FRAM----New Leader of Memory

2013.Nov

What is FRAM?

FRAM = Ferroelectric Random Access Memory

DRAM, SRAM

- Volatile **Need Voltage**
- RAM (Random Access)

Flash E2PROM

- Non Volatile
- ROM (Read Only) **Boost +Erase**
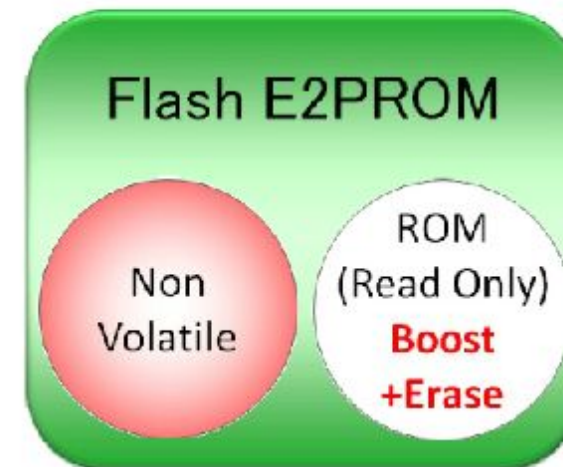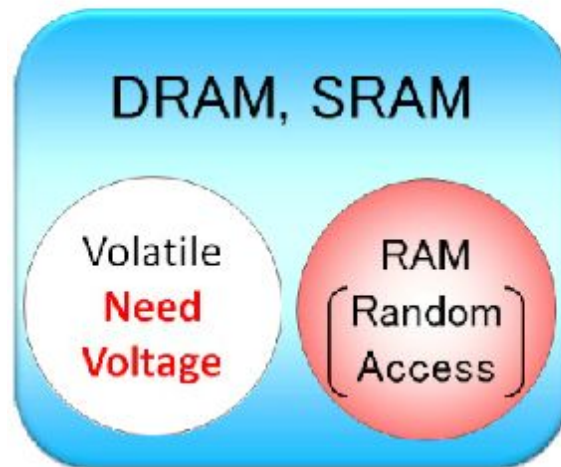
FRAM has a very well balanced combination of features of RAM & ROM

FRAM

- RAM (Random Access)
- Non Volatile
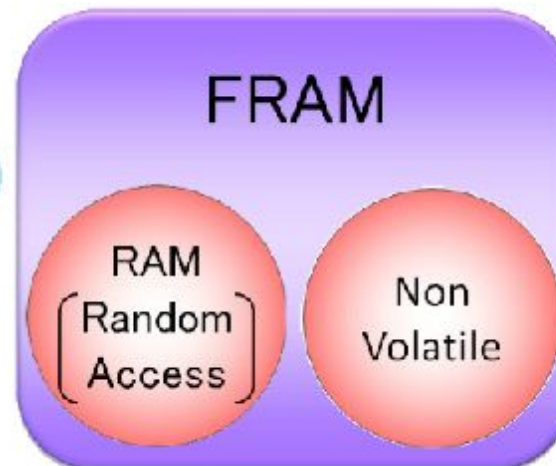
Random-Access (Read/Write)

1

How FRAM works?

