REQUIRED COVER PAGE

APPLICATION FOR FACULTY RESEARCH GRANT

**All questions must be completed to be considered for grant award.

Choose one: [ ] Creative Pro [X] Research F	**Date of Last FRG Award** (Semester and Year awarded): PI has never been awarded an FRG **Date of ATU Faculty Appointment** (Semester and Year): Fall, 2003

1. Project Title: Growth and Characterization of Magnetic Nanoparticles

2. Name of Principal Investigator/Project Director: PI: Daniel Bullock Co-PI: Patricia Buford

3. School (abbrev): PLS / ENGR **4. Department:** Physical Science / Electrical Engineering

5. Campus Mail Address: McEver Hall **6. PI/PD Campus Phone:** 968-0230

7. Amount Requested: $2,000 **8. Total Cost of Project:** $ 5,200

9. Does this project involve: **10. Duration of Project:** 04/06 – 04/07

Yes No
[ ] [X] human subjects?
[ ] [X] animals/animal care facility?
[ ] [X] radioactive materials?
[ ] [X] hazardous materials?
[ ] [X] biological agents or toxins restricted by the USA Patriot Act?
[ ] [X] copyright or patent potential?
[ ] [X] utilization of space **not** currently available to the PI/PD?
[ ] [X] the purchase of equipment/instrumentation/software currently **available** to the PI/PD?

NOTE: If the answer is "yes" to any of the above questions, the investigator must attach appropriate documentation of approval or justification for use/purchase.

SIGNATURES

Department Contribution (if applicable): $ 1,100

Account Number: 2-11730

Jeff W. Robertson 2006/Mar/14
Chairperson **Date**

School Contribution (if applicable): $ N/A

Account Number: ____________

[signature] 3-15-06
Dean **Date**

This Section to be completed by the Office of Academic Affairs

FSBA Committee Award Recommendation: Yes____ No____
FSBA Committee Proposal Rank: ______ of _____ Total Proposals.
Recommendation of VPAA: Yes____ No _____
Recommendation of President: Yes____ No _____
Award Date: ____________________

B. ABSTRACT Quantum dots are nanometer (10^{-9} meter) scale particles that have exciting technological applications in both the biomedical and electronics industries. One type of nanocrystals are composed of magnetic oxide materials. They are of interest due to their potential as high capacity magnetic memory storage devices. To date, these nanocrystals suffer from both poor crystalline quality (which impacts their electronic and magnetic properties) and a lack of size uniformity. What is needed is a novel process to synthesize these particles that will result in a high degree of crystallinity and monodispersion (i.e. single size distribution). Since the growth of these crystals is an *activated* process (i.e. exponentially dependent on temperature) it is necessary to understand the evolution of these crystals during their production process. Our proposal is a detailed study of the effect that different heating rates have on the physical, electronic, and magnetic properties of these technologically important materials.

C. PURPOSE / OBJECTIVES The purpose of this research project is to measure the effect different heating rates have on the physical (i.e. size), electrical, and magnetic properties of iron oxide (Fe_2O_4), magnetite, nanocrystals during their growth process.

D. SIGNIFICANCE / NEED Quantum dots are nanometer (10^{-9} meter) scale particles that are neither small molecules nor bulk solids. Their composition and small size (a few hundred to a few thousand atoms) give these dots extraordinary optical, chemical, electrical, and magnetic properties that cannot be achieved by their bulk counterparts.[1-4] Most of the work in this area has been focused upon the II – VI semiconductors (so called because they are composed of elements from columns, II and VI on the periodic table) due to their potential as biomedical sensors. Unfortunately little work has been conducted upon the fabrication of uniform oxide nanoparticles despite their many important technological applications.[5-6] The fabrication of patterned media arrays of discrete single domain magnetic nanoparticles is very important for their potential applications in multi-terabit/in^2 magnetic memory devices. Such magnetic nanoparticles could also find applications in ferrofluids, refrigeration systems, medical imaging, drug targeting, and catalysis. The syntheses of several uniform-sized magnetic metal nanoparticles has been reported.[7-11] However, relatively little work has been done on the fabrication of monodispersed (i.e. single size distribution) and crystalline magnetic oxide nanoparticles. Several magnetic oxide nanoparticles have been synthesized by using micro-emulsion and other methods.[12-14] However, particle size uniformity and crystallinity of these nanoparticles are poor. Although the syntheses of relatively uniform maghemite and magnetite nanoparticles have been reported, exhaustive size selection procedures were necessary.[15-16] What is desired is a novel process to synthesize these particles which demonstrate both a high degree of crystalline quality as well as a monodispersion. Our proposal is a detailed study of the effect that different heating rates have on these crystals.

