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Value from Innovation

80th Anniversary

Advanced Magnetic Tape Technology for Linear Tape Systems

Barium ferrite technology beyond the limitation of metal particulate media

Osamu Shimizu, Takeshi Harasawa and Hitoshi Noguchi
FUJIFILM Corporation

Contents

Capacity Trends

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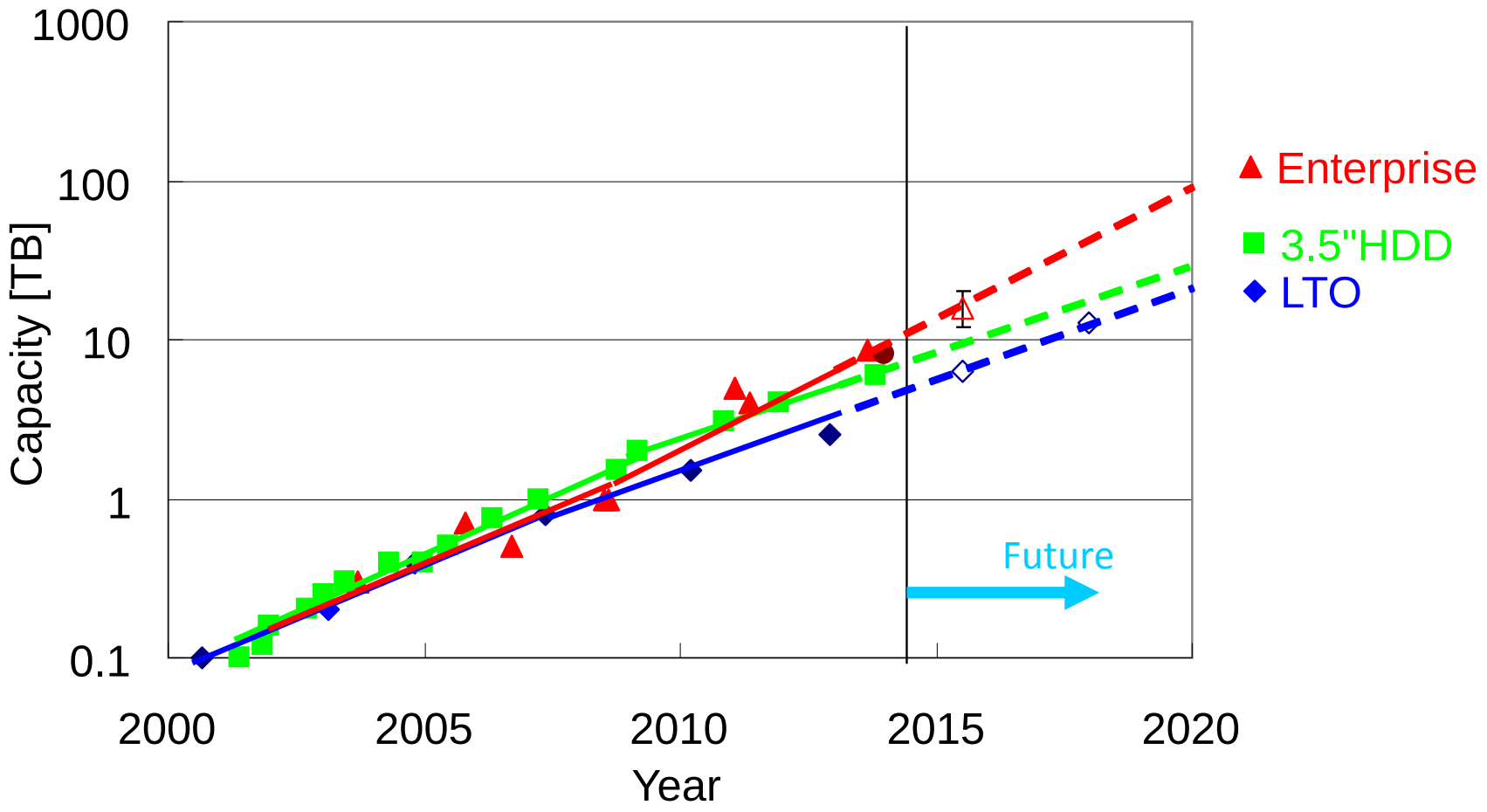

Enterprise roadmap source: http://www.oracle.co.jp/events/jpm120809/materials/20120809-10_StorageSumit_A-2.pdf
LTO roadmap source: http://www.lto.org/technology/index.html

Capacity Trends

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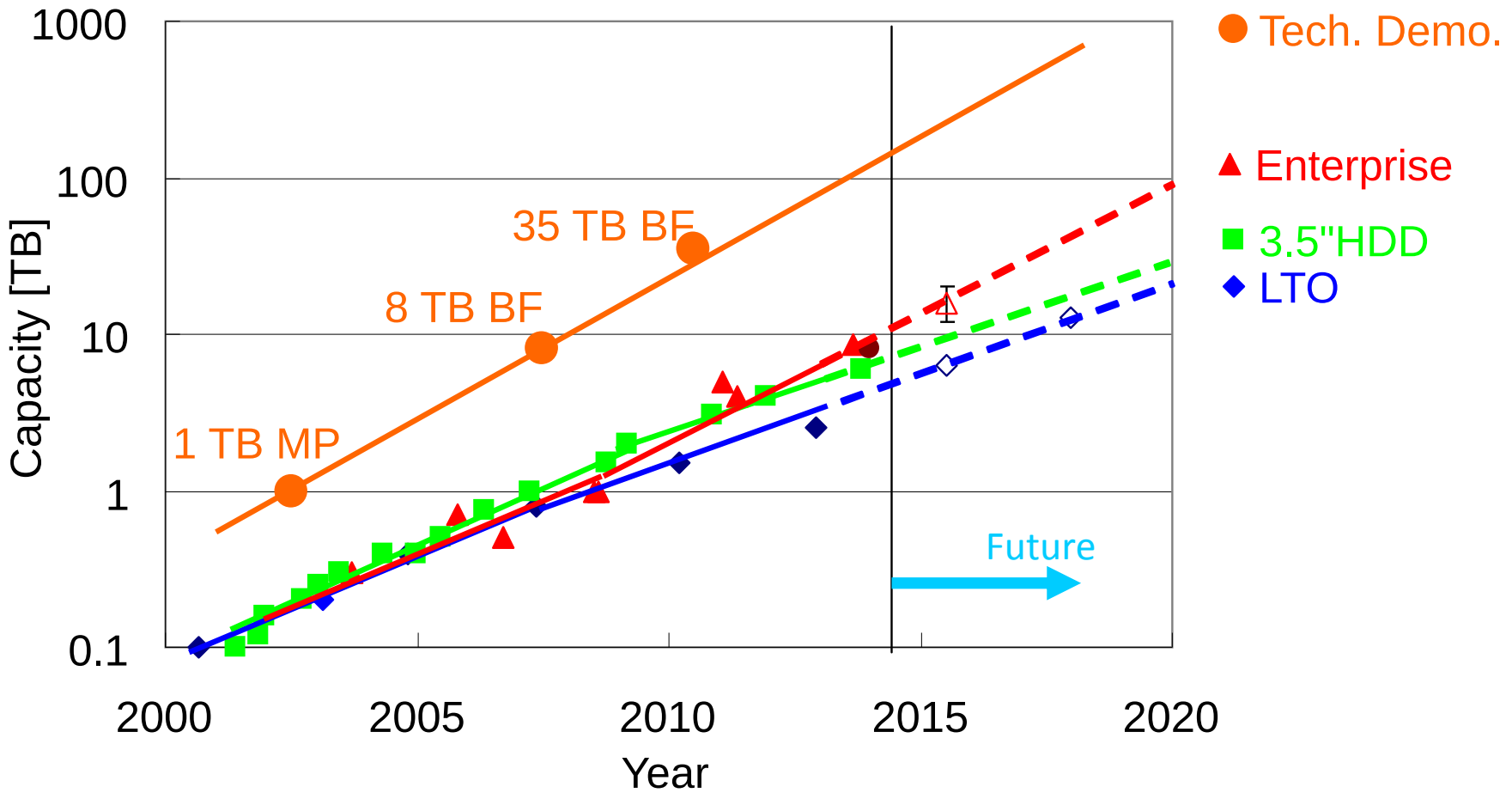

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LTO roadmap source: http://www.lto.org/technology/index.html

Capacity Trends

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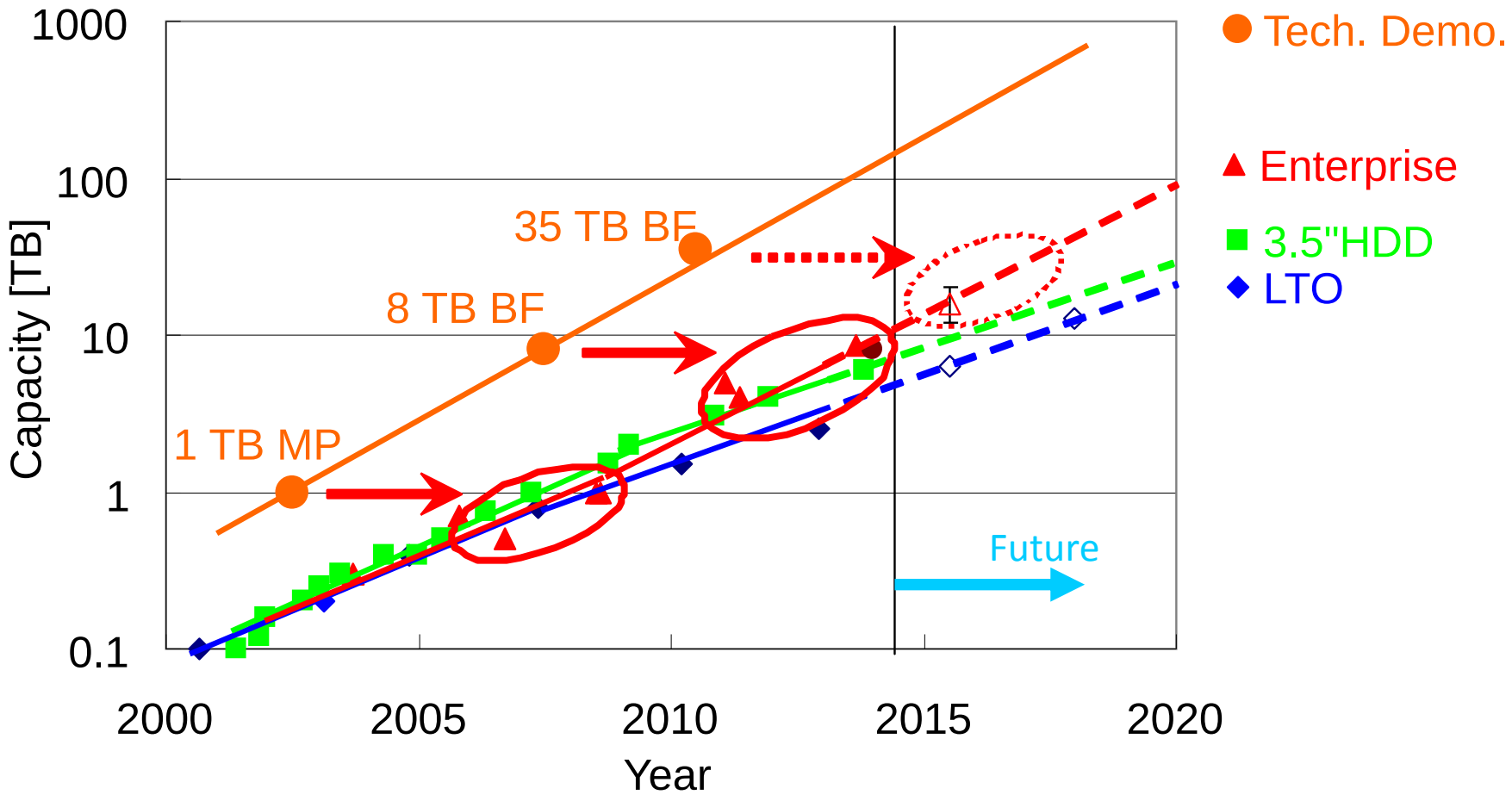

