Magnetic tape storage advances and the growth of archival data

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www.zurich.ibm.com/sto/

Executive summary

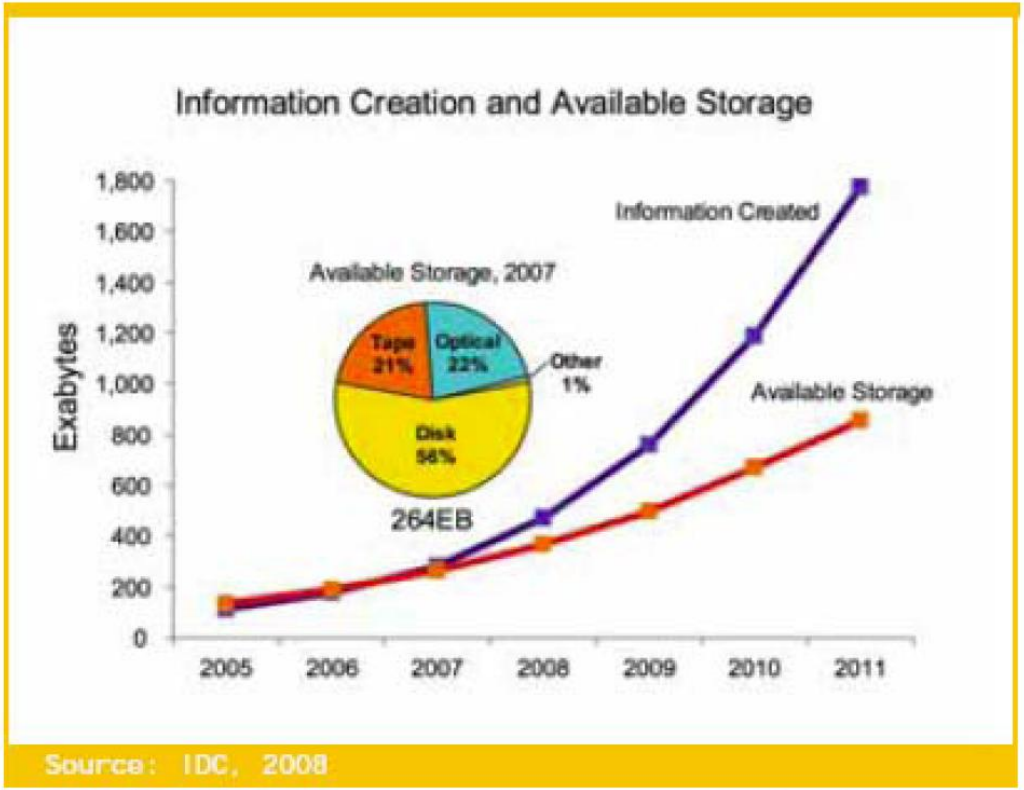
- **Tape remains the most cost-efficient and greenest technology for archival storage**
  - Total cost of ownership advantage of tape over disk >20x
  - Very long lifetime of 30+ years

- **Tape has a sustainable roadmap for at least another decade**
  - 29.5 Gbit/in^2 areal density demonstration shows feasibility of several future tape generations
  - LTO roadmap has just been extended to 8 generations with up to 12.8 TB native capacity

- **Long Term File System enables self-contained tape cartridges**
  - Makes tape look and work like any removable media
  - File system available now with standalone LTO5 tape drives
  - Opens significant new use cases such as video archive and individual scene access