<u>E. PROCESS FOR ATTAINMNET OF OBJECTIVES / GOALS</u> An important component of our project is the design and construction of a high precision reactor vessel. Figure 1 shows a schematic diagram of our proposed reactor vessel. The reactor vessel is where all the necessary chemical reactions take place in order to produce the nanocrystals. In order to produce a highly uniform sample the reactor vessel must (1) have a high degree of temperature uniformity during the sample synthesis process, (2)

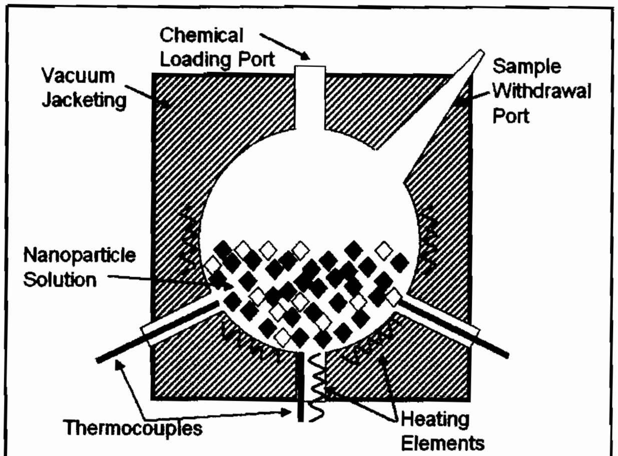

Figure 1 Schematic Diagram of reactor vessel.

not be reactive with any of the chemicals, and finally (3) be accessible for sample withdrawal during the reaction. In order to achieve accurate temperature control it is important to thermally isolate the nanocrystal solution from the ambient atmosphere. This will be achieved by encasing the specially designed glass flask in either vacuum jacket aluminum or a polyurethane enclosure (both of which will be built on site by students). While our reactor vessel is being fabricated we will also be ordering all the materials to the nanocrystals. The needed chemicals for this study include Stearic Acid (95%), 1-Octadecene (90%), Iron (II) Stearate (Fe 9%) and n-tetracosane. After the nanocrystals have been produced the final phase of our project will be to characterize them. Our goal will be to measure the size distribution, electronic structure, and magnetic characteristics. The size distribution will be measured using an instrument called an Atomic Force Microscope (AFM). The AFM works by measuring the deflection of a scanning probe as it drags along the sample surface. The AFM has a resolution on the order of 10 nanometers, which is appropriate for these size particles. The electronic structure of our nanocrystals will be measured using an instrument called a Fourier Transform Infrared Spectrometer (FT-IR). When these nanocrystals are supplied with enough energy they emit infrared light. This instrument measures this light as a function of wavelength. This information can be used to study the electronic structure of these crystals. Finally, the magnetic structure of these nanocrystals will be characterized using a Superconducting Quantum Interference Device (SQUID). The SQUID measures the hysteresis curve of materials which gives the investigator insight into their magnetic structure.

The following Gant chart gives a timeline for the completion of the goals of this project.

