REQUIRED COVER PAGE

APPLICATION FOR FACULTY RESEARCH GRANT

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

Choose one:	
[ ] Creative Project	**Date of Last FRG Award** (Semester and Year awarded): Spring 2006
[X] Research Projec	**Date of ATU Faculty Appointment** (Semester and Year): Fall, 2003

1. Project Title: X –Ray Fluorescence of Thin Films

2. Name of Principal Investigator/Project Director: Daniel Bullock

3. School (abbrev): PLS **4. Department:** Physical Science

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

7. Amount Requested: $2,000 **8. Total Cost of Project:** $ 2,320

9. Does this project involve: **10. Duration of Project:** 04/07 – 04/08

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): $ 320

Account Number: ATU Undergraduate Research Grant

Jeff W Ratts 2007 Jan 16
Chairperson **Date**

School Contribution (if applicable): $_____

Account Number: _____

[signature] 1-16-07
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: 1/25/07

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

B. ABSTRACT X-Ray fluorescence and atomic force microscopy are powerful tools used to analyze the composition and atomic structure of advanced thin film systems. Thin films are material layers with a thickness 100 times thinner than the thickness of a human hair. These films show great promise in increasing the efficiency of photovoltaic cells. The cell's efficiency is directly related to the uniformity and the thickness of the thin film. In this project we propose to deposit thin films under a variety of deposition parameters and analyze them using both x-ray fluorescence and atomic force microscopy.

C. PURPOSE / OBJECTIVES The objective of this project to measure the composition and structure of metallic thin films as a function of deposition conditions (i.e. sample temperature, flux, etc).

D. SIGNIFICANCE / NEED Photovoltaics[1] is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity.

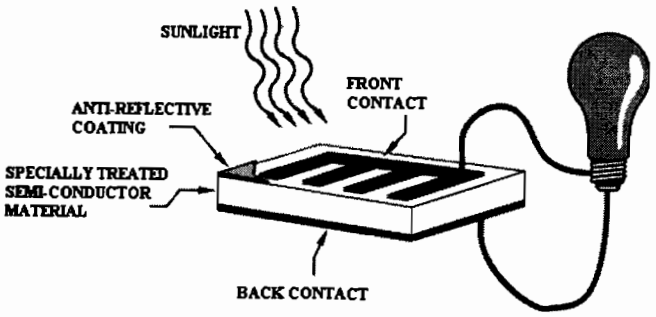

Figure 1 illustrates the operation of a basic photovoltaic cell, also called a solar cell. Solar cells are made of the same kinds of semiconductor materials, such as silicon, used in the microelectronics industry. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached

to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current -- that is, electricity. This electricity can then be used to power a load, such as a light or a tool.

Today's most common PV devices use a single junction, or interface, to create an electric field within a semiconductor such as a PV cell. In a single-junction PV cell, only photons whose energy is equal to or greater than the band gap of the cell material can free an electron for an electric circuit. In other words, the photovoltaic response of single-junction cells is limited to the portion of the sun's spectrum whose energy is above the band gap of the absorbing material, and lower-energy photons are not used.

One way to get around this limitation is to use two (or more) different cells, with more than one band gap and more than one junction, to generate a voltage. These are referred to as "multijunction" cells (also called "cascade" or "tandem" cells). Multijunction devices achieve a higher total conversion efficiency because they can convert more of the energy spectrum of light to electricity. The efficiency of these multijunction PV cells is directly related to the thickness and composition at the junctions of the different cells. Impurity atoms or defects at these junctions will significantly decrease the number of photons converted to electrons thereby inhibiting the electrical power output. Understanding the surface physics involved in the production of these junctions will lead to more efficient PV cells.

E. PROCESS FOR ATTAINMENT OF OBJECTIVES / GOALS To achieve the goals of this project we will request a variety of samples from the University of Arkansas's Center for Materials Research and Engineering (MRSEC). We will then use both x-ray fluorescence (XRF)[2-3] and atomic force microscopy to analyze these samples.

