



***DARPA*Tech**

2002 Symposium

Transforming
Fantasy



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The DSO Approach to Materials Science



The Importance of Materials

New technologies require:

- New devices
- New structures
- *New materials*



Delivering Superior Materials

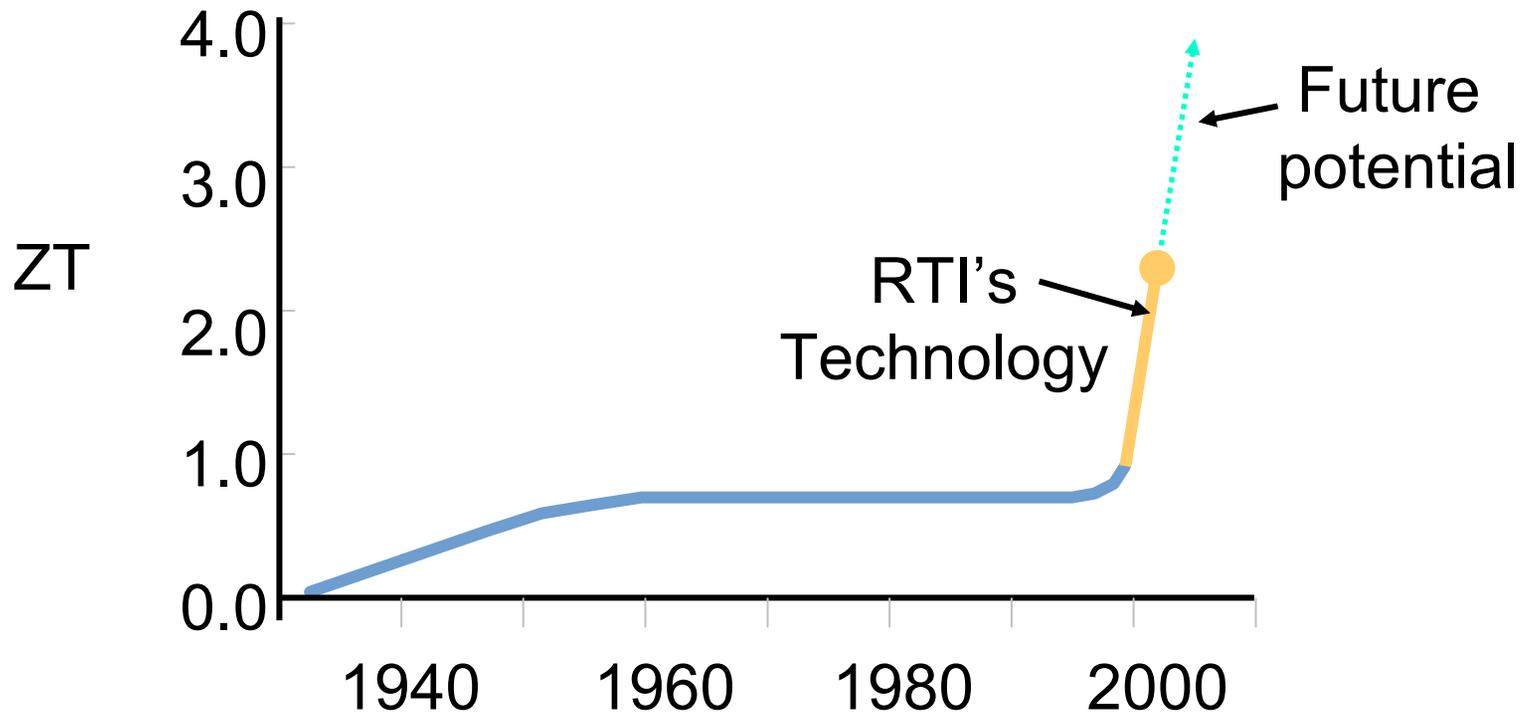
- ▶ Demonstrate new material systems
 - Spins in Semiconductors
 - Structural Amorphous Metals
- ▶ Make “old” materials in “new” ways
 - Advanced Thermoelectric Materials and Devices
 - MetaMaterials
 - BioMagnetICs