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LTO roadmap source: http://www.lto.org/technology/index.html

Contents

Capacity increase in MP media

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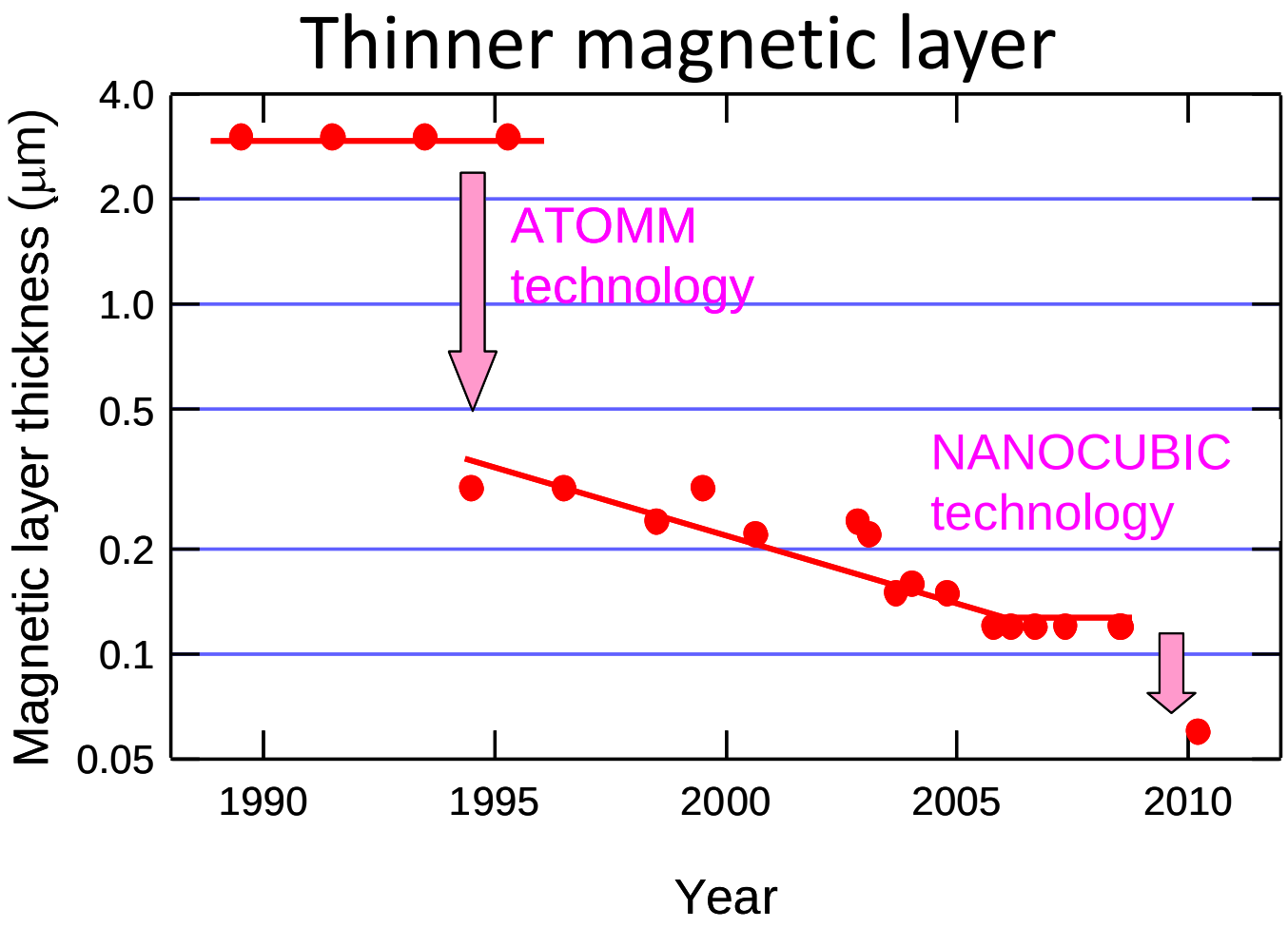

- Thinner magnetic layer makes signal resolution higher, resulting to the achievement of higher linear density.

Capacity increase in MP media

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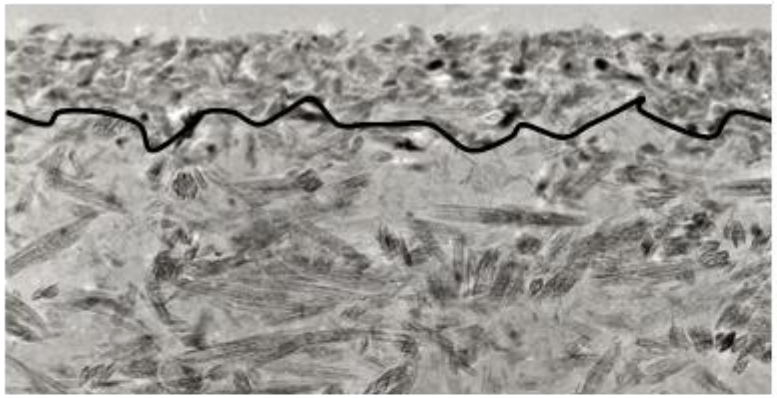
ATOMM Technology

Thickness (t)	110nm
Deviation（δ）	25nm
δ/t	23%



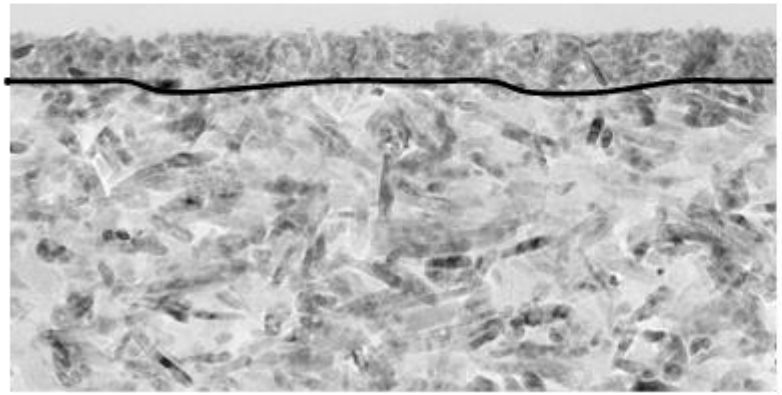
Magnetic layer

Under layer

50nm

NANOCUBIC Technology

Thickness（t）	60nm
Deviation (δ)	6nm
δ/t	10%



Magnetic layer

Under layer

- Thickness variation of magnetic layer is negligibly small by NANO-coating technology.

Capacity increase in MP media

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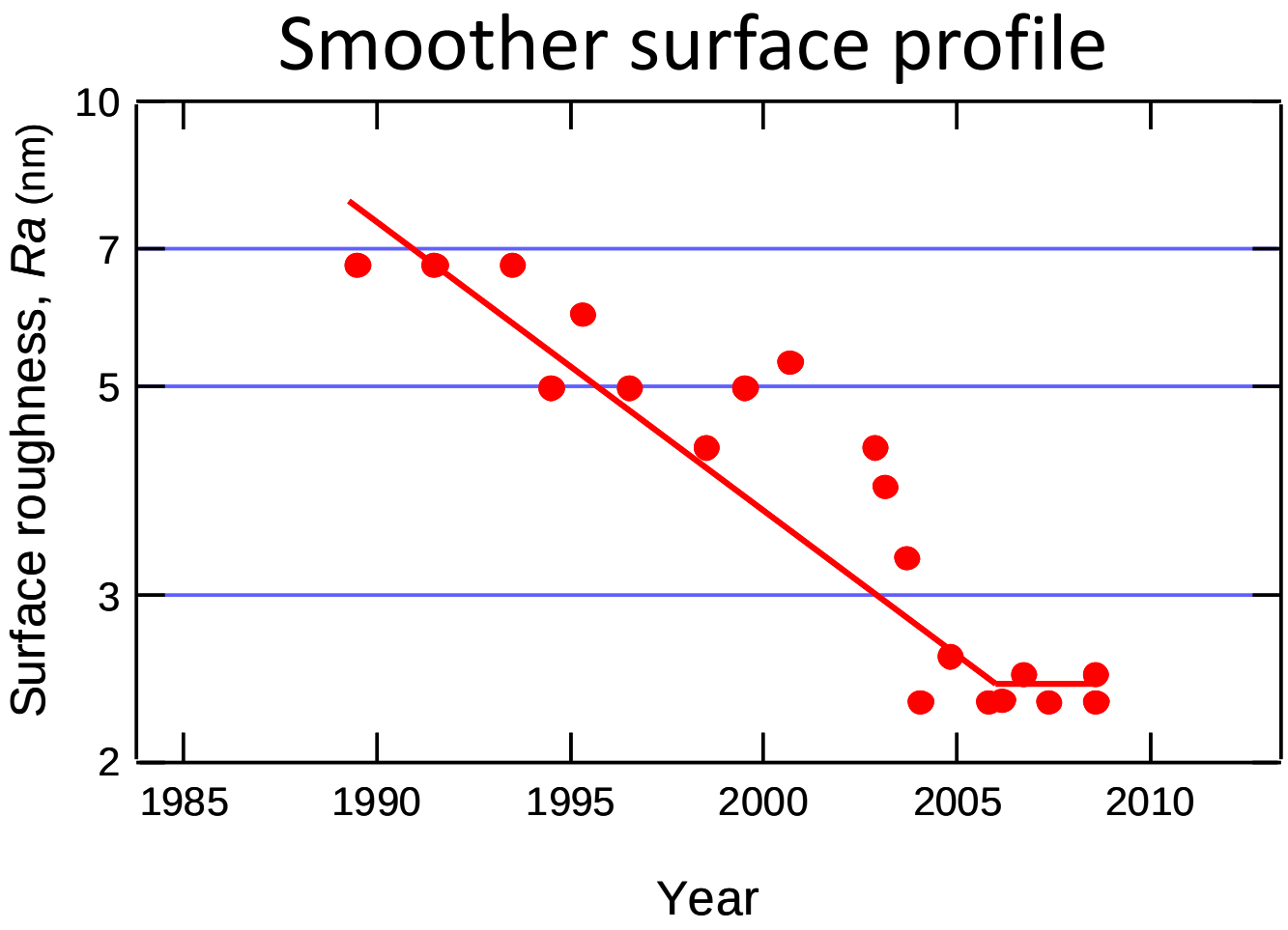
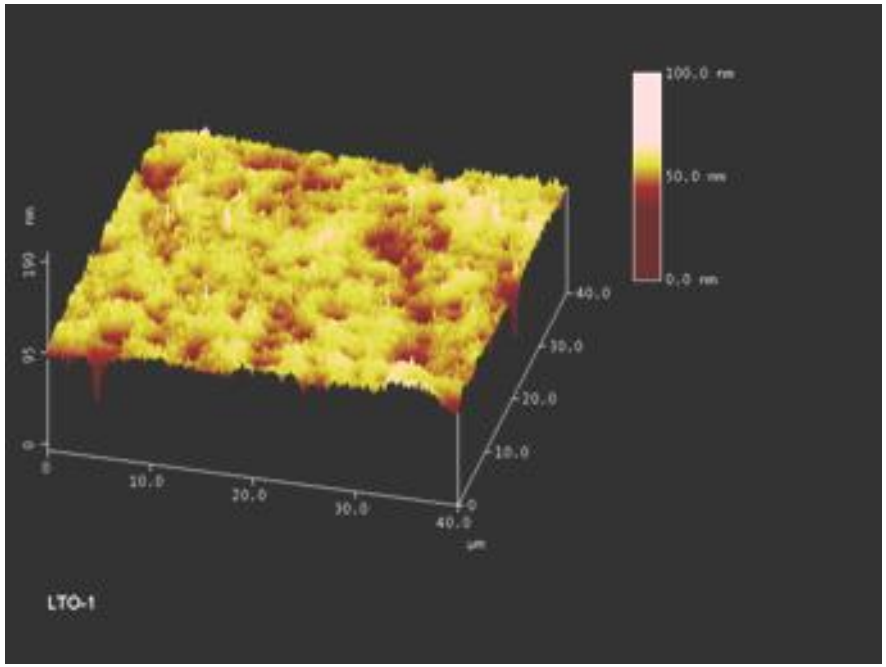


