

# Hard Drive Research at NSIC

---

---

**Barry H. Schechtman**

Executive Director

National Storage Industry Consortium

THIC Meeting

Del Mar, California

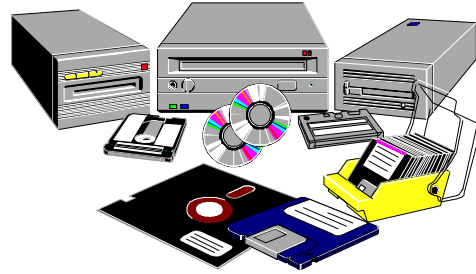
January 24, 1996



# NSIC

## ***INCORPORATED:***

APRIL, 1991



## ***MISSION:***

INCREASE THE WORLDWIDE  
COMPETITIVENESS OF THE U.S.  
INFORMATION STORAGE INDUSTRY

## ***STRATEGIC ELEMENTS:***

- JOINT RESEARCH ON HIGH-RISK ADVANCED STORAGE TECHNOLOGIES
- OBTAIN GOVERNMENT FUNDING
- TECHNOLOGY ROADMAPS
- MAXIMIZE VALUE OF UNIVERSITY RESEARCH
- SPOKESBODY FOR INDUSTRY

# Corporate Members

---

---

APPLIED MAGNETICS  
CENSTOR  
COMMONWEALTH SCIENTIFIC  
CONNER PERIPHERALS  
DATATAPE  
DIGITAL INSTRUMENTS  
EASTMAN KODAK  
GTE GOVERNMENT SYSTEMS  
HEADWAY TECHNOLOGIES  
HEWLETT-PACKARD  
HUGHES  
HUTCHINSON TECHNOLOGY  
IBM  
INTEVAC VACUUM SYSTEMS  
KLA INSTRUMENTS  
KOMAG  
MAXTOR

NONVOLATILE ELECTRONICS  
ONTRACK COMPUTER SYSTEMS  
OPTITEK  
PACIFIC SIERRA RESEARCH  
QUANTUM  
READ-RITE  
ROCHESTER PHOTONICS  
ROCKWELL  
ST-GOBAIN ADV MATERIALS  
SDL  
SEAGATE  
STORAGETEK  
STORMEDIA  
TERABANK SYSTEMS  
UNIPHASE  
VEECO INSTRUMENTS  
WESTERN DIGITAL  
ZYGO



# Associate Members

---

---

|                                 |                   |
|---------------------------------|-------------------|
| ALABAMA                         | NORTHWESTERN      |
| ARIZONA                         | NEBRASKA          |
| CAL TECH                        | OHIO STATE        |
| CARNEGIE MELLON                 | PENN STATE        |
| DAYTON                          | PITTSBURGH        |
| GEORGE WASHINGTON               | RICE              |
| GEORGIA TECH                    | SANTA CLARA       |
| IDEMA                           | STANFORD          |
| LAWRENCE LIVERMORE NAT'L LAB    | SRI INTERNATIONAL |
| LOS ALAMOS NATIONAL LAB         | UC BERKELEY       |
| MIT                             | UCLA              |
| MINNESOTA                       | UC SAN DIEGO      |
| NAT'L INST OF STDS & TECHNOLOGY | UC SANTA BARBARA  |
| NATIONAL MEDIA LAB              | WASHINGTON UNIV   |