Thermoelectric Figure-of-Merit

- ▶ $ZT = S^2\sigma/\kappa$
 - $S \gg 1 \rightarrow$ semiconductor
 - $\sigma \gg 1 \rightarrow$ metal
 - $\kappa \ll 1 \rightarrow$ insulator
- ▶ *It is difficult to optimize ZT in conventional materials!!*

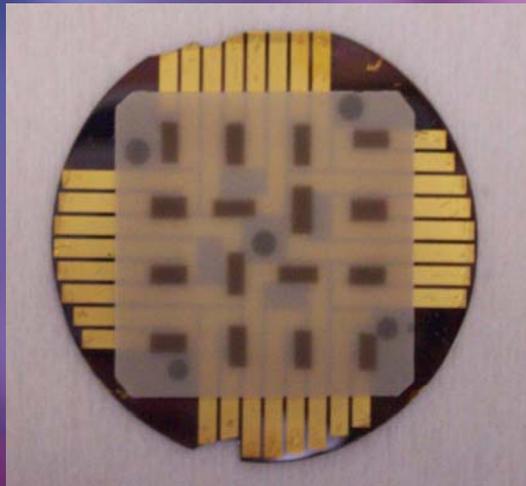
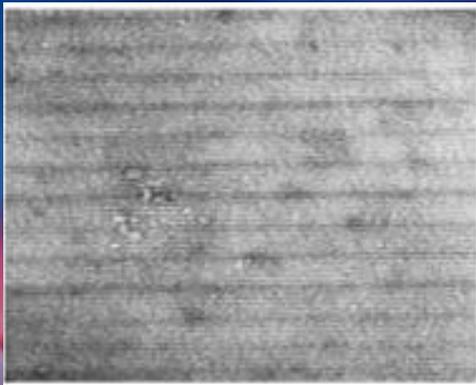
History of ZT



Ref : Nature, 413, 597 (2001)