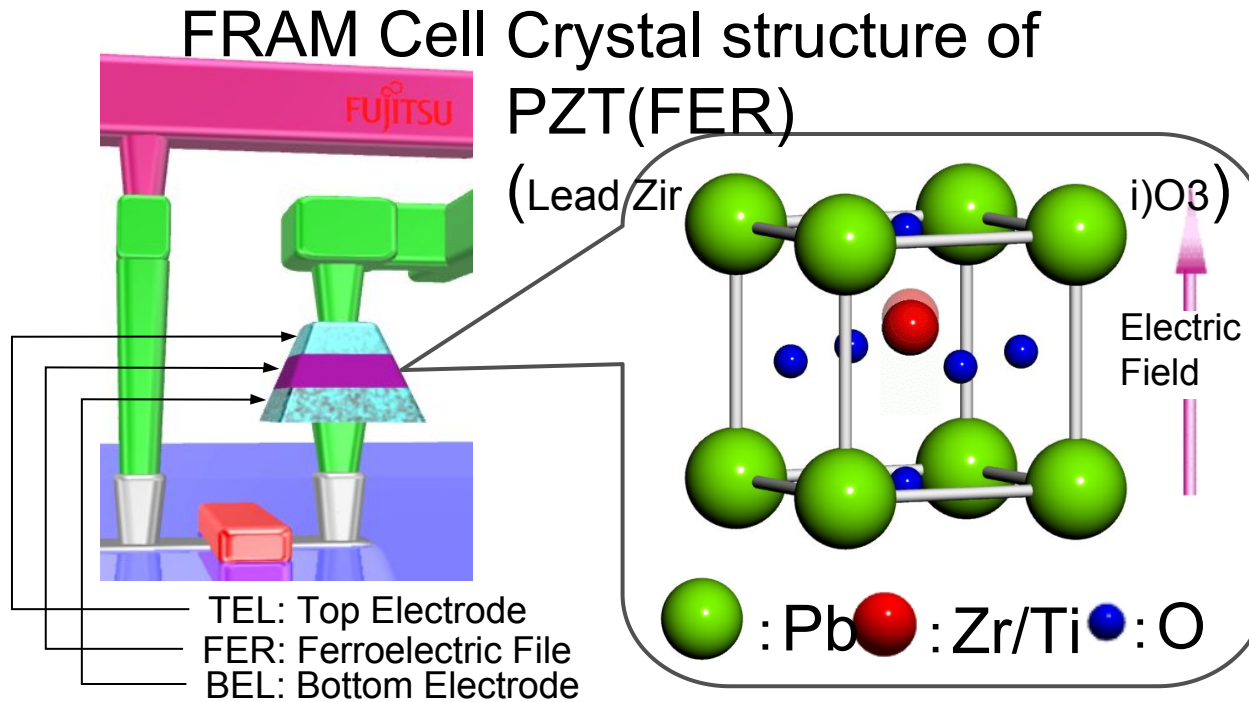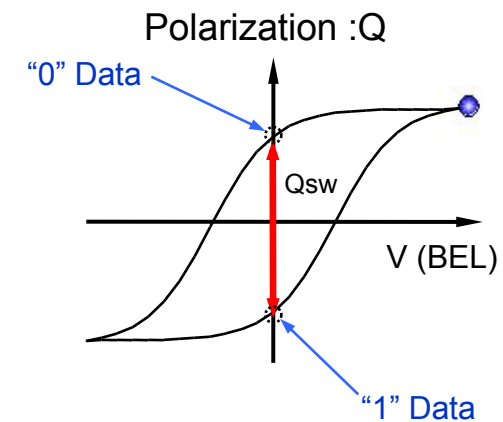※Fujitsu calls FRAM instead of FeRAM.

FRAM is a Nonvolatile Memory,
that incorporates ferroelectric film as a capacitor to hold data.

FRAM Cell Crystal structure of PZT(FER)

(Lead Zir ... i)O3)

Hysteresys Loop of PZT

Electric Field

Polarization :Q

"0" Data

Qsw

V (BEL)

"1" Data

TEL: Top Electrode
FER: Ferroelectric File
BEL: Bottom Electrode

🟢 : Pb 🔴 : Zr/Ti 🔵 : O

(1) Polarization occurs when an electric field is applied.
   (Zr/Ti atoms move upward or downward in the crystal)
(2) Electric polarization remains even in the absence of an applied electric field.
(3) Two stabilized states are stored in the form of "0" & "1" data. => Nonvolatile storage cell

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FRAM Advantage

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Fast Rewriting Time

Infinite Rewritable (1000 Billion)

Low Power Consumption

Strong for the Radiation

Eco-friendly Memory

High Tamper Resistance

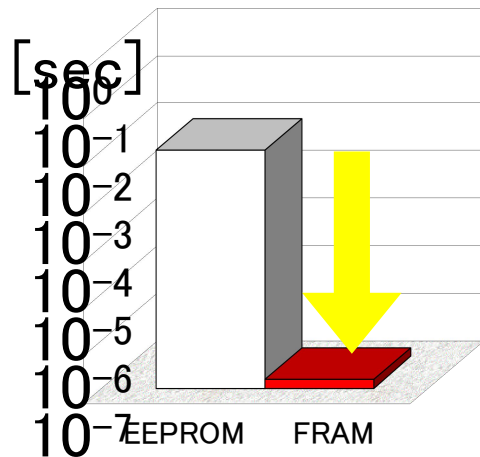# How frequently FRAM can read/write?

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FRAM	read-write(msec)	Endurance	How many years you can use?
	20		634 years
	15		476 years
	10	1,000,000,000,000 times	317 years
	5		159 years
	1		32 years
	…		…
	0.3	₄VS.	10 years

EEPROM	read-write(msec)	Endurance	How many years you can use?
	300000 = 5 mini		10 years
	…		…
	2000	1,000,000	0.06 years
	1500		0.05 years
	1000		0.03 years
	500		0.02 years

Advantages comprare to EEPROM

40,000 times
Faster writing

1 million times
longer endurance

1/1,000 lower
power consumption

[sec]

10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}

EEPROM   FRAM

[Times]

10^{12}
10^{10}
10^8
10^6
10^4
10^2
10^0

EEPROM   FRAM

[mW]

