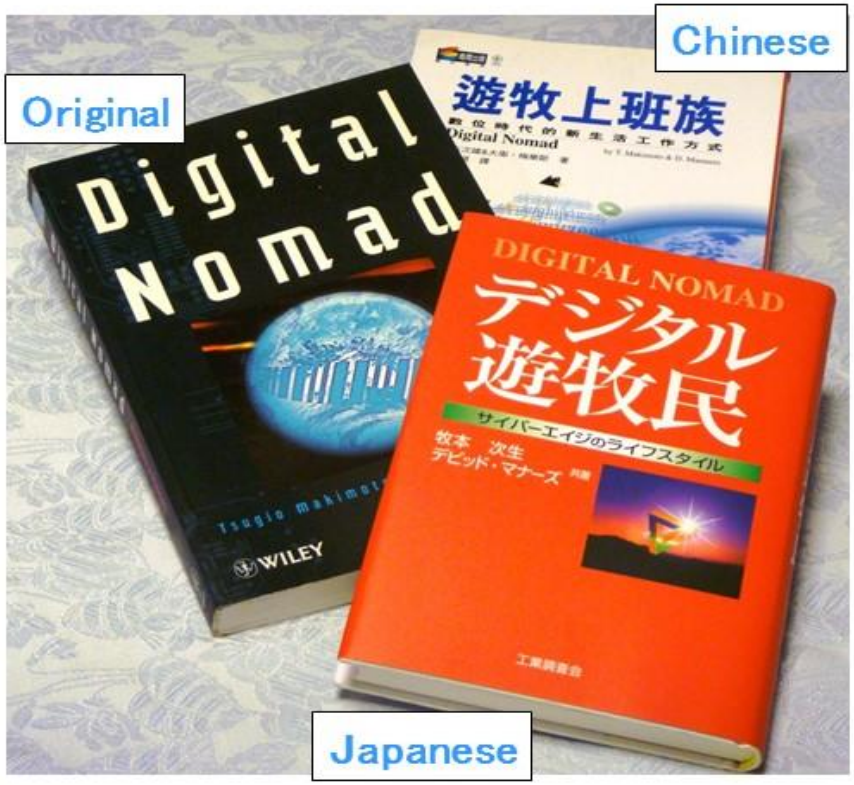
The picture on the left was taken when I visited the Computer History Museum in California in 2007. The performance of Cray's supercomputer introduced in 1976 was 160 MFLOPS, and the weight was 5.5 tons. This performance is about the same level as today's iPod. Such drastic change was made possible by semiconductor innovation; from 5μm bipolar technology to 90 nm CMOS technology.



The figure shows the one to one relationship between semiconductor innovation and "democratization" of computer. In early days, computer, like ENIAC or UNIVAC-1, was a state-owned machine because of its high price and difficulty in handling. As the semiconductor innovation proceeds, computer becomes more readily available for people. Today, “computer is everywhere” thanks to the power of SoC.

"Digital Nomad" Published in 1997



Co-authors
David Manners (left)
Tsugio Makimoto (right)

