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PREPARATION AND PROPERTIES OF ARRAYS OF VERY SMALL
MAGNETIC PARTICLES (U) PENNSYLVANIA UNIV PHILADELPHIA
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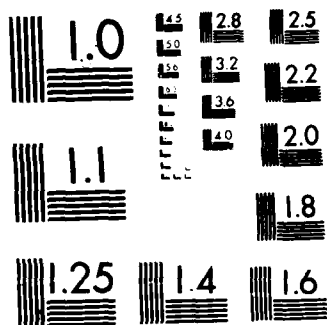
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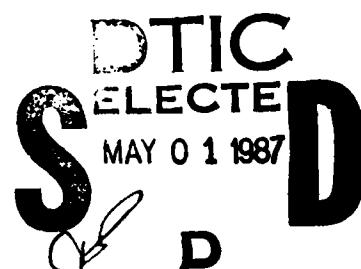
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PREPARATION AND PROPERTIES OF ARRAYS OF
VERY SMALL MAGNETIC PARTICLES

FINAL REPORT

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FORREST KAATZ



MARCH 1, 1987

U.S. ARMY RESEARCH OFFICE

CONTRACT DAAG29-83-G-0104

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING
UNIVERSITY OF PENNSYLVANIA

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Final Report

PREPARATION AND PROPERTIES OF ARRAYS OF VERY SMALL MAGNETIC PARTICLES

The aim of this project was to learn to make two-dimensional arrays of small magnetic particles by electron beam lithography and etching of thin films, and to learn to make magnetic measurements on the arrays. The purpose was to investigate experimentally the behavior of magnetic particles in the size range down to and including single-domain behavior, and also to study experimentally the problem of particle-particle interactions on the magnetic properties of arrays of small particles.

Sputtered amorphous films of $\text{Fe}_{80}\text{B}_{20}$ on glass or silicon substrates were used as starting samples, to eliminate non-uniform etching at grain boundaries. Electron-beam lithography and etching were done at the National Sub-Micron Research Resource Facility at Cornell. Etching was done by ion milling, with generally satisfactory results. We were able to reach the current size limit of the equipment at Cornell, with etched particles approximately $2500 \times 1200 \text{ \AA}$ in cross-section by $25 \text{ \mu m}$ long, spaced about $3000 \text{ \AA}$ apart. The particle array was of the order of 1 mm by 1 mm square. A limitation of this preparation method is that the particle arrays are two-dimensional rather than three-dimensional.

A magnetic measurement technique with sufficient sensitivity to measure the small magnetic moment of these two-dimensional arrays was developed, using a Hall-effect element as the sensor in a vibrating-sample magnetometer. The magnetometer was connected to a computer data-collection system, using a DEC 11-23 machine.

At the smallest particle size we reached, the particles are not single-domain, and the coercive field of the array is about 100 Oe . With newer equipment now installed at Cornell, or by carrying out the electron-beam lithography in a modified scanning electron microscope, it should be possible to produce samples with dimensions less than $1000 \text{ \AA}$; such samples should show single-domain behavior.

In summary, techniques for preparing highly uniform two-dimensional arrays of small magnetic particles (approaching the single-domain size range) have been developed, and appropriate measuring equipment has been built and tested. The student recruited for the project has completed the work for his Master's degree in Materials Science and Engineering, and the degree will be awarded in May 1987.



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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE		5. MONITORING ORGANIZATION REPORT NUMBER(S)	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)		7a. NAME OF MONITORING ORGANIZATION U. S. Army Research Office	
6a. NAME OF PERFORMING ORGANIZATION University of Pennsylvania Dept. Materials Science	6b. OFFICE SYMBOL (If applicable)	7b. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211	
6c. ADDRESS (City, State, and ZIP Code) 3231 Walnut St. Philadelphia PA 19104-6272	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DAAG29-83-G-0104		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office	8b. OFFICE SYMBOL (If applicable)	10. SOURCE OF FUNDING NUMBERS	
8c. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211		PROGRAM ELEMENT NO.	PROJECT NO.
		TASK NO.	WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) PREPARATION AND PROPERTIES OF ARRAYS OF VERY SMALL MAGNETIC PARTICLES			
12. PERSONAL AUTHOR(S) Graham, Charles D. Jr.; Kaatz, Forrest			
13a. TYPE OF REPORT Final	13b. TIME COVERED FROM 84-01-01 TO 86-12-31	14. DATE OF REPORT (Year, Month, Day) 1987 March 1	15. PAGE COUNT 3
16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	Magnetic particles; Fine particles; Magnetic properties Electron-beam lithography; Magnetometers.	
19. ABSTRACT (Continue on reverse if necessary and identify by block number) Techniques were developed to produce two-dimensional arrays of magnetic particles with minimum dimensions of about 2500 A, and to measure their magnetic properties. The purpose of the work was to provide a clean experimental test of the behavior of magnetic particles in the single-domain size range, especially of the effects of particle interactions in this size range. The particles produced were too large to show single-domain behavior, but with improved electron-beam lithography equipment it should be possible to produce arrays of smaller particles. An improved vibrating-sample magnetometer was developed to permit measurement of the magnetic properties of these very small samples.			
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL		22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL

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