1000
100
10
1
0.1

EEPROM   FRAM

✓Saves Crucial system
in the real time and
protect data loss from
sudden power down
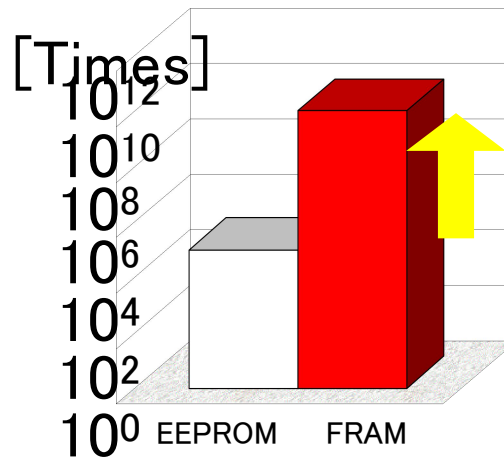
✓Offers virtually unlimited
write endurance

✓Developing higher
endurance

1 trillion--> 10 *trillion*
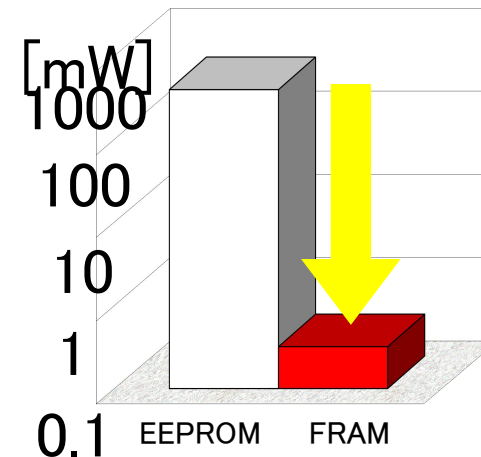
✓Operates without
High voltage,
enabling low power
consumption

How fast can FRAM write?

6
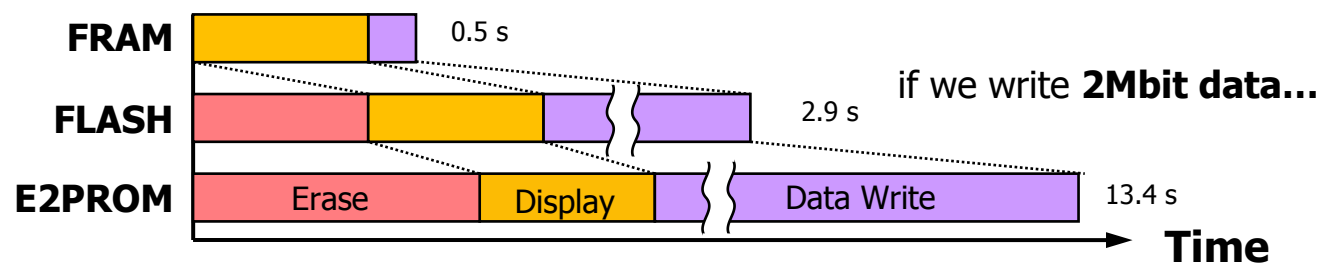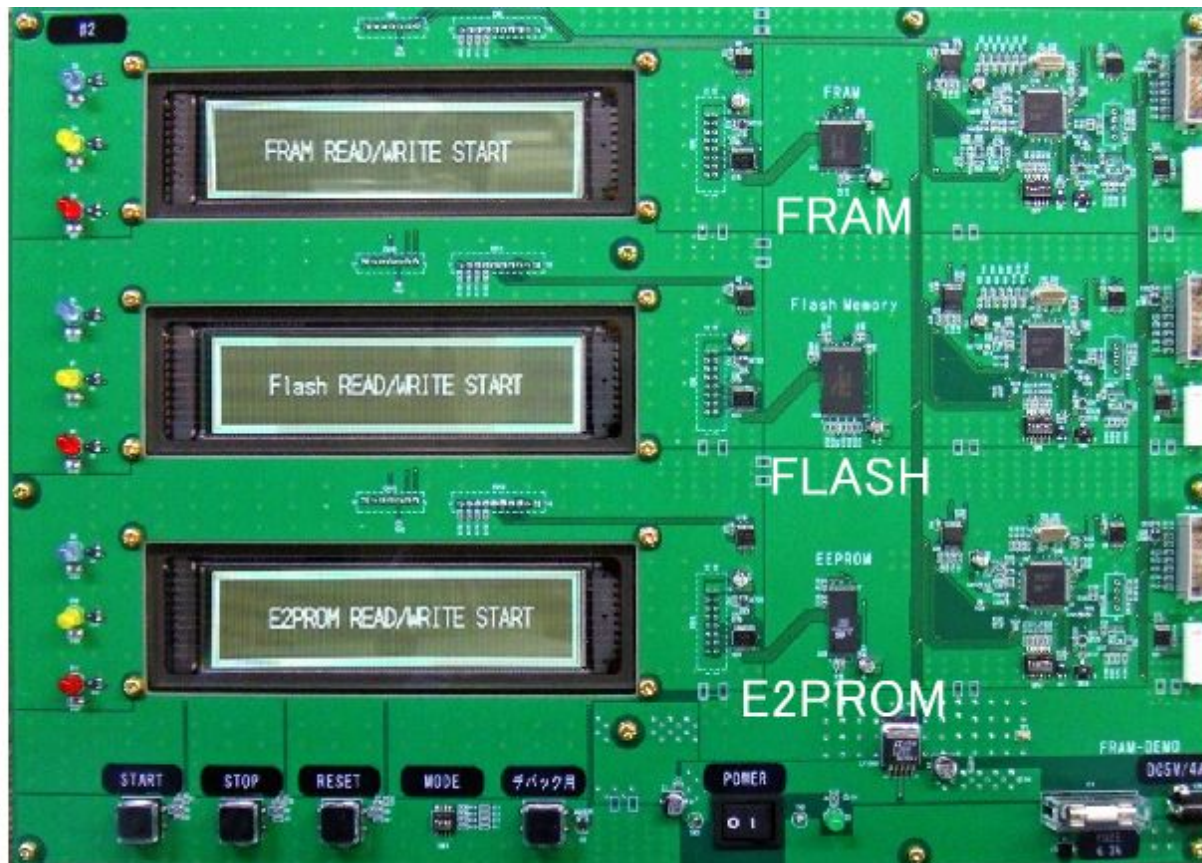
Comparison between FRAM and other memory