# NSIC Research Projects

---

---

## **CURRENT**

### **SWAT: Compact Blue Laser Source**

*ATP (1991-96): 3 companies, 2 universities*

### **HEADS: GMR Heads for 10 Gb/in<sup>2</sup>**

*ATP (1992-97): 9 companies, 7 universities*

### **UHDR: 10 Gb/in<sup>2</sup> Magnetic Disk Recording**

### **1 TB/in<sup>3</sup> Magnetic Tape Recording**

### **2.5 Gb/in<sup>2</sup> Optical Media**

*ARPA (1993-96): 14 companies, 16 universities*

### **PRISM: Holographic Storage Materials**

*ARPA (1994-96): 6 companies, 1 university*

### **HDSS: Holographic Storage Systems**

*ARPA (1995-99): 7 companies, 4 universities*

### **UCOD: 1 Terabyte Optical Disk**

*ATP (1995-99): 2 companies, 1 university*

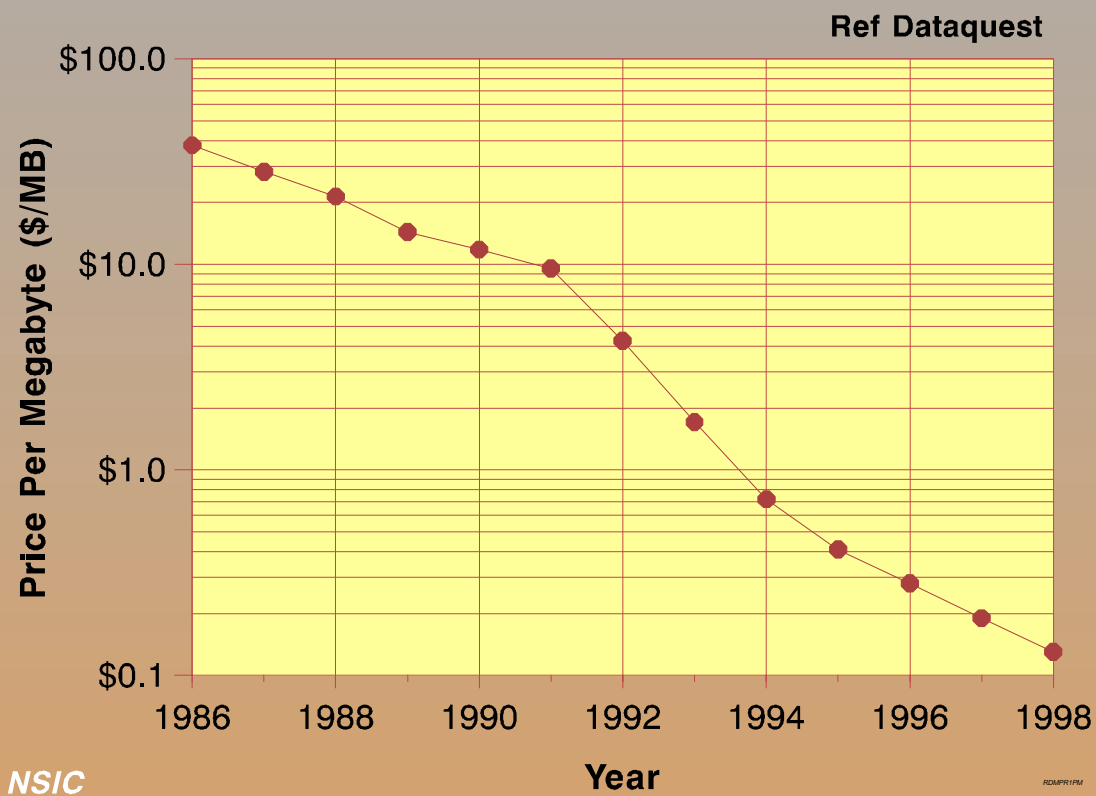
## **PENDING**

### **EHDR: 40 Gbit/in<sup>2</sup> Magnetic Disk Recording**

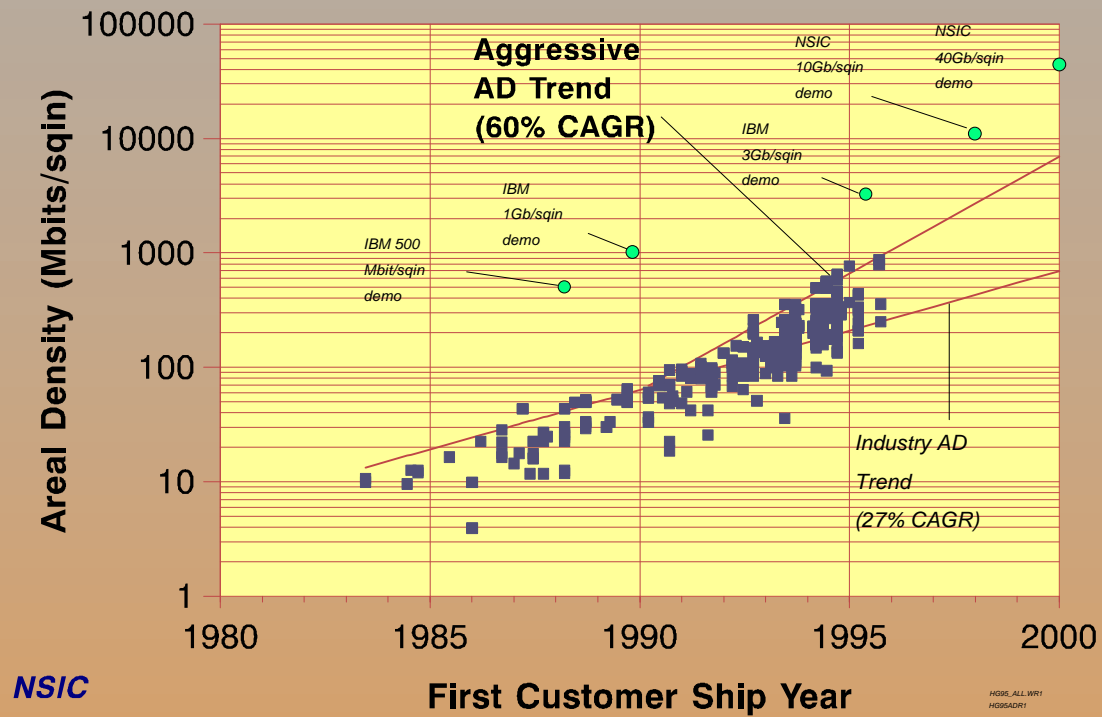
### **NASD: Network Attached Storage Devices**



