Active Project (2015 - 2017)

Fully Printed Flexible 4-bit 2D (4x4) 16-Element Graphene-Based Phased Array Antenna System, Phase II Project

SBIR/STTR Programs | Space Technology Mission Directorate (STMD)

ABSTRACT

Communication technologies support all NASA space missions, among which autonomous communication technologies are extremely beneficial to future missions, including the Asteroid Redirect Mission, and human expedition to Mars and beyond. Low-cost, high gain, light-weight, and flexible active antenna systems are highly desired. In this program, we propose to develop a fully flexible ink-jet printed monolithic graphene-based high frequency PAA communication system. The superior electronic, optical, mechanical, and thermal properties offered by graphene (carrier mobility ~ 200,000cm^2/V.s; optical transparency ~ 98%; high current density ~ 10^8A/cm^2; thermal conductivity ~ 5000W/mK) is expected to significantly enhance the system features compared to the state-of-the-art flexible antenna systems., with operating frequency in excess of 100GHz expected. In Phase I, we printed graphene field-effect transistors and demonstrated a high (38:1) On/Off ratio. Graphene patch antennas were demonstrated with higher gain than silver. Results also indicated the feasibility of reducing the antenna size for a given frequency without sacrificing the gain. Finally, a 2-bit 1x2 graphene PAA was fully printed, and beam steering of a 4GHz RF signal from 0 to 42.4 degrees was demonstrated. The antenna system also showed good stability and tolerance after 5500 bending cycles. In Phase II, the graphene material inks will be further optimized for achieving high performance FETs and conductive films. A fully packaged 4-bit 2D 4x4 S-band PAA on a flexible substrate will be developed, and performance features, including gain/efficiency, frequency range, bandwidth, power consumption, and lifetime/reliability, will be characterized. Additionally, a roll-to-roll process to scale-up production will be developed, and the feasibility of large antenna array manufacturing at low-cost will be demonstrated.

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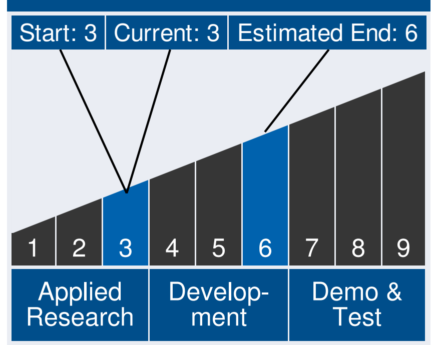
Technology Maturity



Management Team

Program Executives:

- Joseph Grant
- Laguduva Kubendran

Program Manager:

- Carlos Torrez

Continued on following page.

ANTICIPATED BENEFITS

To NASA funded missions:

Potential NASA Commercial Applications: (1) Active phased-array antenna: The flexible graphene-FET is an enabling technology for the construction of high-performance large-area flexible electronics that can be monolithically integrated with deployable antennas and provide distributed control, processing, and reconfiguration functions to achieve active and smart flexible/wearable and conformal antenna systems with enhanced functionalities. (2) High gain, frequency agile, multi-band reconfigurable antenna: The high-speed flexible electronics circuits offer embedded control and reconfiguration functions to achieve the desired gain and band-selection capabilities. (3) High power electronics: Graphene has carrier mobility exceeding 200,000 cm^2/V.s and has a large current-density carrying capacity of ~10^8 A/cm^2. Such a large current carrying capability allows this fully-printed transistor technology to be used in NASA's high power electronics applications. Overall, our technology will provide advanced navigation and communication in order to support several current and future NASA missions, including the asteroid redirect mission, human expedition to Mars, deep space exploration beyond low earth orbit, etc.

To the commercial space industry:

Potential Non-NASA Commercial Applications: Our high-frequency graphene-FET and ink-jet printing technology, apart from being valuable to NASA, can also be of commercial value to Non-NASA applications requiring ultra-sensitive and standalone devices. The commercial applications include: 1. RF identification tags; 2. Smart cards; 3. Electronic papers; 4. Large area flat panel displays and lighting; 5. Sensors; 6. Flexible large area solar cells and batteries; 7. Communication systems;

