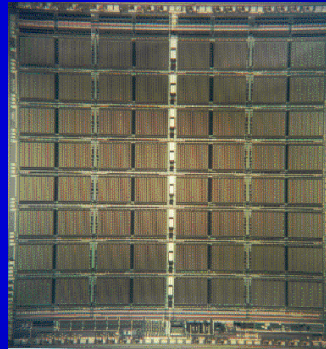


MRAM



Magnetic Random Access Memory

An Introduction by
Graziella Spizzi and Stephan Senn



Non-Volatile RAM-Technology

MRAM

ferroMagnetic RAM

FRAM
(FeRAM)

Ferroelectric RAM

RAM-Technology

OUM

Ovonic Unified Memory



Center of Technology

MRAM

IBM
Infineon
Motorola

FRAM

Fujitsu
Toshiba
Samsung
Hitachi
NEC
Ramtron
Symmetrix
Matsuhita
Micron
IBM
Infineon
Motorola

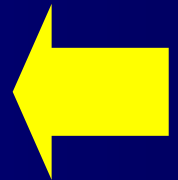
RAM-Technology

OUM

Intel
Ovonyx
ST Micro
British Aerospace

Which Effects are used?

- Giant Magnetoresistance (GMR)
- Spin Dependent Tunneling (SDT) with Magnetic Tunnel Junctions (MTJs)
- Pseudo-Spin Valve (PSV)



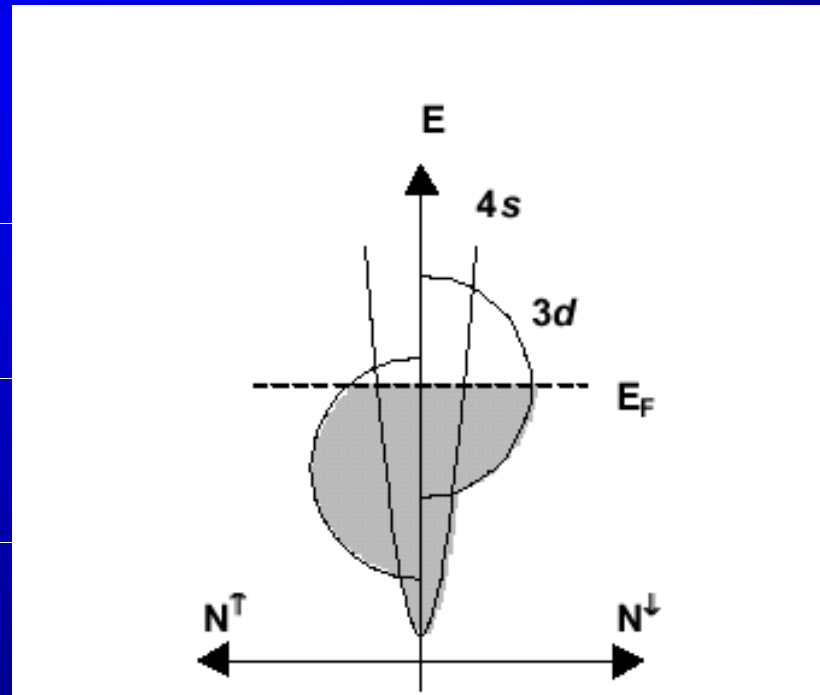


Spin Dependent Tunneling (SDT)

using Magnetic Tunnel Junctions (MTJs)