	FRAM	E²PROM	FLASH	SRAM
Type of Memory	Nonvolatile	Nonvolatile	Nonvolatile	Volatile
Data write	Overwrite	Erase + write	Erase + write	Overwrite
Write Cycle time	150ns	15ms	6μs	40ns
Endurance	$>10^{12}$	$<10^6$	$<10^6$	∞
Operation Current(Max)	10uA	5mA	30mA	8mA

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Shipping and Applications History

2.3 Billion

2000   2002   2004   2006   2008   2010   2012   2020
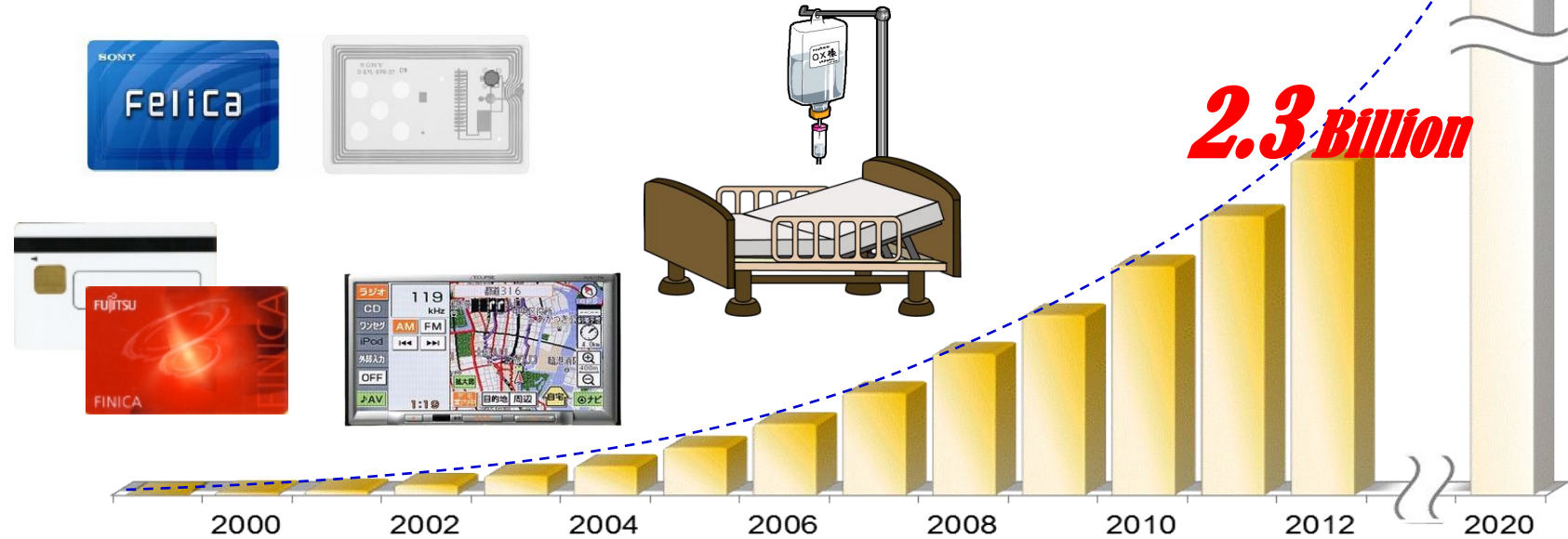
Foundry	(FRAM manufacturing Technology)
Transportation Infrastructure	(Anti-tamper, RF)
Money Card	(Data integrity, Anti-tamper, RF)
Authentication	(Crypt, Anti-tamper)
Car Accessory	(Robust reliability)
Industrial automation	(RF, Data integrity, High temperature)
Medical	(Data integrity, High density)
Meter	(Data integrity, RF, Anti-tamper)
Energy harvest	(Low power technology)
Medical RFID	(RF, γ-radiation)

