REQUIRED COVER PAGE

APPLICATION FOR PROFESSIONAL DEVELOPMENT GRANT

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

Choose one:	
[ ] Creative Activity [x] Research Activity [ ] Professional Enhancement Activity	**Application Deadline Date:** April 15 (i.e. October 1, February 1, or April 15) **Date of Last PDG Award** (Semester and Year awarded): PI has never been awarded a PDG **Date of ATU Faculty Appointment** (Semester and Year): Fall 2000

1. Project Title: Electron Transport Properties of Epitaxially Grown Nanostructures

2. Name of Principal Investigator/Project Director: PI: Dr. Patricia Buford Contributing Investigator: Dr. Daniel Bullock

3. School (abbrev): SS **4. Department:** Electrical Engineering **5. Campus Mail Address:** CES Room 102

6. PI/PD Campus Phone: 479-968-0338 **7. Amount Requested:** $ 5,295 **8. Total Cost of Project:** $ 12,038

9. Will total funds awarded be expended by June 30th of the current fiscal year: Yes X **No**

10. If not, what is the total to be expended this fiscal year: $ N/A

11. What is the total to be carried over to the next fiscal year: $ 0 ***(if approved by the VPAA)***

12. Project Completion Date: 08/01/08 **13. Travel Dates:** N/A (*if applicable*)

14. Does this project involve:

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): $ 3,300[1] +443[2] +3,000[3]* = 6,743

Account Number: AAURCH[1], Dept. of Phys. Sci.[2], NASA[3] (proposal to be submitted April 15)*

Donald E. Anderson 4/4/08 Jeffrey Rafti 2008 Apr 8
Chairperson Date

School Contribution (if applicable): $ 0

Account Number: NA

John White 4-4-08
Dean Date

D. Johnson

This Section to be completed by the Office of Academic Affairs

Previous PDG Award final report received: Yes____ No____ n/a

PDC Committee Award Recommendation: Yes____ No____

PDC Committee Proposal Rank: ____ of ____ Total Proposals.

Recommendation of VPAA: Yes____ No ____ Recommendation of President: Yes____ No ____

Award Date: ____

B. ABSTRACT Traditional electronics work by tracking the amount of charge that flows through the device. This is quickly becoming a problem if manufacturers are to continue to build smaller, faster chips. One possible solution is to develop devices that track both the amount of charge and the spin of the electron. This exciting new field is known as "spintronics" and has the potential to revolutionize the electronics industry.[1-4] In order for a spintronic device to work three requirements must be met: 1) a source of spin polarized electrons must be available, 2) this spin-polarized current must maintain it's spin orientation across the source-device interface and 3) the electrons must maintain their spin orientation while in the device. The focus of this collaborative project is the last criteria. Specifically, we plan to prepare a series of "ferromagnetic semiconductors" by varying the manganese (Mn) doping levels using molecular beam epitaxy (MBE). The spin-dependent transport properties will then be measured using Hall-Effect. We request funds for the purchase of supplies and equipment to complete the project.

C. PURPOSE / OBJECTIVES The purpose of this research activity is to study the electron-spin transport properties of epitaxially grown Manganese (Mn)-doped GaAs. In order to accomplish this we will attempt to meet the following objectives:

- Purchase and install a cryopump and compressor for the sample growth chamber
- Connect growth chamber system to control electronics
- Pump down sample preparation system to ensure proper vacuum environment
- Prepare samples for transport properties and growth rate calibrations
- Grow Mn – doped GaAs samples

D. SIGNIFICANCE / NEED Traditional electronic components such as *pn*-junction diodes or field–effect transistors (FET) essentially work by keeping track of the amount of charge flowing through the device. As these devices become increasingly smaller, the amount of charge (and hence

the number of electrons) available to switch gates "on" and "off" is approaching a fundamental limit as described by Moore's Law (see figure 1).[1-2] One possible solution to this problem is to increase the size of the microchip to accommodate more transistors. The problem with this approach is that the increase in the number transistors results in an increase in heat that negatively affects overall chip performance.