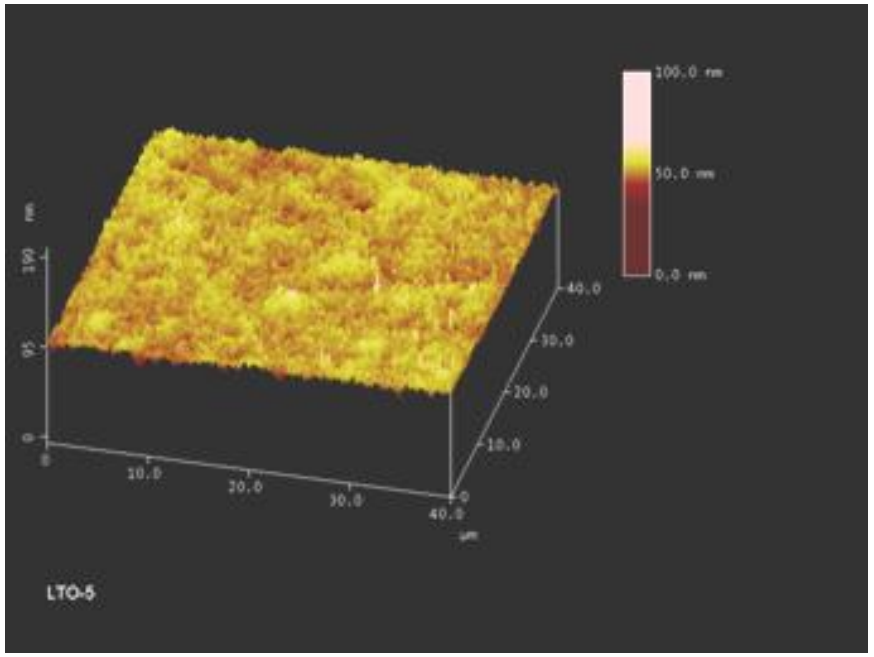
- Smoother surface reduce the spacing between head and media, resulting the significant increase of the signal output at higher linear density region.

Capacity increase in MP media

ATOMM Technology (LTO-1)
Ra:5.2nm



NANOCUBIC Technology (LTO-5)
Ra:2.6nm



- Creates very smooth tapes by NANO-dispersion technology,

Capacity increase in MP media

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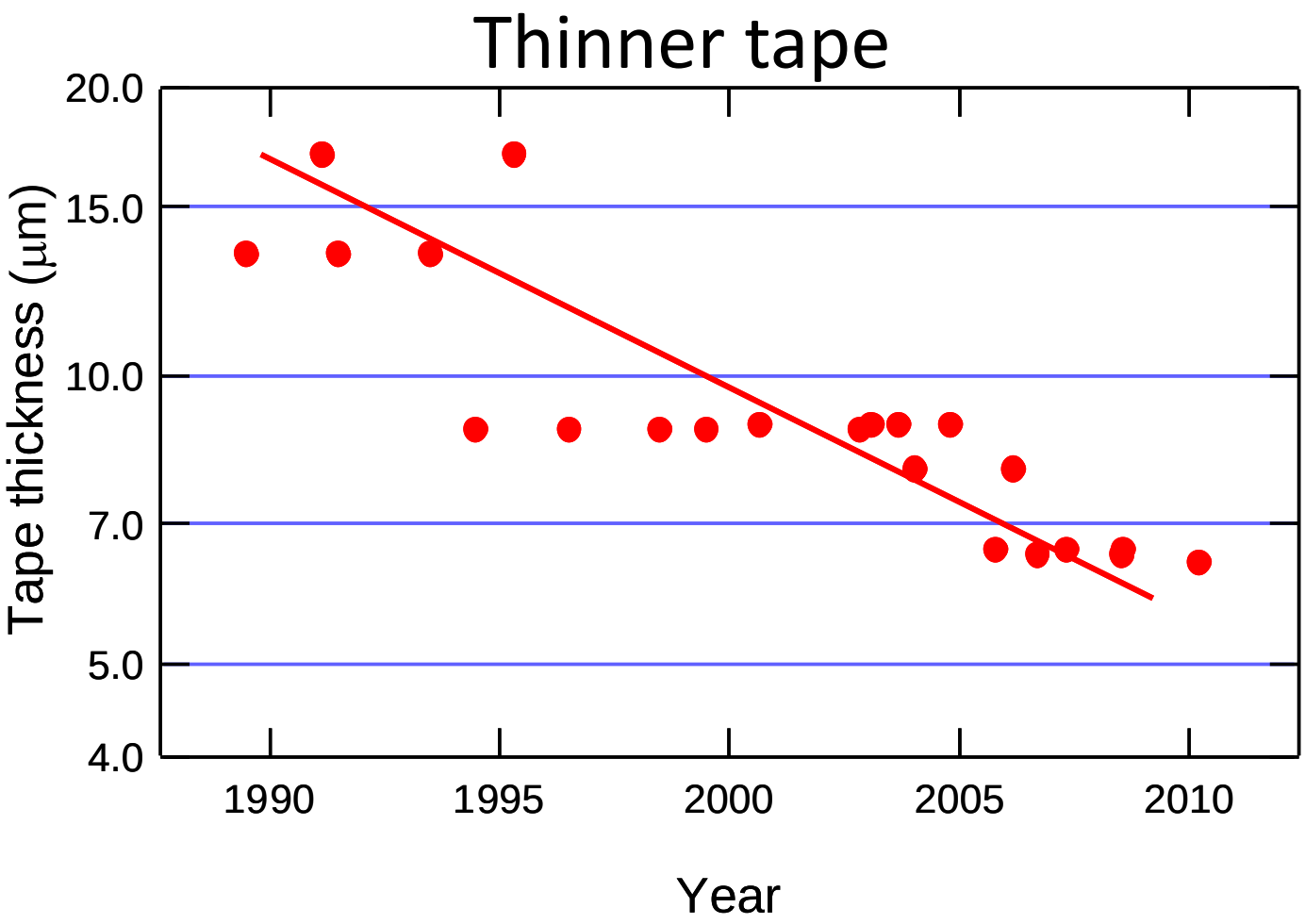

- Thinner tape makes longer tape windable in a same size of cartridge.

Capacity increase in MP media

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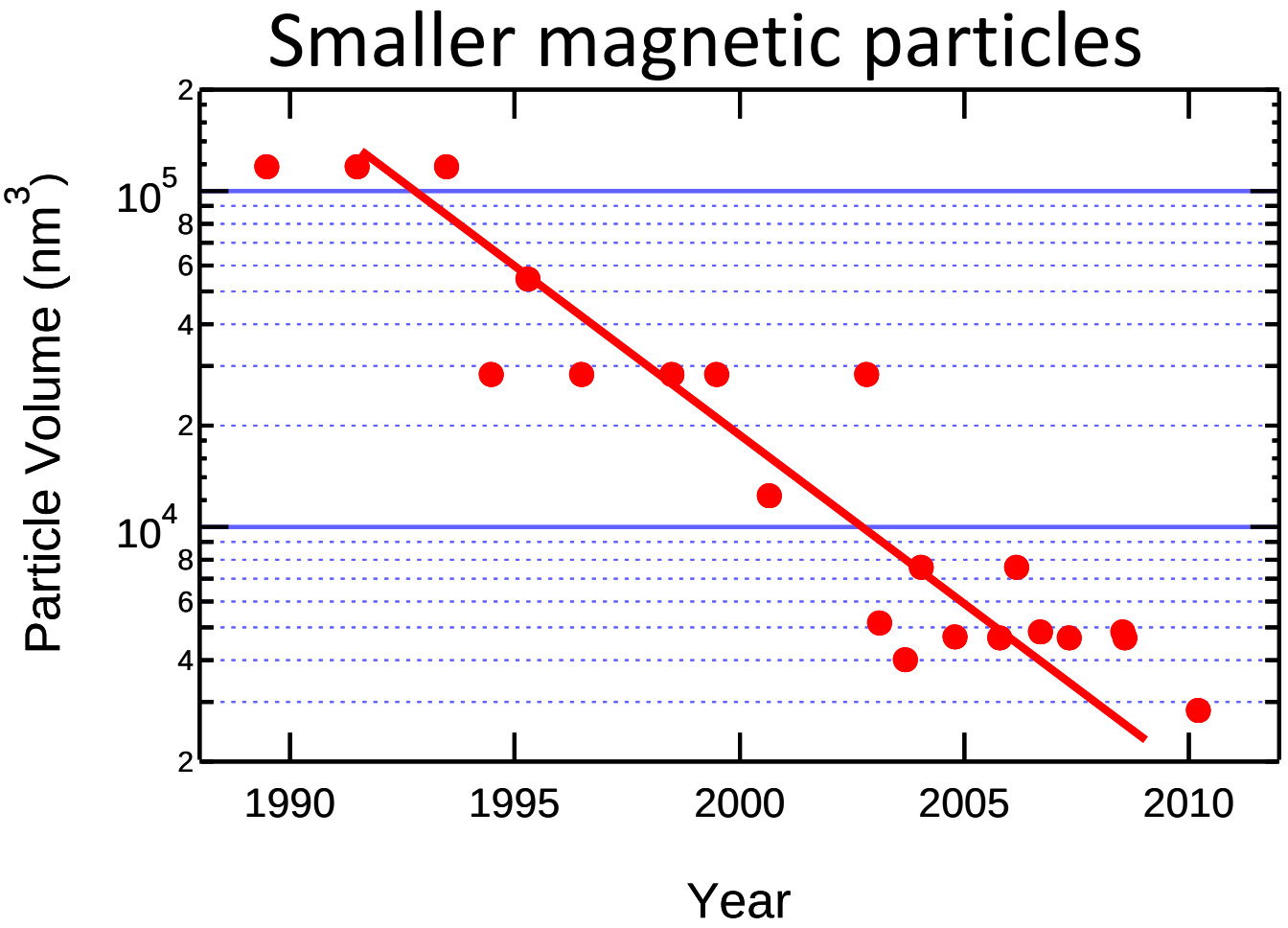

- Smaller magnetic particles are essential to a higher recording density .

