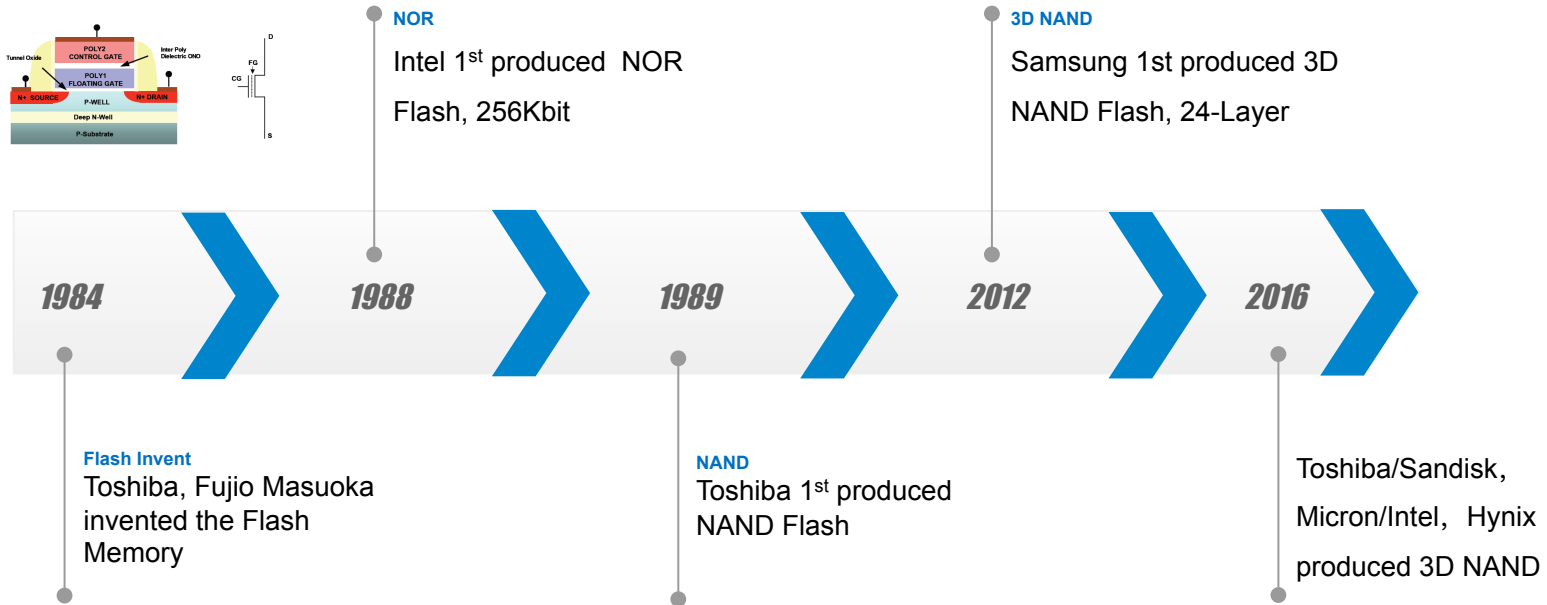# NOR Flash from Greater China : From Follower to Leader

Michael Wang, VP Strategic Marketing
GigaDevice Semiconductor Inc.
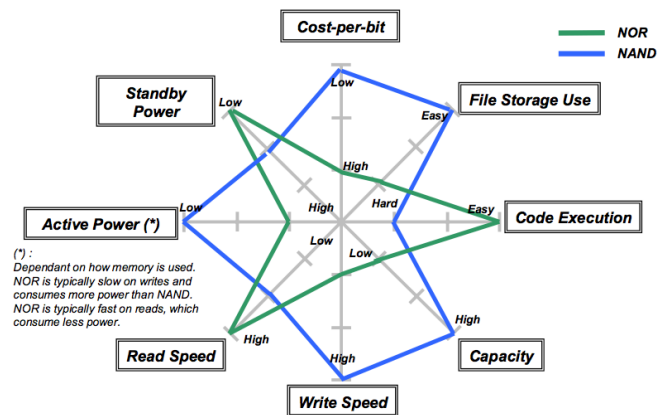
History of Flash Memory Technology

