AFRL-AFOSR-VA-TR-2021-0029

Equipment for the Fabrication of Nanoscale Devices

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14. ABSTRACT
The direct integration of electrical devices and biological systems remains a grand challenge in modern science and medicine. Recently, field effect transistors from graphene have emerged as platforms for probing biological systems, such as living cells and tissues. Graphene represents an ideal material for these studies due to its superior electrical, physical, chemical, and mechanical properties. However, electrically interfacing with biological or physiological systems across multiple relevant length scales (from nanometers to micrometers to centimeters) requires the fabrication of massively parallel arrays of nanoscale graphene-based transistors. The manufacture of such arrays necessitates the acquisition of a glove box-integrated electron beam physical vapor deposition system. We propose the acquisition of this commercial instrument, thereby paving the way for our research on bioelectronic devices.

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Principal Investigator Name:	Prof. Alon Gorodetsky
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Grant/Contract Title:	(DURIP 14RT0602) Equipment for the Fabrication of Nanoscale Devices
Grant/Contract Number:	FA2386-14-1-3026
Program Manager:	Dr. Patrick Bradshaw
Report Type:	Equipment Report

Reporting Period Start Date:	09/23/2014
Reporting Period End Date:	09/22/2016

Abstract:

Abstract from Original Proposal

The direct integration of electrical devices and biological systems remains a grand challenge in modern science and medicine. Recently, field effect transistors from graphene have emerged as platforms for probing biological systems, such as living cells and tissues. Graphene represents an ideal material for these studies due to its superior electrical, physical, chemical, and mechanical properties. However, electrically interfacing with biological or physiological systems across multiple relevant length scales (from nanometers to micrometers to centimeters) requires the fabrication of massively parallel arrays of nanoscale graphene-based transistors. The manufacture of such arrays necessitates the acquisition of a glove box-integrated electron beam physical vapor deposition system. We propose the acquisition of this commercial instrument, thereby paving the way for our research on bioelectronic devices.

Acquired Equipment Key Components and Specifications

(A) EvoVac Base Integrated System (Advanced PC/PLC Automation)
(1) Frame and Baseplate
(2) System Control
(3) Vacuum Pumping and Measurement
(4) 8 in wide × 20 in deep × 28 in high: Aluminum High Vacuum Box Chamber
(5) Viewport for Chamber Hinged Door
(6) Thermal Resistive Deposition/Evaporation Sources and Power Supply
(7) Water Cooled Electrical Feedthrough
(8) Resistive Source Electrical Clamp Extension
(9) PC Based Deposition Rate and Film Thickness Control
(10) QCM Deposition Rate Sensors
(11) Variable Angle Substrate Stage
(12) Backside Quartz Lamp IR Substrate Heating for Variable Angle Stage
(13) Source Shutters and Split 2-Piece Substrate Shutter

(14) Variable Angle Stage – Sample Holder Assembly

(B) 4-Port Innovative Technologies Integrated Glove Box
(1) Integration package for Angstrom Deposition System
(2) Atmosphere control
(3) 6 in Diameter Antechamber

Total Expenditures

The total final associated expenditures were $340,740.00, per the costs in the budget.

Distribution Statement:

SF298 Form:

Report Document

Archival Publications:

Changes in Research objectives:

This project involved the design, acquisition, manufacture, installation, and testing of a customized glove box-integrated, electron beam evaporator deposition system from Angstrom Engineering with advanced substrate rotation/tilting and deposition parameter control capabilities. Some of the cutting-edge functionality of the system is described in instructional videos online, which were filmed by Angstrom Engineering with the Gorodetsky Group (see https://www.youtube.com/watch?v=NXtHO6LxAZk and https://www.youtube.com/watch?v=m8dC4LY1edQ&t=303s). The described system was designed in close collaboration with Angstrom Engineering; installed in the California Institute for Telecommunications and Information Technology (see, for example, http://www.calit2.uci.edu/building-overview/labs/laboratory-for-cephalopod-inspired-materials/); and maintained and operated in close collaboration with the Irvine Materials Research Institute and the Henry Samueli School of Engineering. The testing and maintenance of the system has involved a large number of personnel with experience in the deposition and/or characterization of inorganic and organic materials. The individuals associated with the early stages of installing the deposition system and validating its capabilities were

Change in

AFOSR Program Manager, if any:	Steven Jim, Maurizio Follador, George Stiubianu, David Dibble, Qiyin Lin, Long Phan, Erica Leung, Kyle Naughton, Priyam Patel, and Chengyi Xu. Some of these personnel were super-users who trained other individuals in the proper operation and maintenance of the system. In addition, the system has enabled a number of high-impact publication and general substantial international press (see, for example, https://twitter.com/afosr/status/1124365110980612096). As such, the system achieved its primary purpose of supporting high-impact activities in the Gorodetsky Group and also made a significant contribution to the campus infrastructure by becoming accessible to hundreds of other users on campus. Because of such arrangements, the system even ultimately ended up supporting the senior capstone design project of cadets from the United States Air Force Academy, thus directly and quantifiably contributing to the education of Air Force personnel. We note that the acquisition, installation, testing, operation, and maintenance of the described system was discussed with and approved by the cognizant AFOSR program manager, Dr. Patrick Bradshaw, during routine site visits and programmatic reviews. Moving forward, additional accessories have been and will be acquired as needed in order to maintain and upgrade the functionality of the system, based on changing project needs and objectives. The deposition system is expected to continue supporting and facilitating AFOSR- and DoD-funded research projects for the duration of its lifetime.
Extensions granted or milestones slipped, if any:	The one-of-a-kind instrument acquired under this award was designed to meet specific criteria for proper functionality, and the typical delivery time for a unique system of this kind is 4 to 6 months, with additional time required for testing and installation. Although the order for the equipment was placed at the end of November 2014, there were unexpected delays with regard to delivery, due to the requirement for additional system testing and verification. We therefore requested a no cost extension for the award, which was subsequently approved, to provide sufficient time not only for system installation but also for extensive experimental verification of its capabilities. This extension ensured that the system was fully capable of supporting the required grant activities upon installation, and the acquisition of the equipment were motivated in part by new research discoveries. The extension and all project objectives was discussed with and vetted by Dr. Patrick Bradshaw.

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