	Mar.	Apr.	May	June	July	Aug.	Oct.	Nov.	Dec.	Jan.	Feb.
Literature review	■	■	■	■	■	■	■				
Ordering supplies and materials		■	■	■	■						
Design & fabrication of reactor vessel		■	■	■	■	■					
Sample preparation						■	■				
Physical characterization (AFM)							■	■			
Electronic characterization (FT-IR)							■	■			
Magnetic characterizations (SQUID)							■	■			

F. DISSEMINATION OF RESULTS The results of this project will be prepared in a final report submitted to the FRG committee. Additionally, a paper will be prepared and submitted to the Journal of the American Chemical Society and the Arkansas Academy of Sciences. Finally, the students involved in this project will present their findings at the Arkansas Academy of Sciences Annual Meeting as well as the Arkansas Tech University Undergraduate Research Symposium.

G. REPEATED REQUESTS The PI for this proposal has never requested funds from the FRG program.

H. BUDGET

PROPOSED BUDGET
FACULTY RESEARCH GRANT
(include budget categories as appropriate)

1.	Non-work study stipend	113.00
	Fringe benefits @ .4% (4/10 percent) of non-work study stipend	
2.	*Supplies (please list items to be purchased and estimated price per item including taxes and shipping, if appropriate):	
	Argon gas	30.00
	Gas Distribution tube	253.00
	Tygon hose	5.00
	Gas T glass	55.00
	Jacketed Condenser	48.00
	Heating Mantle	95.00
	Stir Plate	400.00
	Air trap	28.00
	Septa	48.00
	Heatgun	30.00
	Syringes	20.00
	4" Needles	30.00
	Vials	20.00
	Magnets	15.00
	Gloves	20.00
	Iron (II) Stearate	50.00
	Stearic Acid	15.00
	1-Octadecene	25.00
	* Temperature Controller	*1500.00
	**Milling Machine	**2300.00
	Total estimated supplies $	**4987.00**
3.	Travel (please list travel expenditures by date and estimated costs):	
	Arkansas Academy of Science Annual Meeting, April 2007	100.00
	Total estimated travel $	**100.00**
	TOTAL PROPOSED BUDGET $	**5200.00**

* Temperature controller to be purchased using funding awarded to PI from INBRE grant.

** $600 (26%) of the milling machine purchase to come from grant awarded to PI from ASGC, $600 (26%) from the FRG and the balance to be from the department.

I. BIBLIOGRAPHY

1. Alivisatos, A. P. *Science* **1996**, 271,933.
2. Weller, H. *Angew. Chem., Int. Ed. Engl.* **1993,** 32,41.
3. Schmid, G., *Clusters and Colloids;* VCH Press: New York, 1994.
4. Ashoori, R C. *Nature* **1996**, 379, 413.
5. Trentler, T. J., Denler, T. E., Bertone, J. F., Agrwal, A., Colvin, V. L. *J. Am. Chem. Soc.* **1999,** 121, 1613.
6. Liu, C., Zou, B., Rondinone, A. J., ZhangZ. J. *J. Am. Chem. Soc.* **2001,** 123, 4344.
7. Park, S. J., Kim, S., Khim, Z. G., Char, K., Hyeon, T. *J. Am Chem. Soc.* **2000,** 122, 8581.
8. Puntes, A. F., Krishnan, K. M., Alivisatos, A. P. *Science* **2001,** 291, 2115.
9. Sun, S., Murray, C. B., Weller, D., Folks, L., Moser, A. *Science* **2000**, 287, 1989.
10. Suslick, K. S., Fang, M., Hyeon, T. *J. Am. Chem. Soc.* **1996**, 118, 11960.
11. Feltin, N., Pileni, M. P. *Langmuir* **1997,** 13, 3927.
12. Rondinone, A. J., Samia, A. C., Zhang, Z. J. *J. Phys. Chem.* **1999,** 103, 6876.
13. Kang, Y. S., Risbud, S., Rabolt, J. F., Stroeve, P. *Chem. Mater.* **1996,** 8, 2209.
14. Easom, K. A., Klabunde, K. J., Sorensonm C. M. *Polyhedron* **1994**, 13, 1197.
15. Rockenberger, J., Scher, E. C., Alivisatos, A. P. *J. Am. Chem. Soc.* **19999,** 121, 11595.
16. Fried, T., Shemer, G., Markovich, G. *Adv. Mater.* **2001,** 13, 1158.

