Corporate Overview
&
Flash Memory Introduction

GigaDevice Semiconductor (Beijing), Inc.

May, 2018

Company Profile – Overview

- Founded in Silicon Valley, headquartered in Beijing, China.
- A fabless semiconductor company focused on advanced Non-Volatile Memory and 32-bit ARM Cortex Microcontroller solutions.
- Complete Serial Flash product portfolio including SPI NOR, SPI NAND.
- Wide range of 32-bit MCU product lines targeting various application segments.
- Strong R&D resource and capability specialized in NVM and MCU development.
- Dominating Serial Flash Memory and 32-bit MCU market in China with the largest customer base.
- First China memory supplier completed IPO at Shanghai Stock Exchange.

Company Profile – Numbers

2004	Year Established
3	Worldwide Ranking of Serial NOR Flash Suppliers
1	Worldwide First 8-pin Serial NAND Flash Supplier
1 & 1	China Market Share of Flash & 32-bit MCU
400+	Number of Employees
220+	Number of Patents Granted
1,700,000,000+	Annual Serial Flash Shipment Units in 2017

Company Profile – Milestones

June, 2004 — Moved HQ to Beijing

April, 2005 — First SRAM IC

April, 2005 — Founded in Silicon Valley

May, 2008 — China's First SPI NOR Flash

April, 2013 — China's First Cortex-M3 32-Bit MCU

May, 2013 — World's First SPI NAND Flash

Dec, 2014 — Annual Shipment of 1 Billion+ units SPI NOR Flash

Aug., 2015 — China's First NAND Flash

March, 2016 — Opened EU office

June, 2016 — SPI NOR Passed AEC-Q100 Qual

Aug., 2016 — IPO at Shanghai Stock Exchange

Mar., 2018 — Market Cap: ~US$6B

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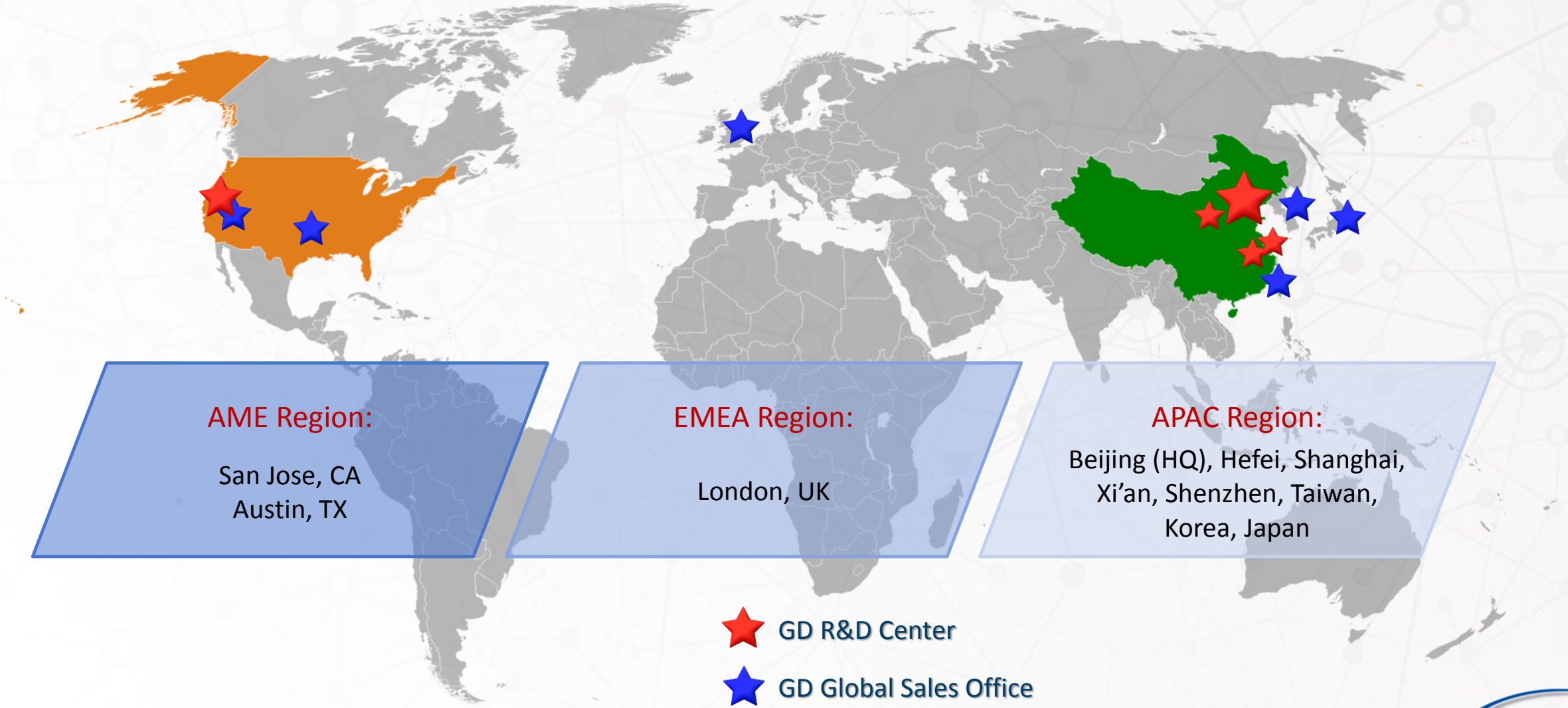
Company Profile – Globalization



AME Region:

San Jose, CA
Austin, TX

EMEA Region:

London, UK

APAC Region:

Beijing (HQ), Hefei, Shanghai, Xi'an, Shenzhen, Taiwan, Korea, Japan

GD R&D Center

GD Global Sales Office

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Company Profile – Chipset Partners (for Flash)

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Company Profile – Major Customers

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Company Profile – Major Customers

