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14. ABSTRACT
This proposal introduces a new program in DNA technology research. It will also focus on chemical, material, and environmental sciences, as well as academic teaching in these areas. The major piece of equipment that is the subject of this application is the Atomic Force Microscope (AFM). Using this equipment, faculty and students will seek to explore two questions, (1) “What are some of the changes in the electric properties (voltage and current) of surfaces with DNA nanostructures binding on surfaces?”, and (2) “Can we reposition DNA nanostructures bound to a surface, i.e. can we control binding and orientation with the use of an applied potential on a patterned surface?”

15. SUBJECT TERMS
AFM, DNA nanostructures, electrochemical

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Valerie Goss
UU	UU	UU	UU		19b. TELEPHONE NUMBER 773-995-3892

Report Title

Final Report: Electrochemical Positioning of Ordered Nanostructures

ABSTRACT

This proposal introduces a new program in DNA technology research. It will also focus on chemical, material, and environmental sciences, as well as academic teaching in these areas. The major piece of equipment that is the subject of this application is the Atomic Force Microscope (AFM). Using this equipment, faculty and students will seek to explore two questions, (1) "What are some of the changes in the electric properties (voltage and current) of surfaces with DNA nanostructures binding on surfaces?", and (2) "Can we reposition DNA nanostructures bound to a surface, i.e. can we control binding and orientation with the use of an applied potential on a patterned surface?". This proposal is designed to increase the capabilities at Chicago State University (CSU) to conduct research and to train students in areas important to the Army Research Laboratory. We will pursue research in the area of biomaterials and devices that have controllable features on the nanometer scale (tens of angstroms). Ultimately, undergraduate students who are mostly located on the economically-deprived south side of Chicago will be better prepared for new technology-driven jobs.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

List of Conference Poster Presentations
Louis Stokes Alliance for Minority Participation, Spring Conference, February 26-27, 2016:

1. Synthesis of Carbon Nanostructures Using Microwave Irradiation
Jasher Garbutt and Valerie Goss
Department of Chemistry, Physics, and Engineering Studies
Chicago State University, Chicago, IL 60628
2. Nanostructure Binding Behavior on Modified Surfaces
Keenan P Linder, Reginald Griffin and Valerie Goss
Department of Chemistry, Physics, and Engineering Studies
Chicago State University, Chicago, IL 60628
3. Binding Nanoscale Electrical Components Comprised of DNA Origami to Meteorite and Mica Surfaces
Curry Williams(1), Valerie Goss(2) (1)Department of Electrical & Computer Engineering, Illinois Institute of Technology, Chicago, Il 60616 (2)Department of Chemistry, Physics, and Engineering Studies, Chicago State University, Chicago, IL 60628

Number of Presentations: 3.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:...... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):...... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:...... 0.00

Names of Personnel receiving masters degrees

NAME
Total Number:

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

Instrument Acquisition:
The new Atomic Force Microscope arrived at CSU on March 26, 2015. The CSU shipping department received the boxed/crated items, which were then transported locally to the Williams Science Building at CSU. CSU movers and carpenters assisted Bruker's on site installer with assembly and installation. Installation and set-up was completed in 1 day, which was then followed by 2 days of instrument training.
Instrument Description:
The acquisition of Bruker's Dimension Icon® Atomic Force Microscope (AFM) System allows young scientists at Chicago State University an introduction to nanoscale research. This instrument was developed by the Bruker Corporation, leaders in science scanning probe microscopy. The Dimension Icon is capable of both, AFM and STM (scanning tunneling microscopy). The AFM system delivers low drift and low noise that is perfect for our laboratory which is on the second floor of the main science building at Chicago State University. The instrument has fast performance due to the ScanAsyst® mode which employs automatic image optimization technology. This feature enables fast and consistent results. The decision to purchase this model is due to our student-focused research program, and allows for the development of experienced users. There is no trade-off in performance nor usage, so high –resolution images are obtained with ease.