NOR
Intel 1st produced NOR
Flash, 256Kbit

3D NAND
Samsung 1st produced 3D
NAND Flash, 24-Layer

| 1984 | 1988 | 1989 | 2012 | 2016 |

Flash Invent
Toshiba, Fujio Masuoka
invented the Flash
Memory

NAND
Toshiba 1st produced
NAND Flash

Toshiba/Sandisk,
Micron/Intel, Hynix
produced 3D NAND

NAND vs. NOR Flash

NAND dominates Flash landscape, yet NOR continues finding its niche. . .

NAND chart — companies: Samsung, Toshiba, Sandisk, Micron, Hynix, Intel (2015, 2016, 2017)

NOR chart — companies: Macronix, Cypress, Winbond, Gigadevice, PSC

Source: Webfeet Research, 2016
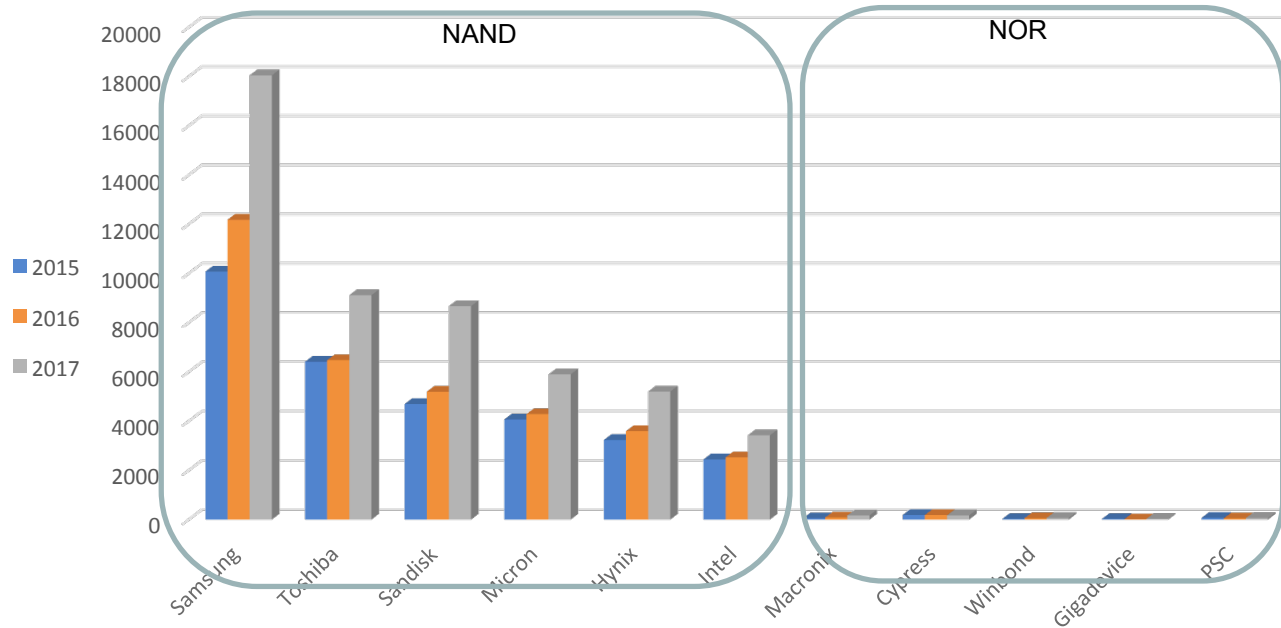
Turning around for NOR Flash Market