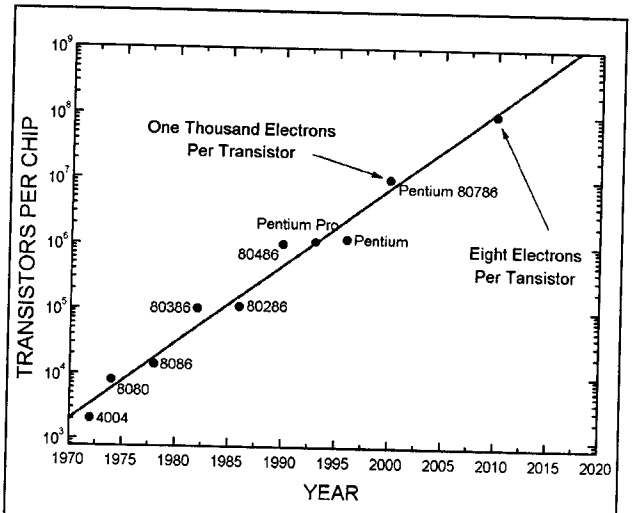

Figure 1 – A graph illustrating Moore's Law which says that the number of transistors on a chip doubles roughly every five years.

Another possible solution is the development of a novel device that not only tracks the charge of the electrons but also their spin. One proposed device, known as the spin field-effect transistor (or spin-FET) would use the precessions of a spin-polarized current to increase the gate switching speed by a factor of ten.[1-4] Additionally, it is predicted that the spin-FET would also allow for a new multi-level logic. So, instead of the computer translating "0" (off) or "1" (on) bits into commands, the spin-FET offers the possibility for higher order logic such as "0", "1", "2", etc. In order for a "spintronic" device to work it must have a long spin relaxation time, this is the amount of time an inject electron will maintain it's spin orientation. One promising material system is ferromagnetic semiconductors such as InMnAs, GaMnAs, and Mn-doped GaN.[5] These systems have been shown to become magnetic at temperatures ~ 100K.[6-7] In order for these materials to be used for devices it is necessary to measure the spin-dependent transport properties of these systems.

E. PROCESS FOR ATTAINMENT OF OBJECTIVES / GOALS In order to achieve the goals of this study we will first need to prepare our sample preparation chamber by pumping out all the contaminate gases using a high-capacity cryopump. When the chamber has achieved a low pressure ($\sim 10^{-9}$ Torr) we will remove the native oxide layer from the GaAs substrate. After the oxide layer has been removed we will grow a buffer layer followed by the Mn-doped transport layer. Our study will prepare a series of samples with different Mn doping levels. The spin dependent transport properties will then be analyzed using a technique known as Hall-Effect.

F. DISSEMINATION OF RESULTS The results of this project will be prepared in a final report submitted to the PDG committee. Additionally, the PI(s) will present their findings at the Arkansas Academy of Sciences Annual Meeting. Furthermore, it is possible that this work will be written as a publication submitted to the Journal of Crystal Growth.

G. REPEATED REQUESTS The PI has never received funding from this committee.

H. BUDGET

1. Non-work study stipend
   Fringe benefits @ .27% (27/100 percent) of non-work study stipend — $400.00

2. Supplies (please list items to be purchased and estimated price per item including taxes and shipping, if appropriate):

Gallium Ingot (Ga 99.9999999% pure)	Estimated Price	$1,025.00
Indium Ingot (In 99.9999999% pure)	Estimated Price	$1,400.00
Manganese Sourse (Mn 99.9999% pure)	Estimated Price	$875.50
	Total estimated supplies	$3,300.50

BUDGET CONTINUED

3. *Capital Outlay (please list items to be purchased and estimated price per item including taxes and shipping, if appropriate):

Cryopump	Estimated Price	$5,525.00
Compressor	Estimated Price	$2,812.50
	Total estimated capital outlay	$8,337.50
	Total Proposed Budget	$12,038.00

4. Matching Funds

Center for Energy Studies Grant	$3,300.00
Department of Physical Science	$443.00
NASA Collaborative Grant*	$3,000.00
Total matching funds	$6,743.00