- **Tape is alive and doing well**

Rapidly increasing demand for storage

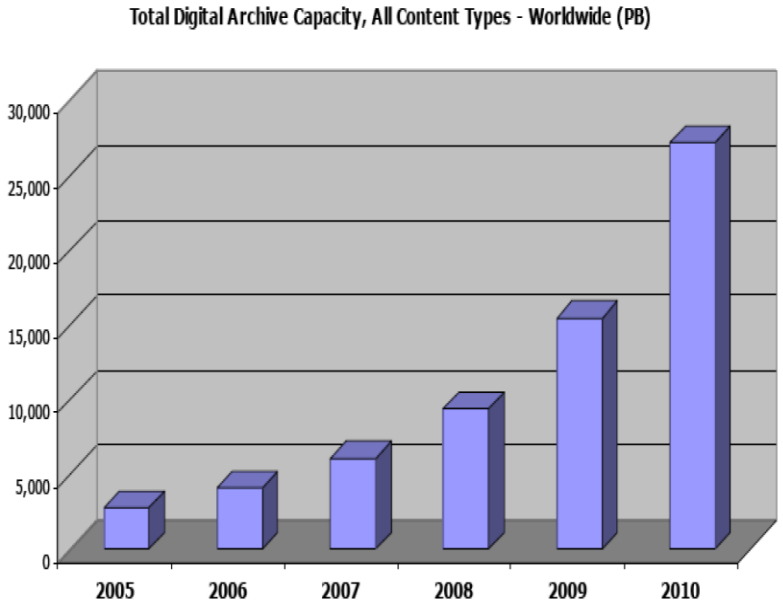


Available storage media capacity will not keep up with the amount of information. Going forward to 2011 storage media capacity CAGR = 35%, while information creation and replication CAGR = 57%.

2007 marked the beginning of a divergence.

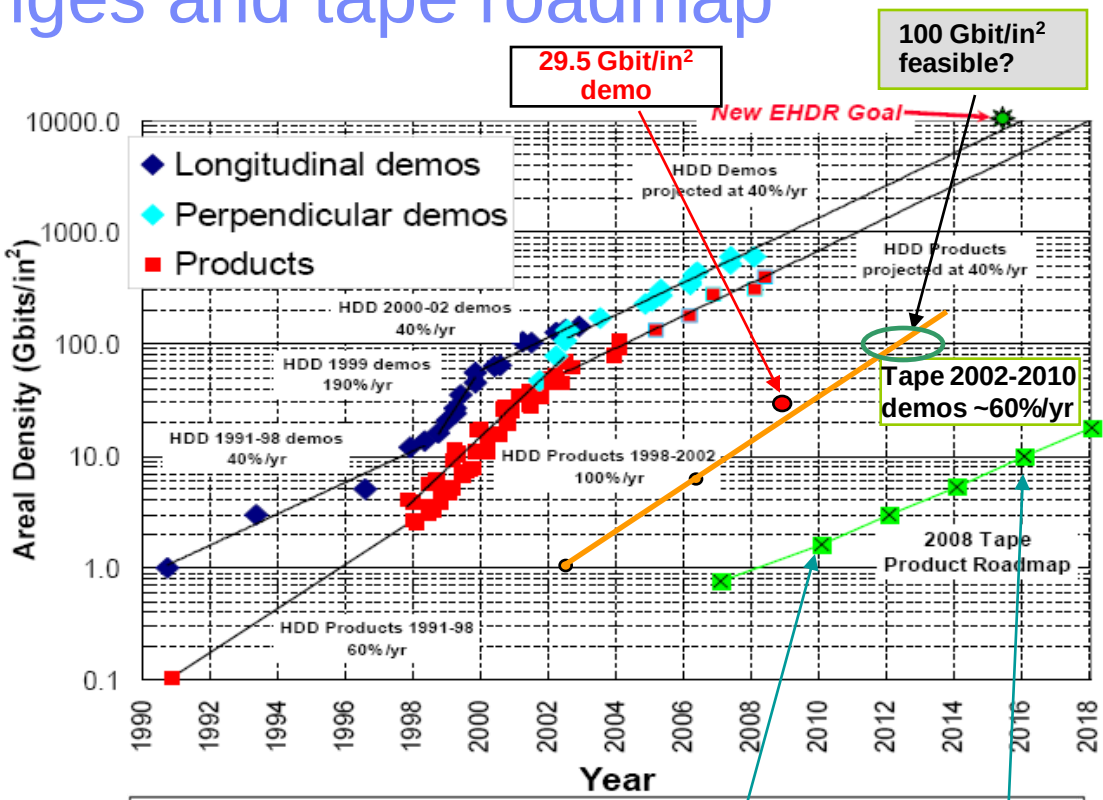
IDC White Paper, "The Diverse and Exploding Digital Universe," Sponsored by EMC, March 2008
http://www.emc.com/collateral/analyst-reports/diverse-exploding-digital-universe.pdf