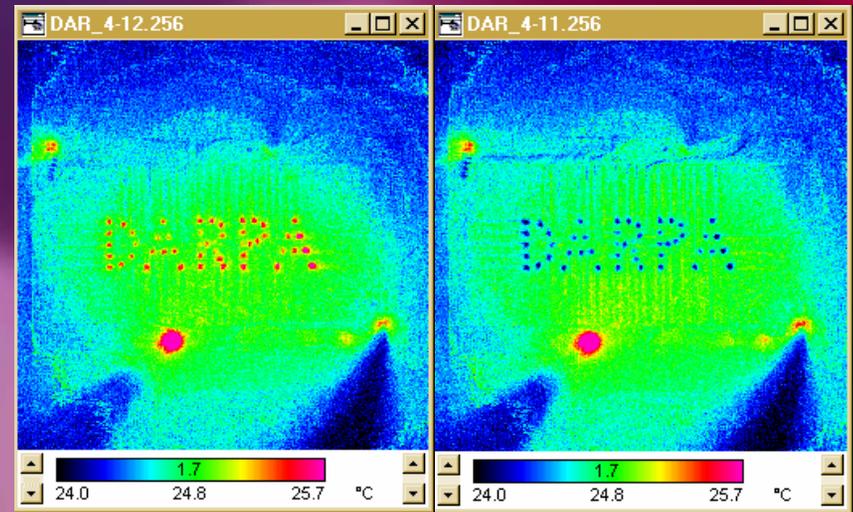
Thermoelectric Superlattices

superlattice structure



Patterned superlattice thermoelectric device

Potential Application: Spot cooling and/or heating for microelectronics



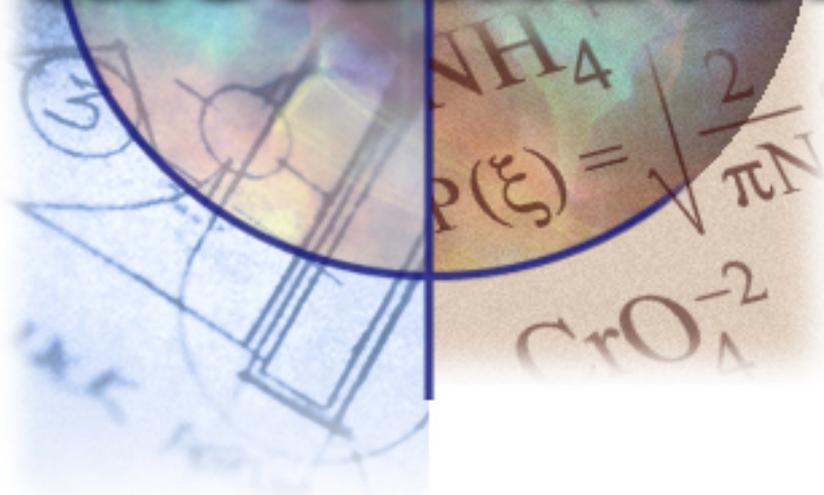
Thermoelectrics run hot and cold!!

- *fast*
- *efficient*
- *high power density*



ENGINEERING MATERIALS FOR THE FUTURE

MetaMaterials



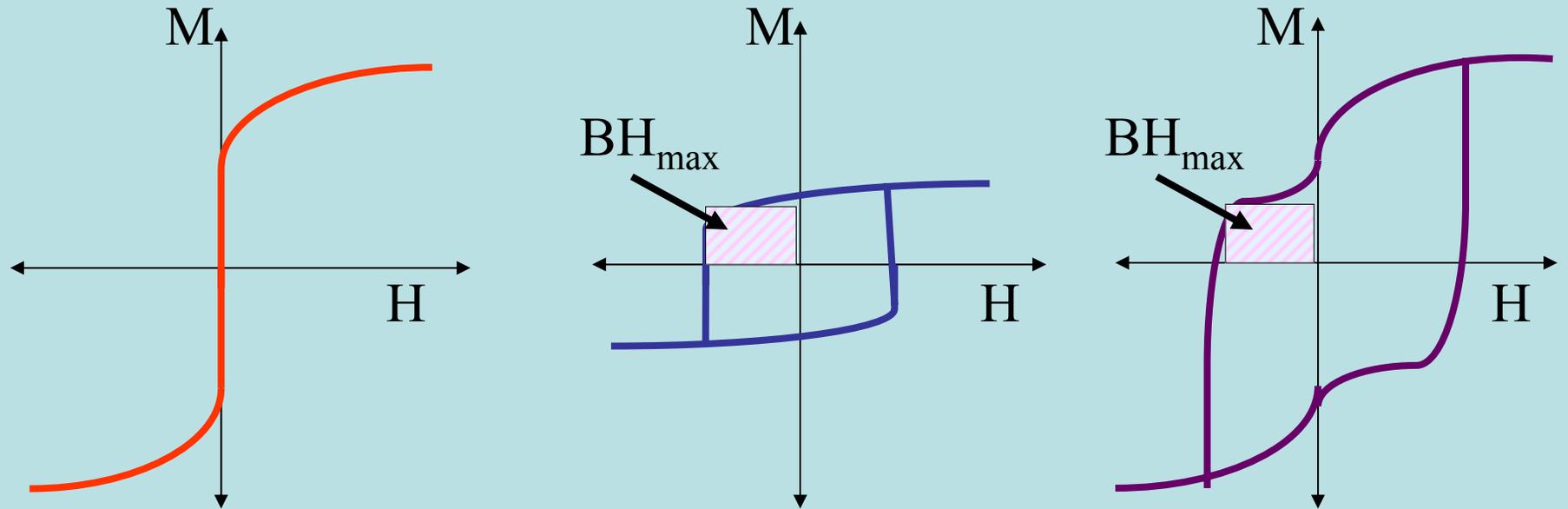
High Performance Magnets

- ▶ Electric Propulsion
- ▶ Electric Drive
- ▶ Power Generation
- ▶ Power Electronics