119 kHz

0299.9
meter

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Applications FRAM standalone memory used
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Isolation Circuit

Circuit Breaker

Measurement Equipment

Robot

CNC

PLC

Transformer

Smart meter

Thermostat

Invertor

Motor control

Industrial Battery

Car Navigation
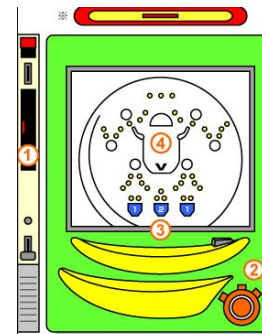
Slot Machine

Gaming Machine

POS

Vending machine

ATM

Radio Transceiver

Security Camera

Renewable Energy

Communication module

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Power Meter

Landis+Gyr+ — **WW No.1**

HOLLEY — **WW No.3**

Itron — **WW No.2**

IUSA

三 SANXING 星

林 洋 LINYANG

Global Meter customer list:

- "Itron" -SG- MB85RC16
- "IUSA" -USA- MB85RC64
- "Linyang" -China- MB85RC16
- "Sanxing" -China- MB85RC64
- "Holley" -China- MB85RC64
- "Landis+gyr" -Swiss- MB85RC16/RS256A

Write log ⇩ 💥 = Abnormal event or Brown out

Power

EEPROM — Write time = 10ms

FRAM — Write time = 150ns
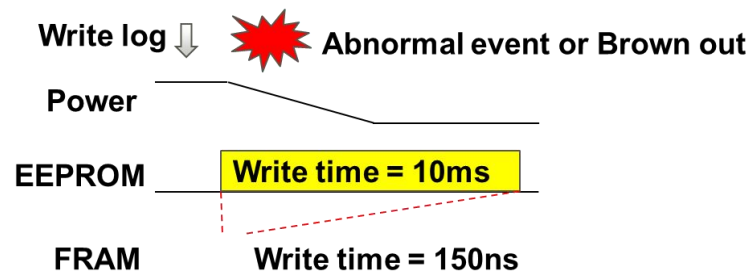
✓Why FRAM?

·Store crucial data in FRAM. Protect Data loss from sudden power down.

✓·FRAM enable per 0.3ms access frequency@ 10yrs

More than "30M pcs" FRAM shipped for power meter application.

Industrial Automation

Global customer list:

"ABB" -Swiss- MB85RS128B circuit breakers

"Emerson" -U.S.- MB85RS256B motion controller

"Rockwell" -U.S.- MB85RS256B inverter

"Yokogawa" -Japan- MB85RS256A flow meter

"Krohne" –Germany- MB85RS64 flow meter

✓**Why FRAM?**

・To keep fine data log just before abnormal event.

・To keep long battery life and perform under strict power consumption. Also suitable for wireless models.

・Explosion proof
 FRAM doesn't use a pumping circuit, differing from EEPROM/Flash ROM

In such critical industrial environment, FRAM is the best choice for design

ATM/POS/Currency acceptor

Global customer list:

"Itautec" -Brazil- MB85RS256A ATM

"福建新大陆" -China- MB85RC64 POS

"中科英泰" -China- MB85RC64 POS

"Fujitsu frontech" -Japan- MB85RC16 ATM

"Takamizawa cyber" -Japan- MB85R4001A

✓**Why FRAM?**

•With fast read/write cycle, even the last transaction data will safely be recorded in case of sudden power loss.

•Can take fine log. Almost times.

We have worldwide customers for this application.

Green energy

コルコート株式会社
COLCOAT CO.,LTD.

WW No.6

HITACHI
Inspire the Next

Global customer list:

"Colcoat" -Japan- MB85R256F solar equipment

"Hitachi" -Japan- MB85R1002A/4002A wind electricity

"Eaton" -Taiwan- MB85RC04V PV inverter

✓Why FRAM?

•Store frequent data such as calibration parameters, cumulative power data..etc.
•Protect Data loss from sudden power down with higher read/write cycle.
•Battery-free, environmentally friendly

FRAM is key elements for Green energy.