Capacity increase in MP media

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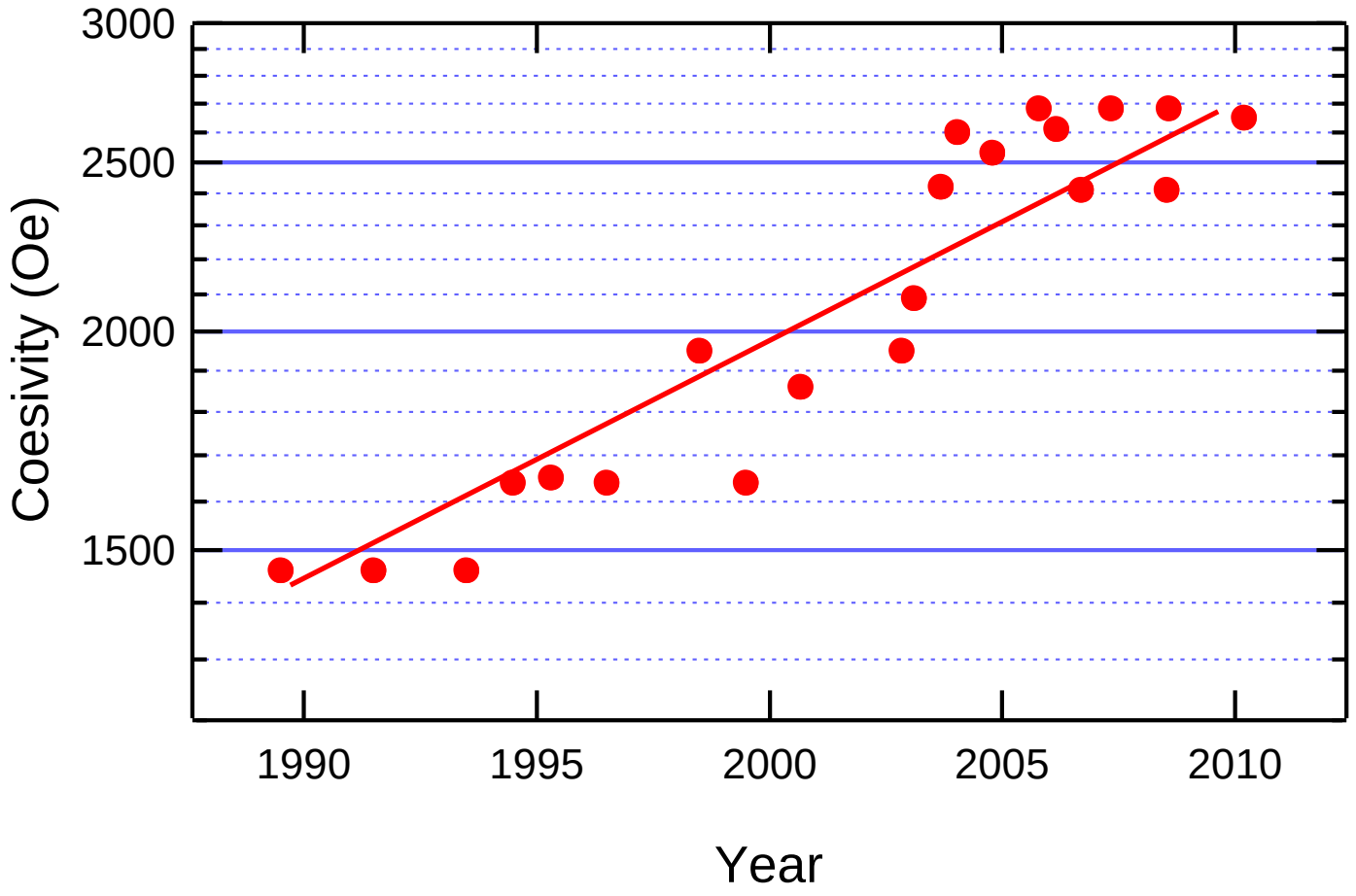

- Increasing the magnetic coercivity while reducing the particle size down to 3,000 (nm^3).

Capacity increase in MP media

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Microscopic Comparison of Metal Magnetic Particles

ATOMM technology

NANOCUBIC Technology

- Creates new high coersivity metal particles that is just 35nm in size and 2850 nm^3 in volume by Nano-particle technology

Contents

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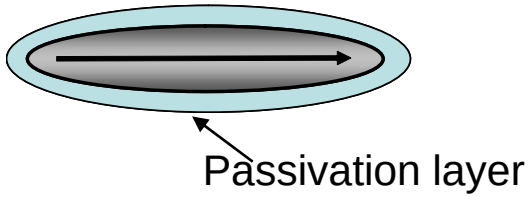
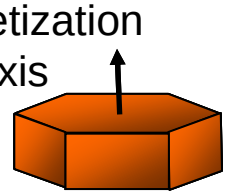
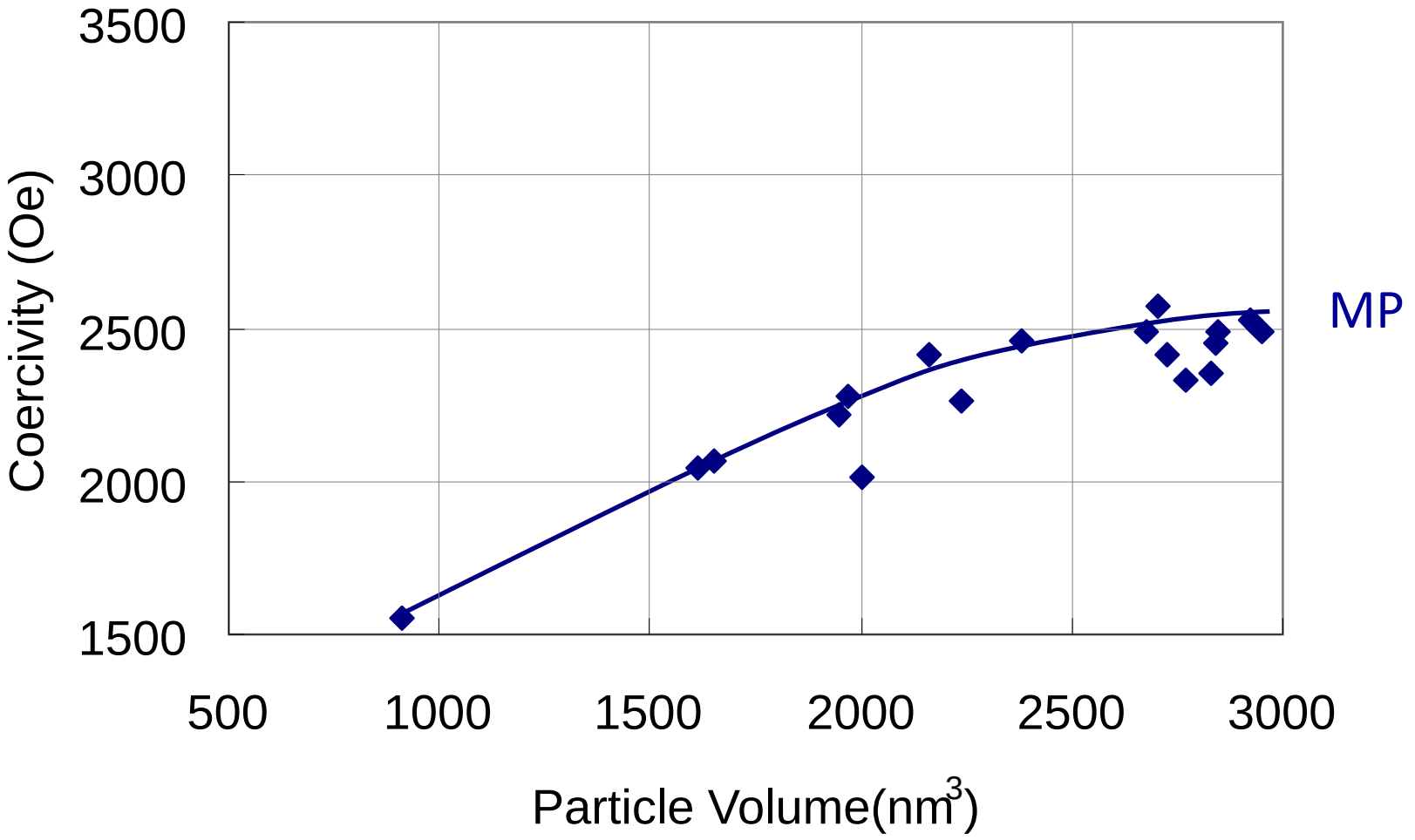
	MP	BF
Particle Shape	 Acicular	 Hexagonal platelet shaped
Origin of magnetic energy	Shape anisotropy	Magneto-crystalline anisotropy
Material	FeCo alloy	$BaO(Fe_2O_3)_6$ Oxide
Passivation layer	Required	Not Required

- The magnetic property of barium-ferrite particle is NOT affected from its shape.
- The barium-ferrite particle does NOT need the passivation layer because it is oxide from the beginning.

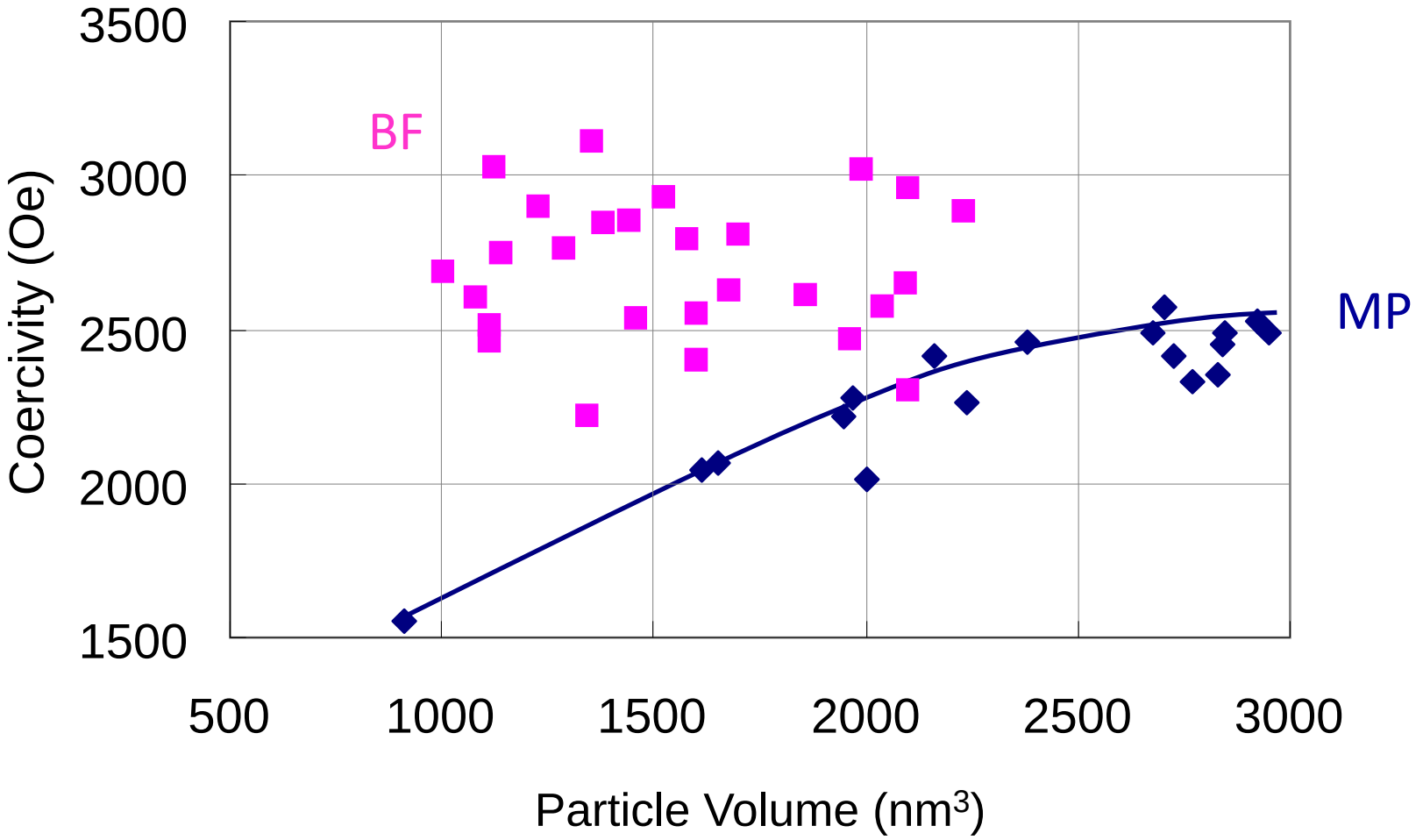
➔The size of barium ferrite particle can be reduced with maintaining high coercivity.