- Downward of traditional Market slow down in 2015

- Now we have cross "V" wave and back to ramp

Legend: NOR Flash($Mn) ■ | YoY —
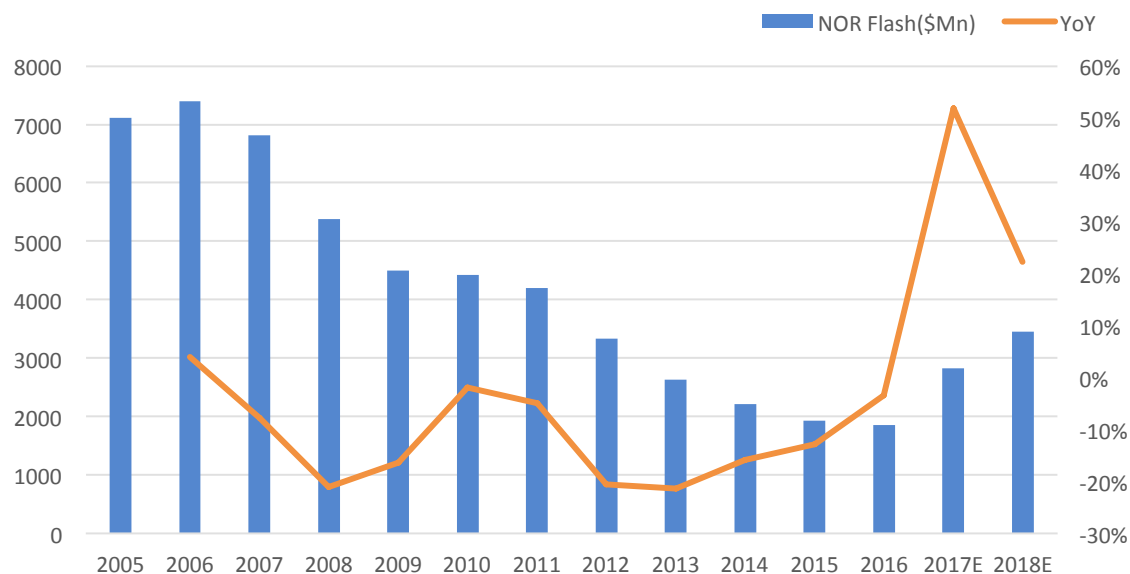
Feature Phone(-)

Embedded System IoT and Modules(+)

NOR Flash in Growing Applications
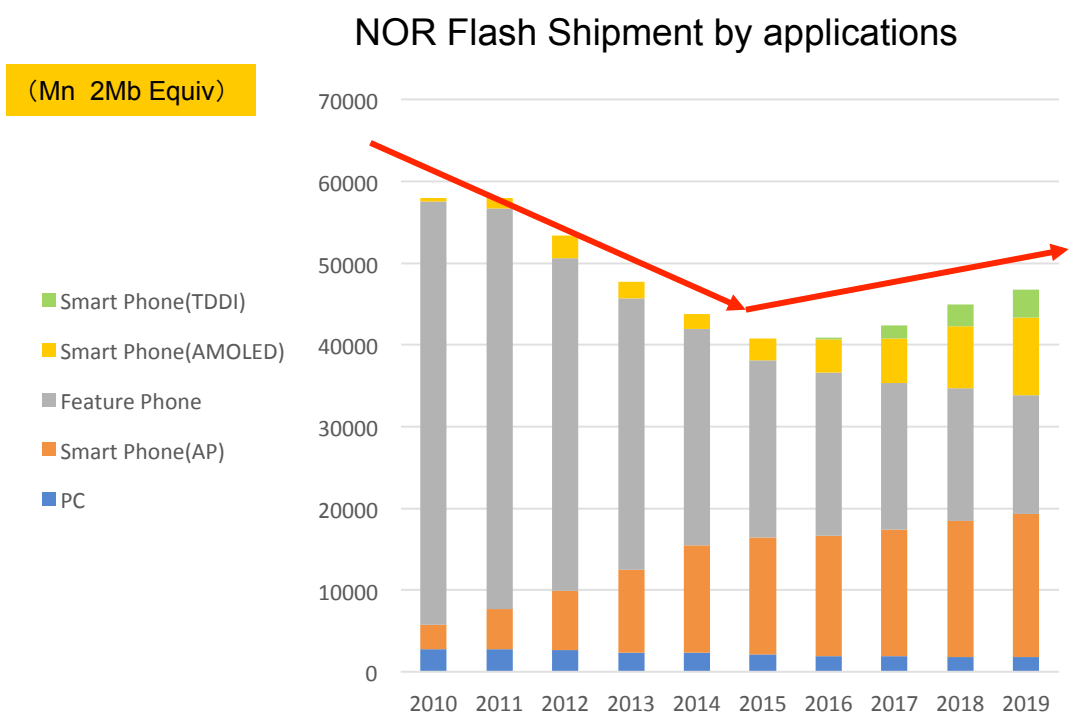
Flash Memory Summit