J. APPLICATION VITA

Daniel Bullock
Assistant Professor of Physics
Arkansas Tech University

i. Professional Preparation

Ph.D.	Physics, May 2001, University of Arkansas
M.S.	Physics, May 2000, University of Arkansas
B.S.	Physics, May 1997, Arkansas Tech University

ii. Appointments

Fall 2003-	Assistant Professor of Physics, Arkansas Tech University
2001-2003	Post Doctoral Research Associate, Department of Physics University of Arkansas
1997-2001	Research Assistant, Department of Physics University of Arkansas

iii. Publications

1. *Growth Rate Calculations,* D. W. Bullock, W. Nelson, and A. Ong, submitted to Proceedings of the Arkansas Academy of Sciences (2005)
2. *Speediness and Classroom Response Systems: A Pilot Study,* D. W. Bullock and W. J. Gonzalez-Espada, submitted to American Journal of Physics (2005).
3. *Time-evolution of the GaAs(001) pre-roughening process*, Z. Ding, D. W. Bullock, P. M. Thibado, V. P. LaBella, and Kieran Mullen Surface Science, Vol. 540 No.2-3 p. 491 (2003).
4. *Atomic-Scale Observation of Temperature and Pressure Driven Preroughening and Roughening*, Z. Ding, D. W. Bullock, P. M. Thibado, V. P. LaBella, and Kieran Mullen Physical Review Letters, Vol. 90 No. 21 p. 216109 (2003).
5. *Dynamics of Spontaneous Roughening on the GaAs (001)-(2 × 4) Surface,* Z. Ding, D. W. Bullock, W. F. Oliver and P. M. Thibado, Journal of Crystal Growth, Vol. 251 No.1-4 p.35 (2003).
6. *Simultaneous Surface Topography and Spin-Injection Probability,* D. W. Bullock, V. P. LaBella, Z. Ding, and P. M. Thibado Journal of Vacuum Science and Technology B, Vol. 21 No. 1 p.67 (2003).

iv. Synergistic Activities

1. Implemented a campus wide teaching initiative using personalized wireless remote control technology to enhance the teacher-student engagement process.
2. Participated in a campus wide retention program, "Bridge to Excellence", by mentoring five incoming freshmen students.

v. Collaborators & Other Affiliations

1. G. Salamo, University Professor of Physics, Endowed Chair of Nanoscience, University of Arkansas, collaborated on research project entitled "Cross-sectional STM studies of nanostructures" . (2005)
2. J. Robertson, Associate Professor of Astrophysics, Arkansas Tech University, Department Head, collaborated on research project entitled "Portable Spectrograph for Astronomical Observations". (2005)
3. L. Kondrick, Assistant Professor of Physical Science, Arkansas Tech University, collaborated on research project entitled, "Real-Time Classroom Assessment". (2005)

4. W. Gonzales-Espada, Assistant Professor of Physical Science, submitted a collaborated paper entitled "Speedeness and Classroom Response Systems: A Pilot Study", submitted to *The Physics Teacher.* (2004)
5. P. Buford, Assistant Professor of Electrical Engineering, collaborated on research project entitled "Portable Spectrograph for Astronomical Observations". (2005)

f. Presentations (Examples for last five years)

1. *Automated Growth Rate Calculations for Electronic Device Production*, Willie Nelson, Alvin Ong and Daniel Bullock, Arkansas Academy of Sciences Research Symposium Spring 05.
2. *Student Response Time in Introductory Level Physical Science Class*, Daniel Bullock and Wilson Gonzalez-Espada, Arkansas – Oklahoma – Kansas Spring 2004 meeting.
3. *Growth Rate Calculations for Electronic Device Production*, Willie Nelson, Alvin Ong and Daniel Bullock, Arkansas Tech Undergraduate Research Symposium Spring 04.