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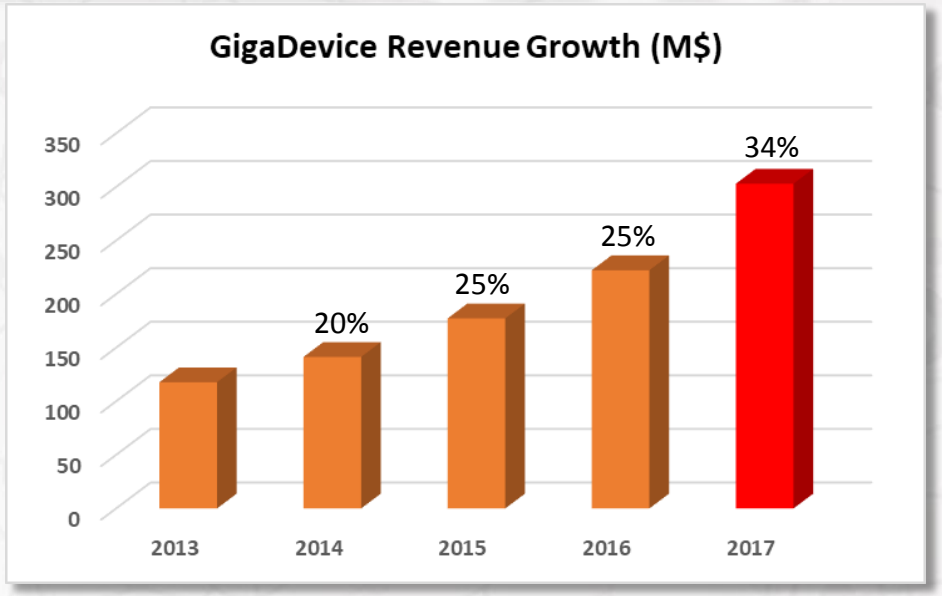
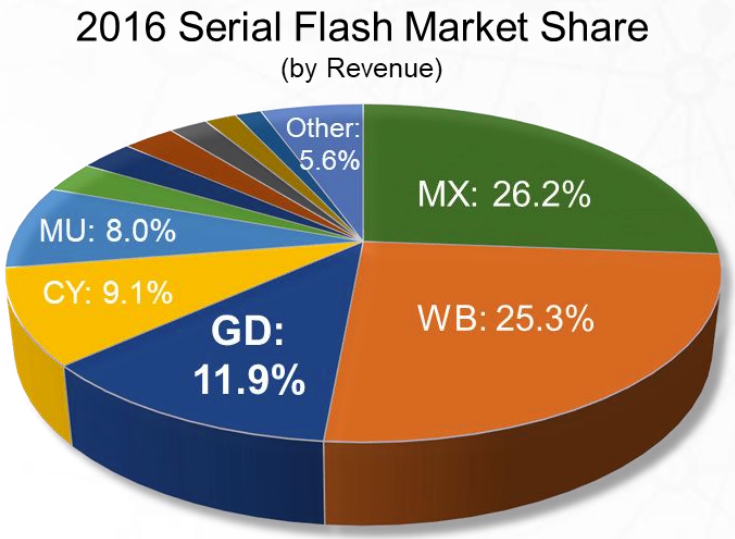
Company Profile – Growth

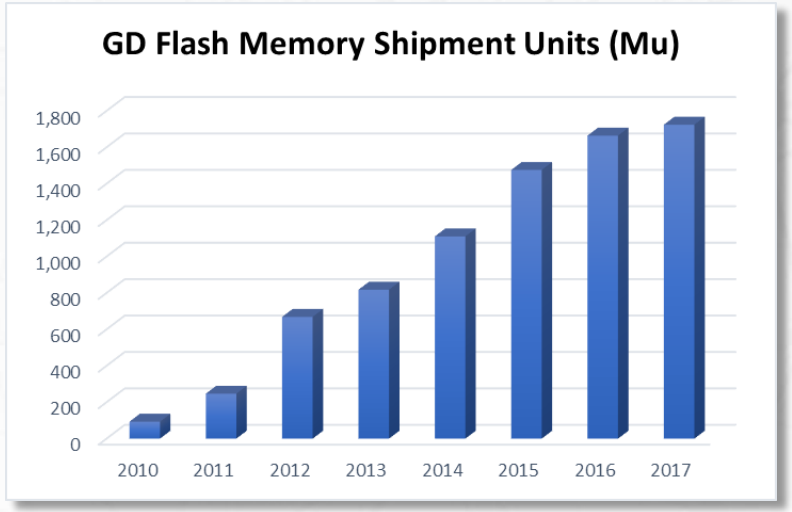
- GigaDevice has been ranked **worldwide #3** Serial Flash Supplier since 2013, with **~12% market share.**
  .
- 32-bit ARM Cortex **MCU shipment has grown rapidly** since the introduction in 2013.

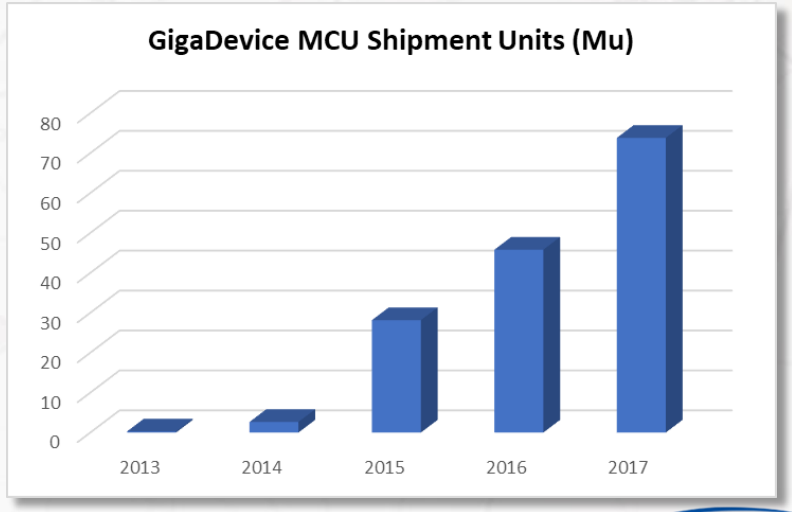
- 2017 was a record-breaking year for both Flash & MCU due to **global shortage**.





Source: Web-Feet Research, 2017





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Company Profile – Manufacturing

- Foundry Partners

SMIC (for Flash, MCU)

UMC (for MCU)

HLMC (for Flash)

- Assembly Houses

ASE GROUP

HUA TIAN 华天科技

PTI Powertech Technology Inc.

长电科技 CHANGJIANG ELEC.TECH.