# Price Per Megabyte Trends



# Areal Density Growth Curves (All Drives)





**PLEASE TAKE NOTE:**

**60% CGR**

**Means**

**10×**

**Every 5 Years**

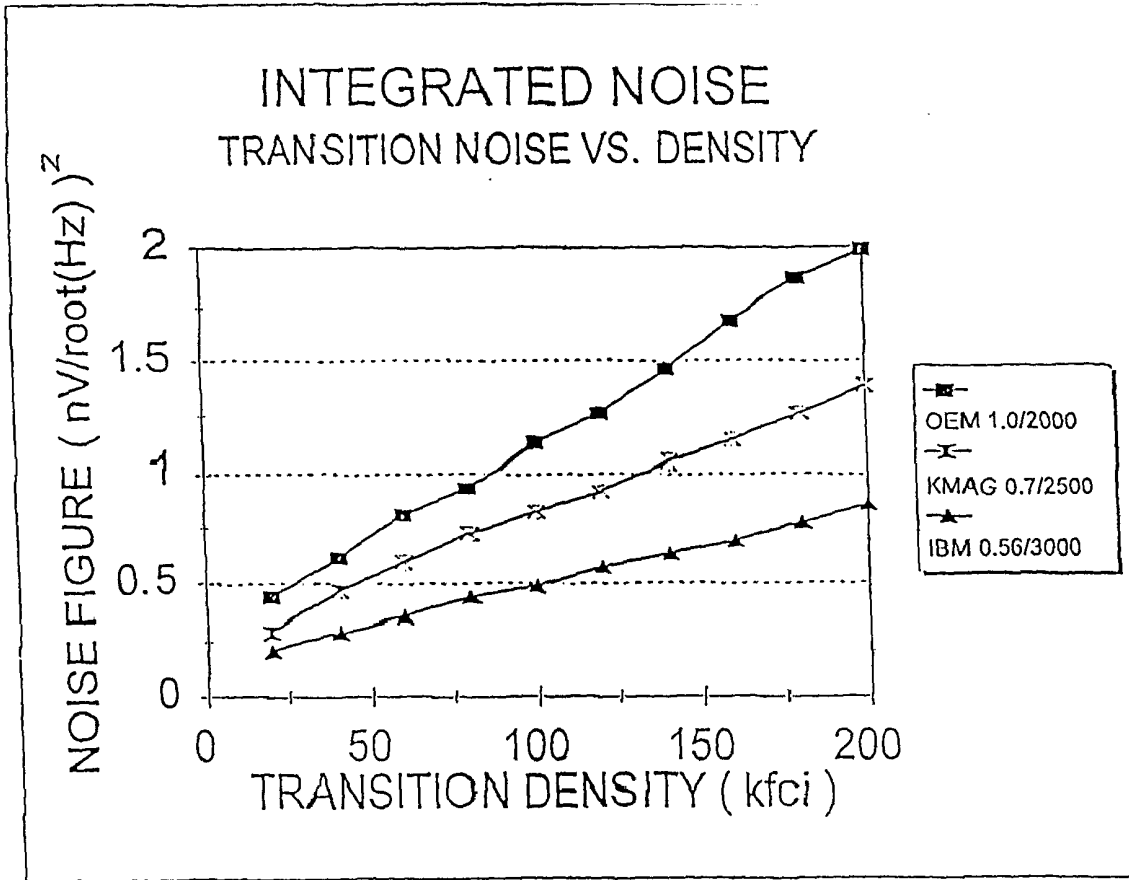
***This Is Not Easy!!***



# Overall Product Parameters

|                           | 1995  | 2000    | 2005    | Units     |
|---------------------------|-------|---------|---------|-----------|
| Areal Density             | ▲ 1   | 10      | ▼ 40    | Gb/sq.in  |
| Bit Density               | 100 K | 400 K   | 800 K   | bits/in   |
| Track Density             | 6 K   | 25 K    | 50 K    | tracks/in |
| Physical Spacing          | 50    | 15      | < 5     | nm        |
| Data Rate<br>(65 mm disk) | 30-60 | 150-300 | 300-600 | Mb/sec    |