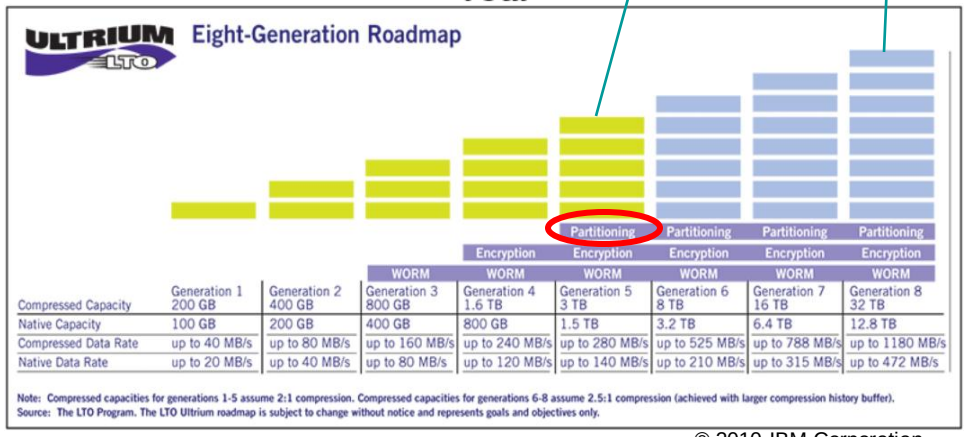
Archival storage challenges and tape roadmap



Source: ESG Research Report: Digital Archiving: End-User Survey and Market Forecast 2006 - 2010, 20

Source: http://www.enterprisestrategygroup.com/ESGPublications/ReportDetail.asp?ReportID=591

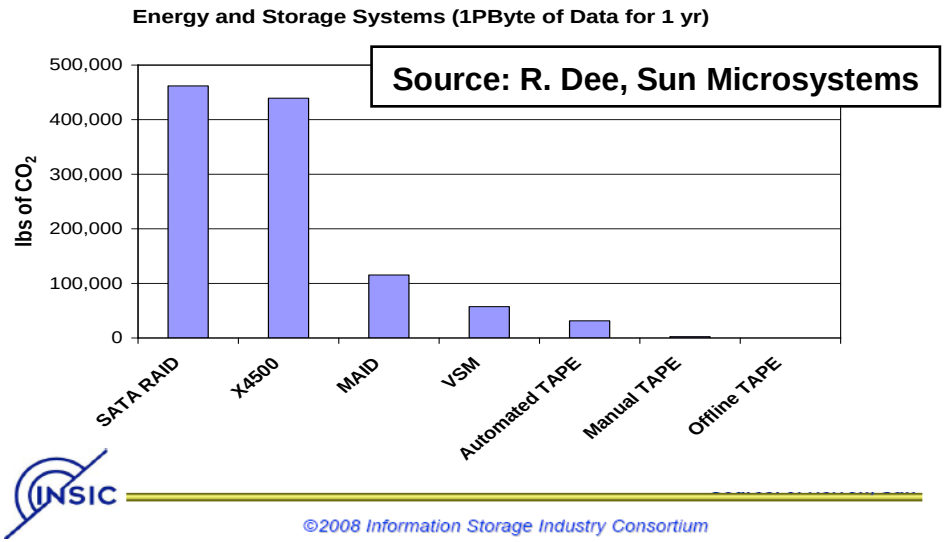




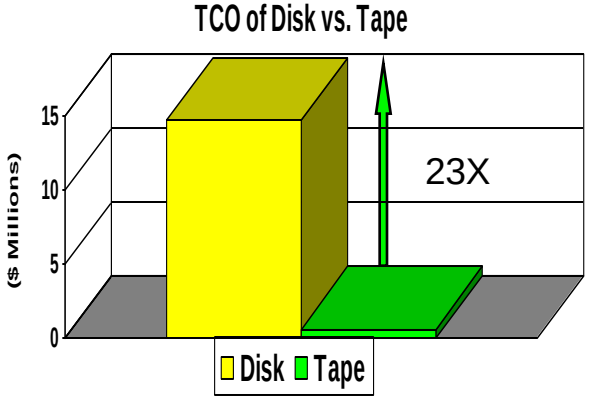
- Tape has a viable roadmap (LTO)
- Recent areal density demo of 29.5 Gbit/in^2 shows feasibility of tape roadmap for the next 10+ years
- HDD is going to face severe scaling challenges at around 1 Tbit/in^2