ChipMOS

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Company Profile – Quality

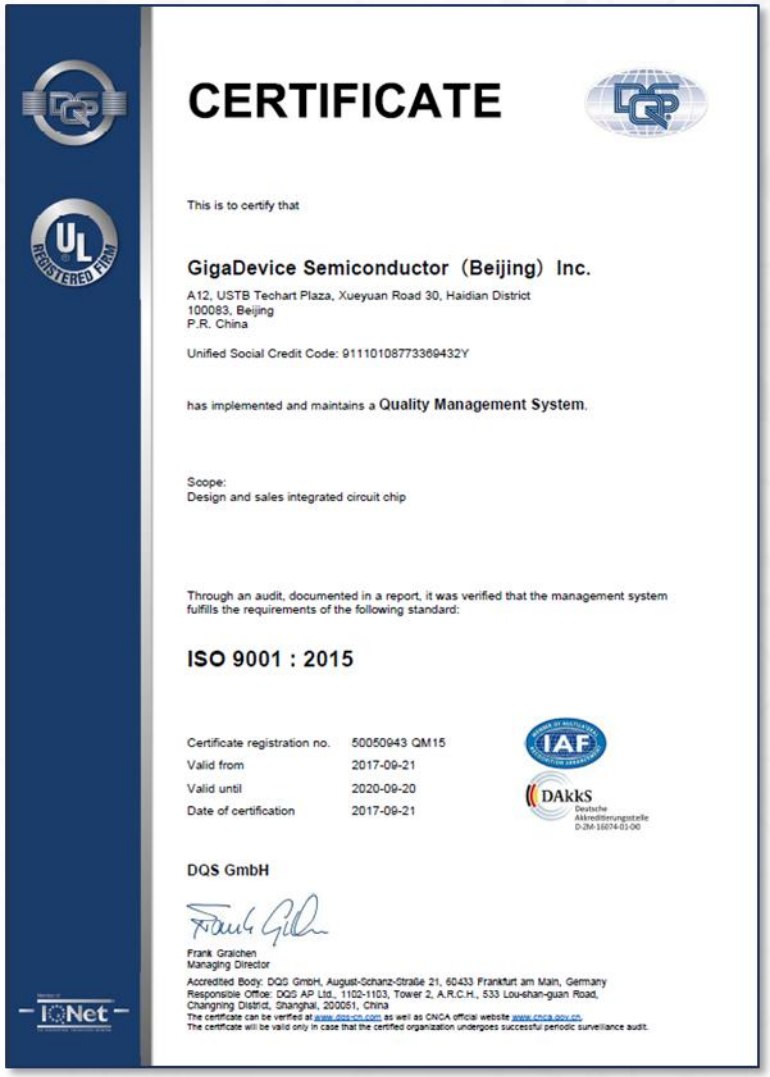
CEO

Quality VP

Quality Org. & Function

Product Assurance	Product Quality Control	Quality System Management
• New product Qualification • Reliability monitor • Customer Engineering Service • RMA	• Supplier Control • Non-conformity control • Change Control • Traceability Control • Incoming & Outgoing Quality Assurance • CIP	• Quality Planning • Quality System management • Environment System Management • Internal & External Audit • DCC

Company Profile – Certificates



CERTIFICATE

This is to certify that

GigaDevice Semiconductor (Beijing) Inc.

A12, USTB Techart Plaza, Xueyuan Road 30, Haidian District
100083, Beijing
P.R. China

Unified Social Credit Code: 91110108773369432Y

has implemented and maintains a Quality Management System.

Scope:
Design and sales integrated circuit chip

Through an audit, documented in a report, it was verified that the management system fulfills the requirements of the following standard:

ISO 9001 : 2015

Certificate registration no.	50050943 QM15
Valid from	2017-09-21
Valid until	2020-09-20
Date of certification	2017-09-21

DQS GmbH

Frank Gralchen
Managing Director

Accredited Body: DQS GmbH, August-Schanz-Straße 21, 60433 Frankfurt am Main, Germany
Responsible Office: DQS AP Ltd., 1102-1103, Tower 2, A.R.C.H., 533 Lou-shan-guan Road, Changning District, Shanghai, 200051, China
The certificate can be verified at www.dqs-cn.com as well as CNCA official website www.cnca.gov.cn.
The certificate will be valid only in case that the certified organization undergoes successful periodic surveillance audit.

CERTIFICATE

This is to certify that

GigaDevice Semiconductor (Beijing) Inc.

A12, USTB Techart Plaza, Xueyuan Road 30, Haidian District
100083, Beijing
P.R. China

has implemented and maintains an Environmental Management System.

Scope:
Design and sales integrated circuit chip

Through an audit, documented in a report, it was verified that the management system fulfills the requirements of the following standard:

ISO 14001 : 2015

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Company Profile – Awards

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Years in a row!

GigaDevice received Excellent Supplier Award by **Samsung** for our support in 2013 / 2014 / 2015 / 2016 / 2017.

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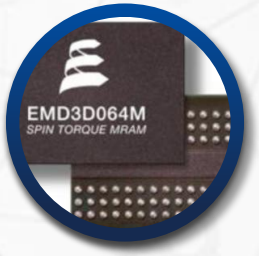
Company Profile – Product Portfolio



New Memory

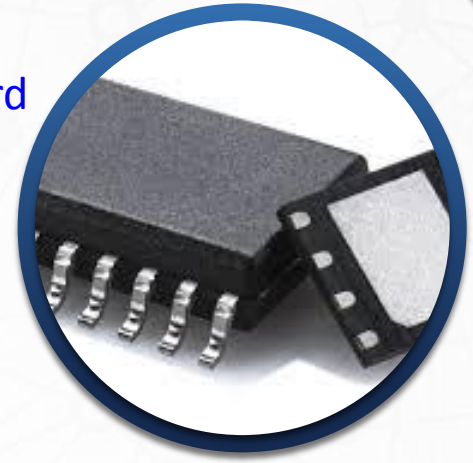
- Invested in Everspin, CIYU for MRAM technology
- Joint venture with Rambus to develop RRAM

32-bit ARM MCU

- China's #1 supplier

Serial NOR Flash

- World's #3 supplier
- China national standard
- Dedicated to NOR Flash market



Serial NAND Flash

- World's 1st small package supplier
- China national standard
- Defining next generation spec to lead the market