XRF is the emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays. The phenomenon is widely used for chemical analysis, particularly in the investigation of metals, glass, ceramics and building materials, and for research in geochemistry, forensic science and archaeology. The fluorescent radiation can be analyzed either by sorting the energies of the photons (energy-dispersive analysis) or by separating the wavelengths of the radiation (wavelength-dispersive analysis). Once sorted, the intensity of each characteristic radiation is directly related to the amount of each element in the material.

Atomic Force Microscopy (AFM)[4-5] is a very high-resolution type of scanning probe microscope, with demonstrated resolution of fractions of an Angstrom, more than 1000 times better than the optical diffraction limit. AFM is one of the foremost tools for imaging, measuring and manipulating matter at the nanoscale.

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											
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, 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 This proposal is not a repeat project.

H. BUDGET

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

1.	Non-work study stipend	0.00
	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):	
	*X-Ray Energy Analyzer	2320.00
	Total estimated supplies $	**2320.00**
3.	Travel (please list travel expenditures by date and estimated costs):	
	** Arkansas Academy of Science Annual Meeting, April 2007	0.00
	Total estimated travel $	**0.00**
	TOTAL PROPOSED BUDGET $	**2320.00**

* $320 of this money will come from a Tech Undergraduate Research Grant that was awarded in the Fall of 2006.
** This meeting will be held on the Lake Point Conference Center so travel money will not be necessary.

I. BIBLIOGRAPHY

1. *How do Photovoltaics Work?*, Gil Knier, NASA Scientific Documents, science.nasa.gov.

2. Bertin, E. P., *Principles and Practice of X-ray Spectrometric Analysis*, Kluwer Academic / Plenum Publishers, New York (1975).

3. Jenkins, R., *X-ray Fluorescence Spectrometry*, Wiley, New York (1999).

4. R. Wiesendanger, *Scanning Probe Microscopy and Spectroscopy*, Cambridge University Press, Cambridge (1994).

5. D. Sarid, *Scanning Force Microscopy*, Oxford Series in Optical and Imaging Sciences, Oxford University Press, New York (1991)

J. APPLICATION VITA (maximum: 3 pages)

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EDUCATION

UNIVERSITY OF ARKANSAS — Fayetteville, AR
Ph. D. Physics (Nanoscience) — May 2001

UNIVERSITY OF ARKANSAS — Fayetteville, AR
M. S. Applied Physics — May 2000

ARKANSAS TECH UNIVERSITY — Russellville, AR
B. S. Physics — May 1997

EXPERIENCE

Assistant Professor of Physics
Arkansas Tech University, Department of Physical Science, Russellville, AR, 5/2003 – present, Department Head: Professor Jeff Robertson
Teaching Activities

- Awarded "Outstanding Professor of the Year" by the Arkansas Tech University Student Government Association (2006).
- Implemented a campus wide teaching initiative using personalized wireless remote control technology to enhance the teacher-student engagement process.
- Averaged 4.50 out of 5.00 from 2004-2006 on all course student evaluations compared to the department average of 4.34 over the same three years.
- Upper division courses taught: Solid State Physics, Statistical Mechanics, Advanced Modern Physics Laboratory, Introduction to Nanoscience.
- Lower division courses taught: Physical Principles I & II (algebra based physics for pre-professional students), General Physics I & II (calculus based physics for engineering students), Physics I & II Lab, Introduction to Physical Science (freshman level introductory physics course for non-majors), Introduction to Physical Science Lab