BF technology



- Reducing the particle size less than 3,000 (nm^3) declined the magnetic coercivity, which is very important to keep the information, resulting the saturation of capacity increase with metal particles

BF technology



- Coercivity of barium ferrite particles is independent of their size. Smaller particles can be utilized for higher capacity.

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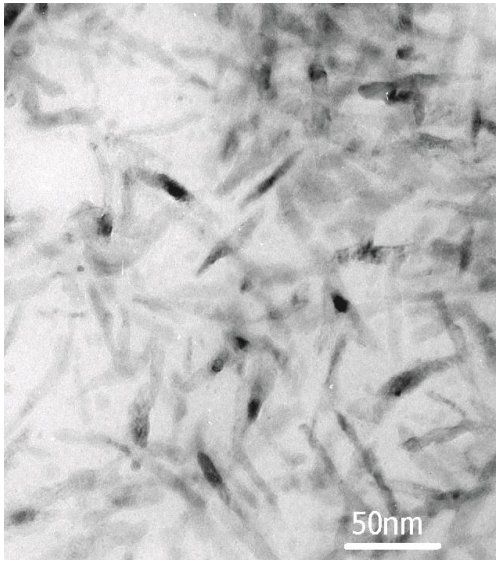
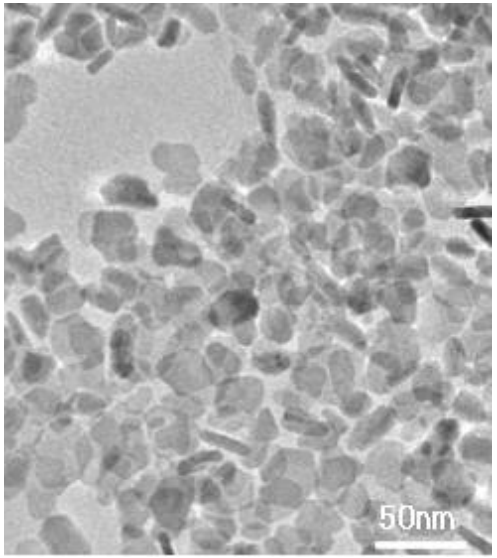
TEM image of fine Barium-ferrite particles

Latest MP
Volume: 2850 nm^3
coercivity: 2380 [Oe]

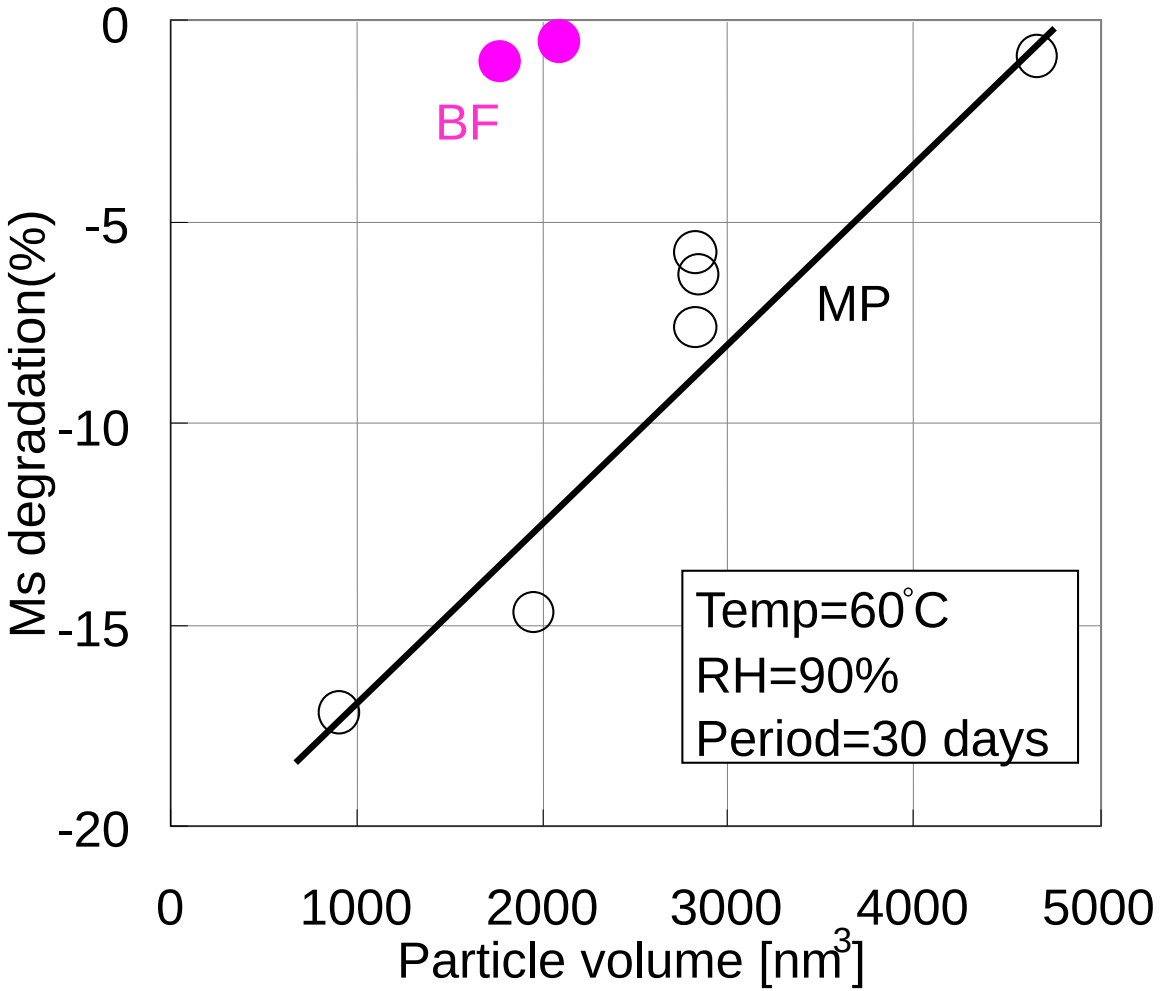


BF
Volume: 1600 nm^3
coercivity: 2400 [Oe]



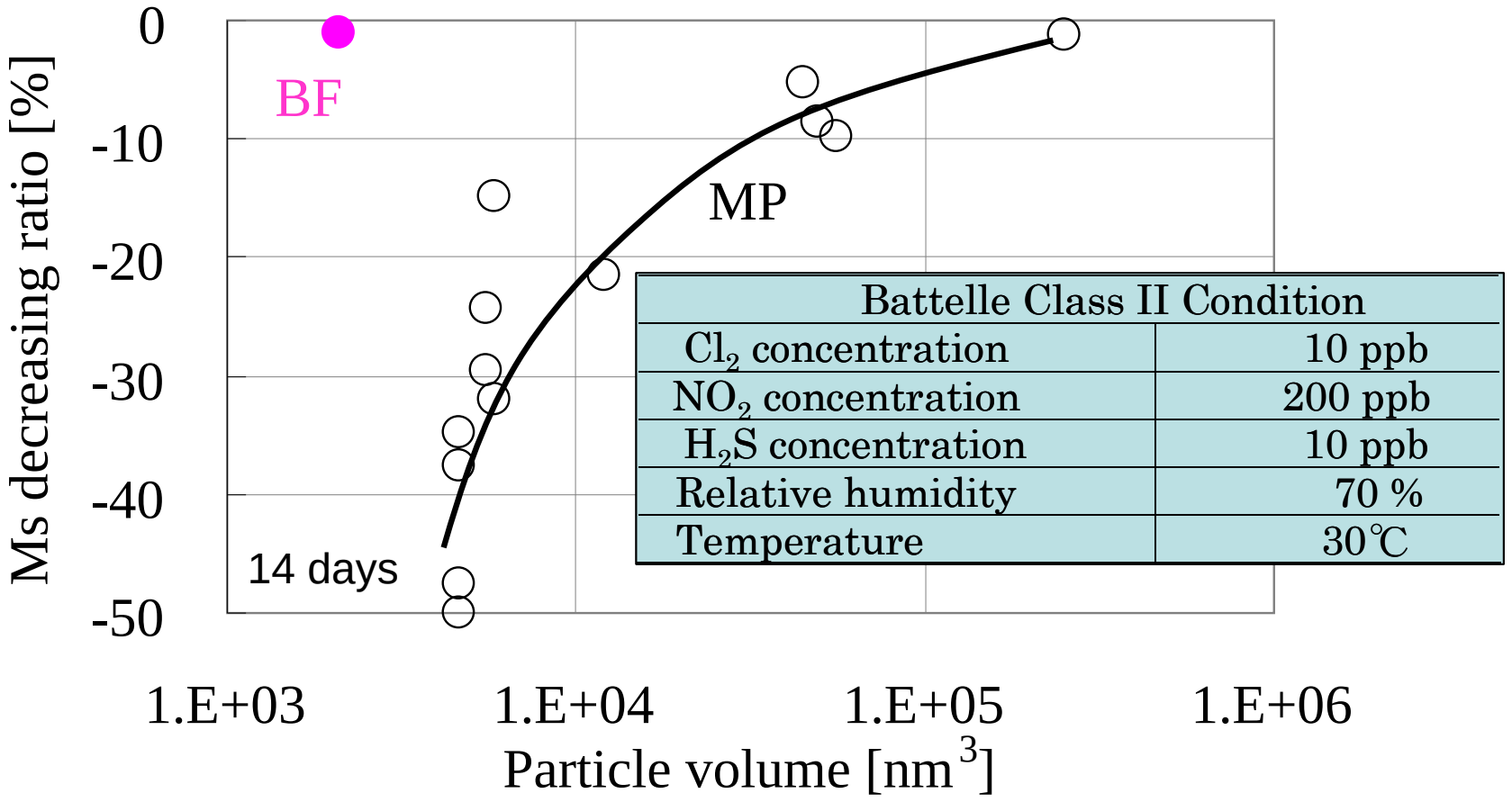
- Even the volume of barium ferrite shown above is 45 % smaller than the latest MP, their coercivity can be maintained.

BF technology



- Barium ferrite media are stable enough even in the very hot and humid conditions.

BF technology



Battelle Class II Condition	
Cl_2 concentration	10 ppb
NO_2 concentration	200 ppb
H_2S concentration	10 ppb
Relative humidity	70 %
Temperature	30℃

- Barium ferrite media are stable enough even in the corrosive atmosphere (Battelle Class II, 14 days).