Conventional Magnetic Composites

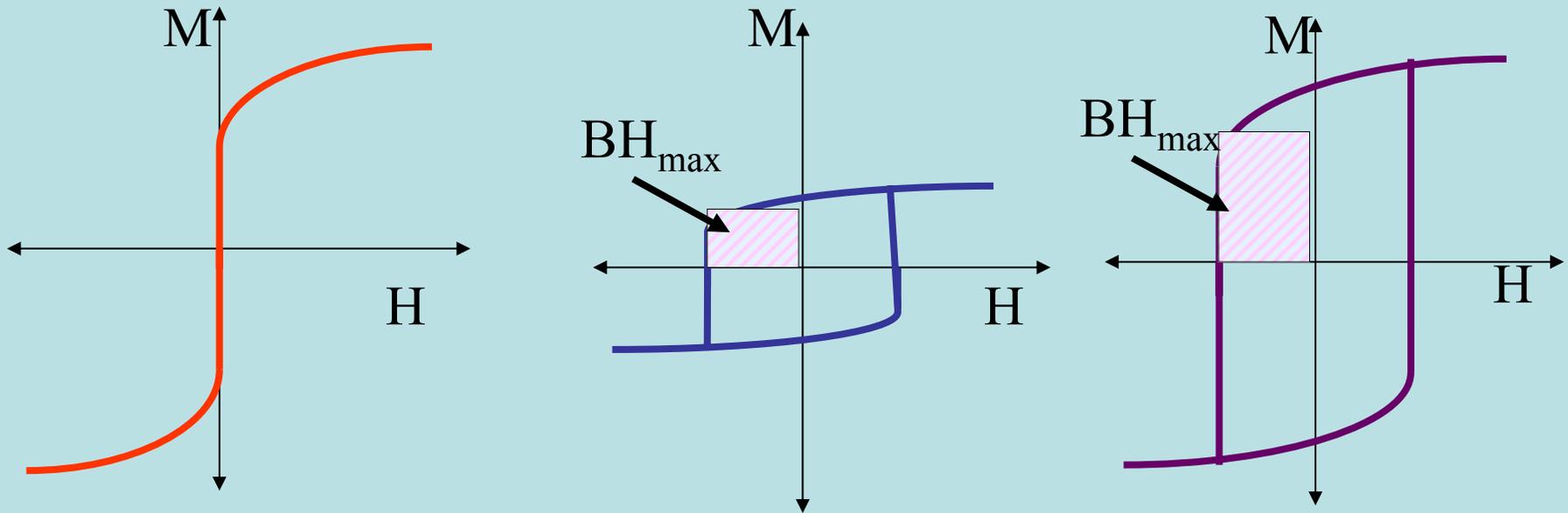
Soft phase + Hard phase = Simple composite



No improvement in figure-of-merit BH_{max} !!