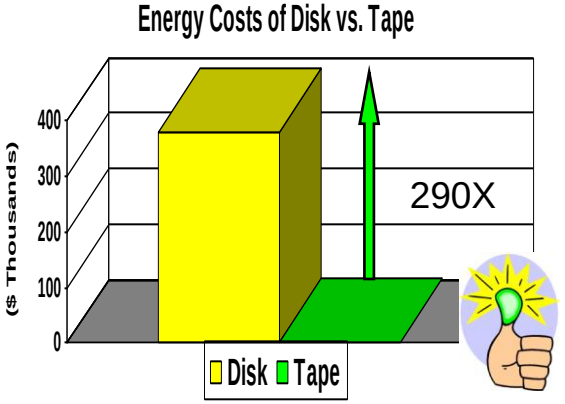
Tape advantages for long-term archival storage

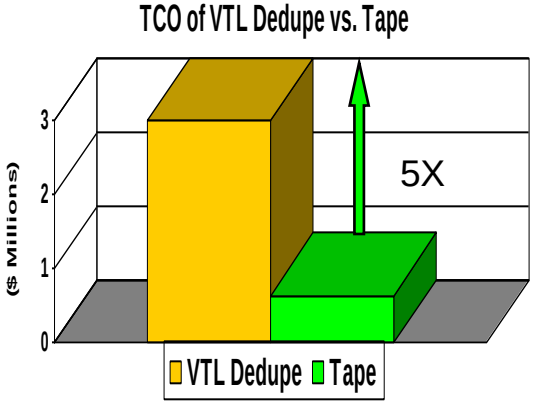
- **Very energy efficient**: no power needed once data is recorded
- **Very secure**:
  - Data is inaccessible when cartridge is not mounted
  - Drive level encryption
- **Very long** expected media **lifetime** (30+ years)
- **Very reliable**: Typically no data loss in case of drive failure



➢ Main net advantage of tape for archival storage is **cost**





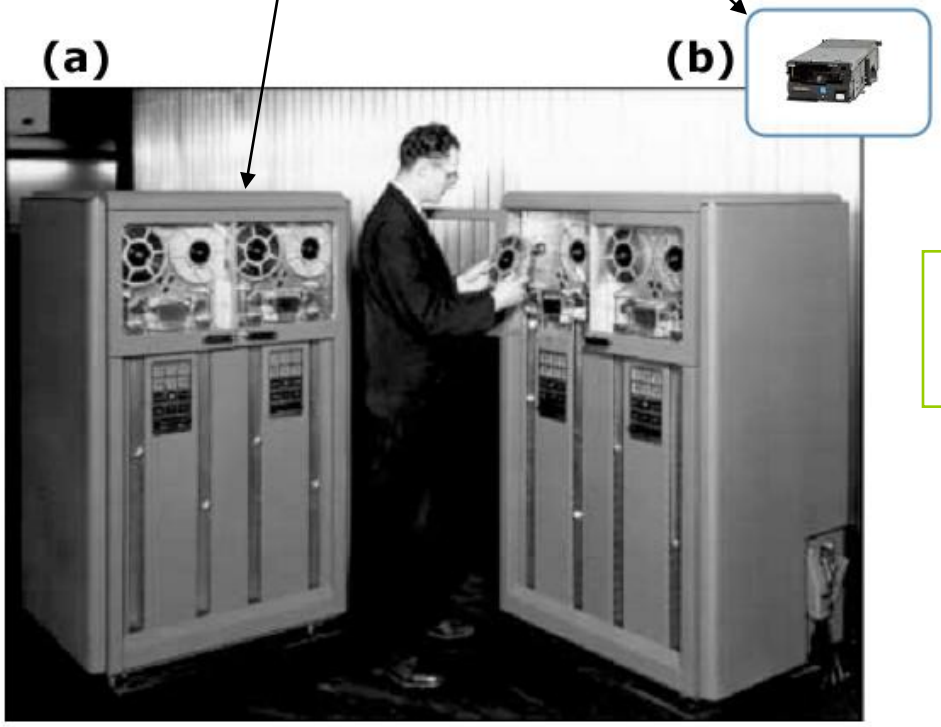


"Tape continues to provide the fiscal responsibility and functional value that enterprises require in the twenty-first century." The Clipper Group