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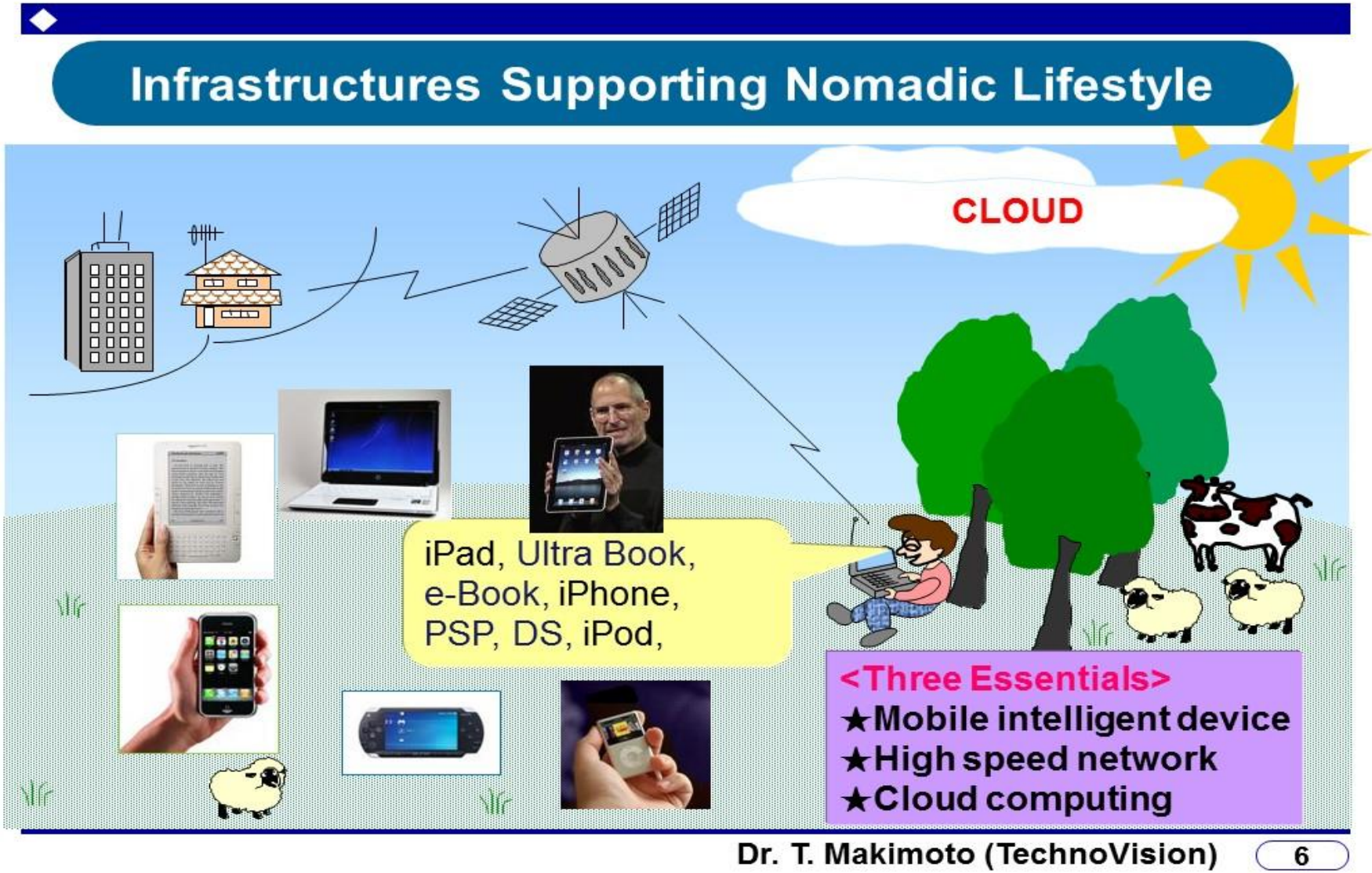
People are freed from constraints of time and location by semiconductor innovation, resulting in a new lifestyle. "Digital Nomad" was co-authored by Makimoto & Manners in 1997. After 10 years from the publication, the smart phone was released from Apple, and the new lifestyle of "Digital Nomad" has been realized. It is amazing to note that semiconductor has the power to change the whole world!



The figure shows the infrastructure to support nomadic lifestyle. The essential three elements are: mobile intelligent terminals, high-speed communication networks, and cloud computing. Intelligent mobile devices are appearing one after another as shown in the figure. This field is the main battleground for the current semiconductor market.

