Final Report
For

ADVANCED STUDY INSTITUTE ON THE SCIENCE & TECHNOLOGY

OF

NANOSTRUCTURED MAGNETIC MATERIALS

Crete, Greece
June 25, 1990 to July 6, 1990

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The Institute reviewed the remarkable progress made in magnetic materials over the last few years and addressed the current state-of-the-art research and its impact on technological applications. The subject matter fell into a number of broad areas including thin films, multilayers, disordered systems, ultrafine particles, intermetallic compounds, permanent magnets and magnetic imaging techniques.

The development of new techniques for materials preparation has made a dramatic impact in the area of epitaxial growth of magnetic films. Several presentations have shown that this process can be controlled on the scale of atomic layers permitting the growth of artificial structures such as artificial superlattices with nearly atomic resolution. Epitaxial growth has also permitted the stabilization of metastable phases in thin films which often possess a strong perpendicular anisotropy.

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which may prove useful for technological applications. In magnetic multilayers and superlattices the complex coupling between different magnetic layers was discussed both experimentally and theoretically. Magnetic surfaces and interfaces show large magnetic anisotropy (surface anisotropy), coercivity, magnetoresistance, galvanomagnetic and magnetooptic effects that can lead to future storage technologies. Several contributions discussed the physics of ultrafine particles and granular solids with interesting and unique properties from superparamagnetism to strong magnetic hysteresis. The magnetic properties of rare-earth intermetallic compounds with potential applications in permanent magnets have been discussed including the crystal field effects and the origin of magnetic anisotropy. The magnetic hysteresis behavior of fine particles, permanent magnets, melt-spun ribbons and mechanically alloyed magnets have been discussed.

Finally the applications of magnetic materials in magnetic recording, magneto-optic recording and permanent magnets have been discussed with more emphasis given to the improvement of material properties for these applications.

CHAPTERS

I. Thin Films, Surfaces and Interfaces

II. Multilayers

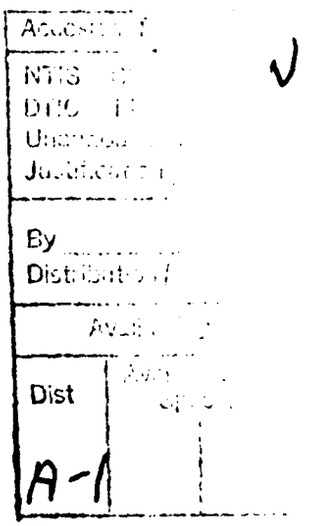
III. Domain Walls, Magnetic Domains and Techniques for Their Observation

IV. Magnetic Anisotropy and Random Magnets

V. Magnetic Semiconductors and Intermetallic Compounds

VI. Fine Particles

VII. Magnetic Hysteresis and Permanent Magnets



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The Institute reviewed the remarkable progress made in magnetic materials over the last few years and addressed the current state-of-the-art research and its impact on technological applications. The subject matter fell into a number of broad areas including thin films, multilayers, disordered systems, ultrafine particles, intermetallic compounds, permanent magnets and magnetic imaging techniques.

The development of new techniques for materials preparation has made a dramatic impact in the area of epitaxial growth of magnetic films. Several presentations have shown that this process can be controlled on the scale of atomic layers permitting the growth of artificial structures such as artificial superlattices with nearly atomic resolution. Epitaxial growth has also permitted the stabilization of metastable phases in thin films which often possess a strong perpendicular anisotropy which may prove useful for technological applications. In magnetic multilayers and superlattices the complex coupling between different magnetic layers was discussed both experimentally and theoretically. In superlattices it was proposed that a strong coupling between two ferromagnetic layers can be carried out through an intervening layer which is not ferromagnetic. This coupling leads to new properties not seen in the past. Magnetic surfaces and interfaces show large magnetic anisotropy (surface anistropy), coercivity, magnetoresistance, galvanomagnetic and magnetooptic effects that can lead to future storage technologies. Band structure studies using statistical techniques of Monte Carlo calculations, led to accurate calculations of the Curie temperature of Fe, Co, Ni films. The solution of this problem opened the door for other important phenomena which are due to "spin orbit" coupling. Several contributions discussed the physics of ultrafine particles and granular solids with interesting and unique properties from superparamagnetism to strong magnetic hysteresis. The magnetic properties of rare-earth intermetallic compounds with potential applications in permanent magnets have been discussed including the crystal field effects and the origin of magnetic anisotropy. The magnetic hysteresis behavior of fine particles, permanent magnets, melt-spun ribbons and mechanically alloyed magnets have been discussed. The magnetic hysteresis models of "domain wall pinning" and "nucleation of reversed domains" have been reviewed and their applicability in different magnetic materials was discussed. The micromagnetic approach using the Landau-Lifshitz-Gilbert equation was also presented to explain the hysteresis behavior of thin films.