FRAM product line

I^{2}C

256Kbit, 3V-5V
MB85RC256V

128Kbit, 3V
MB85RC128

64Kbit, 3V MB85RC64	64Kbit, 5V MB85RC64V
16Kbit, 3V MB85RC16	16Kbit, 5V MB85RC16V

4Kbit, 3V-5V
MB85RC04V

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SPI

2Mbit 1.8-3V
MB85RS2MT

1Mbit 1.8-3V
MB85RS1MT

256Kbit, 3V
MB85RS256

128Kbit, 3V
MB85RS128

64Kbit, 3V MB85RS64	64Kbit, 5V MB85RS64V

16Kbit, 3V
MB85RS16

Parallel

4Mbit, 3V
MB85R400XA

1Mbit, 3V
MB85R100XA

256Kbit, 3V
MB85R256F

FRAM Roadmap: I2C interface

NRND	Under Study	Plan	Mass Production

Serial IIC   * Plans are subject to change without notice.

Density bit	CY2013				CY2014			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1M				ES		Plan (1.8 − 3.6V, 3.4MHz)		
512K				ES		Plan (1.8 − 3.6V, 3.4MHz)		
256K					Under Study, (+RTC, VDD->TBD) in 2014 -2015			
	MB85RC256V (2.7 − 5.5V, 1MHz)							
128K	MB85RC128A (2.7 − 3.6V, 1MHz)							
	MB85RC128 NRND, but no plan to EOL (2.7 − 3.6V, 400kHz) -> MB85RC128A							
64K					Under Study, (+RTC, VDD->TBD) in 2014 -2015			
	MB85RC64V (3.0 − 5.5V, 1MHz)							
	MB85RC64A (2.7 − 3.6V, 1MHz)							
	MB85RC64 NRND, but no plan to EOL (2.7 − 3.6V, 400kHz) -> MB85RC64A							
16K	MB85RC16V (3.0 − 5.5V, 1MHz)							
	MB85RC16 (2.7 − 3.6V, 1MHz)							
4K	MB85RC04V (3.0 − 5.5V, 1MHz)							

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⊘ INTERNAL USE ONLY

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NRND	Under Study	Plan / ES	Mass Production

Serial SPI

* Plans are subject to change without notice.

Density bit	CY2013				CY2014			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
4M					Plan (1.8 − 3.6V, Quad SPI , 80Mbps)			ES
2M		ES		ES available now (1.8 − 3.6V, 25MHz, 40MHz *1))				
1M		ES		ES available now (1.8 − 2.7V: 25MHz, 2.7 − 3.6V: 30MHz, 40MHz *1)				
512K					ES	Plan (1.8 − 3.6V, 25MHz)		
					Under Study, (+RTC, VDD->TBD) in 2014 -2015			
256K	MB85RS256B (2.7 − 3.6V, 25MHz, 33MHz fast mode)							
	MB85RS256A NRND, but no plan to EOL (3.0 − 3.6V, 25MHz) -> MB85RS256B							
128K	MB85RS128B (2.7 − 3.6V, 25MHz, 33MHz fast mode)							
	MB85RS128A NRND, but no plan to EOL (3.0 − 3.6V, 25MHz) -> MB85RS128B							
64K	MB85RS64V (3.0 − 5.5V, 20MHz)							
	MB85RS64 (2.7 − 3.6V, 20MHz)							
16K						ES	Plan (For Energy harvest)	
	MB85RS16 (2.7 − 3.6V, 20MHz)							

*1) 40MHz works only for fast read mode when voltage is 2.7-3.6V.

FRAM Roadmap: Parallel interface

NRND	Under Study	Under Dev. / Plan	Mass Production

Parallel

17 Plans are subject to change without notice.

Density bit	CY2013				CY2014			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
16M					*Under Study (1.8-3.6V, 150ns, TSOP or FBGA) in 2015*			
8M					*Under Study (1.8-3.6V, 150ns, TSOP or FBGA) in 2015*			
4M				ES	**Under Dev. (1.8-3.6V, 150ns, TSOP44)**			
	MB85R4001/2 (3.0 – 3.6V, 150ns, TSOP48)							
2M					*Under Study (1.8-3.6V, 150ns, TSOP44) in mid of 2014*			
1M					*Plan (1.8-3.6V, 150ns, TSOP44)*		ES	
	MB85R1001/2 (3.0 – 3.6V, 150ns, TSOP48)							
256K	MB85R256F (2.7 – 3.6V, 150ns, TSOP28/SOP28)							

FRAM vs EEPROM

	EEPROM	EEPROM + Super Cap	FRAM
Price	⭕ Low	🔺 Mid*	❌ High
Data Lost Risk At brown out	❌ High risk (Slow write)	⭕ Low risk (with cap*)	⭕ Low risk (Fast write)
Data log interval	❌ 300sec (10^6)		⭕ 0.3ms (10^{12})
Power consumption	❌ High power write		⭕ Low power write

* Since capacitor value is degraded at high temp such as 1,000 hours @70'C large cap must be required in high temp environment.