NOR Flash Shipment by applications

（Mn 2Mb Equiv）

Legend:
- Smart Phone(TDDI)
- Smart Phone(AMOLED)
- Feature Phone
- Smart Phone(AP)
- PC

NOR Flash: Indispensable in every Embedded Systems

Boot code in system from shadowing to eXecution In Place

Finds new Applications

IoT

Feature Phone

Embedded System

Modules in Smart phone:
OLED
TDDI
AP
Camera

Automotive
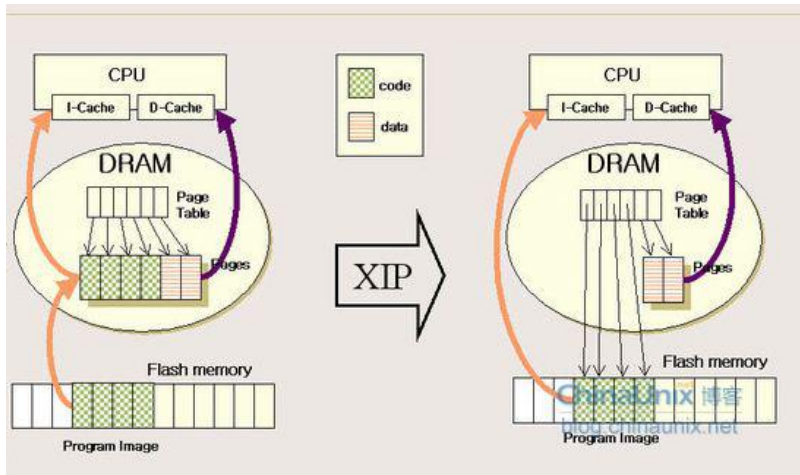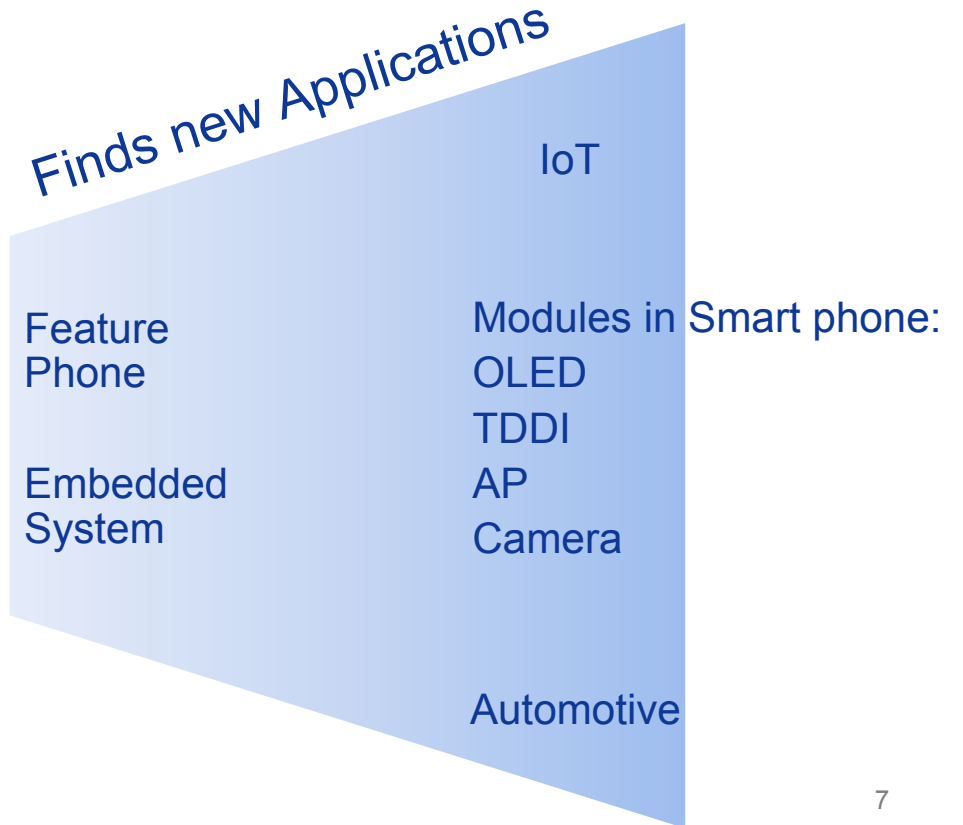
Growing Presence from Greater China NOR Suppliers