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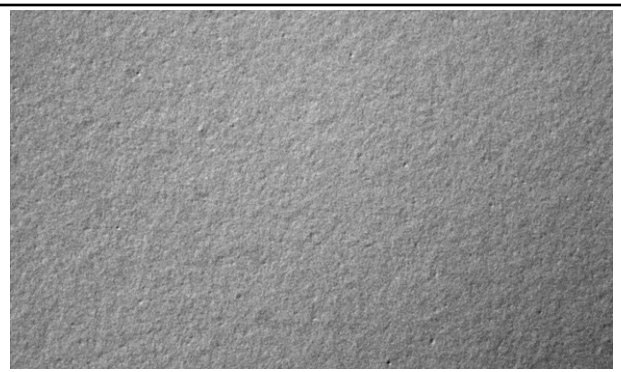
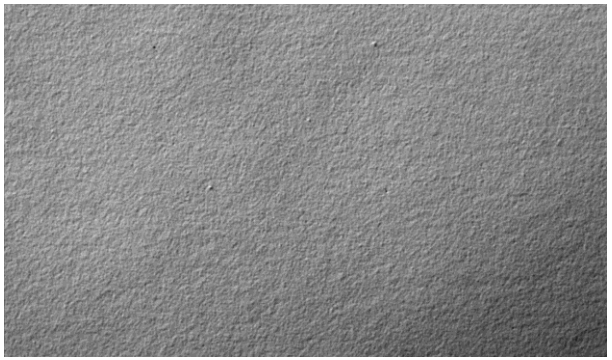
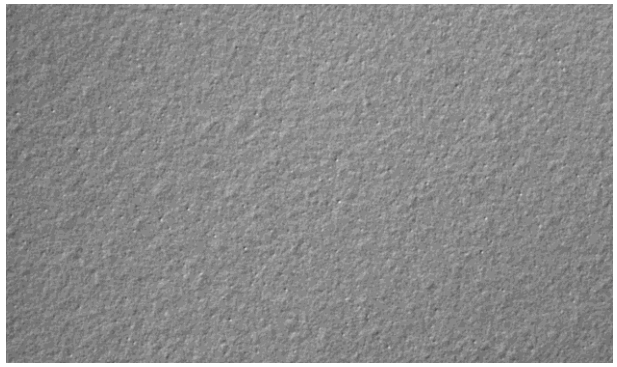
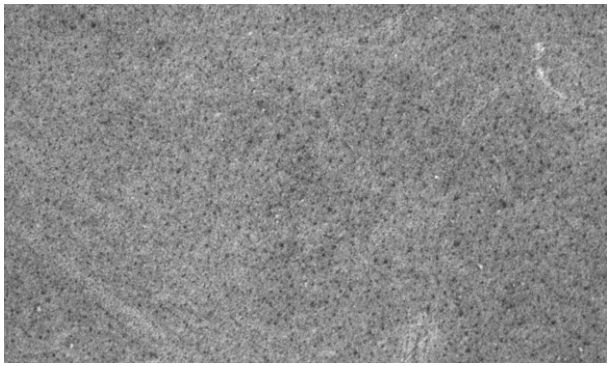
	Initial	After exposure
BF		
MP		

- Barium ferrite media are stable enough even in the corrosive atmosphere (Battelle Class II, 14 days).

BF technology

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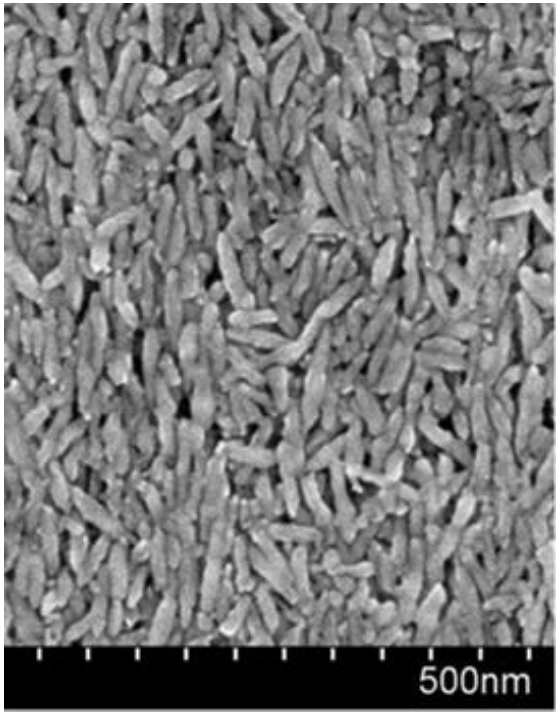
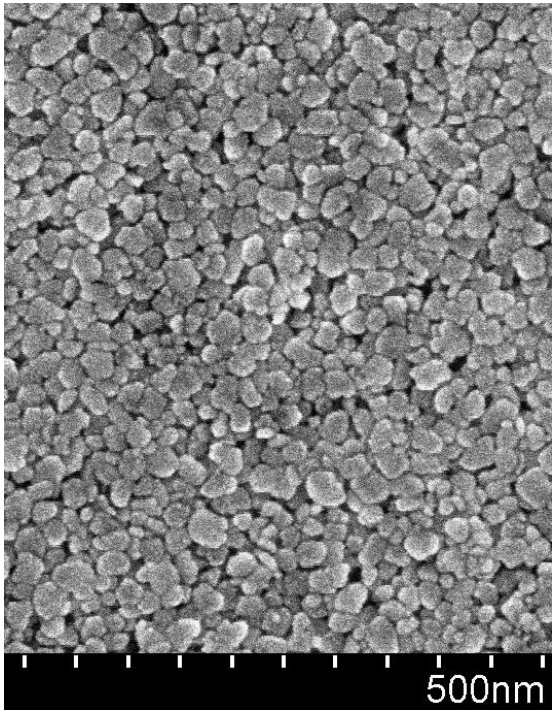
SEM Image of tape surface

Latest MP tape



BF Tape



- Barium ferrite particles are well isolated and packed in the high density.

BF technology

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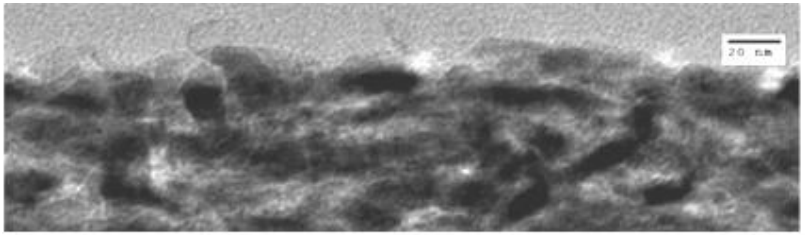
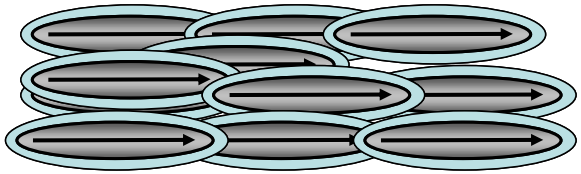
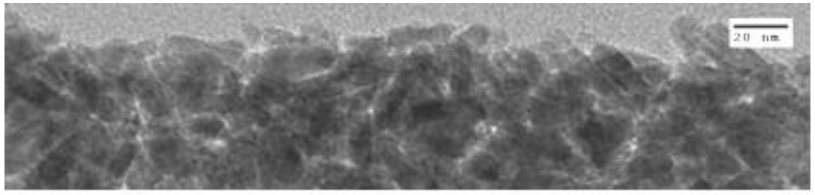
Particle Orientation

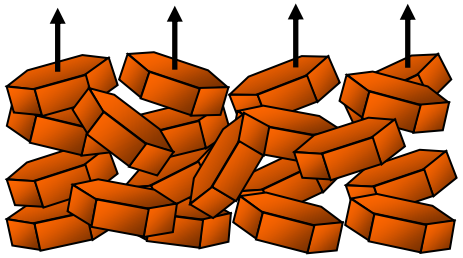
MP tape



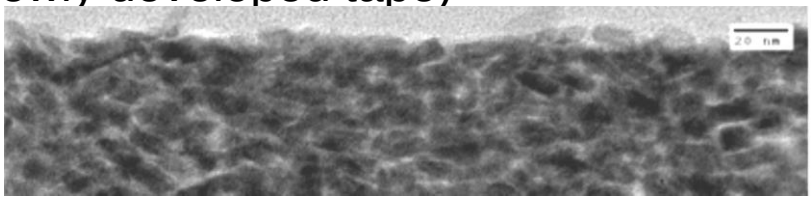


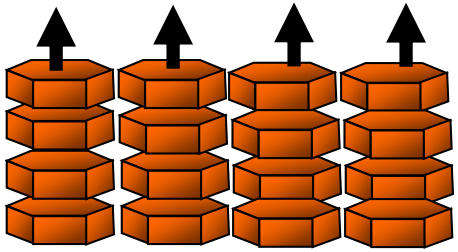
BF tape (product tape)





BF tape (newly developed tape)





- Barium ferrite particles can be oriented perpendicularly while MP are oriented longitudinally.

BF technology

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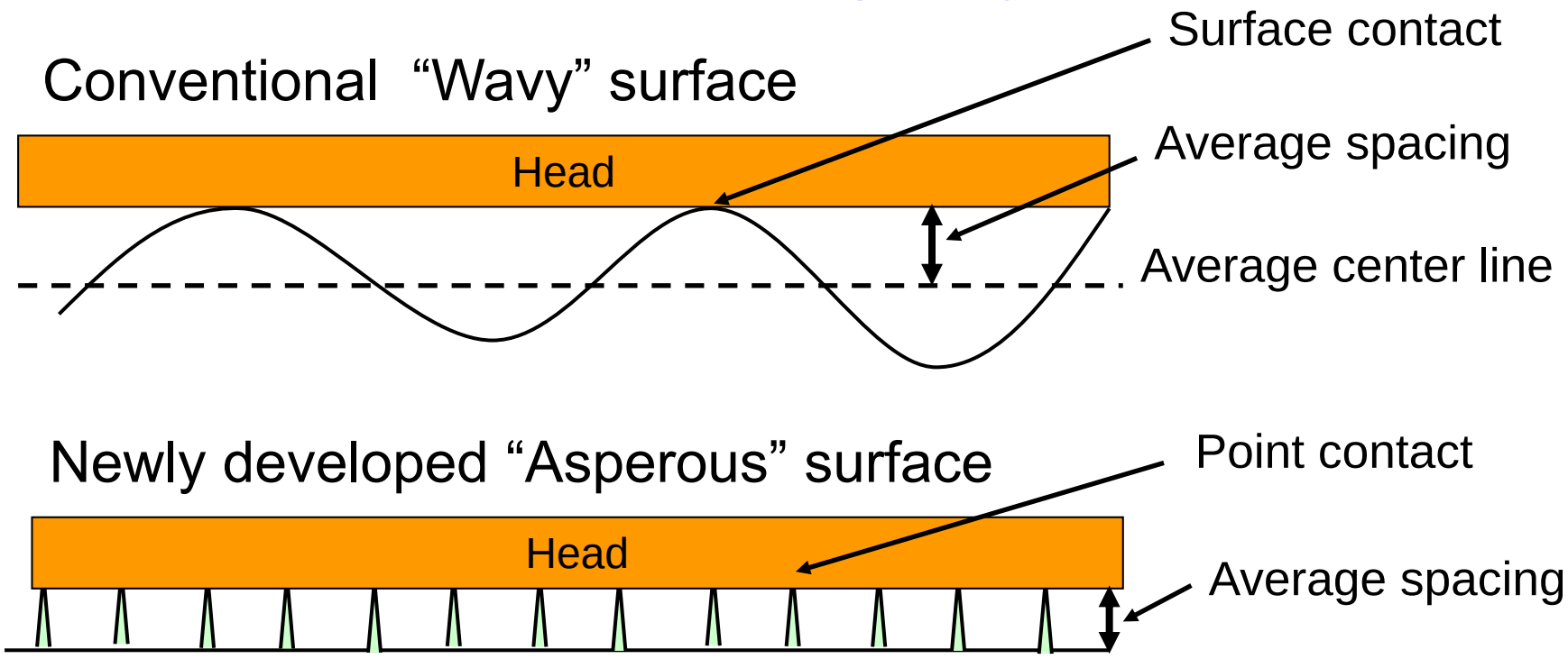
Surface Design Concept

Low friction with narrow spacing



- Asperous surface can reduce the friction without increasing the spacing.