Outline

★ Impact of Chip Innovation

★Nothing is on the Extrapolation

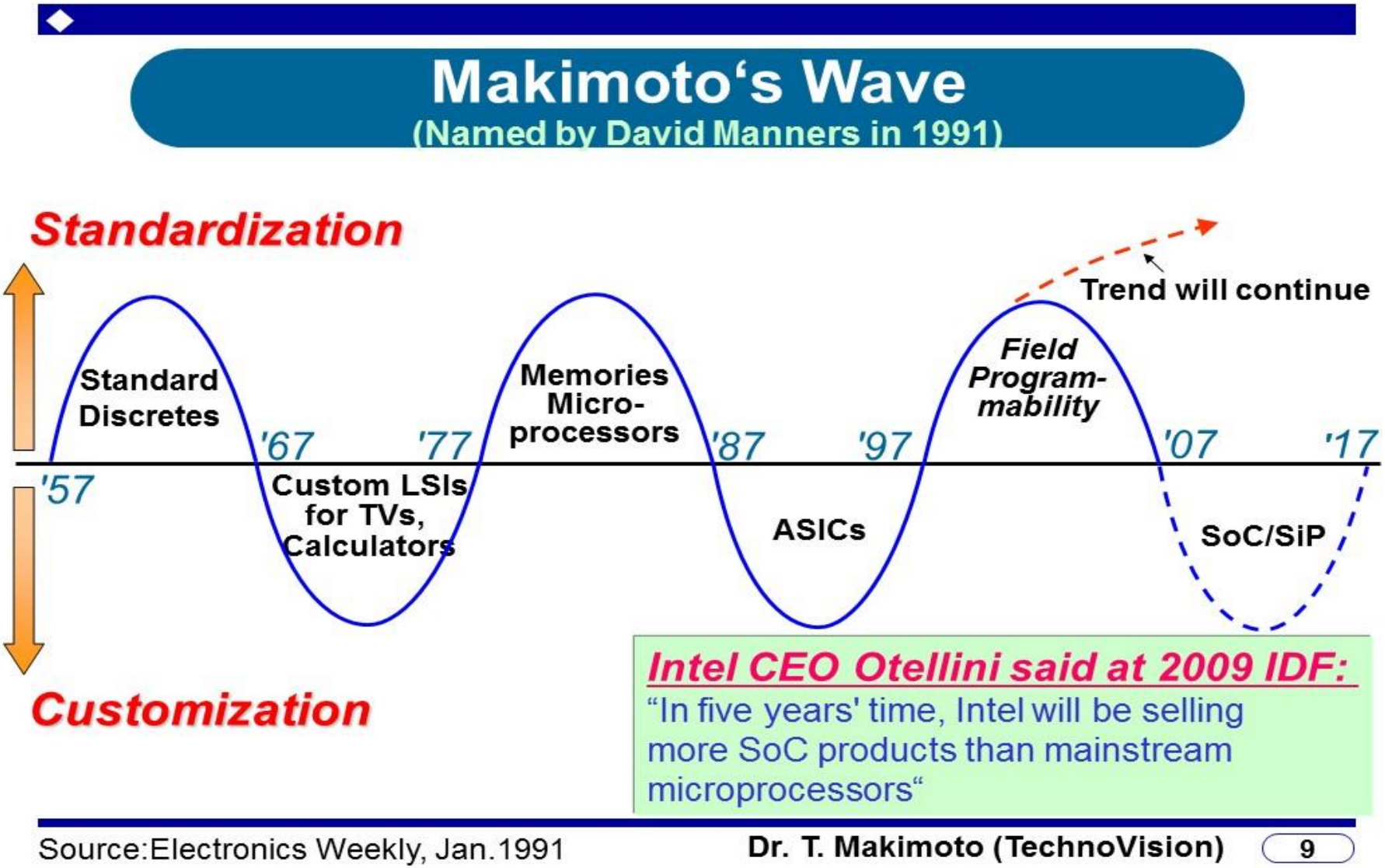
★ Longtime Dreams Coming True

Customer is the King

The King Wants	Choice
Differentiation	Custom
Flexibility	Standard
Hi Performance/Lo Power	Custom
Time to Market	Standard
Low Initial Cost	Standard
Low Unit Cost	Custom

Standard	Discrete, MCU, MPU, DSP, Memory, FPGA, etc.
Custom	Pure Custom, ASIC(ASCP & ASSP), SoC & SiP, etc.

As is said that “customer is the king”, requests from customers are not easy to cope with. As shown in the Table, demands from customers are quite diverse, and they cannot be dealt with simply by either custom or standard products. Custom-orientation and standard-orientation have been alternating in order to maximize “customer satisfaction”., and the trend will continue toward the future.

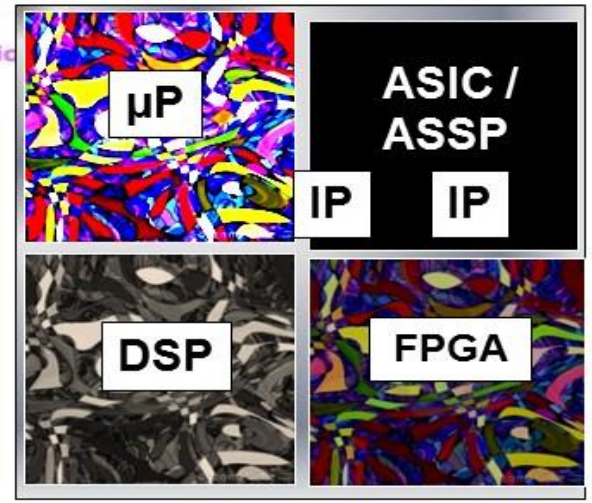


This figure shows the standard vs custom cycles in the semiconductor industry. This is a typical example of "Nothing is on the simple extension in the future". The original version covered until 2007, and the new trend at the time of the speech (2012) was custom oriented SoC / SiP. At that time, Intel was groping for the change to SoC as is seen by the comment of Ottelini, Intel CEO at the time.

Extension of the Wave Beyond 2017
(Altera's Vision)

Programmable Silicon Convergence

Microprocessor and DSP: Standard
Application specific IP: Custom
FPGA fabric: Programmable
…….contains every component for flexibility and differentiation



Source: Altera corp.