Magnetic tape (r)evolution

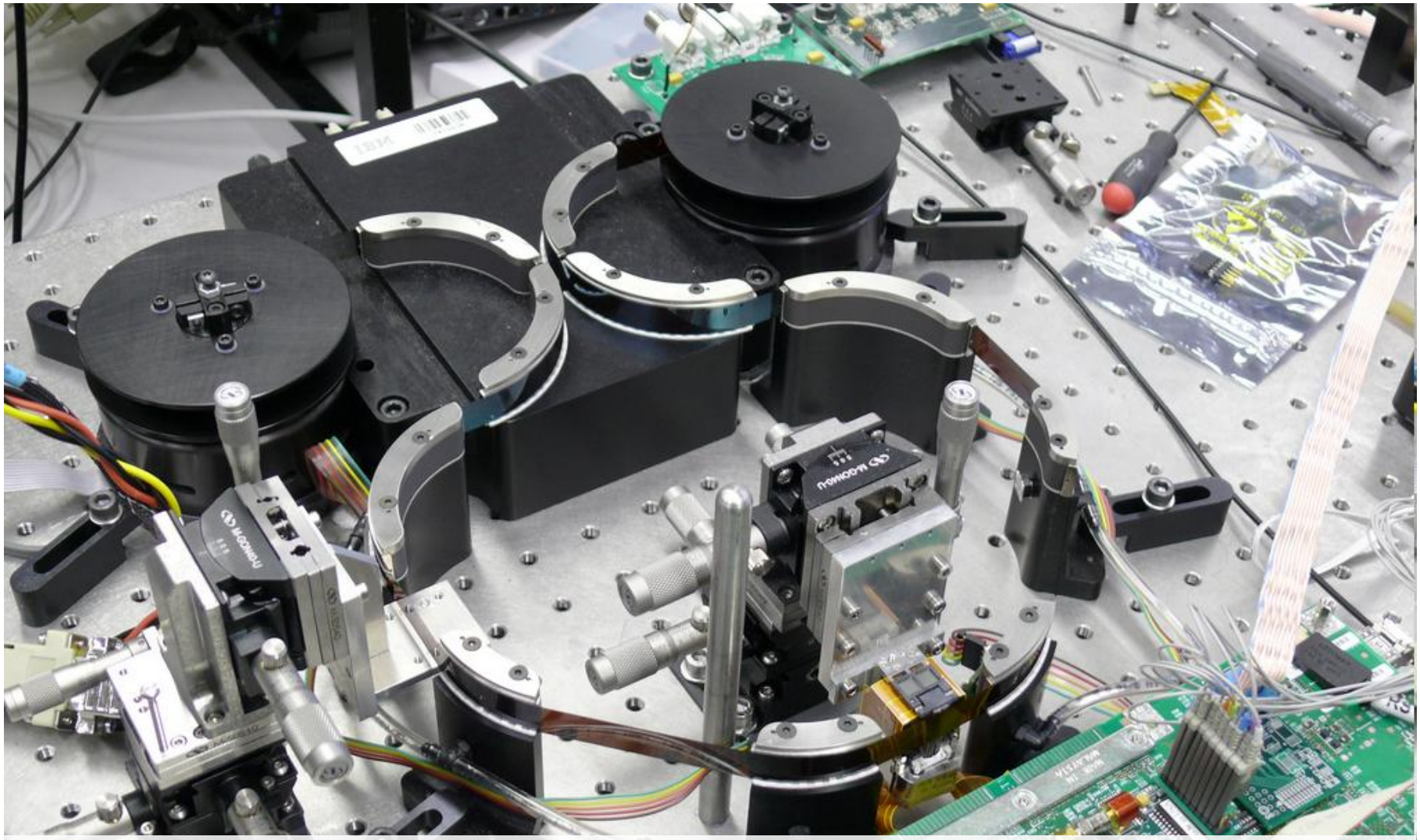
Product / Year:	IBM 726 /1952	LTO5 / 2010	**Demo 2010**
Capacity:	2.3MByte	1.6TByte	35TByte
Areal Density:	1400 bit/in^2	1.21Gbit/in^2	29.5Gbit/in^2
Linear Density:	100 bit/in	385 kbit/in	518 kbit/in
Track Density:	14 tracks/in	3.14 ktracks/in	57 ktracks/in