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Flash Memory Introduction

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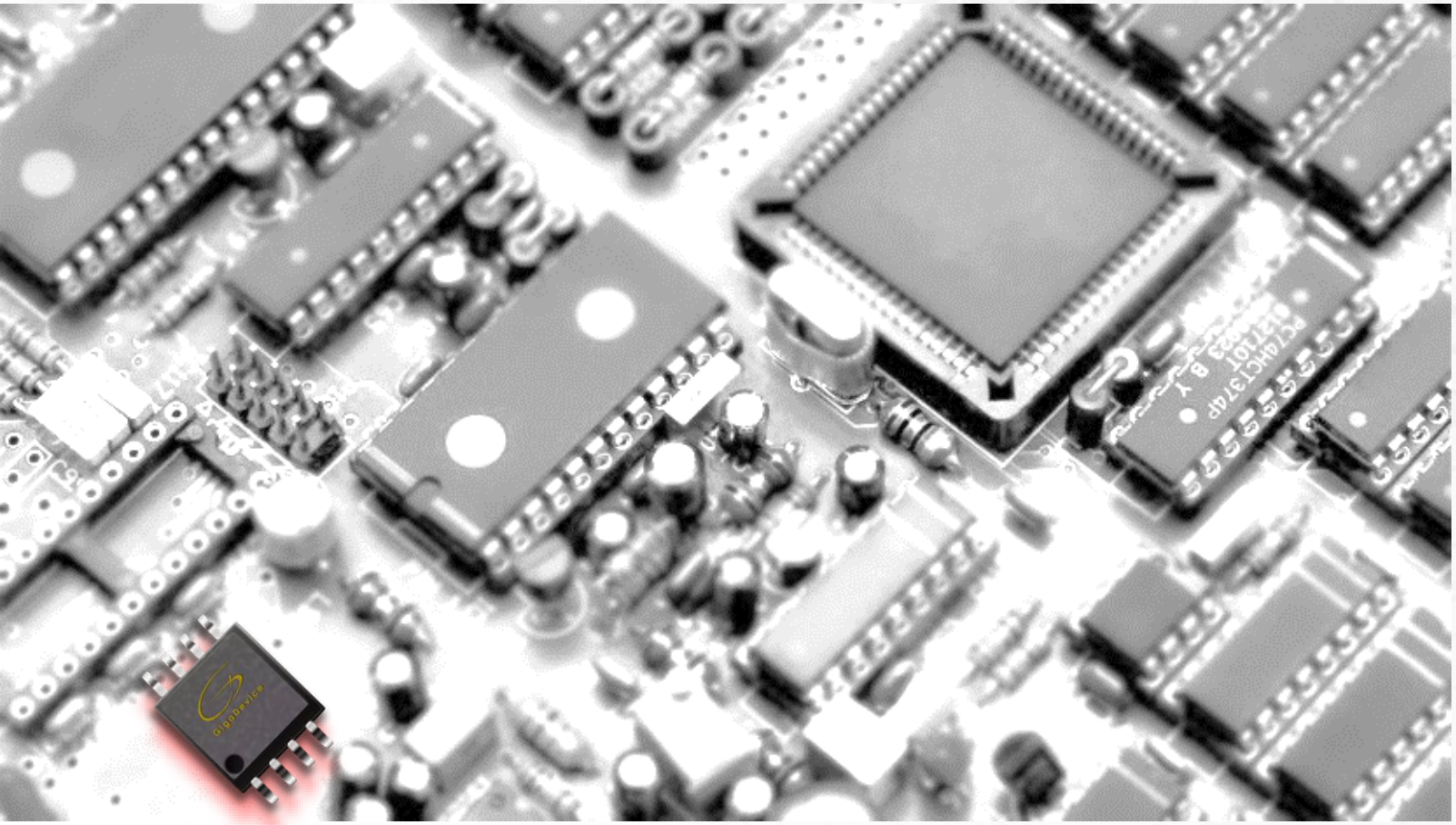
Welcome to the Digital Era!



GigaDevice has powered up more than 10 Billion electronic devices since 2010!

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Flash Memory Applications

	Density	Performance	Security	Reliability	Power Consumption	Package Size
Computing	Medium ~ High	Low	Medium	Normal	Normal	Normal
Networking	High	Medium	Medium ~ High	Normal	Normal	Normal
Consumer	Low ~ High	Medium	Medium	Normal	Low ~ Normal	Normal
Mobile	Low ~ Medium	Medium	Medium	Normal	Normal	Small
Automotive	High	Very High	Medium ~ High	Very High	Normal	Normal
IoT	Low ~ Medium	Low	Medium ~ High	Normal	Low	Small

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Flash Memory Applications

	Density			Performance			Security			Reliability			Power			Package Size		
	NOR	NAND	eMMC	X4	X8 DTR	P/E	WP	UID OTP	RPMC	100K P/E	DR	ECC	STBY DPD	Read P/E	VCC	SOP SON	BGA	WLCSP
Computing	✓			✓		✓ (HDD)	✓		✓		✓	✓			3V 1.8V	✓		
Networking	✓	✓		✓			✓	✓		✓	✓				3V 1.8V	✓	✓	
Consumer	✓			✓						✓			✓	✓	3V 1.8V	✓		✓
Mobile	✓			✓									✓		1.8V	✓		✓
Automotive	✓	✓		✓ DTR	✓ 200MHz		✓	✓	✓ RPMC+	✓	✓	✓			3V (1.8V)	✓	✓	
IoT	✓			✓ X2			✓	✓	✓ RPMC+		✓		✓	✓	1.8V wide	✓		✓

✓ Standard Features

✓ Advanced Features

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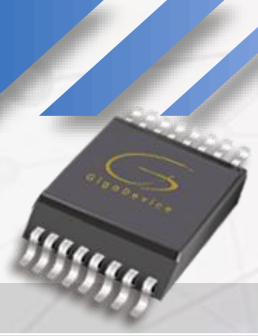
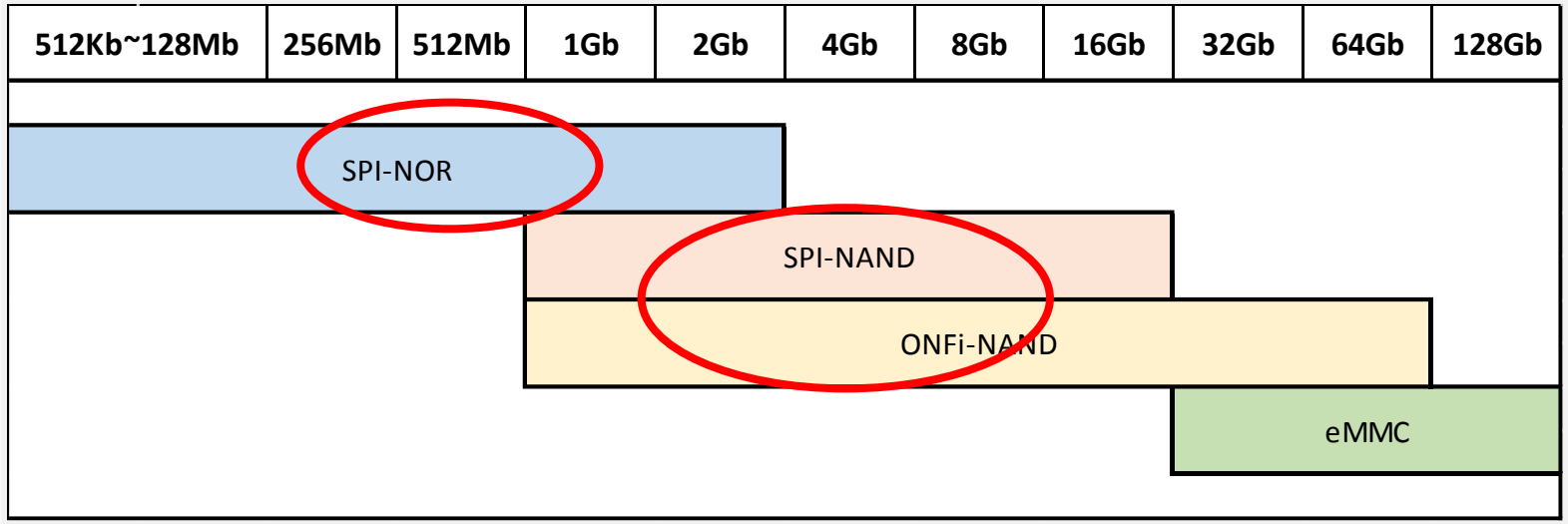
Flash Memory Density – GD Solutions