Magnetic Meta-Materials

Soft phase + Hard phase = Meta-Material

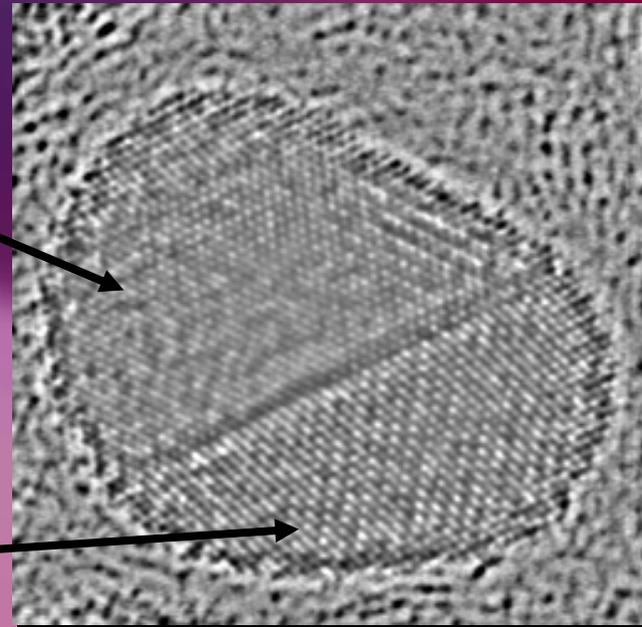


Enhanced figure-of-merit, $BH_{max}!!$

Magnetic MetaMaterials

Hard Phase

Soft Phase



~ 10 nm

Bio-Magnetic Interfacing Concepts

Re-defining “cellular” communications!!

Nano-magnetics + biology =

- ▶ detection
- ▶ manipulation
- ▶ ***control***

...of single cells and bio-molecules



Magnetic Manipulation of Cells

Use VHS Tape "Single Cell Manipulations" in presentation



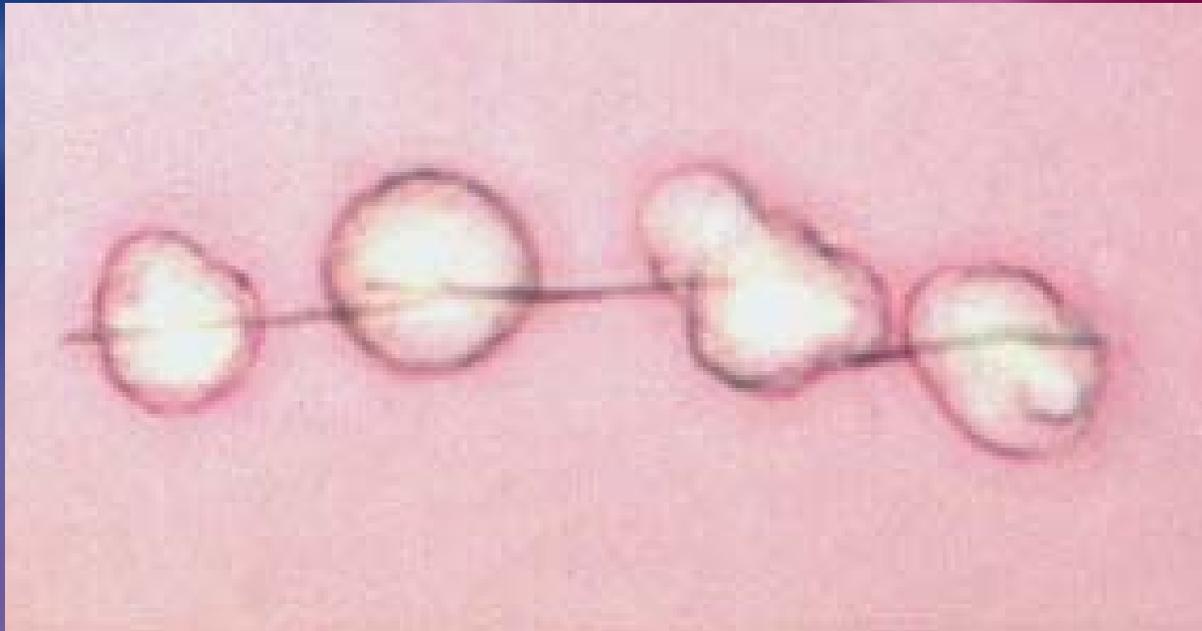
Cluster Manipulations

(Use VHS Tape "Cluster Manipulations")



Directed Assembly of Cells

Line of cells formed by using magnetic nanowires



D. Reich et al., Johns Hopkins University



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