Management Team *(cont.)*

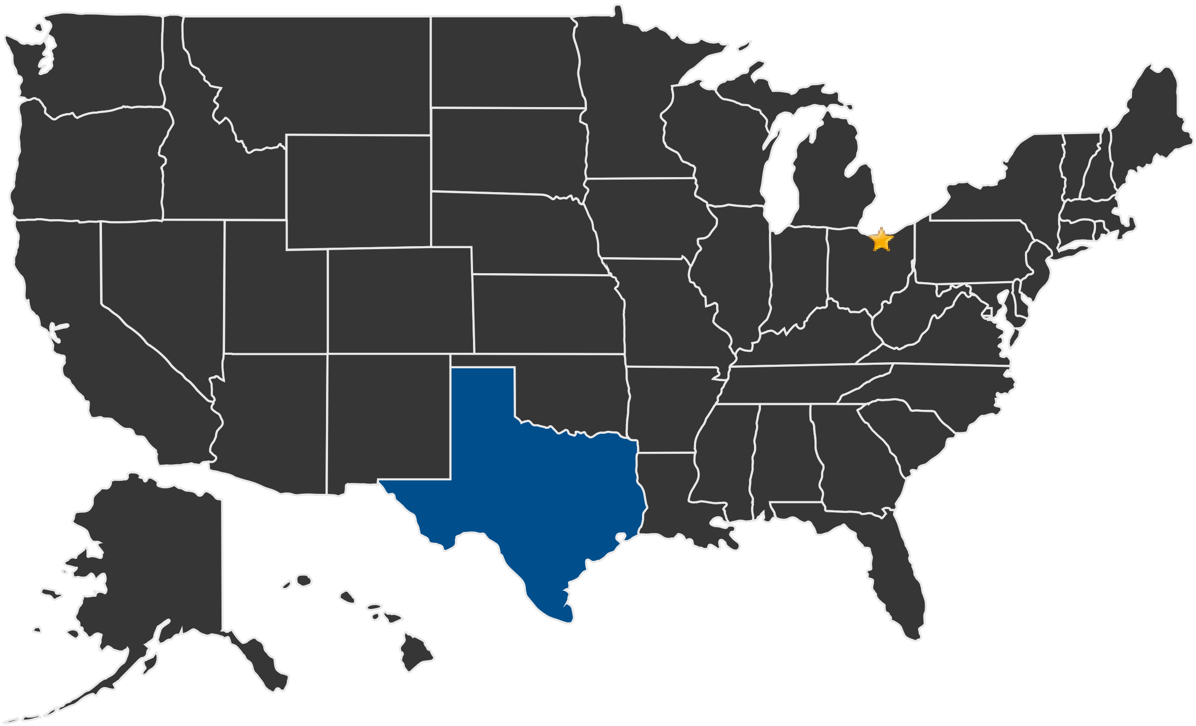
Principal Investigators:

- Harish Subbaraman
- Xiaochuan Xu

Technology Areas

Primary Technology Area:
Communications, Navigation, and Orbital Debris Tracking and Characterization Systems (TA 5)
└ Radio Frequency Communications (TA 5.2)
  └ Antennas (TA 5.2.6)
    └ Phased Array Antennas (TA 5.2.6.2)

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Glenn Research Center

Other Organizations Performing Work:

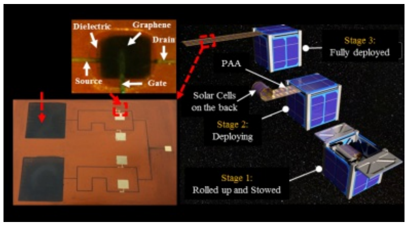
- Omega Optics, Inc. (Austin, TX)
- TEXAS STATE UNIVERSITY

PROJECT LIBRARY

Presentations

- Briefing Chart
  - (http://techport.nasa.gov:80/file/17788)

IMAGE GALLERY



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DETAILS FOR TECHNOLOGY 1

Technology Title

Fully Printed Flexible 4-bit 2D (4x4) 16-Element Graphene-Based Phased Array Antenna System

Potential Applications

(1) Active phased-array antenna: The flexible graphene-FET is an enabling technology for the construction of high-performance large-area flexible electronics that can be monolithically integrated with deployable antennas and provide distributed control, processing, and reconfiguration functions to achieve active and smart flexible/wearable and conformal antenna systems with enhanced functionalities. (2) High gain, frequency agile, multi-band reconfigurable antenna: The high-speed flexible electronics circuits offer embedded control and reconfiguration functions to achieve the desired gain and band-selection capabilities. (3) High power electronics: Graphene has carrier mobility exceeding 200,000 cm^2/V.s and has a large current-density carrying capacity of ~10^8 A/cm^2. Such a large current carrying capability allows this fully-printed transistor technology to be used in NASA's high power electronics applications. Overall, our technology will provide advanced navigation and communication in order to support several current and future NASA missions, including the asteroid redirect mission, human expedition to Mars, deep space exploration beyond low earth orbit, etc.