NSIC MEETING\6/1/95\GJTarnopol\sky\SEAGATE TECHNOLOGY

150 KFCI Recordings By E. M. T. Velu Using A Tripad Head On  
IBM NSIC Media

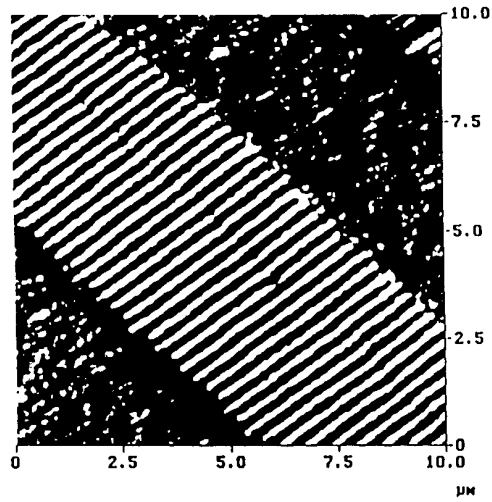


Image by Digital Instruments MFM

*Data Storage Systems Center*



250 KFCI Recordings By E. M. T. Velu Using A Tripad Head On  
IBM NSIC Media

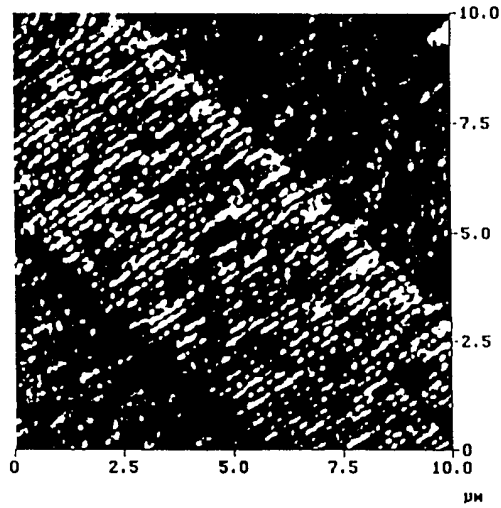
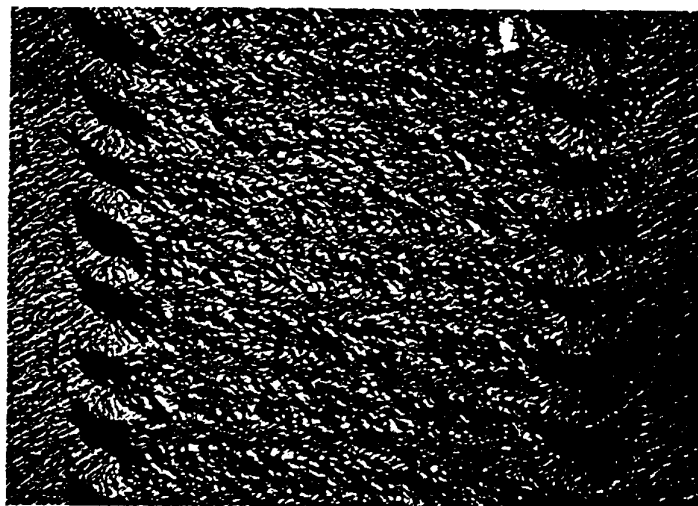
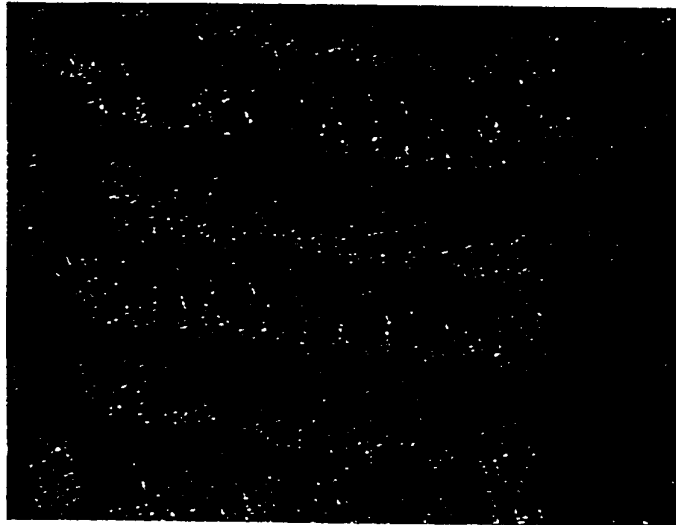