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The figure shows Altera's view on extension of Makimoto's Wave. From 2017 onwards, a standard-oriented new trend will rise and is named "programmable silicon convergence". As shown in the figure at the bottom right, FPGA is integrated together with MPU, DSP, various IPs on one chip, providing flexibility and differentiation. This shows a new trend of chip structure as the degree of integration exceeds today's SoC.

Evolution of Application Market

Tesla born in Si valley

Bio/Medical

Auto/Robot

Digital Consumer (Soc/Sip)

PC (MPU/Memory)

Calculator (MOSLSI)

Consumer AV (Bipolar/MCU

Computer (Transistor/IC)

Military (Transistor/IC)

1960 1970 1980 1990 2000 2010 2020

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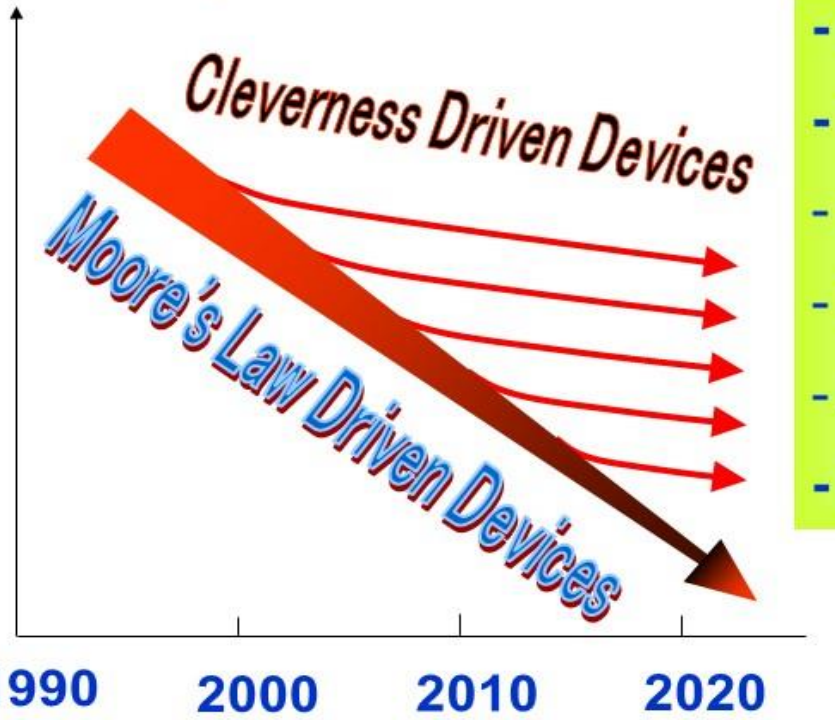
Due to semiconductor innovation, entirely new market will emerge. The figure shows the transition of the market created by the emergence of new devices. MPU and memory created the PC market, and the driving force for the smartphone market was SoC / SiP. New devices such as sensors will contribute to opening the new market such as robot, automobile, and bio / medical.

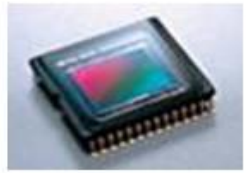
Diversifying Directions of Chip Technologies

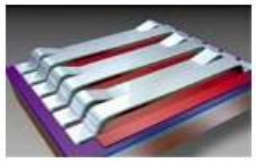
Presented at 2002 IEDM

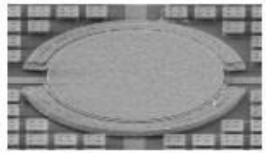
Geometry of Devices



- Optical Sensors
- Inertial Sensors
- Force Sensors
- Display Devices
- Actuators
- RF Devices etc.