	Density
Computing	Medium ~ High
Networking	High
Consumer	Low ~ High
Mobile	Low ~ Medium
Automotive	High
IoT	Low ~ Medium



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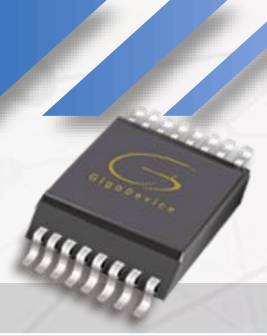
Flash Memory Density – GD Solutions



	Density
Computing	Medium ~ High
Networking	High
Consumer	Low ~ High
Mobile	Low ~ Medium
Automotive	High
IoT	Low ~ Medium

- GigaDevice offers full density coverage for SPI NOR Flash product lines:
  - 512Kb ~ 256Mb (**512Mb / 1Gb / 2Gb** in plan)
  - 3V 256Mb (with ECC) is available for sample.
  - 3V 512Mb (with "Software Die Select") is available for sample.
- NAND Flash continues the density coverage up to 64Gb:
  - 1Gb / **2Gb / 4Gb / 8Gb**, SLC technology (16Gb/32Gb/64Gb in plan)
  - **SPI NAND** management features improve NAND reliability.
  - **ONFi NAND** to support legacy products with 2D NAND shortage.

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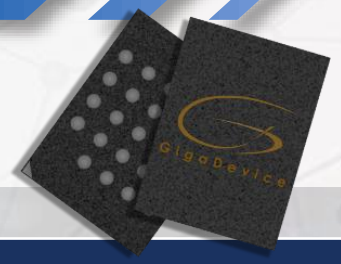
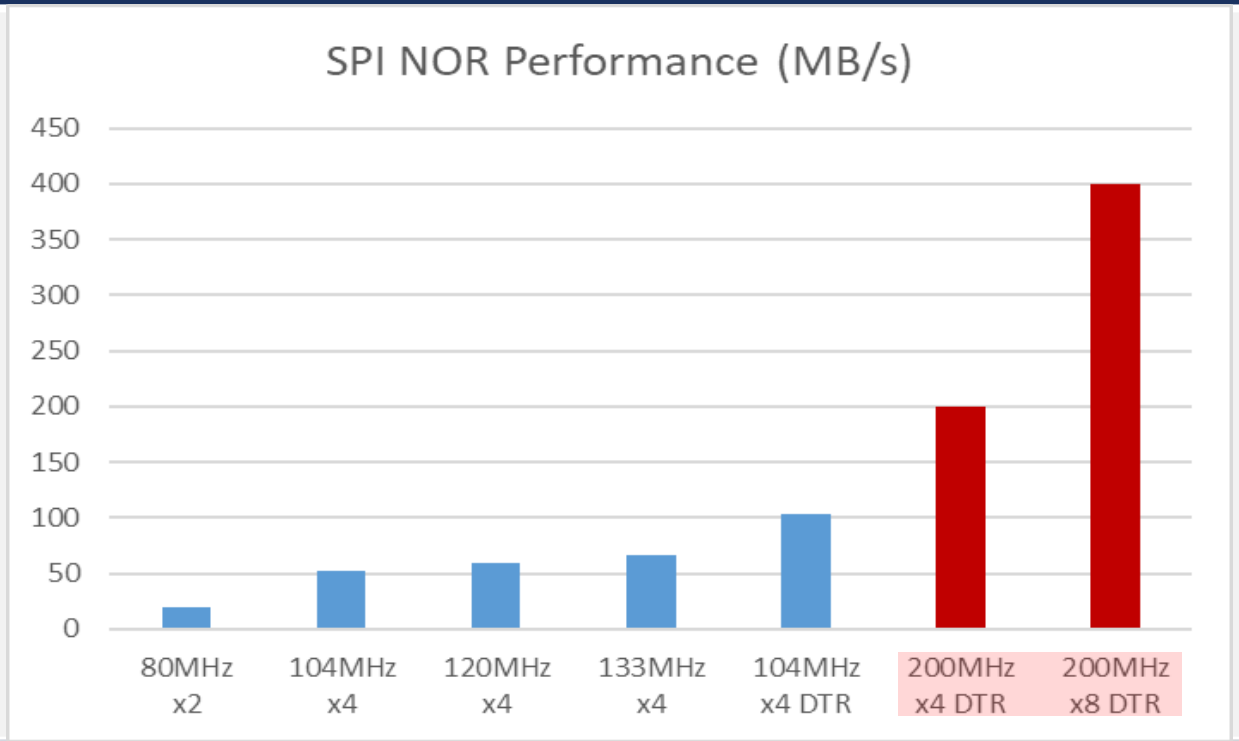
Flash Memory Performance – GD Solutions



	Performance
Computing	Low
Networking	Medium ~ High
Consumer	Medium
Mobile	Medium
Automotive	Very High
IoT	Low



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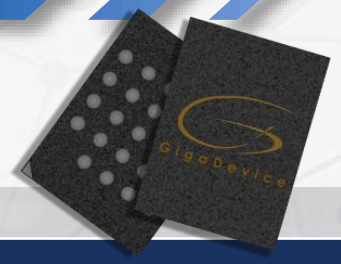
Flash Memory Performance – GD Solutions



	Performance
Computing	Low
Networking	Medium ~ High
Consumer	Medium
Mobile	Medium
Automotive	Very High
IoT	Low

- 104MHz x4 is the standard maximum Read speed for GD SPI NOR:
  120 / 133MHz are supported by some new generation products.
  DTR is supported.
- Automotive application has driven SPI NOR Read performance to x8 I/O:
  GD joined Xccela™ Consortium with Micron, Winbond.
  First Octal DTR SPI product is **1.8V 256Mb** with
  200MHz x8 DTR (400MB/s) data throughput.
- However, Xccela™ SPI NOR requires new interface design by chipset:
  Some customers may prefer current **Quad SPI (x4) interface with 200MHz DTR (200MB/s).**

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Flash Memory Security – GD Solutions

	Security
Computing	Medium
Networking	Medium ~ High
Consumer	Medium
Mobile	Medium
Automotive	Medium ~ High
IoT	Medium ~ High

- All standard Security feature are support by GD SPI NOR products:
  - Unique ID for individual device
  - Status Register /WP protect; Array protection
  - OTP area for customer key storage
- Intel developed RPMC protocol for SPI NOR Flash on PC platform:
  - GD supports **3V RPMC with 64/128/256Mb** density.
  - 1.8V RPMC will be available late ’18.
- GD extended RPMC feature set by adding “**Memory Access Control**”:
  - Typical RPMC separates memory and device authentication.
  - GD’s new concept is to put authentication in front of memory.
  - First Product is **1.8V 16Mb with WLCSP** package.