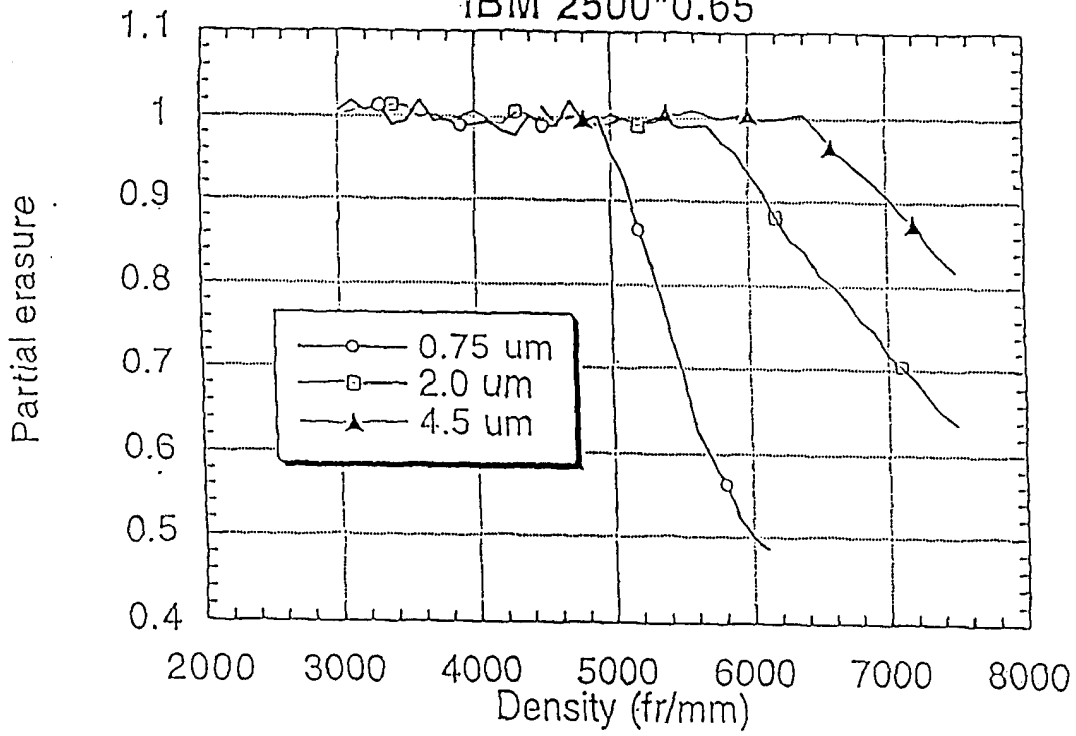
Image by Digital Instruments MFM

*Data Storage Systems Center*



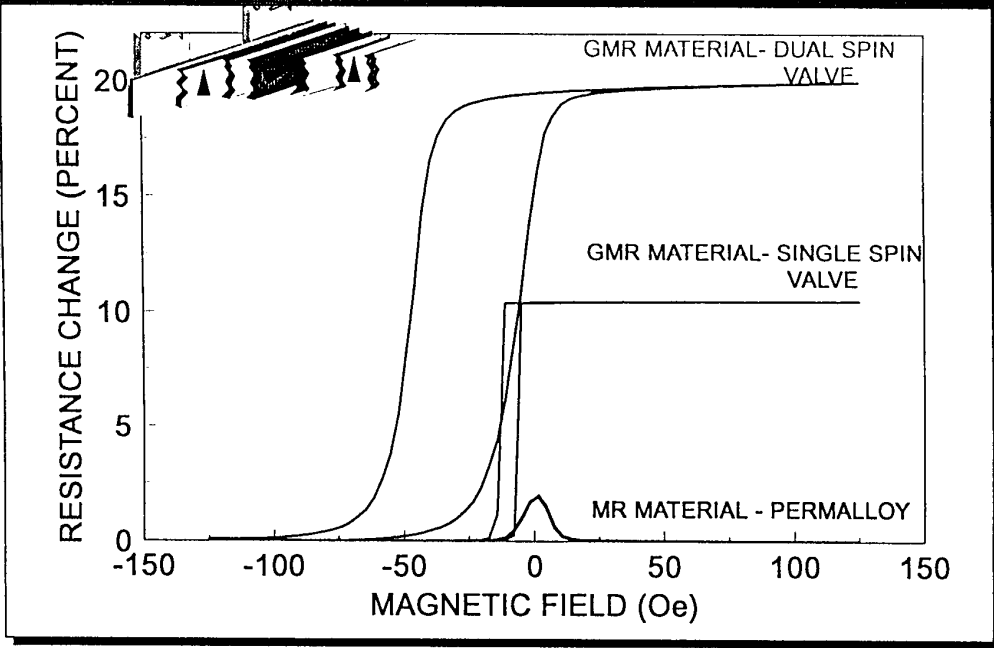


# Partial erasure vs Density IBM 2500\*0.65



National Storage Industry Consortium

# Spin valve GMR Materials

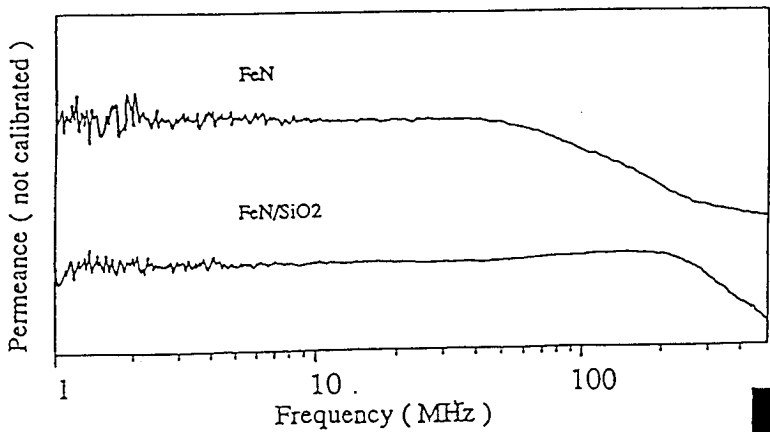
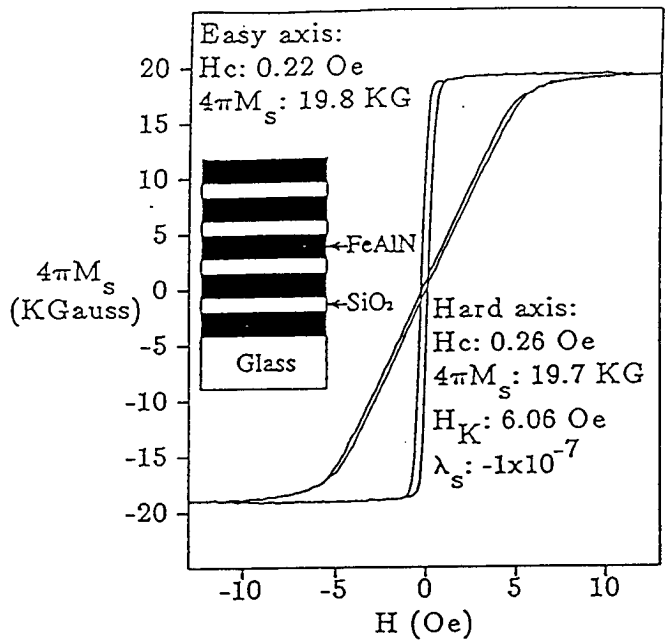