Assistant Professor of Physics continued

Research Activities

- Awarded a "Nanoscience Education Initiative" grant from the Arkansas Tech University Office of Academic Affairs worth $100,000 (2006).
- Principal Investigator on funded Center for Energy Studies proposal titled, "Nanoscale Surface Effects on Biological Solar Cells", worth $10,000 (2006).
- Principal Investigator on funded Arkansas Tech University Undergraduate Research Council proposal title, "Domain Mapping of Magnetic Nanoparticles" worth $2,500 (2006). This project includes funding to support one undergraduate student.
- Awarded summer research fellowship with the Materials Science and Engineering Center at the University of Arkansas for, "Cross – Sectional Scanning Tunneling Microscopy of Quantum Dot Arrays", worth $7,000 (2006).
- Principal Investigator on funded Arkansas Tech University Professional Development Grant entitled, "Cross Sectional Scanning Tunneling Microscopy (STM) Studies of Quantum Nanostructures", worth $1,000 (2006).
- Co-Principal Investigator on funded Arkansas Space Grant Consortium – NASA proposal entitled, "Autonomous Warehouse Robot", worth $3,486 (2005). This robot was entered into the South Central robotics competition and won 1st place against school such as Louisiana State University, University of Texas – Austin, Texas A & M, and Texas Tech University.
- Principal Investigator on funded Arkansas Space Grant Consortium – NASA proposal entitled, "Sample Preparation Algorithms for Cross Sectional Scanning Tunneling Microscopy Experiments", worth $4,150 for one year (2005).
- Awarded summer research fellowship with the Materials Science and Engineering Center for "Cross-Sectional Scanning Tunneling Microscopy on III-V Based Nanostructures", worth $13,000 (2005).
- Principal Investigator on funded 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 (2005).
- Co-Principal Investigator on funded Arkansas Space Grant Consortium – NASA grant entitled, "Portable Spectrograph for Astronomical Observations", worth $18,175 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 (2005).
- Principal Investigator on funded 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.
- Attended the 2004 Arkansas Tech University Undergraduate Research Symposium, Russellville, AR. – 04/14/04.
- Attended the 88th Annual Meeting of the Arkansas Academy of Science, Jonesboro, AR. – 04/02/04 – 04/03/04.

Assistant Professor of Physics continued

Research Activities

- Principal Investigator on funded 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.
- Co-Principle Investigator on funded Arkansas Space Grant Consortium – NASA grant entitled, "Practical Solar – Electric Car", worth $5,350 for one year.

Service Activities

- Appointed to University Assessment Committee (3 year appointment).
- Elected to University Library and Media Committee.
- Served on Nanotechnology Group formed by the Vice-President of Academic Affairs.
- Served on the selection committee for the Truman McEver and the Ruben Caudle scholarship awards.
- Served on Faculty Peer Review Committee (2 years).
- Served on Faculty Athletic Committee (elected 2 years, and appointed by the President of ATU one year).
- Chaired Department of Physical Science Machine Shop Committee.
- Taught Upward Bound Math & Science Students during a six-week summer program.
- Principal Investigator on funded 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 (2005).
- Guest speaker for Upward Bound Math & Science Winter Program.
- Judged Student Organization Booths for 2006 Homecoming.
- Judged Student Organization Floats for 2006 Homecoming Parade.
- Judge for the Arkansas Junior Humanity and Science Symposium.
- Attended an Assessment Conference, Little Rock, AR – 04/30/04.
- Attended an Assessment Workshop, Little Rock, AR – 05/25/04.

OFFICE OF ACADEMIC AFFAIRS

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fax: 479-968-0644

www.atu.edu

January 25, 2007

Dr. Daniel Bullock
McEver Hall
Arkansas Tech University
Russellville, AR 72801

Dear Dr. Bullock:

Congratulations! Academic Affairs is pleased to announce your application for the Spring, 2007 Faculty Research Grant has been recommended by the Faculty Salary, Benefits, and Awards Committee. Based on this recommendation, Academic Affairs has approved the $2,000.00 budget. Requisitions regarding the grant will be processed through your Dean's office and should be expended by June 30, 2007.

Your research on this project is sure to not only benefit your department, but Arkansas Tech University as a whole. We wish you success with this endeavor.

Sincerely,

Jack Hamm
Vice President for Academic Affairs

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