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FRAM vs SRAM + Battery

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■ FRAM 实现了无电池的划时代提案

	SRAM + Battery	SRAM + FRAM	FRAM
Price	⭕ Low	△ Mid	❌ High → Mid
Cycle time	⭕ 55/70ns		△ 150ns
Access endurance	⭕ Unlimited		△ 10^{10} → 10^{13}
Data lost Risk	❌ Removal or Depletion	⭕ Low Risk	
Maintenance	❌ Battery Replace	⭕ Maintenance Free	
Eco friendly	❌ Disposal Restriction	⭕ Yes	

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FRAM vs MRAM

■ Ex) 256kbit, SPI, 3.3V

存储器分类	MRAM	FRAM
供应商	Everspin	Fujitsu
时钟频率	✔ 40MHz	33MHz
读写耐久性	✔ Unlimited	10^{12}
Iddr@33MHz (Read)	8.7mA	✔ 6.5mA
Iddw@33MHz (Write)	24.5mA	✔ 6.5mA
待机电流	115uA (100%)	✔ 50uA (43.5%)
tPU(Power up to 1st access)	400us (100%)(*1)	✔ 85ns (0.021%)
是否受磁场限制	Yes	✔ No

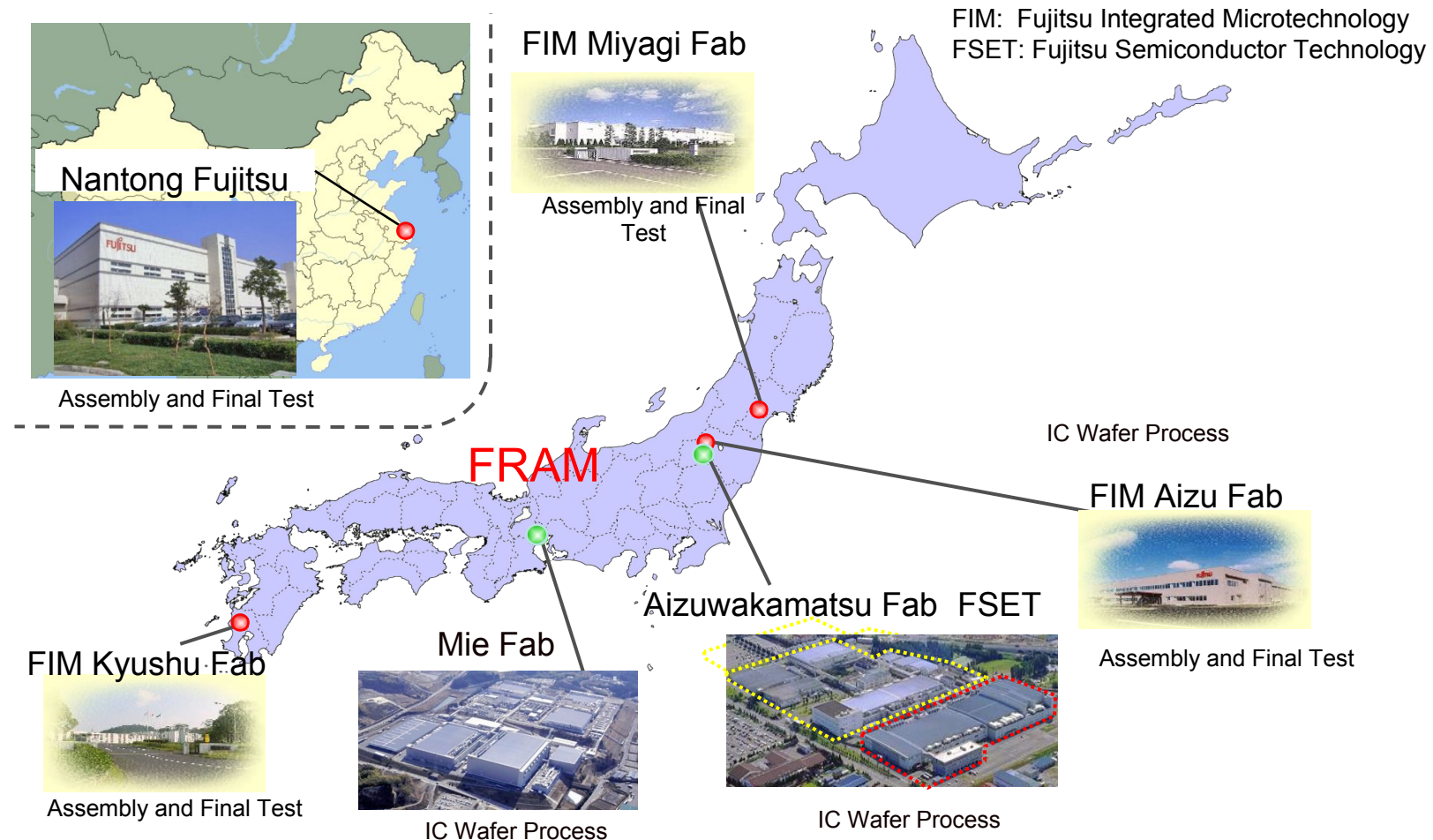*1:internal voltage references need to become stable