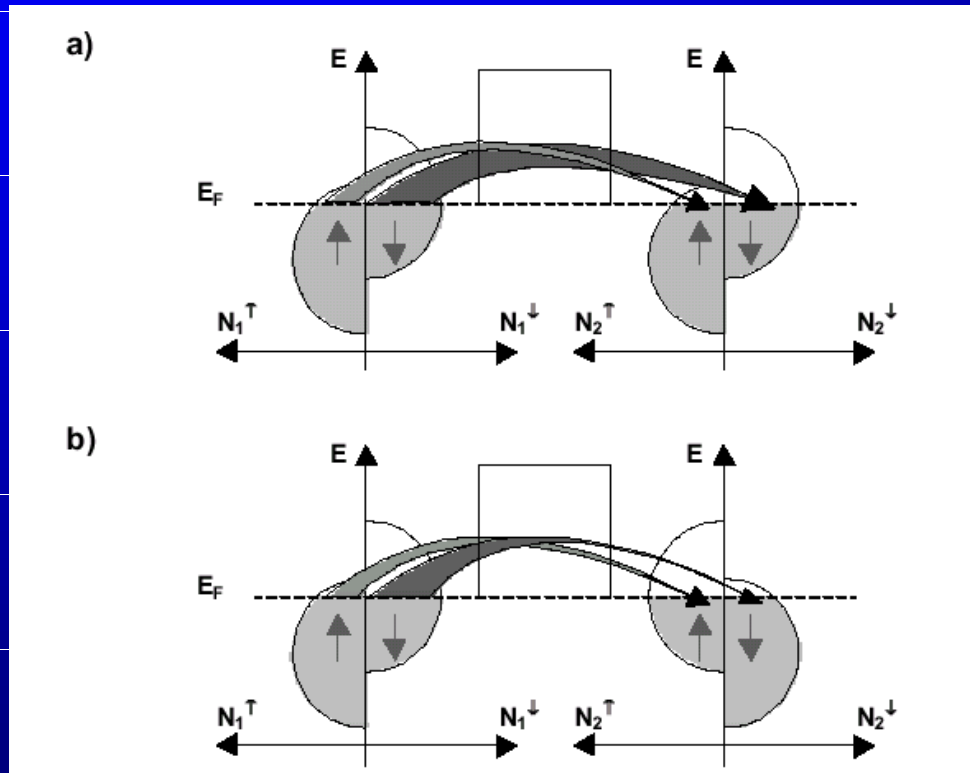
How does MRAM technology work?

Simplified band structure



Spin-spin coupling results in an increase / decrease of 3d bands energy (depending on spin orientation)