Thin Film Department  
Jim BrugV950228



# FeAlN/SiO<sub>2</sub> Multilayers

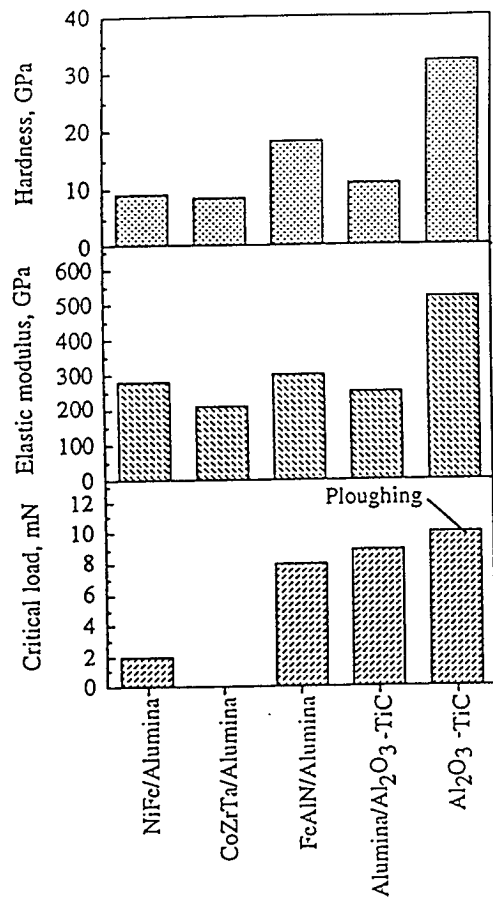
S-X. Wang, J. A. Bain and M.H. Kryder



Data Storage Systems Center

National Storage Industry Consortium





Comparison of hardness, elastic modulus, and critical load for various coatings

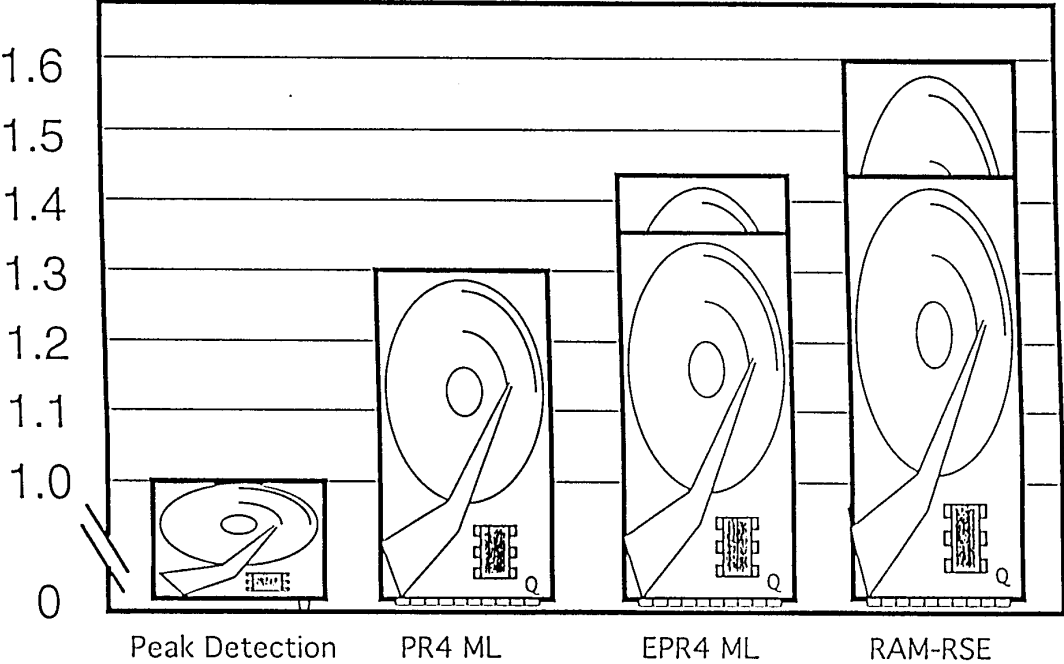
(Coatings were deposited by Carnegie Mellon Univ., Adv. Res. Corp. and Storage Technology Corp. Measurements were made by The Ohio State Univ.)