Technology Transfer

Contract Number	W911NF-15-1-0029

Army Research Office
Instrumentation Grant
Award Recipient: Chicago State University
Purchased Item: **Bruker, Dimensions Icon, Atomic Force Microscope**
Principal Investigator: Valerie Goss
Key Personnel: Amber Wise, Asare Nkansah, David Kanis

Equipment Grant Contract Date:	Feb 01, 2015
Equipment Delivery Date:	March 26, 2015
Report Due Date:	April 30, 2016

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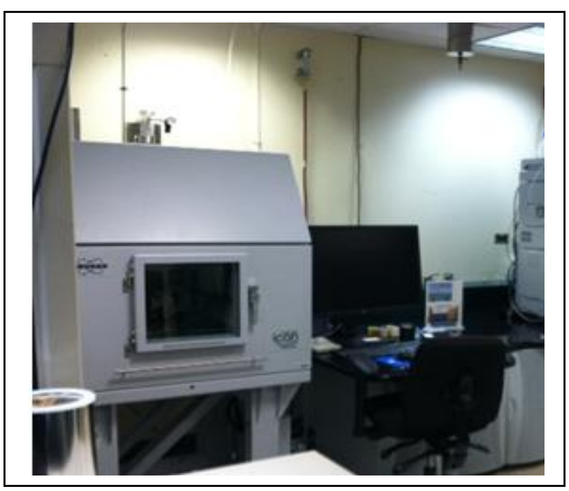

System Specifications:
x-y scan range, 90 µm x 90 µm
z range, 10 µm in imaging and force modes
x-y position noise ,< 0.10 nm RMS
vertical noise floor, <30 pm
sample holder, 15 mm thick 210 mm vacuum chuck
microscope optics
nanoScope V controller
Vibration isolation
Acoustic isolation
AFM SCAN head
STM SCAN head
Icon System Workstation, Icon-Monitor
NanoScope Analysis Software Package

Instrument Highlights:

The new instrument has been in operation since installation by students and faculty. We have trained students, presented data, provided demonstrations, and used the instrument in course work at CSU.

Trained three undergraduate students on the AFM; K. Linder, L.Boyd, Y.Freeman
3 research poster presentation using images obtained from the AFM
Outreach, such as AFM Tours for Chicago Public School High School Students
Biology 4450/5450, AFM Electron Microscopy lecture/demonstration
Chemistry 4210, AFM Microscopic Physical Chemistry Laboratory

Instrument Future Plans:

Using the AFM, we seek to explore two fundamental questions, (1) "What are some of the changes in the electric properties (voltage and current) of surfaces with DNA nanostructures binding on surfaces?", and (2) "Can we reposition DNA nanostructures bound to a surface, i.e. can we control binding and orientation with the use of an applied potential on a patterned surface?". Thus far, we have had great success at making DNA nanostructures and imaging them. We have mastered imaging in air and in liquid. Our next step is to show that we can make images on semiconducting surfaces and to show that we can modify the surface of DNA nanostructures with electro-active molecules. We will use highly doped silicon with gold electrical connections in our circuit design. We have seen that current-voltage (I-V) cures in conductive AFM imaging (C-AFM) to determine change in topography, as well as changes in electrical behavior at the surface.

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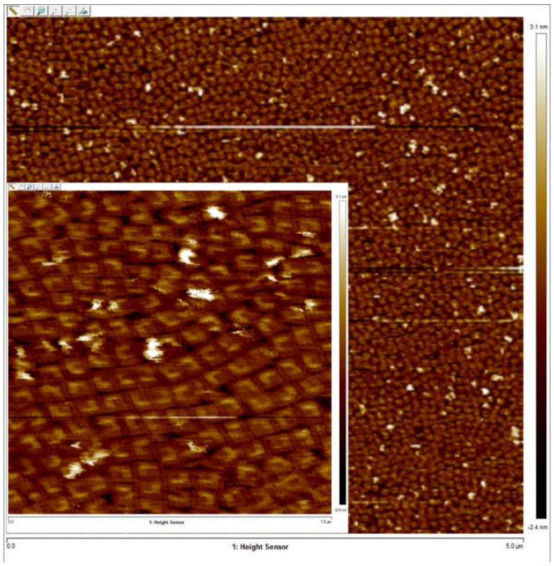
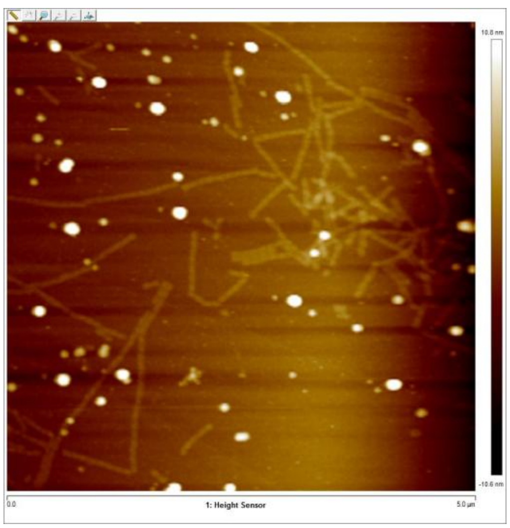
Curry Williams[1], Valerie Goss[2]
[1]Department of Electrical & Computer Engineering, Illinois Institute of Technology, Chicago, Il 60616 [2]Department of Chemistry, Physics, and Engineering Studies, Chicago State University, Chicago, IL 60628