The magnetic properties of all of these materials are strongly influenced by their microstructure and several methods to evaluate their growth, lattice structure and sample integrity were discussed. These included spin-polarized electron spectroscopy, DPC and RHEED/RE Microscopy and Lorentz microscopy.

Finally the applications of magnetic materials in magnetic recording, magneto-optic recording and permanent magnets have been discussed with more emphasis given to the improvement of material properties for these applications.

I. THIN FILMS, SURFACES AND INTERFACES

1.	Electronic Structure and Magnetism of Metal Surfaces, Overlayers & Interfaces	Freeman
*2.	Metastable Phases Via MBE	G. Prinz
3.	Spin Resolved Photoemmision	Kirschner
4.	Growth and Magnetic Properties of Metastable Structures	Heinrich
5.	Correlation of Crystalline and Electronic Structure in Epitaxial FCC-Cobalt Monolayers on Cu(100)	Schneider
6.	Mössbauer Studies of Ultrathin Magnetic Films of Fe/Ag(100)	Koon
7.	Spin-Dependence of Absorbed and Reflected Current on Fe(110)	Hammond
8.	MBE Growth of Metal/Semiconductor Interfaces	Slaughter
9.	Surface and Interface Magnetism	Meier
10.	Ferromagnetic Resonance Studies of Epitaxial Ultrathin Fe(001)/Cu(001) Bilayers and Fe(001)/Cu(001)/Fe(001) Trilayers	Celinski
11.	Laser Ablation Deposition of Metallic Thin Films	Gavigan
12.	Exchange Coupled Films for Magneto-Optic Applications	Gambino
13.	Temperature Dependence of Micromagnetic Domain Structure in Cobalt Films	McFadyen
14.	Hyperfine Interaction Techniques Applied to the Study of Surfaces and Interfaces	Rots
15.	Surface Magnetostriction	O'Handley

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II. MULTILAYERS

1.	Magnetic Rare-Earth Artificial Metallic Superlattices	Rhyne
2.	X-Ray Characterization of Magnetic Multilayers and Superlattices	Falco
3.	The Characterization of Interface Roughness and Other Defects in Multilayers by X-Ray Scattering	Sinha
4.	Magnetism of Nanostructured Rare-Earth Multilayers	Sellmyer
5.	FMR Studies of Metallic Magnetic Thin Films in Layered Structures	Hurdequint
6.	Compositionally Modulated Magnetic Multilayers: Temperature and Modulation Dependent Properties	Flevaris
7.	Structural and Magnetic Properties of Epitaxial Co/Pd Superlattices	Engel
8.	First Principle Calculation of the Magnetocrystalline Anisotropy Energy of Co_nPd_m Multilayers	Daalderop
9.	Structural and Magnetic Studies in Co-Pt Multilayers	Krishnan
10.	Magnetic Properties of Hexagonal Fe/Ru Superlattice With Short Periodicities	Piecuch
11.	Magnetic Studies of Fe-Si Compositionally Modulated Thin Films	Tejada
12.	Mössbauer Spectroscopy of the Fe/Ni Interface	Donzelli
13.	Analysis of Amorphous Dysprosium - Transition Metal Nanoscale Magnetic Multilayers	Shan
14.	Transport Properties of Metallic Thin Films and Multilayers	Fert