TOTAL REQUESTED FROM PROFESSIONAL DEVELOPMENT GRANT $5,295

I. BIBLIOGRAPHY:

1. "Spin-Polarized Transport" Gary A. Prinz, *Phys. Today* 48(4) 58 (1995)
2. "Electron spin and optical coherence in semiconductors" Awschalom, D. D., Kikkawa, J. M., *Phys. Today* 52(6) 33 (1999)
3. "Electrical spin injection in a ferromagnetic semiconductor heterostructure" Ohno, Y., Young, D.K., Beschoten, B., Matsukura, F., Ohno, H., Awschalom, D.D., *Nature* 402(6763) 790 (1999)
4. "Spin-valve effects in a semiconductor field-effect transistor: A spintronic device" Gardelis, S., Smith, C. G., Barnes, C. H. W., Linfield, E.H., Ritchie, D.A. *Phys. Rev. B* 60(11) 7764 (1999)
5. "Observation of spin injection at a ferromagnet-semiconductor interface", Hammar, P.R., Bennett, B.R., Yang, M.J., Johnson, M., *Phys. Rev. Lett.* 83(1) 203 (1999)
6. "Injection and detection of a spin-polarized current in a light-emitting diode" Fiederling, R., Keim, M., Reuscher, G., Ossau, W., Schmidt, G., Waag, A., Molenkamp, L.W., *Nature* 402(6763) 787 (1999)
7. "Lateral drag of spin coherence in gallium arsenide" Kikkawa, J. M., Awschalom, D. D., *Nature* 397(6715) 139 (1999)

*NASA Proposal is currently being submitted with University of Arkansas – Little Rock, University of Arkansas at Pine Bluff, if funded monies will be used for matching funds.

J. APPLICATION VITA

Patricia S. Buford
Assistant Professor of Electrical Engineering

Professional Preparation	Ph.D. Applied Science in Engineering Science and Systems University of Arkansas at Little Rock, Little Rock, Arkansas, May 2007
	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.
Additional Teaching Experience:	1989-1993: Assistant Professor, Arkansas State University Beebe.
	1984-1985: Research Assistant, Graduate Institute of Technology, Branch of the University of Arkansas, Fayetteville.
	1980-1987: Adjunct Instructor, University of Arkansas at Little Rock.
Industrial Experience:	1978-1985: Technical Research Engineer, Arkansas Power and Light Company, (AP&L). Projects include: Attic Ventilation Study; Active and Passive Solar Energy Studies; and Cogeneration Studies.
	Distribution Engineer, Arkansas Power and Light Company, (AP&L), 1975-1978. Five-year distribution planning studies for several geographic areas of Central Arkansas.
	Distribution Engineer, Memphis Light, Gas, and Water Division, 1974-1975. Distribution planning studies for a geographic area of Memphis and Shelby County, Tennessee.
Registration:	Registered Professional Engineer in Arkansas, 1984-present.
Memberships:	Institute of Electrical and Electronic Engineers (IEEE) – 33 years
	American Society for Engineering Education (ASEE) – 8 years
Institutional Service:	Student Advisor

Member, Faculty Welfare (2007-)

Member, Faculty Senate (2006-)

Prepare and Edit the EE Department Newsletter & Brochure (2006-)

Chair, Convocations and Programs Committee (2005-06)

Admissions, Academic Standards, and Student Honors Committee (2005-06)

Faculty Advisor, Student Chapter of IEEE. (2004 -)

Curriculum Committee Chairman, Electrical Engineering (2001 -)

Faculty Mentor, Robotics Team (2005 -)

Established, supervised and coordinated Engineering Learning Lab (2000 - 2006)

Who's Who Committee (2000-01)

Professional Service:

Past President of the Arkansas River Valley Section, IEEE – 3 years

Student Activities Chairman, Arkansas River Valley Section, IEEE – 2 years.

Community Service:

Director, St. Leo's Catholic Campus Ministry 1995 -

Spring Break Alternative Work Trips –7 years

All night study session from Sunday – Thursday during finals week – each semester last 10 years

Help Network Board Member 2000 - 2001

Director of Religious Education and Youth Minister St. John's Church 1993 - 2000

Research:

Co-Principal Investigator of Arkansas Space Grant Consortium program entitled, "Autonomous Robotics Challenge" awarded September, 2006, $2,500.

Co-Principal Investigator of Arkansas Tech University Faculty Undergraduate Research Grant, "Growth and Characterization of Magnetic Nanoparticles" awarded March, 2006, $2,000.

Co-Principal Investigator of Arkansas Tech University Faculty Undergraduate Research Grant entitled, "Mock Automated Warehouse Autonomous Robotics

Project" awarded January, 2006, $2700.

Co-Principle Investigator of Arkansas Space Grant Consortium program entitled, "Portable Spectrograph for Astronomical Observation" awarded 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: *A Mathematical Model of the Human Uterine Myocyte*, Arkansas Biomedical Engineering Forum, UAMS, June 8, 2007.

Innovative Air Flow Measurement, 2004 American Society for Engineering Education Midwest Section Conference. October 1, 2004.