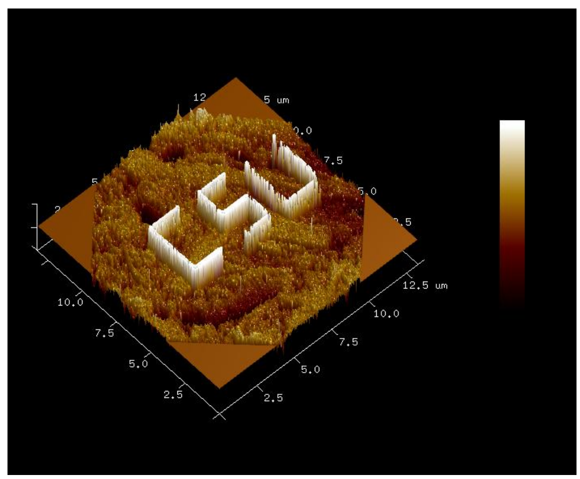
AFM IMAGES



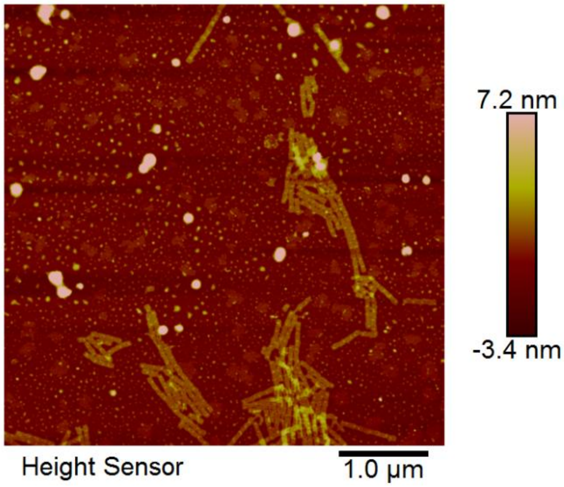
AFM images of DNA origami on mica shows the wide area scan. The insert, high resolution image which show the “L” features on the surface of DNA origami rectangles, not seen in the lower resolution image. The white flecks in the image are fragments on unannealed DNA. Image taken by student, Keenan Linder.



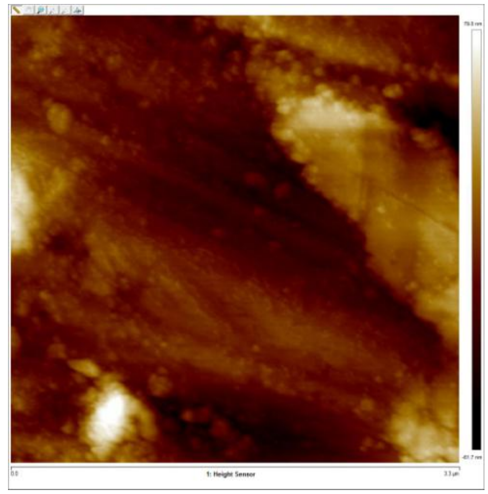
DNA origami images showing long-chain formation of DNA. Image taken by Curry Williams, student.



CSU structure formed on polyurethane surface (surface of a CD), inscribed using nanoindention. Image taken by Yvonne Freeman, student.



DNA origami images showing long-chain formation of DNA. Image taken by Keenan Linder, student.



AFM image of an iron meterorite surface shows variable rough surface. Image taken by Curry Williams, student

Application Modes:

- Scanning Spreading Resistance Microscopy (SSRM) Application Module for the Dimension SPMs
- PeakForce TUNA Application Module for Dimension Icon SPM
- TUNA Mode
- TR TUNA uses torsional resonance
- Conductive AFM
- Magnetic AFM
- Liquid AFM
- NanoMan/Nanolithography Software for NanoScope v9
- 35°C to 250°C High Temperature Heater/Cooler Package for Dimension SPMs
- Integrated Acoustic and Vibration Isolation Enclosure for the Dimension FastScan and Icon SPMs