2007

Legend (2007):
- Macronix
- Spanson
- Mircon
- Samsung
- SST
- Others

Mainland + Taiwan ~8%

2017

Legend (2017):
- Macronix
- Winbond
- Gigadevice
- Micron
- Cypress
- Others
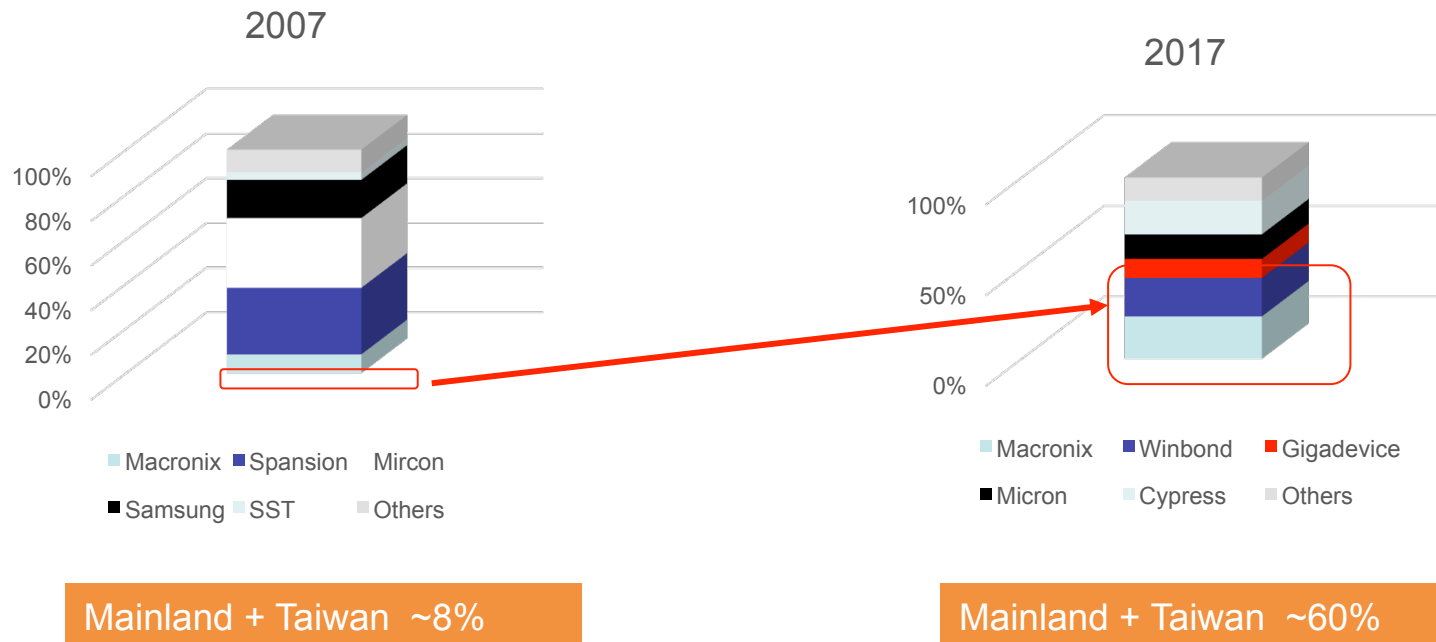
Mainland + Taiwan ~60%