Source: T. Makimoto, IEDM 2002

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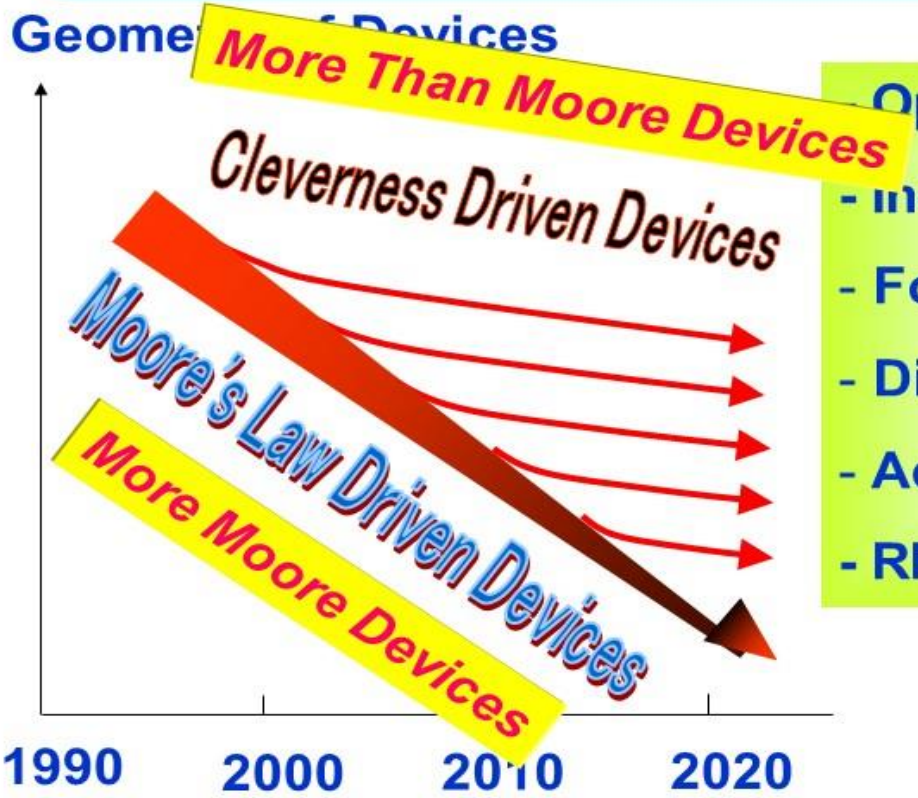
Devices such as sensors and actuators, as well as high-performance SoCs, are indispensable in the robotics which will lead the semiconductor market in the future. For these devices, it is important to better utilize the fundamental properties of matter rather than simply relying on finer geometry of devices. I named it "Cleverness Driven Devices“ in the IEDM keynote in 2002. (See Exhibit VI, No.11, p.34 for detail).

Diversifying Directions of Chip Technologies

Presented at 2002 IEDM



- Optical Sensors
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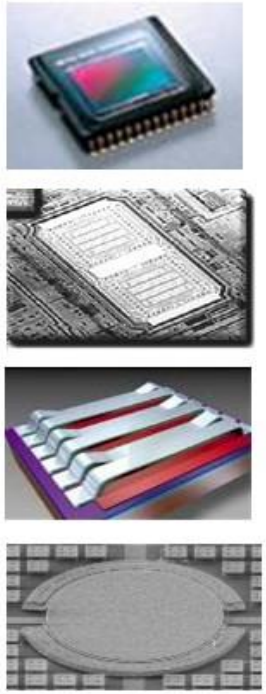
- RF Devices etc.