18x



Track density increase will be the key contributor for future tape capacity increase

Demonstration of 29.5 Gb/in^2 on tape



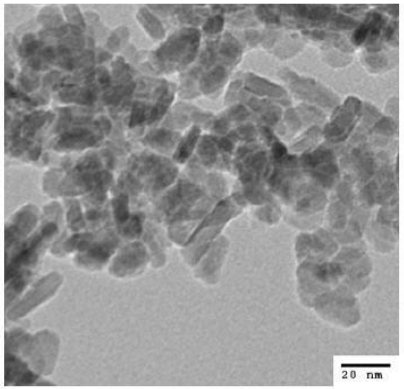
This demonstration shows that tape can sustain the roadmap for at least another decade while maintaining a cost advantage over other storage technologies.

Highlights of 29.5 Gb/in^2 tape areal density demo

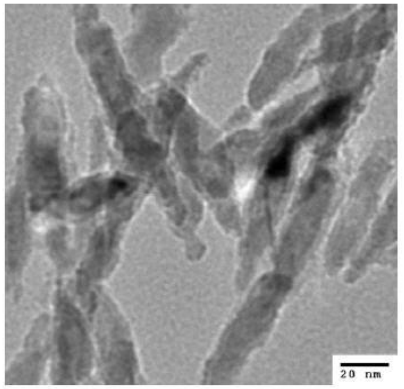
- Record storage density on magnetic tape of 29.5Gbit/in^2
  - **39x** increase over LTO 4 drives
  - A bit is **49 nm** wide and **446 nm** high
  - Made possible thanks to
    - advanced BaFe media
    - improved signal processing (Noise predictive maximum likelihood detection)
    - better head position control
    - enhanced mechanics

- Strawman operating point for 100 Gbit/in^2
  - Linear Density = 800 kbit/in
  - Track Density = 125 ktrack/in
  - Bit area = 32 nm × 200 nm
  - *Only 36 magnetic particles per bit!*

* TEM: Transmission Electron Microscope



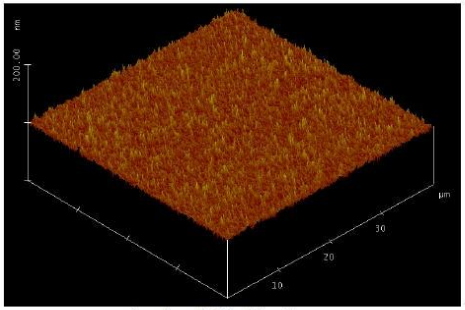
Latest BaFe particle
Volume: 1600nm^3



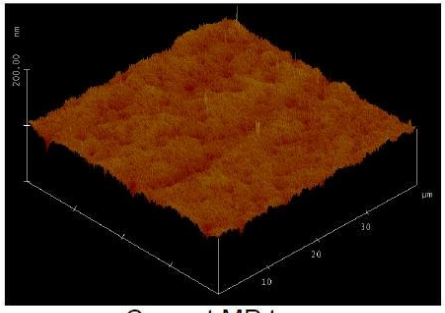
Current metal particle
Volume: 4650nm^3

- FUJIFILM succeeded in the microparticulation of BaFe particles to 1600nm^3 which is approximately one-third of current metal particle volume.