Healthy NOR Supply Chain in Greater China

Business Model	Design house	Fab/Foundry	OSAT	Programmer
Mainland	Gigadevice Dosilicon Fudan Micro ISSI	SMIC XMC HLMC	CJ TFMicro Huatian	Xelteck ZLG
Taiwan	MXIC Winbond ESMT	MXIC Winbond Powerchip	PTI ASE/SPIL	Deliprog

NOR is currently the only self-supplied memory in Mainland China

System	Device	Core IC	Self Sufficiency
Computer System	Server	MPU	0%
	PC	MPU	0%
	Industrial	MPU	2%
General Purpose System	Programmable Logic Device	FPGA/CPLD	0%
	Digital Signal Processing	DSP	0%
		Application Processor	18%
		Communication Processor	22%
		Embedded MP	
		Embedded DSP	0%
	Routers & Switches	Network Processor Unit	15%
Storage System	Semiconductor Memory	DRAM	0%
		NAND Flash	0%
		NOR Flash	5%
Display System	TV	Image Processor	5%
		Display Driver	0%

Memory consumption in Mainland China >$30B USD in 2017

Mainly supplied by

GigaDevice

New Applications Driving NOR Flash Market

IOT& Module
- Low Size
- Low Power
- Low Cost
- Low Pin out

Auto
- Long product lifecycle
- High Performance
- Octal SPI/DDR
- High reliability ECC

GigaDevice Milestones

Headquarter to Beijing, China

June 2004

April 2005

China's first
SPI NOR Flash

May 2008

China's first
Cortex-M3
32-Bit MCU

April 2013

China's first
NAND Flash Mass
Production

August 2015

May 2013

World's first SPI
NAND Flash

August 2016

IPO at Shanghai Stock
Exchange (SH:603986)

National IC Fund purchased
11% of GigaDevice shares,
becoming GD's second largest
shareholder

September 2017

October 2017

Signed co-development
agreement with Hefei
Industrial Investment Fund.
Launched 19nm DRAM
project in Hefei