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Flash Memory Reliability – GD Solutions

	Reliability	
Computing	Normal	• All GD SPI NOR products support 100K P/E Cycles and 20-yr Data Retention: 90/65/55/45nm NOR Technology • **ECC** is the latest Reliability feature for GD SPI NOR products: 1-bit/8-Byte SEC/DED algorithm Real-time ECC Status during Read Page Program in 8-Byte granularity First product is **3V 256Mb (GD25Q257D), in production.** ECC effectively extends the product life time • All GD SPI NAND products has on-chip ECC engine: 8-bit/512B for the current generation. Up to 16-bit/512B for the **next generation**.
Networking	High	
Consumer	Normal	
Mobile	Normal	
Automotive	Very High	
IoT	Normal	

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Flash Memory Power – GD Solutions

	Power Consumption
Computing	Normal
Networking	Normal
Consumer	Low ~ Normal
Mobile	Normal
Automotive	Normal
IoT	Low

- Typical power parameters for SPI NOR products:
  - VCC: 3V, 1.8V
  - Deep Power Down / Standby current: 0.1 ~ 10µA
  - Read current: 5 ~ 15mA
  - Program/Erase current: 15 ~ 30mA
- Some new features related to Low Power Consumption:
  - **Wide VCC range 1.65 ~ 3.6V**
  - **"Zero" standby current: 0.1µA** (no need for DPD)
  - Active Read current: <5mA
  - Program/Erase current: <10mA
- Multiple product series designed for various Low Power applications:
  - **GD25WD, GD25VE, GD25D, GD25LD, GD25LE**

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Package Highlights for SPI NOR Flash

- **WLCSP** (Wafer Level CSP)
  - Advantage:

    package size = die size
  - Disadvantage:

    Higher cost &
    difficult to handle

- **Supported Products:**
  - 1.8V 8Mb~128Mb

- **USON8 3x2mm**
  - High Yield & Low Cost
  - **Smallest Molding Package**
  - Supports 512Kb~16Mb
  - **Introducing 1.5x1.5mm USON8**

- **BGA24 5x5 ball**
  - Default “Octal” package defined by JEDEC
  - **High Density Package**

Flash Memory Package – GD Solutions

	Package Size
Computing	Normal
Networking	Normal
Consumer	Normal
Mobile	Small
Automotive	Normal
IoT	Small

- **WLCSP** packages:
  X, Y dimensions vary from products
  Maximum 0.5mm thickness
  Current devices support WLCSP: 1.8V 16/32/64/128Mb
- Various **USON** packages:
  USON 3x2mm, 3x3mm, 4x3mm, 3x4mm, 4x4mm, **1.5x1.5mm (new)** with 0.5~0.6mm thickness
- **8x6mm TFBGA** (5x5 ball array) is the key package for high density products:
  Support additional features (RESET#, ECC) than 8-pin packages.
  Future compatibility with Octal SPI Interface.
  SOIC-16 may also be considered.

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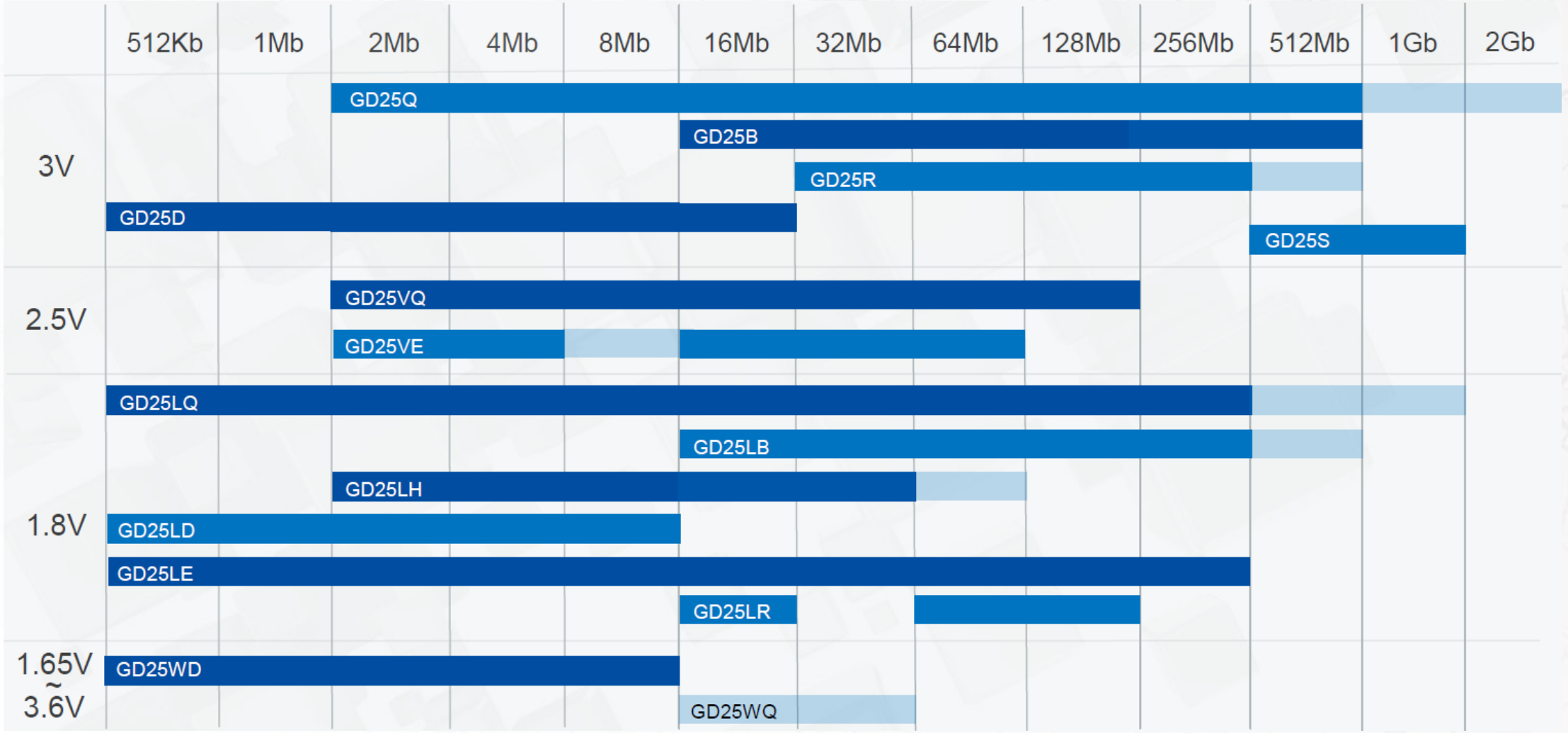
SPI NOR Flash Portfolio