Tunneling Probability

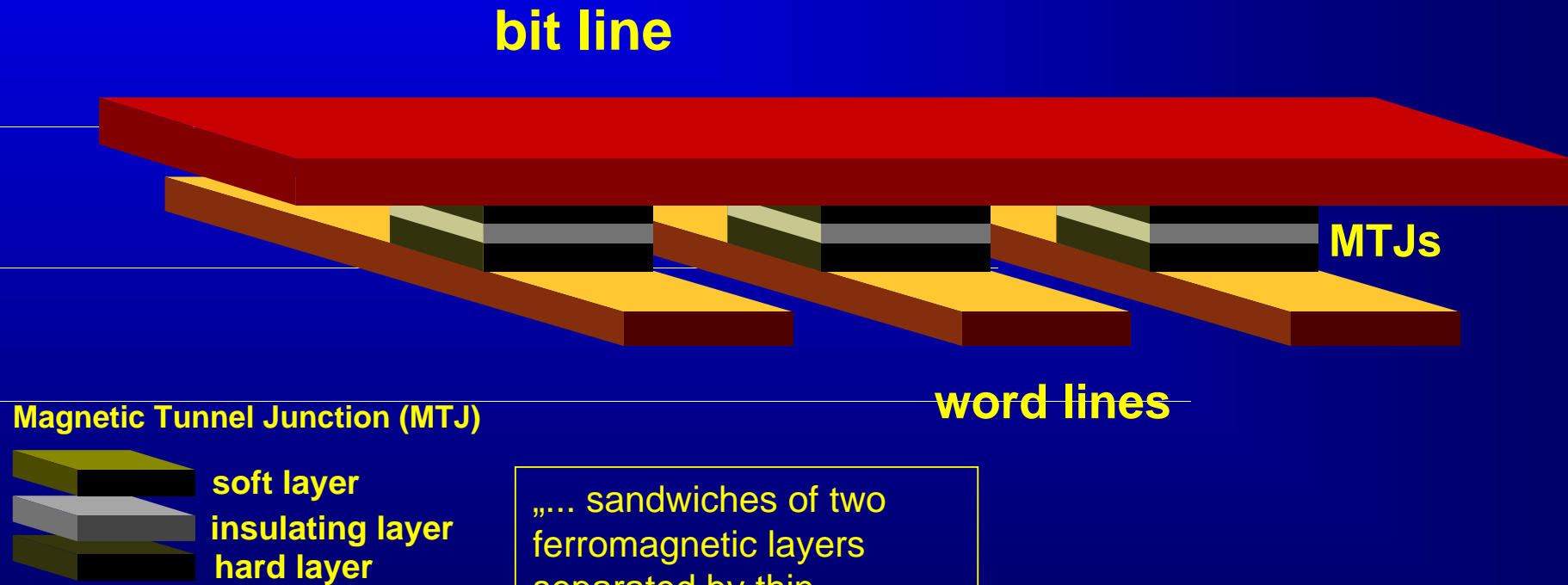


Parallel configuration:
Low resistance.

Antiparallel
configuration:
High resistance.

MRAM using MTJs

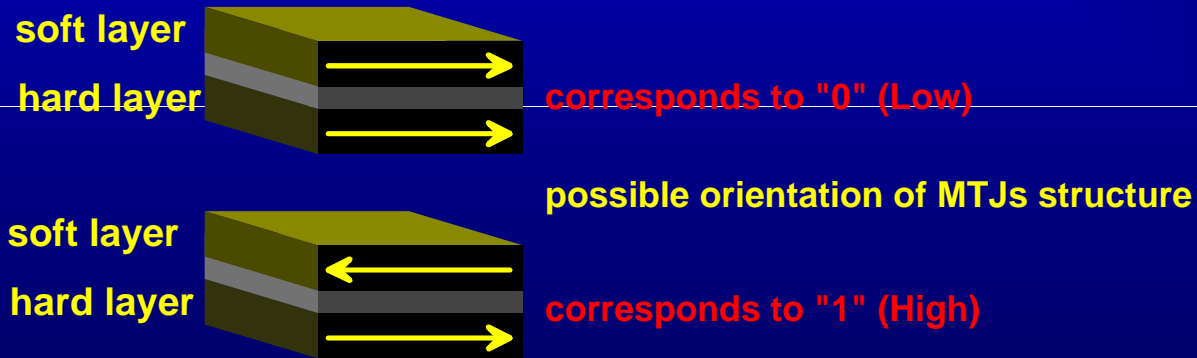
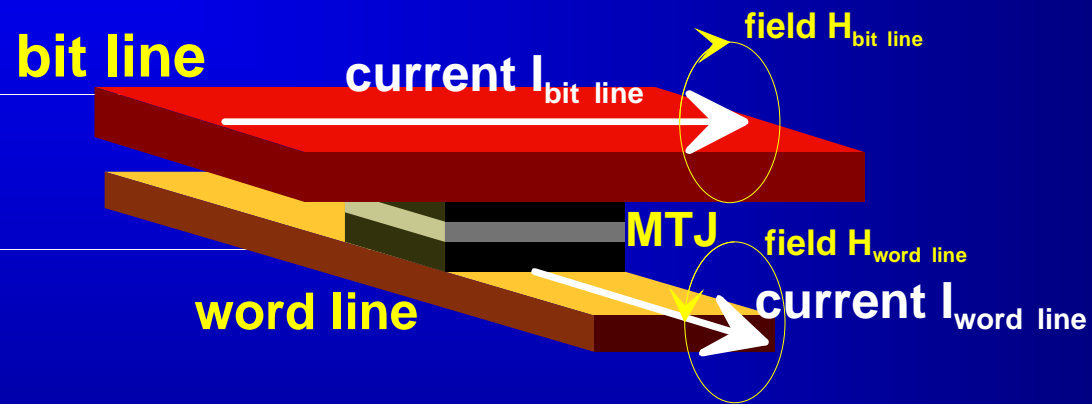
Part 1: structure



„... sandwiches of two ferromagnetic layers separated by thin insulating layers.“