III. DOMAIN WALLS, MAGNETIC DOMAINS AND TECHNIQUES FOR THEIR OBSERVATION

1.	Micromagnetics of Longitudinal Recording Media	Alexopoulos
2.	MO-Recording: The Switching Process and Its Relation to the Magnetic Properties of Thin Films	Mergel
3.	Micromagnetic Computations of Magnetization Configurations	Jakubovics
4.	Domain Walls and Domain Wall Structure	Humphrey
5.	Domain Wall Multiplication in Amorphous Ferromagnetic Alloys	Beatrice
6.	Electron Microscope Methods for Imaging Internal Magnetic Fields at High Spatial Resolution	Spence
7.	Scanning Tunneling Microscopy and Force Microscopy Applied to Magnetic Materials	Garcia
8.	Special Session on Spin-Polarized Vacuum Tunneling	Notes by Hathaway
9.	Magnetic Imaging Via Scanning Electron Microscopy with Polarization Analysis	Celotta
10.	Atomic Scale Probe Into High-Tc Superconductors Using Scanning Tunneling Microscopy	Rao

IV. MAGNETIC ANISOTROPY AND RANDOM MAGNETS

1.	Magnetic Anisotropy	Jansen
2.	Random Anisotropy in Magnetic Materials	Cullen
3.	Perpendicular and In-Plane Anisotropy in Amorphous Tb-Fe	O'Shea
4.	Magnetostriction in Amorphous Magnets	Hernando
5.	Anderson Localization in 3-Dimensional Amorphous Alloys: Evolution with the Content of Magnetic Ions	Filippi
6.	On the Law of Approach to Saturation in the Series of Amorphous Alloys α-$Dy_xGd_{1-x}Ni$	Amaral
7.	Magnetoresistance of Amorphous $U_{1-x}Sb_x$ Films	Freitas
8.	Absence of Temperature-Driven First Order Phase Transitions in Systems with Random Bonds	Berker

V. MAGNETIC SEMICONDUCTORS AND INTERMETALLIC COMPOUNDS

VI. FINE PARTICLES

1.	Granular Solids	Chien
2.	Ultrafine Magnetic Particles	Hadjipanayis
3.	Magnetic Nanometer Systems and Mössbauer Spectroscopy	Morrish
4.	Some Topics in Fine Particle Magnetism	Berkowitz
5.	Mössbauer Studies of Fine Fe-Based Particles	Morup
6.	Mössbauer Studies of Fine Particles of Fe-Cr-B	Kostikas
7.	Chemical Preparation of Fe-Cr-B Particles	Koch
8.	Composition and Structure of Fe-Ni-B Alloy Particles Prepared by Chemical Reductions with $NaBH_4$	Linderoth
9.	Quantum Effects in Ultrafine Nd-Fe-B Particles	Quintela
10.	Magnetization Reversal in Clusters of Magnetic Particles	Hendriksen
11.	Electric and Magnetic Properties of Small Systems	Arajs
12.	Existence of Frequency Cut-Off in the Spin Wave Spectrum of Small Magnetic Particles	Garcia

VII. MAGNETIC HYSTERESIS AND PERMANENT MAGNETS

1.	Mechanically Alloyed Permanent Magnets	Schultz
2.	Melt-Spun Magnets	Pinkerton
3.	Solid NdFeB Magnets Made by Gas Atomization and Extrusion	Dulis
4.	The Role of Microstructure in Permanent Magnets	Hadjipanayis
5.	Lorentz Microscopy in Permanent Magnets	Fidler
6.	Coercivity in Hard Magnetic Materials	Givord
7.	Micromagnetism and Magnetization Processes in Modern Magnetic Materials	Kronmüller
8.	Micromagnetic Approach to Magnetic Hysteresis	Victora
9.	Magnetic Hysteresis in Disordered Magnets	Soukoulis
10.	Coercivity of Nanostructured Materials	Otani
11.	Magnetic Hysteresis of Co-Pt Films	Tsoukatos
12.	Technology and Application of Permanent Magnets	Narasimhan

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