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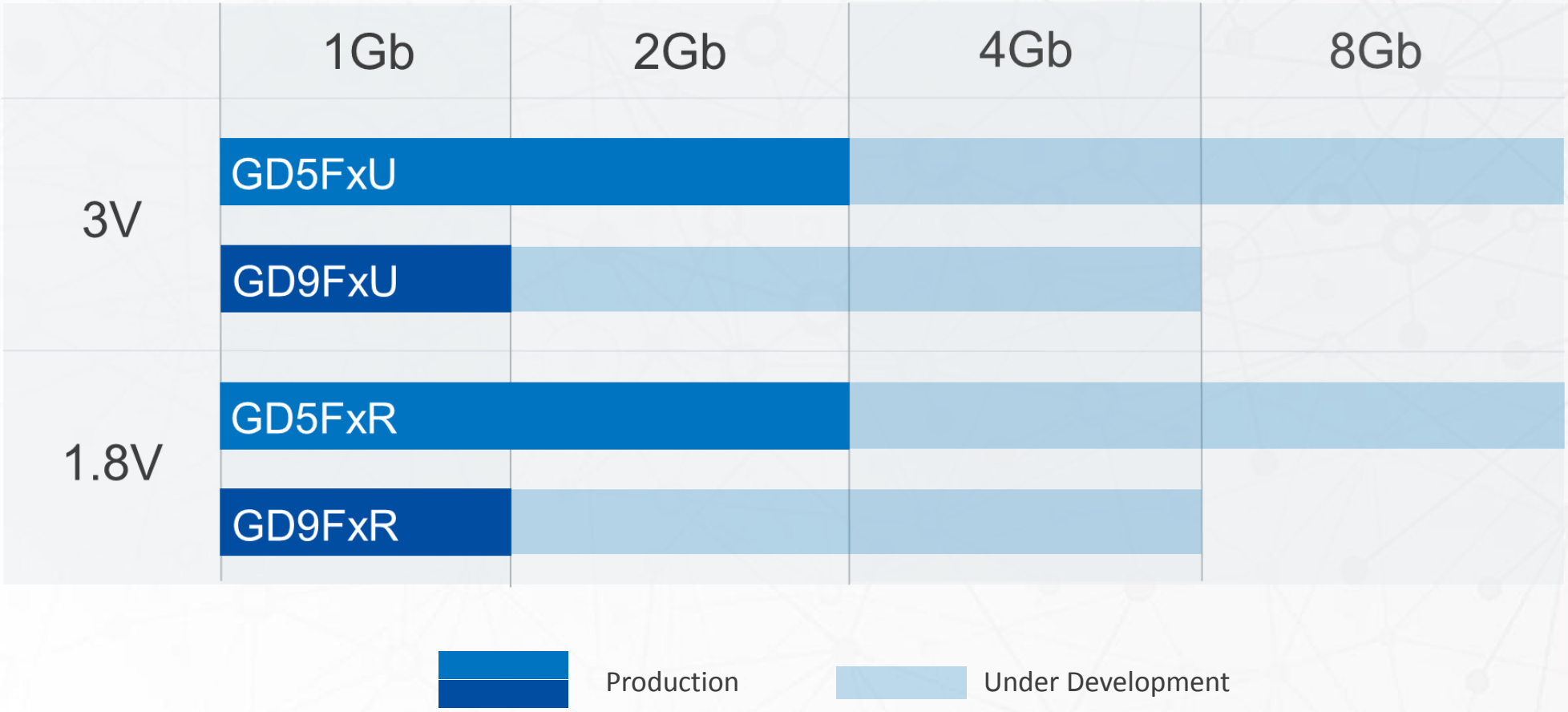
NAND Flash Portfolio (GD5F – SPI interface; GD9F – ONFi interface)



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Cortex-M Microcontroller Introduction

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GD32 MCU Introduction

With GigaDevice rich memory and controller IC design experiences…

- **2005 – SRAM**
- **2008 – SPI NOR Flash**
- **2013 – 32-bit Cortex® -M3 MCU**
- **2016 – 32-bit Cortex® -M4 MCU**

All the No.1 Product in mainland China

GD32 ARM® CORTEX® Processor Technology ARM® University Worldwide Education Program ARM® Connected Community

GD32 Family of 32-bit ARM® MCUs

- ✓ Latest 32-bit ARM® Cortex® -M core
- ✓ **17** complete product lines
- ✓ **>300** P/Ns for selection
- ✓ Excellent performance & real-time response
- ✓ Optimized active power consumption
- ✓ Outstanding ESD & EMC level
- ✓ Rich peripherals & interface combination
- ✓ Comprehensive IDE & software compatible