Source: T. Makimoto, IEDM 2002

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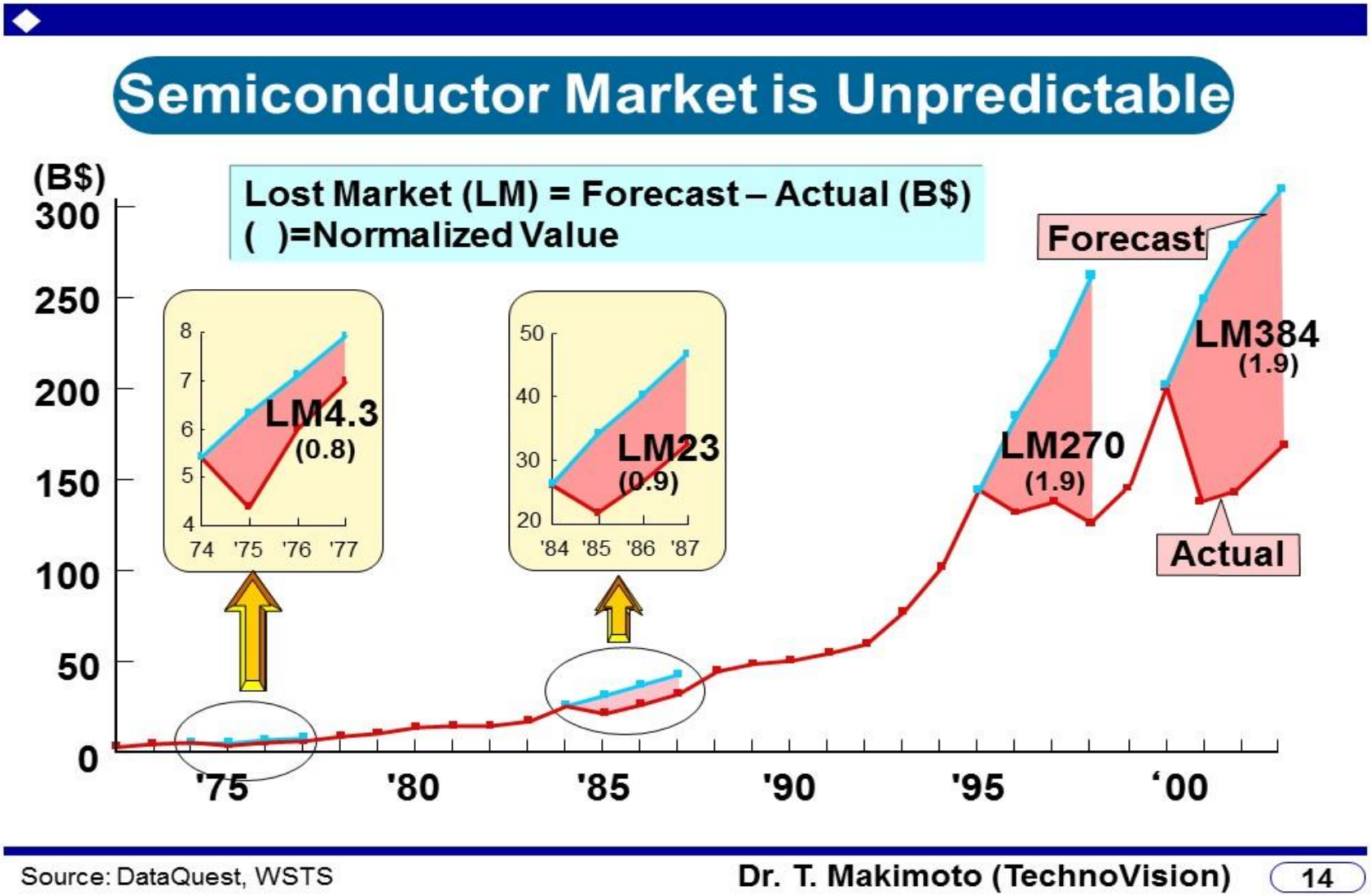
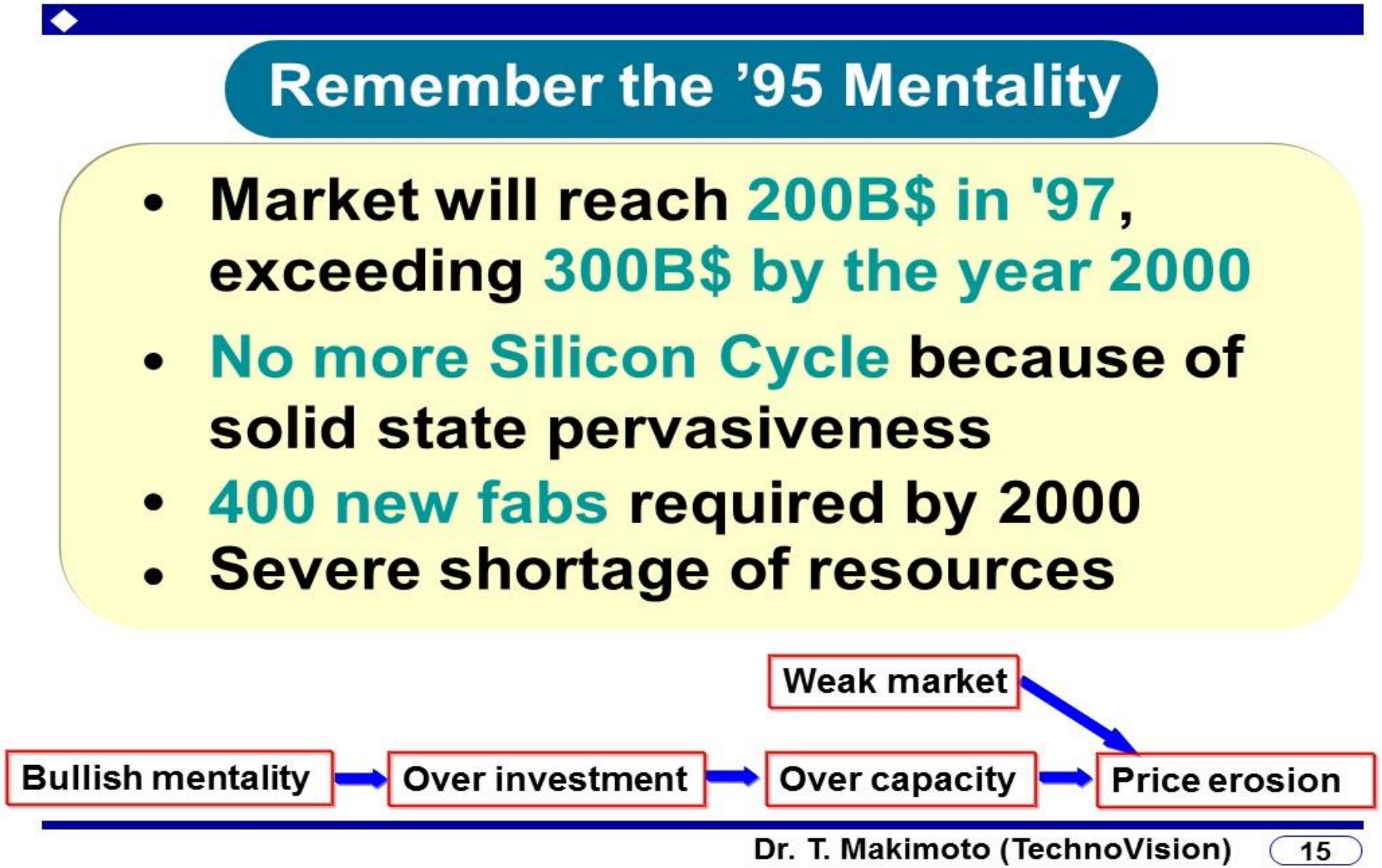
This figure emphasizes that the direction of chip technology is not simply finer geometry, but the directions are diversifying to include more dependence on the properties of matter. This concept has been succeeded at ITRS 2005 and is expressed as "More Than Moore" devices. The direction of technology development is not a simple extension of the traditional one called “More Moore Devices”.