Purchased 1.02%
share of SMIC,
becoming SMIC's
fifth largest
shareholder

November 2017

December 2017

Announced the
acquisition of
Silead

April 2005

SRAM
Product

Founded in Silicon
Valley, US

Rapid Growing of GigaDevice

Revenue （$Million）
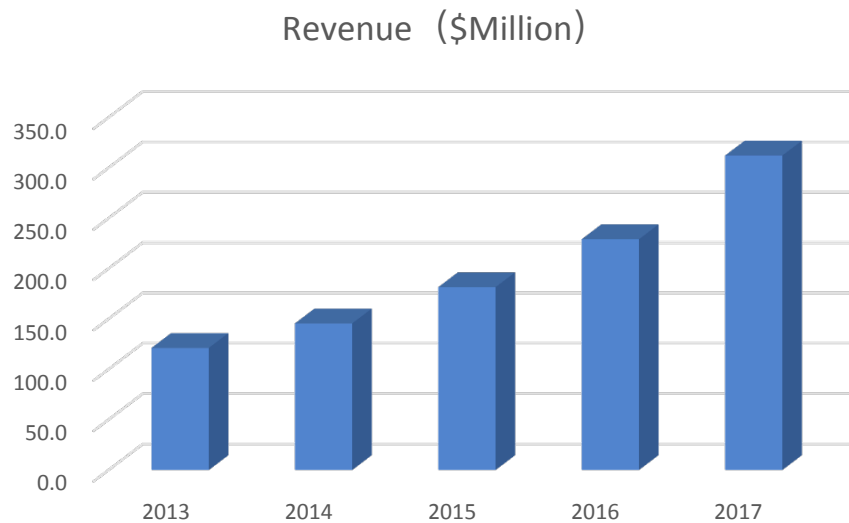
- 2017 top 10 IC design companies in China
- Top 500 listed companies in China
- Current company market value at ~USD $5B
- Total employees: 450+, 60% in R&D, Revenue >USD $720K per employee
- Filed 800+ patents with 323 patents granted

No. 1 NOR Flash Supplier of Mainland China

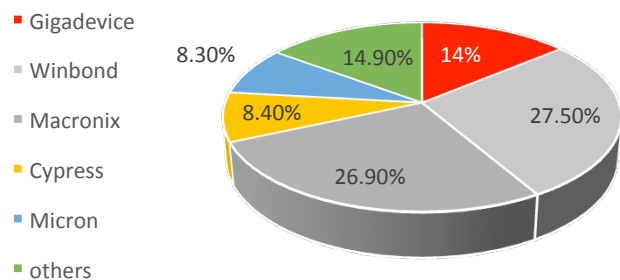## Serial NOR Flash 2017 Vendor Market Shares

- Gigadevice
- Winbond
- Macronix
- Cypress
- Micron
- others

14%
27.50%
26.90%
8.40%
8.30%
14.90%

Table 2. Flash Memory 2017 Vendor Market Shares

Rank			Flash Vendor	$ in Millions			% Change	Market Share		% Change
2015	2016	2017		2015	2016	2017		2016	2017	
1	1	1	Samsung	10,080	12,180	18,047	48.2%	33.2%	33.8%	0.6
2	2	2	Toshiba	6,409	6,473	9,115	40.8%	17.7%	17.1%	(0.6)
3	3	3	WDC (SanDisk)	4,692	5,193	8,669	66.9%	14.2%	16.2%	2.1
4	4	4	Micron	4,431	4,617	6,241	35.2%	12.6%	11.7%	(0.9)
5	5	5	Hynix	3,230	3,589	5,198	44.8%	9.8%	9.7%	(0.0)
6	6	6	Intel	2,440	2,528	3,419	35.2%	6.9%	6.4%	(0.5)
8	8	7	Macronix	473	521	759	45.7%	1.4%	1.4%	0.0
7	7	8	Cypress	642	635	634	(0.1%)	1.7%	1.2%	(0.5)
9	9	9	Winbond	354	397	597	50.4%	1.1%	1.1%	0.0
10	10	10	GigaDevice	185	166	285	71.7%	0.5%	0.5%	0.1

- No. 3 SPI NOR Flash provider in the World
- The only company from Mainland China in top 10 Global Flash Memory Suppliers

Source: Webfeet Research, 2017

Takeaway Messages

1. NOR was once the main Flash till feature phone years. As NAND Flash dominates in smart phone and SSD in data storage era, NOR continues to find its niche in various applications, as the indispensable code memory in every embedded system.

2. IoT, smart phone modules and automotive applications drive the NOR Flash ramping up again, both in revenue and in unit counts.

3. Suppliers from Greater China are leading the NOR Flash production and market share. GigaDevice is one of leading NOR Flash suppliers in the world and the largest NOR Flash supplier from mainland China.

Thank you