BF technology

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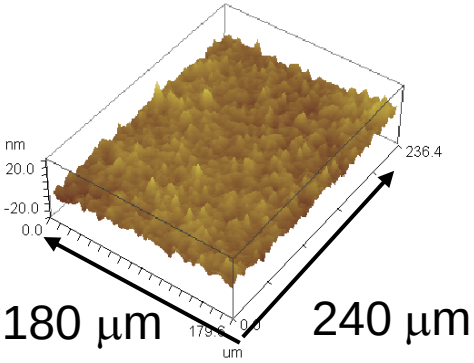
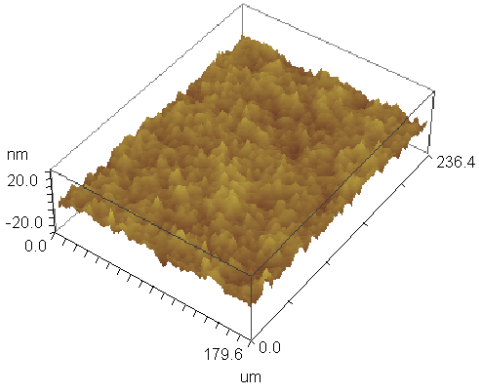
Optical interferometry roughness meter

Latest MP



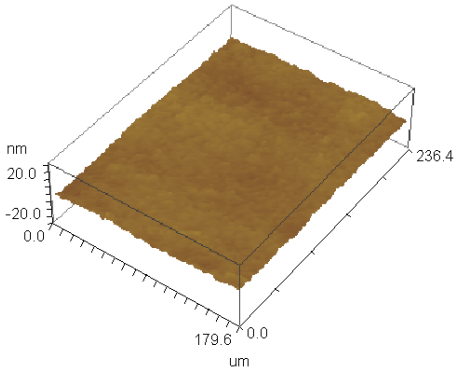
Ra=2.0 nm

BF (product)



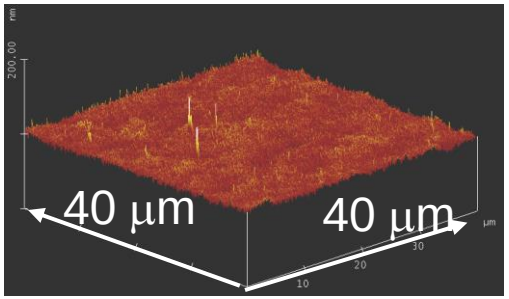
Ra=2.0 nm

BF (domoed)

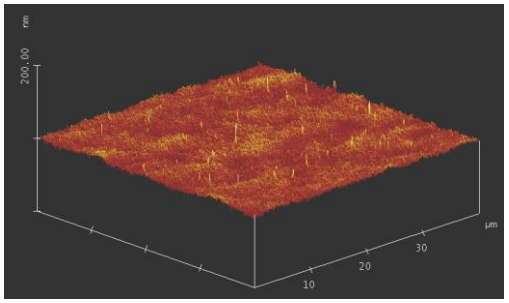


Ra =0.8 nm

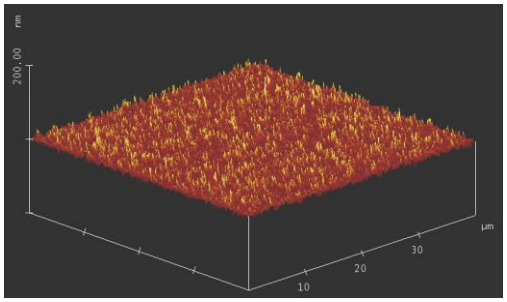
AFM



Ra=2.4 nm



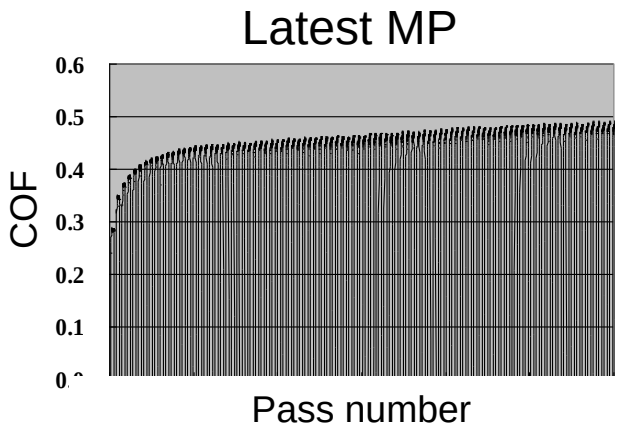
Ra=2.2 nm

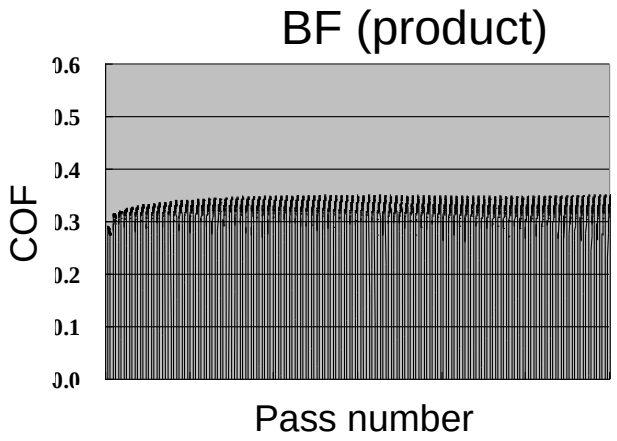


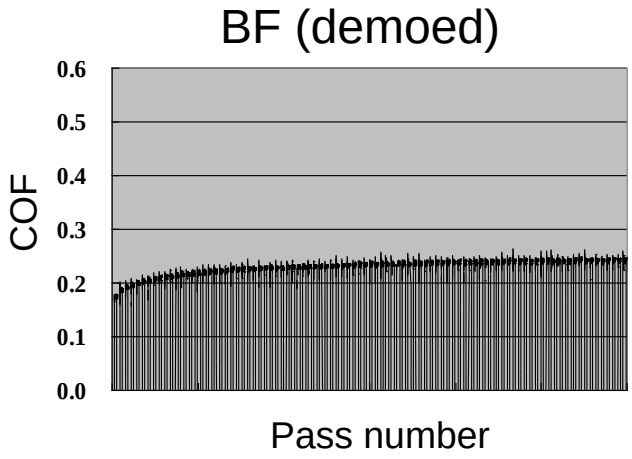
Ra=2.1 nm

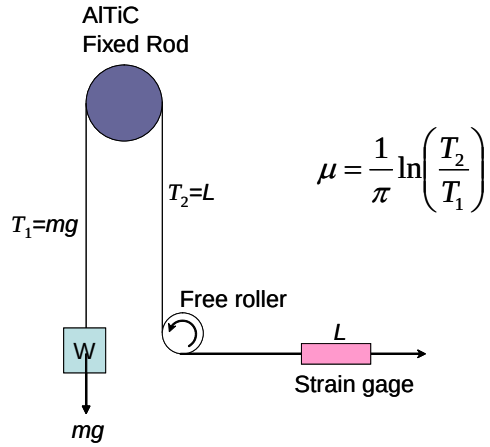
- The surface profile of latest MP and BF product are similar but that of newly developed BF is not “Wavy” but “Asperous”.

BF technology









AlTiC: Mixture of Al_2O_3 and TiC, Substrate Material of Magnetic Heads
Running speed: 14mm/sec

- The friction of BF product is lower than MP even though surface profle of them are similar. In addition, The friction of newly developed BF is lowest

BF technology

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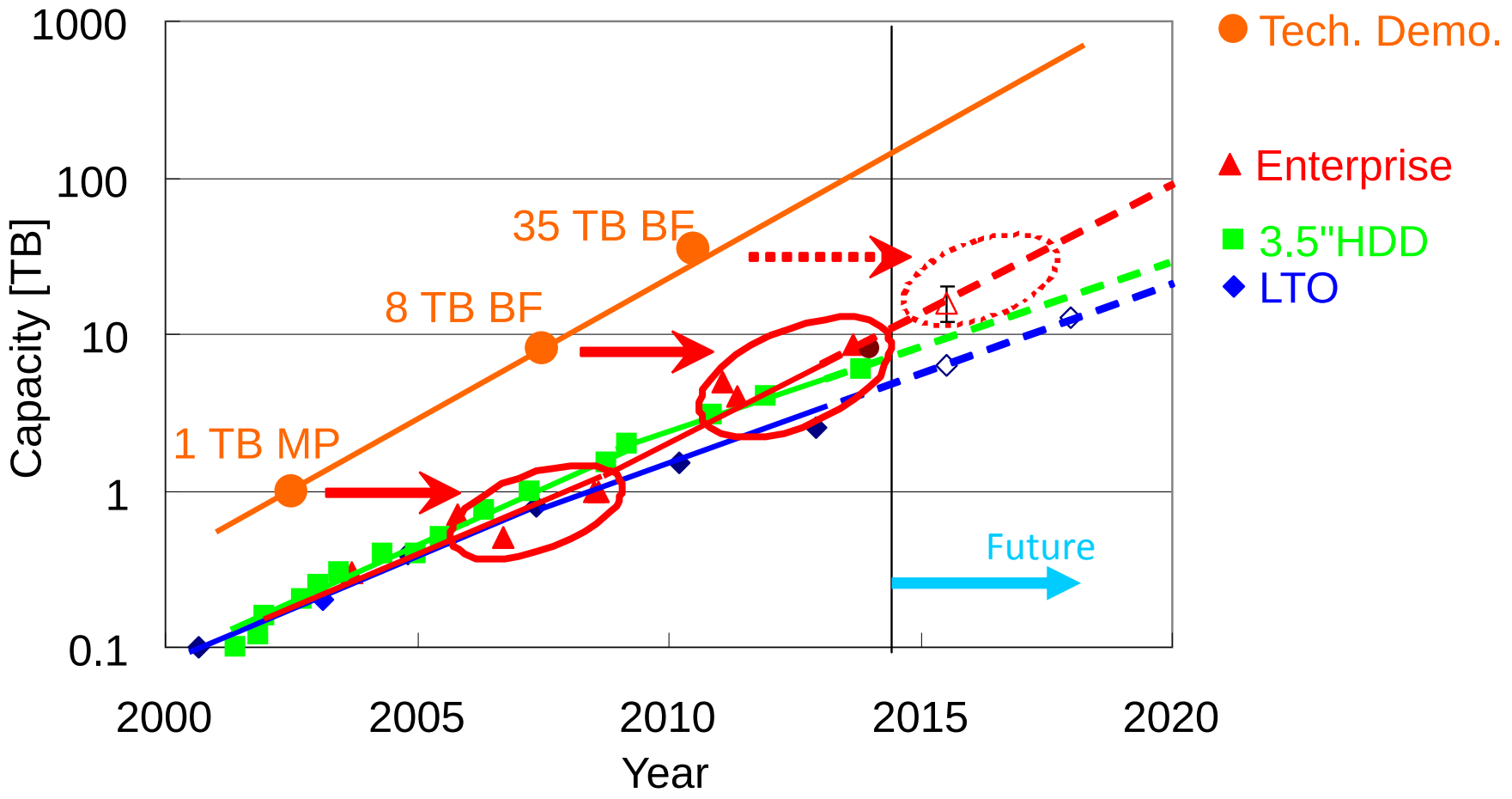