FRAM vs nvSRAM-**1**-

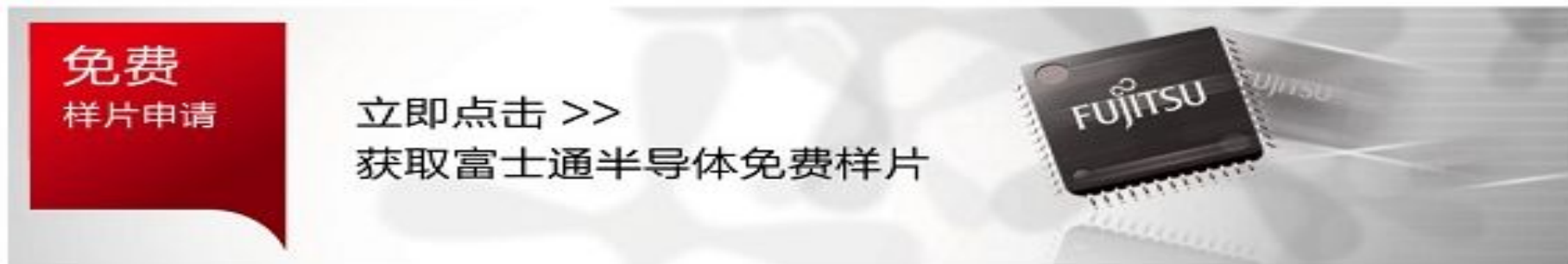| 存储器分类	nvSRAM	FRAM
供应商	Cypress	Ramtron, Fujitsu
容量	16kbit – 8Mbit	4Kbit – 4Mbit
接口	I^2C, SPI, Parallel(x8,x16)	I^2C, SPI, Parallel(x8,x16)
读写耐久性	✔ Unlimited for SRAM 10^6 for EEPROM	10^{10} or 10^{12}
数据保持	✔20years	10years
数据写入周期时间 Cycle time	✔20-45ns for SRAM 8ms for EEPROM	150ns
STORE to NV initiated by	Software, device pin, or AutoStore on power-down	✔ No
External Capacitor (for AutoStore)	Need (47uF – 220uF)	✔ No

WW No.1 supplier of FRAM

13 year experience of FRAM mass production (since 1999)
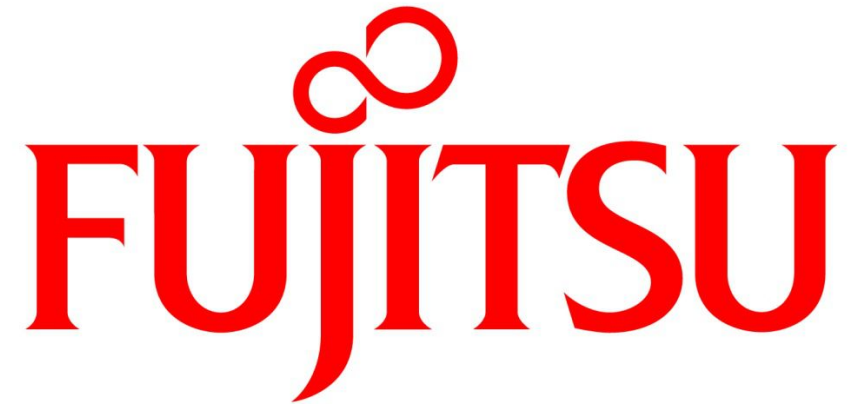
Stable and high quality product supply from own fabs

FIM: Fujitsu Integrated Microtechnology
FSET: Fujitsu Semiconductor Technology

FIM Miyagi Fab

Assembly and Final Test

Nantong Fujitsu

Assembly and Final Test

FRAM

IC Wafer Process

FIM Aizu Fab

Assembly and Final Test

Aizuwakamatsu Fab FSET

FIM Kyushu Fab

Assembly and Final Test

Mie Fab

IC Wafer Process

IC Wafer Process

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http://www.fujitsu.com/cn/fss/freesample/

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样片申请

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样品分类

样品表单

样品型号	样品类型	免费样品	购买
MB85R256HPF-G-BND-ERAE1	FRAM	sample	SQ Buy
MB85RC128PNF-G-JNERE1	FRAM	sample	SQ Buy
MB85RC16PNF-G-JNERE1	FRAM	sample	SQ Buy
MB85RC16VPNF-G-JNERE1	FRAM	sample	SQ Buy
MB85RC64PNF-G-JNERE1	FRAM	sample	SQ Buy
MB85RC64VPNF-G-JNERE1	FRAM	sample	SQ Buy

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