* AFM: Atomic Force Microscope



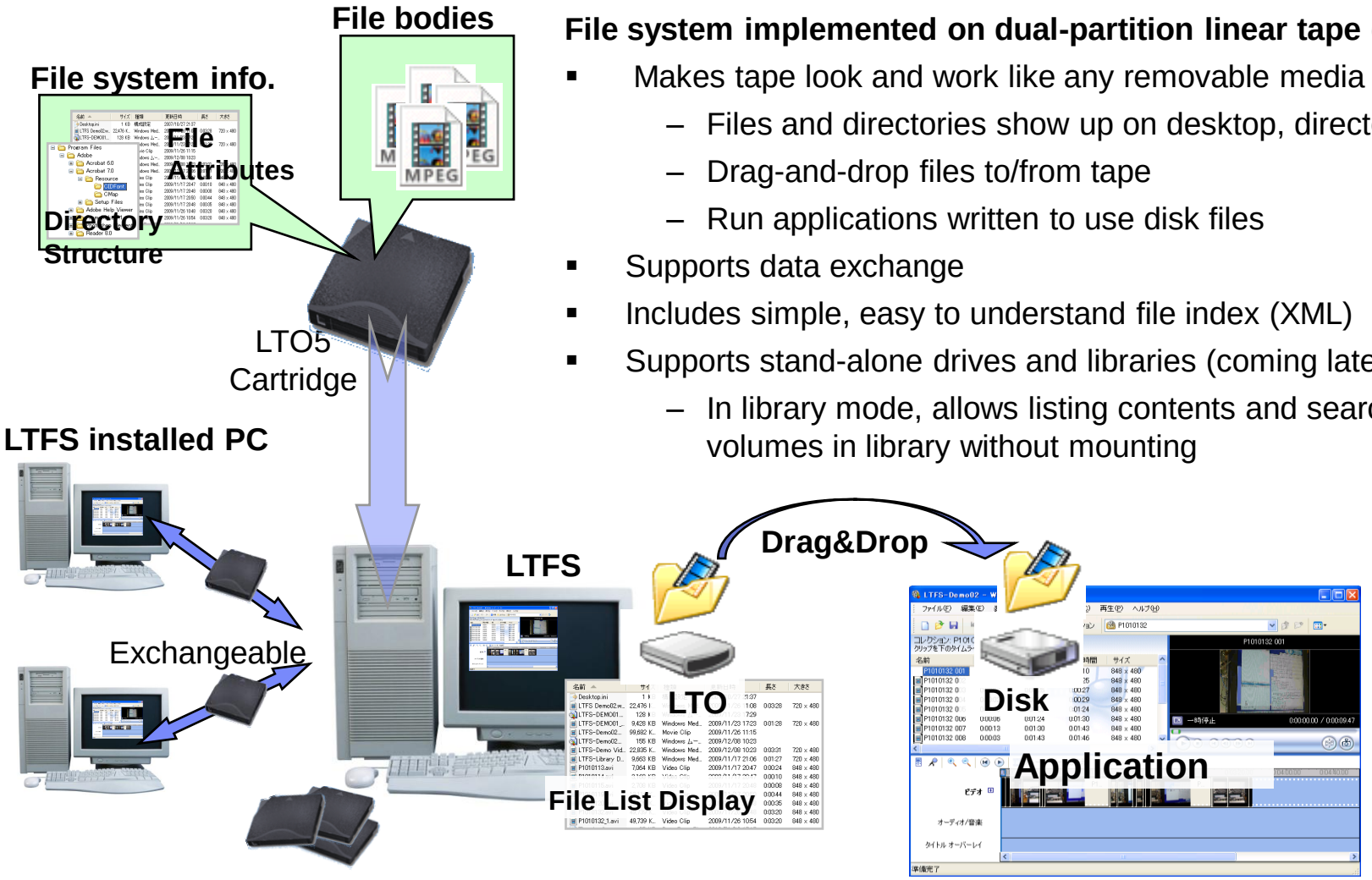
Latest BaFe tape
Ra: 2.1nm



Current MP tape
Ra: 3.6nm

- The BaFe particle is dispersed more uniformly than the current metal particle, the surface of the latest BaFe tape is smoother than the current MP tape.

Long Term File System (LTFS) to make tape even more attractive for archival storage



File system implemented on dual-partition linear tape (LTO 5)

- Makes tape look and work like any removable media
  - Files and directories show up on desktop, directory listing
  - Drag-and-drop files to/from tape
  - Run applications written to use disk files
- Supports data exchange
- Includes simple, easy to understand file index (XML)
- Supports stand-alone drives and libraries (coming later this year)
  - In library mode, allows listing contents and searching of all volumes in library without mounting

LTFS main features

- File system available with standalone LTO5 tape drives
  - Two tape partitions: data partition, index partition
- Self-describing tape cartridge
  - index enables recovery w/o external information
  - directory structure, file attributes, multiple file extends
- Directory and file structure available after tape mount
- Helps reduce tape, file management and archive costs
  - Eliminates dependency on middleware layer
  - Lower cost per GB stored with higher efficiency
- Supports sharing of data between platforms
- Tape is cross-platform portable (Linux/Mac/Windows)
- Opens significant new use cases
  (video archives, medical images, etc.)