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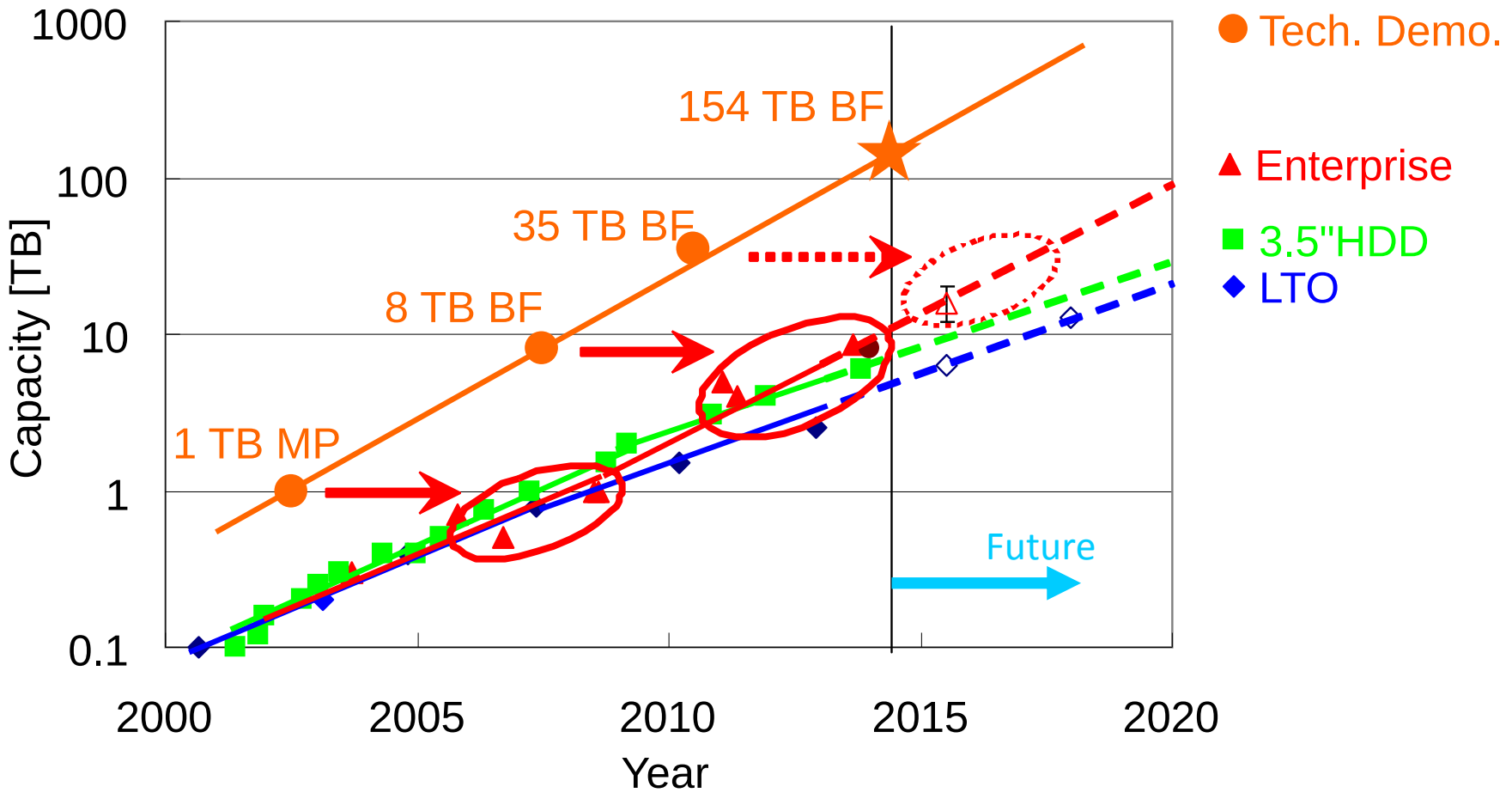

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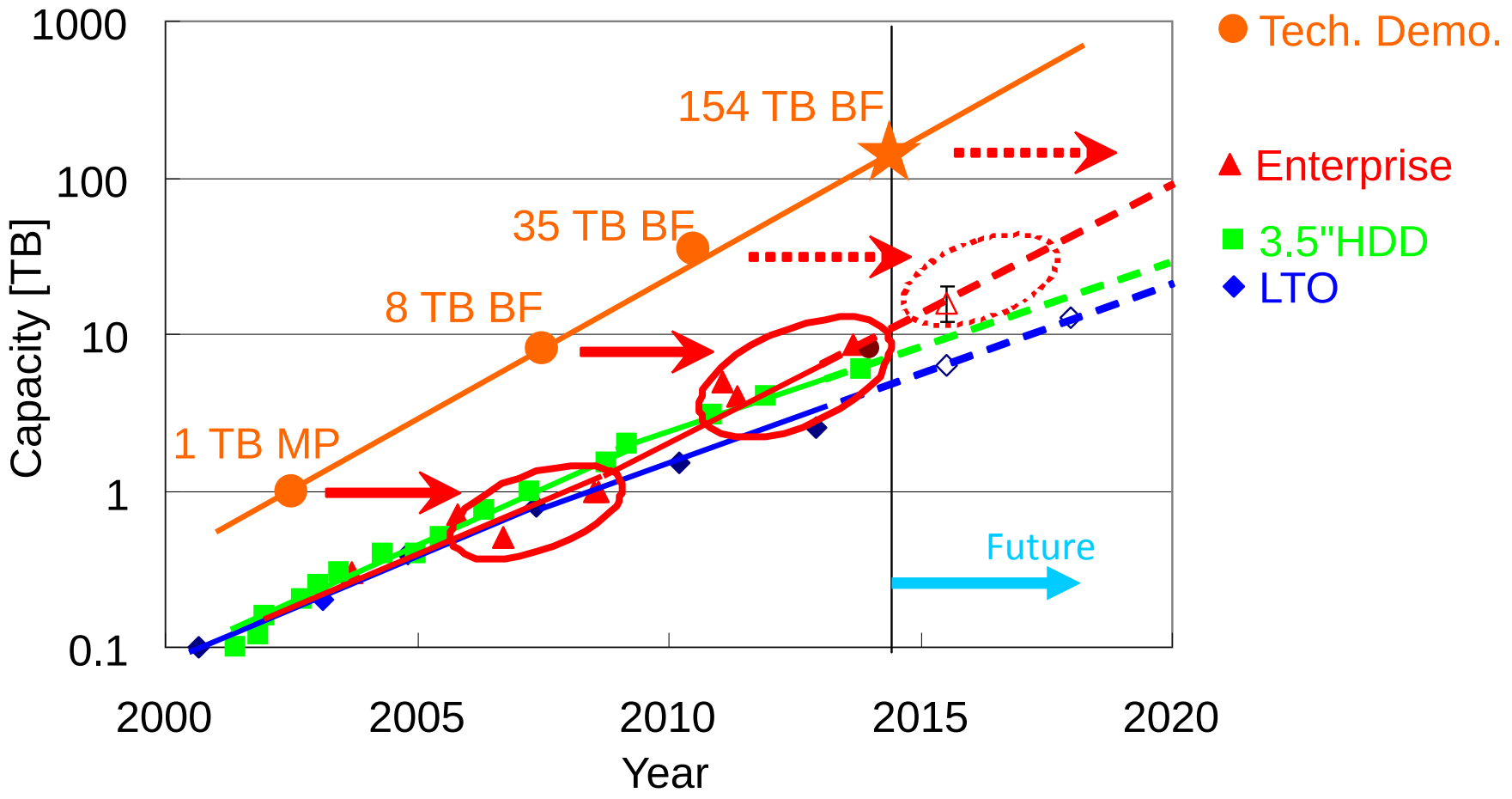

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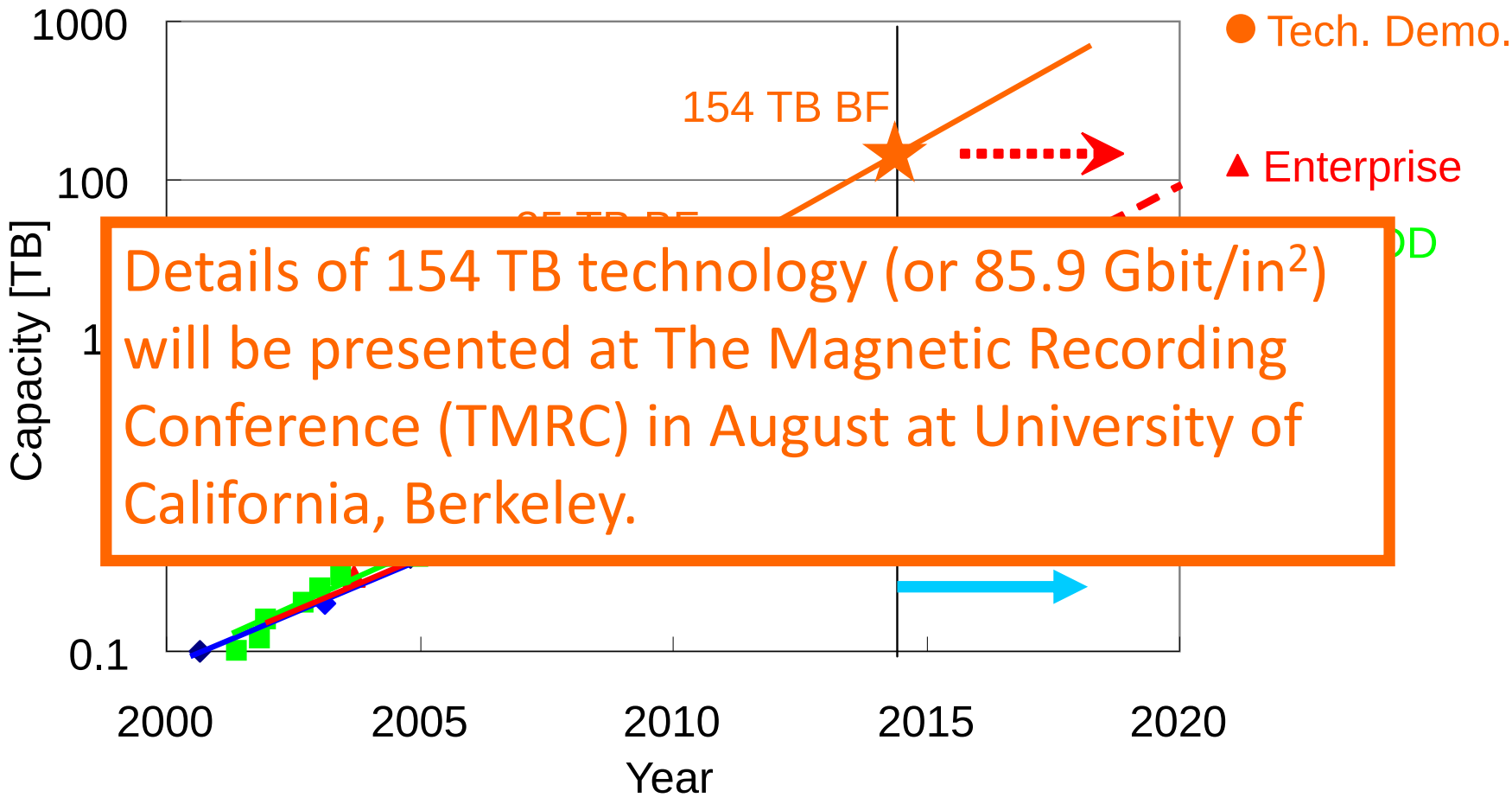

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Summary

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- The Capacity of magnetic tape cartridge has been increased by reducing
  - Particle volume,
  - Magnetic layer thickness,
  - Surface roughness, and
  - Total tape thickness.
- Increasing cartridge capacity using MP with keeping long term stability becomes difficult because MP no longer can reduce their size without reducing coercivity.
- BF particles are very promising magnetic particles and more than 100 TB per cartridge will be realized using BF in several years.

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