We have experienced some big recessions so far. The figure shows the deviation of market forecast (blue line) from the actual value (red line). The area painted in vermillion is defined as "lost market (LM)". For example, in the recession of 2001, the lost market was 384B$ which was equivalent to 1.9-year-worth value. It is important to keep in mind that “the semiconductor market is unpredictable”.



1995 was the boom year of the chip industry, and the bullish mentality prevailed in the community, as shown above. It was forecasted that the market would exceed 300B$ by 2000, but actually it was 2013. It was argued that “there would be no more silicon cycle because of solid state pervasiveness”, but actually, the next 1996 was the disaster. This is an important lesson which should be shared in the semiconductor community.

Outline

★ Impact of Chip Innovation

★Nothing is on the Extrapolation

★ Longtime Dreams Coming True

Emerging Non-Volatile RAM

	FeRAM	MRAM	PCRAM	RRAM
Basic mechanism	Polarization of ferroelectric crystal	Tunneling magneto-resistance effect	Resistance change by material's phase change	Mechanism depends on material used
Current status	Production	Early production	Limited production	R&D
Prospects	Embedded low power application	Embedded/ stand-alone hi-speed application	8Gb chip was presented at ISSCC 2012	Promising candidate for SCM (storage class memory)

Source: G. W. Burr et. al., IBM Res. and Dev., No.4/5, 2008

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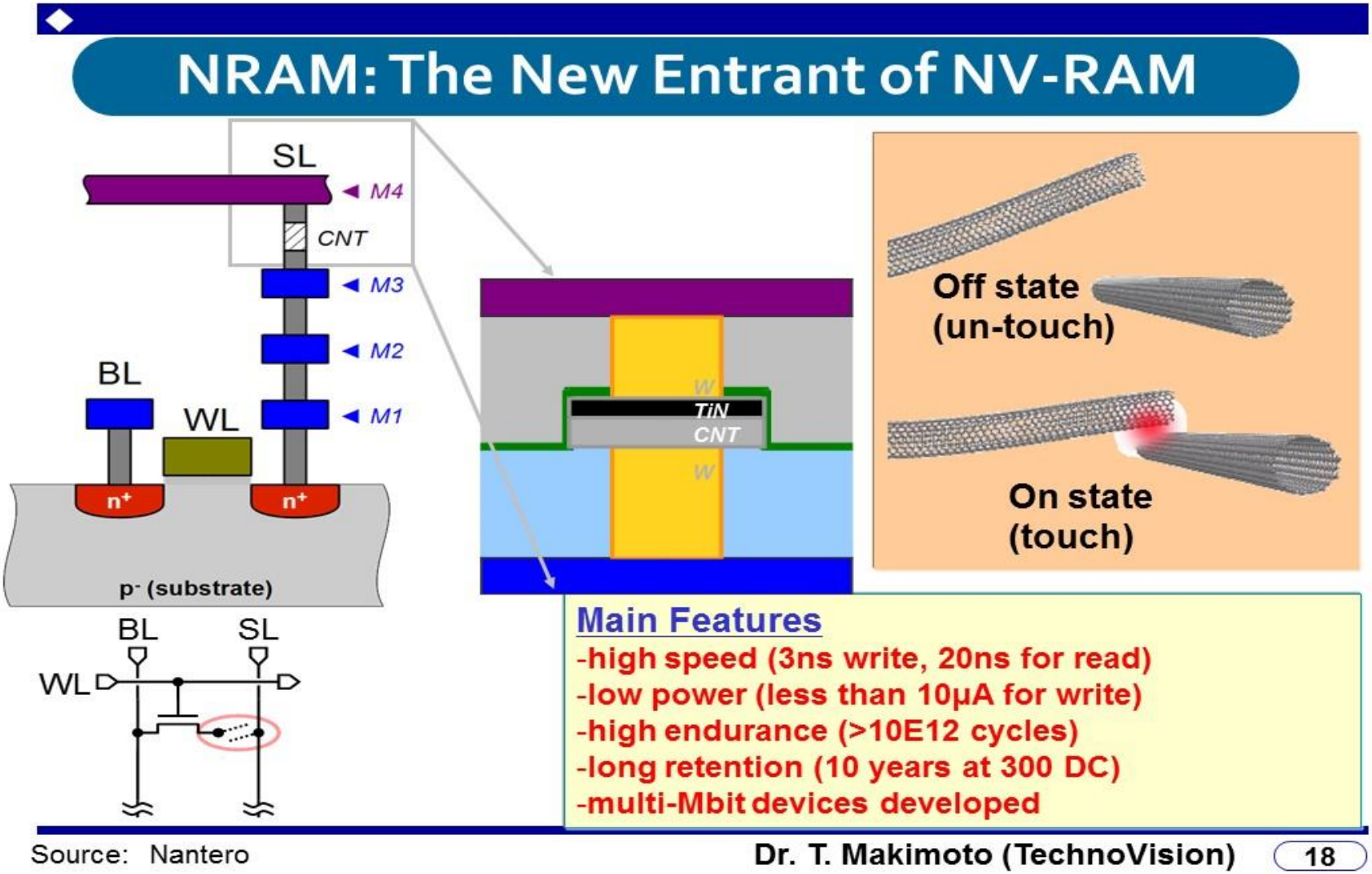
One of longtime dreams for the semiconductor is nonvolatile RAM. Semiconductor memory has made great strides since 1 Kbit DRAM in 1970, but the only unsolved problem is its volatility, or loss of data when the power is turned off. Recently, development of various types of nonvolatile RAM has advanced, and FeRAM has been put into practical use. However, nonvolatile RAM of major significance is just around the corner.



Here is a promising novel nonvolatile RAM using CNT, or carbon nanotube. The basic mechanism is shown in right hand side figure. The cross section of the memory is shown in the center drawing, and it is a simple structure in which the CNT film is sandwiched between metal electrodes. In addition to the performance of high speed and low power, high reliability is expected, as shown in the box.

Challenging the Language Barrier

New business potential is opening

Presented at 1999 Instat Conference

Special Report Business Week / Feb 23, 1998

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The above figure was presented at In-Stat conference 13 years ago in 1999. It says that a new business opportunity is opening by overcoming the language barrier. BusinessWeek published a special report of “Let’s Talk” in the previous year of 1998, and the momentum was growing. However, it was too early. After a long time since, its time is finally approaching.

Language Barrier Getting Lower

★ **Language understanding has been the longtime dream and challenge for semiconductor technology**

★ **Why so difficult?**

- Many languages in the world
- Many dialects for one language
- One word, different meanings
- Everyone talks differently
- Noise in the real environment

★ **Siri as intelligent assistant**

-Siri makes phone call, sends messages, sets reminders, and answers your question

-Siri supports English, French, and German

iPhone 4S

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"Language understanding" by machine has been very difficult because of several reasons raised above. However the language barrier is coming lower these days. For example, Siri which is installed in iPhone 4S understands speaker's words and answers questions. The language related business will become "next big thing". Note: A lot of activities are going on in Japan (in 2019), preparing for Tokyo Olympic Games 2020.

Summary

Nothing is on the extrapolation of the past

- ★Custom or Standard
- ★Unpredictable semiconductor market
- ★Diversifying technology directions
- ★Emergence of new market

Longtime dreams coming true

- ★NV RAM and language technology

"Catch the turning point and ride the new wave! Bravely!!"

This is to summarize today's talk. It should be emphasized that semiconductor industry is very complex and difficult to predict, either for technology or for market. Unexpected situations may happen, and semiconductor persons have always to be prepared for these. It is important to catch the turning point and ride the new wave.


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Thank you for your attention!
Tsugio Makimoto, Ph. D