Computer Microtribology & Contamination Laboratory

National Storage Industry Consortium

# Areal Gains



National Storage Industry Consortium

# More Paradigm Changes Likely

---

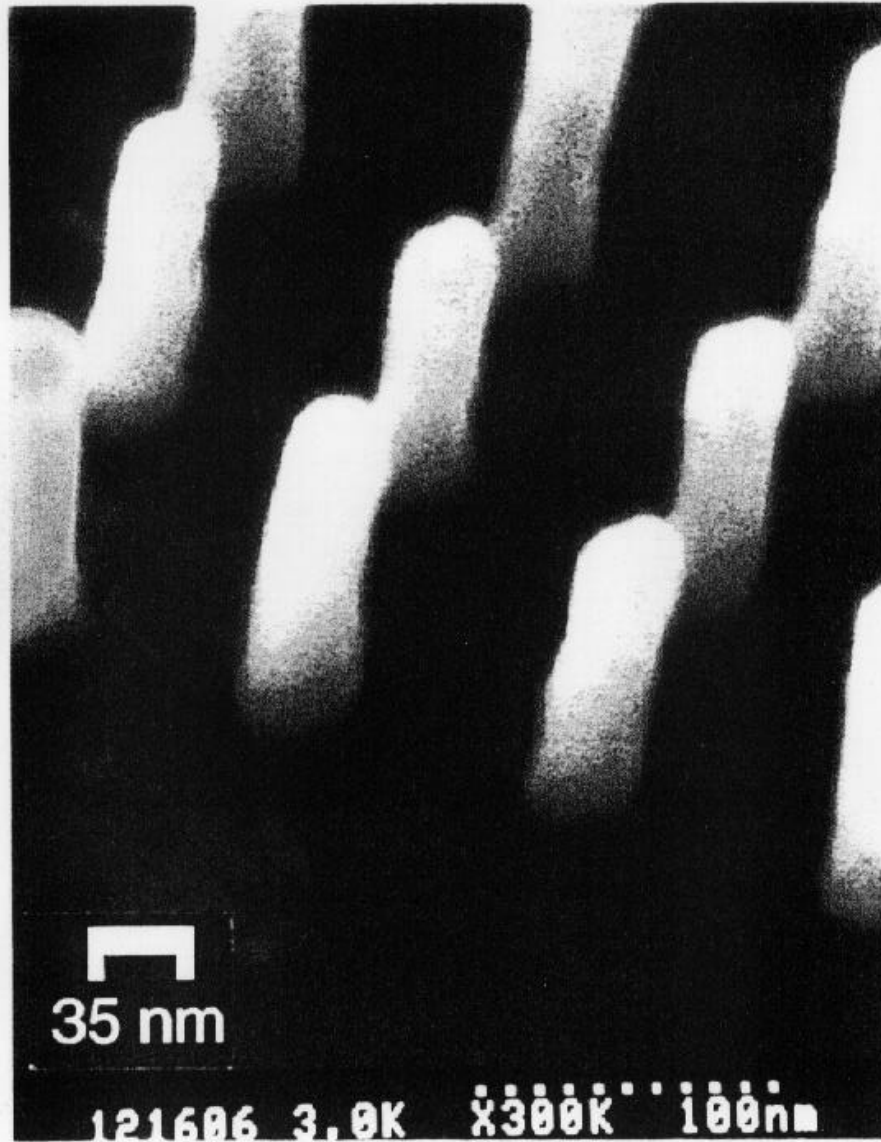
---

- Heads:** Inductive → MR → GMR → CMR?  
Ferrite → Plated Film → Thin Film/Laminate?
- Media:** Particles → Continuous → Discrete?  
Binder → Overcoat → Bare?
- Head-Disk:** Flying → Near-Contact → Contact?
- Tracking:** Sector → Continuous → Two-stage?
- Channel:** Analog → Digital → Enhanced Digital?