g. Honors and Awards (Grant Proposals- Examples for the last five years)

1. Awarded Nanoscience Education Initiative funding from Dr. Jack Hamm, Vice President of Academic Affairs worth $130,000.
2. Principal Investigator on an Arkansas Space Grant Consortium – NASA grant entitled, "Cross-Sectional STM sample Preparation Algorithms", worth $14,150.
3. Awarded summer research fellowship from the Materials Science and Engineering Center (MRSEC) at the University of Arkansas nanoscience labs, worth $13,000 for three months (2005).
4. Co-principal investigator on Arkansas Tech University Undergraduate research Council grant entitled, "Mock Automated Warehouse Autonomous Robot", worth $3,486 (2005).
5. Principal investigator on Arkansas Tech University Assessment Committee grant entitled, "Real-Time Classroom Assessment", worth $1,220 for one year. This project, in collaboration with another faculty member, studies the effects of different technologies used in the classroom on learning (2004).
6. Co-principal investigator on Arkansas Space Grant Consortium – NASA grant entitled, "Portable Spectrograph for Astronomical Observations", worth $4,415 for one year. This project in involves three faculty members from two different departments. Additionally, the funds from this project will support two undergraduate students to conduct the research for one year. These students were able to visit Johnson Space Center to review current NASA research projects.
7. Principal investigator on Arkansas Space Grant Consortium – NASA grant entitled, "Dynamic Electronic Device Production Software", worth $2,600 for one year. This proposal was able to fund research performed by two undergraduate students in 2004. Additionally, these students were able to travel to the Stennis Space Center to observe current NASA research projects.
8. Principal investigator on Arkansas Tech University Undergraduate Research grant entitled, "Growth Rate Calculations", worth $2,500 for one year. This proposal was able to fund research performed by two undergraduate students in 2003.

Patricia S. Buford
Assistant Professor of Electrical Engineering

Professional Preparation	M.S. Instrumental Science University of Arkansas, Fayetteville, Graduate Institute of Technology, May 1985 B.S. Electrical Engineering Christian Brothers University, Memphis, Tennessee, May 1974
Years on Faculty:	Assistant Professor, Arkansas Tech University, Fall 2000 - present. Part-Time Instructor, Arkansas Tech University, Fall 1994-Spring 1996.
Registration:	Registered Professional Engineer in Arkansas, 1984-present.
Memberships:	Institute of Electrical and Electronic Engineers (IEEE) – 30 years American Society for Engineering Education (ASEE) – 5 years
Research:	Co-Principle Investigator of Arkansas Tech University Faculty Undergraduate Research Grant entitled, "Mock Automated Warehouse Autonomous Robotics Project" January, 2006, $2700. Co-Principle Investigator of Arkansas Space Grant Consortium program entitled, "Portable Spectrograph for Astronomical Observation" March, 2005, $4415.
Publications:	*Innovative Air Flow Measurement*, L. Howard, J. Hayes, P. Buford, W. Helmer; Proceedings of the 2004 American Society for Engineering Educators Midwest Section Conference, October 1, 2004
Presentations:	*Innovative Air Flow Measurement,* 2004 American Society for Engineering Education Midwest Section Conference. October 1, 2004.

DEPARTMENT OF PHYSICAL SCIENCES

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10/19/06

Dr. Hamm,

Please find enclosed the final report on the "Growth and Characterization of Magnetic Nanoparticles" per the Faculty Research Grant guidelines.

Thank you for funding our project we hope to continue this work in the future and the findings will be integrated into our junior-senior level physics courses. Additionally, we were able to use some of the equipment from the new Nanoscience Lab!

If you have any questions please do not hesitate to contact me at: 479-968-0230, or via e-mail daniel.bullock@atu.edu.

Sincerely,

Daniel Bullock, Ph. D.
Assistant Professor of Physics
McEver Hall 03

cc: Dr. Richard Cohoon, Dean of Physical and Life Sciences
Dr. Jeff Robertson, Department Head of Physical Sciences