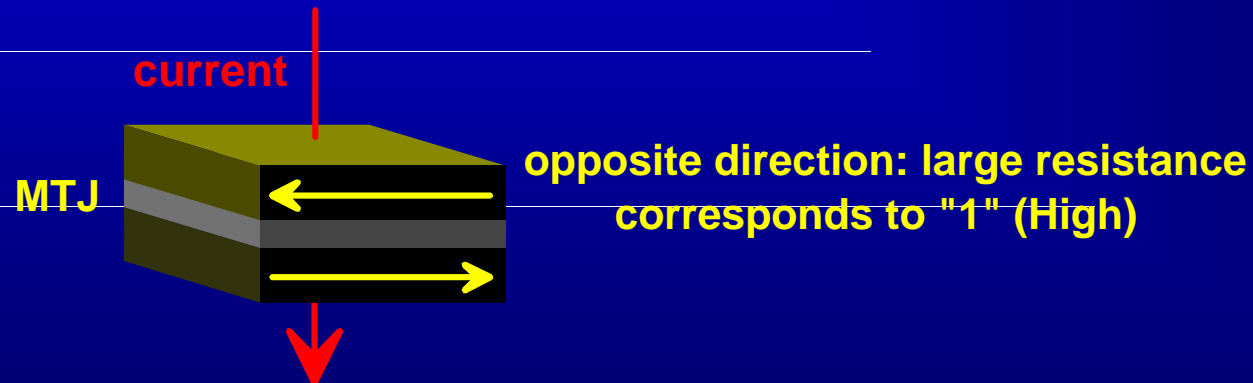
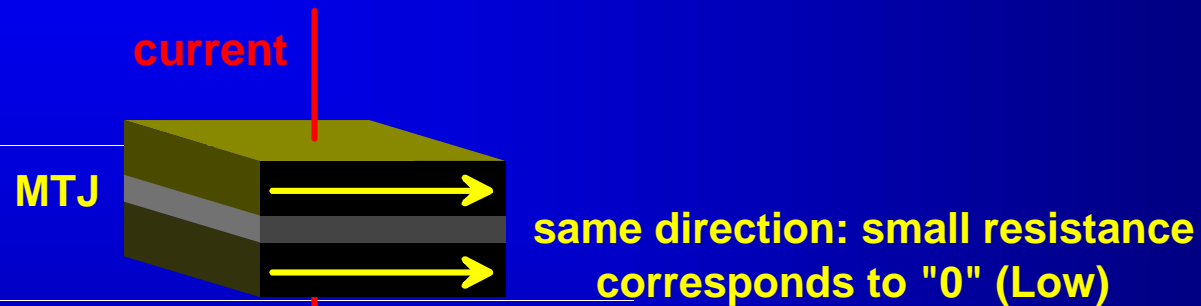
MRAM using MTJs