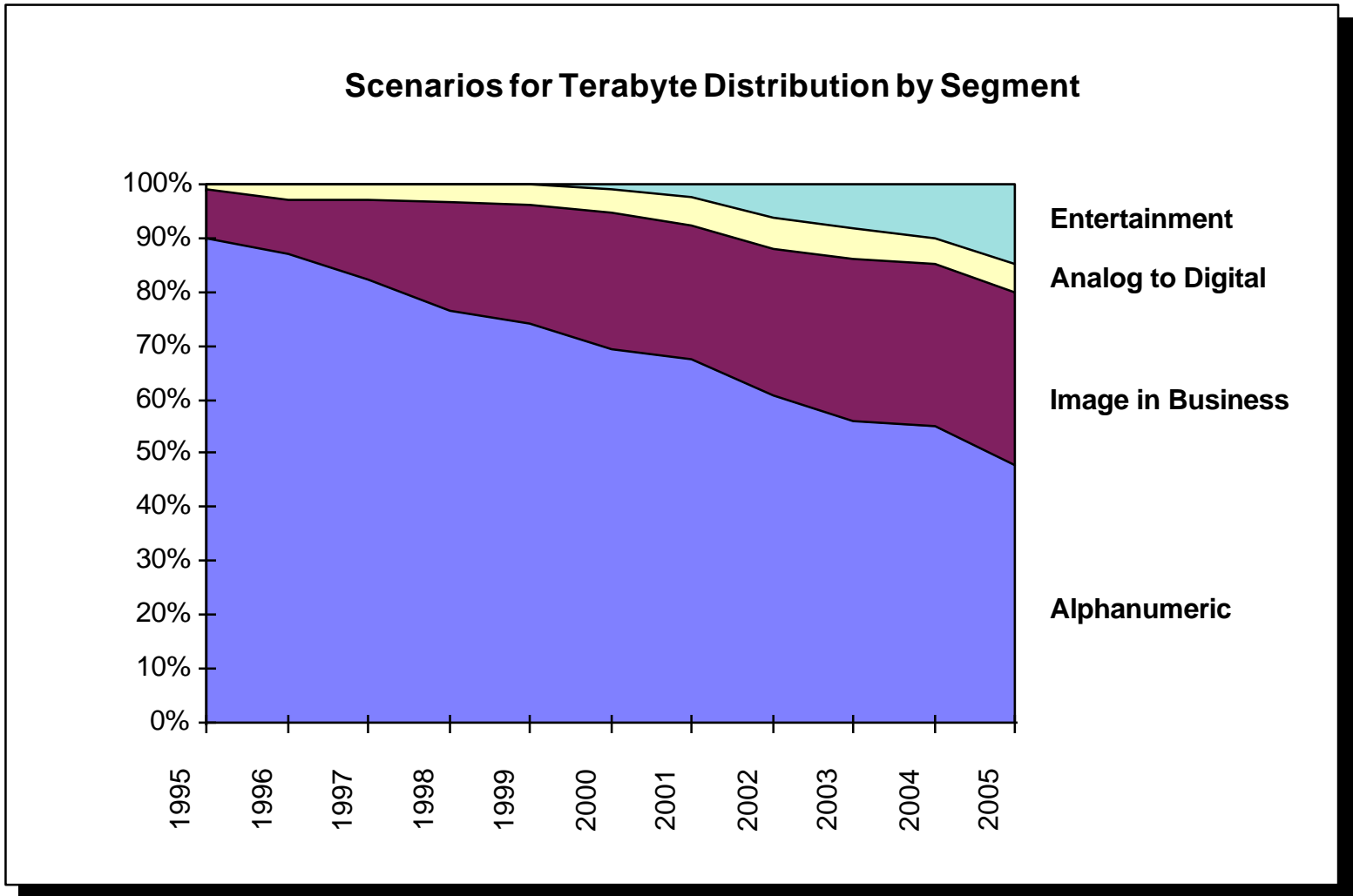
# 65 Gbits/in<sup>2</sup> Nickel Pillar Array

---



*NanoStructure Lab*  
UNIVERSITY OF MINNESOTA

# Forecasting Future Terabyte Distribution



# Target Market Segments