- High performance
- Cost-effective
- Easy use

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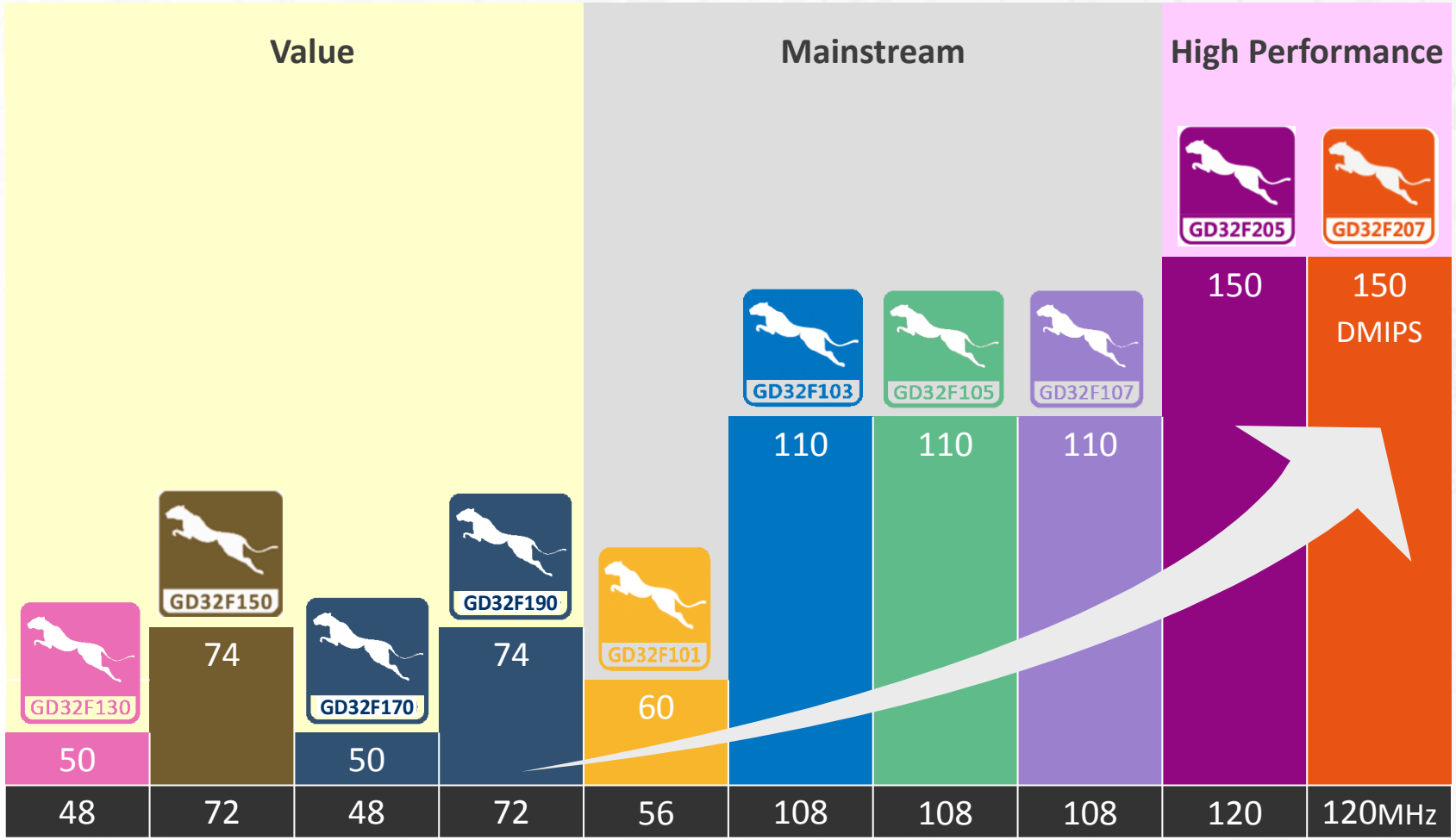
GD32 Cortex®-M3 Portfolio ~200 P/N



- Arm® Cortex®-M3 core
- All SMIC 110nm process
- All in mass production

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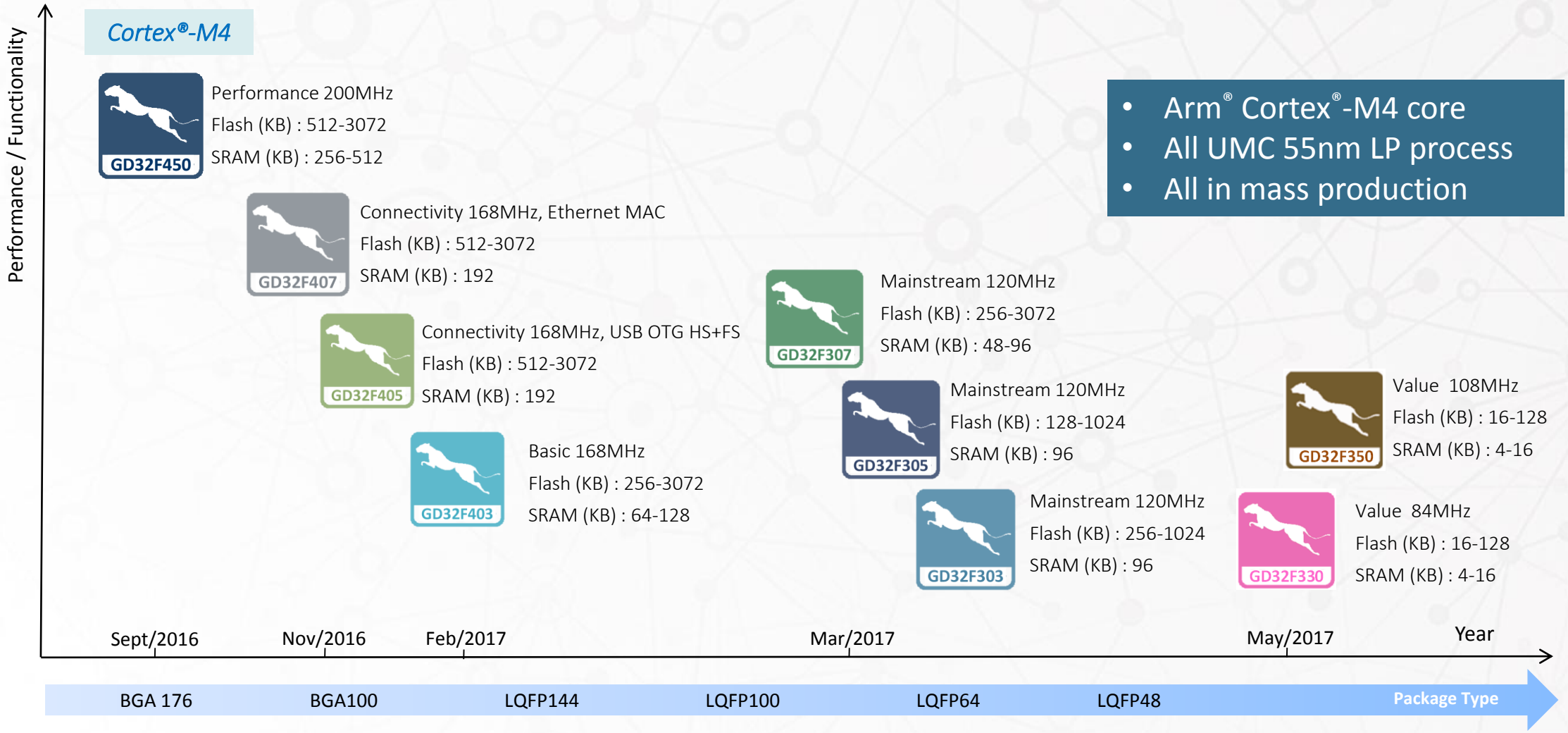
GD32 Cortex®-M4 Portfolio ~100 P/N



- Arm® Cortex®-M4 core
- All UMC 55nm LP process
- All in mass production

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Thank You!