Part 2: writing data



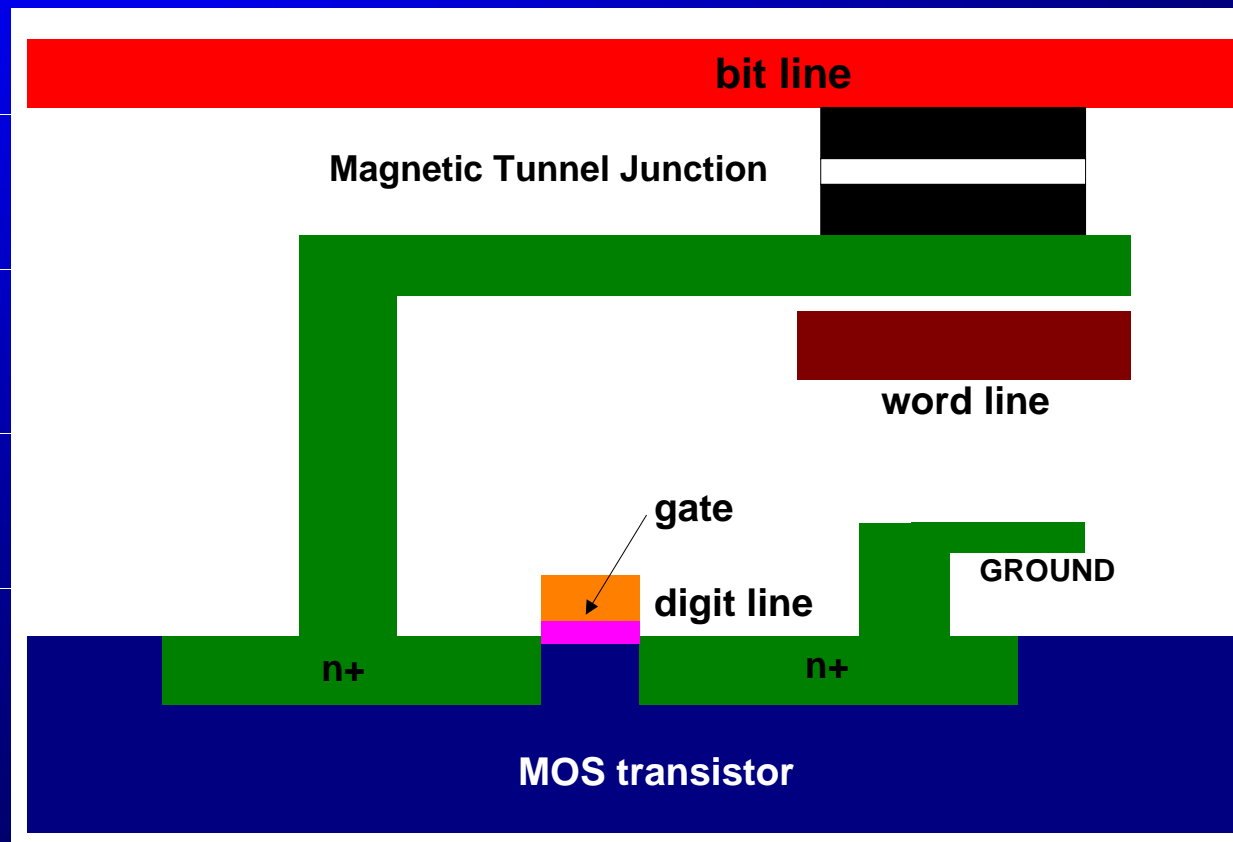
MRAM using MTJs

Part 3: reading data (1)



MRAM using MTJs

Part 3: reading data (2)





Comparison to other RAMs

	SRAM	DRAM	Flash	EEPROM	FeRAM	MRAM
access time	6-70ns	40-70ns	40-70ns	40-70ns	40-70ns	5-40ns
write time	~1ns	~1ns	1 μ s-1ms	1-10ms	~1ns	<10ns
write energy	-	10-200pJ	10-200pJ	1pJ	1pJ	10-200pJ
cell size	12.5X	Reference	1-1.5X	5X	1.1-1.6X	0.5-1X
power consumption	2X	Reference	1-1.5X	1-1.5X	0.5-1X	0.5-1X
endurance	no limitation	no limitation	10 ⁶ -10 ⁸ write cycles	>10 ⁴ -10 ⁶ write cycles	10 ¹¹ -10 ¹⁵ write cycles	no limitation
type	volatile	volatile	non-volatile	non-volatile	non-volatile	non-volatile

Advantage of MRAM

- Non-volatile
- Unlimited read and write endurance
- High density (capacity of several Gbits possible)
- Low supply voltage
- High access speed
- CMOS compatibility (MRAM tunnel junction can be added within a post-processing step)

Disadvantage of MRAM

- High demands on manufacturing tolerances (very thin layers, down to 10-50Å)
- Alloys needed
- Thermal instabilities
- Vortices
- High currents during write cycle (~1-16mA)

References

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by IBM, James Daughton
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by M.Gluth, G.Schmerber, A.Dinia
- **Advanced MRAM Concepts**
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- **Spin Polarised Transport in Metal/Semiconductor/Metal Magnetic Tunnel Junctions**
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