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The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

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RPPR Final Report
as of 31-Jan-2019

Agency Code:

Proposal Number: 67216MSREP **Agreement Number: W911NF-15-1-0425**
INVESTIGATOR(S):

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DUNS Number: 132051285 EIN: 746000813
Report Date: 20-Nov-2018 Date Received: 30-Jan-2019
Final Report for Period Beginning 21-Aug-2015 and Ending 20-Aug-2018
Title: Properties of Solution-Processed and Vapor-Grown 2D-Layered Materials and Heterostructures
Begin Performance Period: 21-Aug-2015 **End Performance Period:** 20-Aug-2018
Report Term: 0-Other

Submitted By: Luis Garcia Email: lgarcia37@utep.edu
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Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees: 0 **STEM Participants:** 0

Major Goals: see uploaded report under upload section.

Accomplishments: see uploaded report under upload section.

Training Opportunities: Nothing to Report

Results Dissemination: Nothing to Report

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: Graduate Student (research assistant)
Participant: Carlos Francisco De Anda Orea
Person Months Worked: 4.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Jay Amrish Desai
Person Months Worked: 12.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N

Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Ridwan Hossain Fayaz
Person Months Worked: 5.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: PD/PI
Participant: Anupama Kaul
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Gustavo Alberto Lara Saenz
Person Months Worked: 5.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Postdoctoral (scholar, fellow or other postdoctoral position)
Participant: Misook Min
Person Months Worked: 5.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Postdoctoral (scholar, fellow or other postdoctoral position)
Participant: Nirmal Adhikari
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Avra Sankar Bandyopadhyay
Person Months Worked: 5.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:

National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Jorge A Catalan Gonzalez
Person Months Worked: 4.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Srishti Chugh
Person Months Worked: 12.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Dr. Kaul moved from the University of Texas, El Paso (UTEP) to the University of North Texas (UNT) in the Fall of 2017 and continued to advise students at UTEP in her absence toward meeting the research goals of this project. The research outputs emerging from this grant are noted below. The Kaul group is grateful to the support received from Dr. Pani Varanasi's program at the ARO, and also to UTEP Engineering Dean, whose assistance has been invaluable during the transition process.

PUBLICATIONS

JOURNAL (published and/or in review)

1. A. Delgado, J. A. Catalan, H. Yamaguchi, C. N. Villarrubia, A. D. Mohite, and A. B. Kaul, " Opto-electro-mechanical percolative composites from 2D layered materials: properties and applications in strain sensing," manuscript in preparation, to be submitted.

2. J. Desai, S. Chugh, and A. B. Kaul, "Highly conductive, ink-jet printed graphene and WS2 inks scalable over large areas," submitted (in review).

3. S. Chugh, N. Adhikari, J. Lee, D. Berman, L. Echegoyen, and A. B. Kaul, "Dramatic enhancement of optoelectronic properties of electrophoretically deposited C60-graphene hybrids," to be submitted.

4. J. Desai, N. Adhikari, A. S. Bandyopadhyay, and A. B. Kaul, "High photoresponsivity in an all ink-jet printed heterostructure WS2-graphene photodetector," manuscript in preparation, to be submitted.

5. J. Desai, A. S. Bandyopadhyay, and A. B. Kaul, "Dielectric boron nitride inks in a metal-insulator platform and its photoinduced capacitance modulation," manuscript in preparation, to be submitted, 2018.

6. S. Chugh, N. Adhikari, M. Min, L. Echegoyen, and A. B. Kaul, "Endohedral-doped graphene with ScN@C80 and La@C82 for a new class of optoelectronic devices," manuscript in preparation, to be submitted.

7. S. Chugh, A. S. Bandyopadhyay, R. Hossain, N. Adhikari, M. Min, L. Echegoyen, and A. B. Kaul, "Photo-induced electron transfer and exciton-trion dynamics in 0D-2D WSe2 structures," manuscript in preparation, to be submitted.

8. J. Desai, A. S. Bandyopadhyay, D. Biswas, I. Mahbub, and A. B. Kaul, "Ink-jet printed hexagonal-boron nitride integrated with graphene in a microstrip transmission line configuration and its high-frequency response," manuscript in preparation, to be submitted, 2018.

9. S. Chugh, N. Adhikari, R. Hossain, M. Min, L. Echegoyen, and A. B. Kaul, "Probing charge carrier dynamics in quantum dots and Sc3N@C80 endohedrals integrated with monolayer WSe2," manuscript in preparation, to be submitted.

Published (Journal)

1. R. Hossain, I. Deaguero, T. Boland, and **A. B. Kaul**, "Large-format, biocompatible, ink-jet printed 2D-heterostructure photodetector on flexible substrates," *Nature npj 2D Materials and Applications Journal*, **1**(28) (2017); DOI: 10.1038/s41699-0170034-2.

2. M. Michel, C. Biswas, R. Hossain, C. Tiwary, P. M. Ajayan, and **A. B. Kaul**, "A thermally-invariant, high-power graphite resistor for flexible electronics formed using additive manufacturing," *2D Materials Journal (IOP)* **4**(2), 025076 (2017).

3. M. Michel, C. Biswas, and **A. B. Kaul**, "High-performance ink-jet printed graphene resistors formed with environmentally-friendly, surfactant-free inks for extreme thermal environments," *Applied Materials Today* **6**, 16 (2017).

4. J. A. Desai, C. Biswas, A. B. Kaul, "Inkjet printing of liquid-exfoliated, highly conducting graphene/poly(3,4 ethylenedioxythiophene): poly(styerene sulfonate) nanoscheets for organic electronics," *J. Vacuum Sci. & Technol. B, Nanotechnology and Microelectronics: Materials, Processing, Measurement and Phenomena,* vol. 35, issue 3, 03D112, American Vacuum Society, 2017.

5. J. A. Catalan and A. B. Kaul, "Polydimethylsiloxane and polyisoprene-based graphene composites for strain-sensing," *J. Vacuum Sci. & Technol. B, Nanotechnology and Microelectronics: Materials, Processing, Measurement and Phenomena,* vol. 35, issue 3, 03D106, American Vacuum Society, 2017.

6. S. Chugh, C. Biswas, L. Echegoyen, and A. B. Kaul, "Investigation of structural morphology and electrical properties of graphene-C60 hybrids," *J. Vacuum Sci. & Technol. B, Nanotechnology and Microelectronics: Materials, Processing, Measurement and Phenomena*, vol. 35, issue 3, 03D111, American Vacuum Society, 2017.

CONFERENCE PUBLICATIONS & PROCEEDINGS ARTICLES

1. J. Catalan, R. Martinez, Y. Lin, and A. B. Kaul, "Electrical Characterization and Nano-indentation of Opto-electro-mechanical Percolative Composites From 2D Layered Materials," *MRS Advances*, vol. 2, issue 60 (Electronics and Photonics), pp. 3741-3747, 2017.
2. J. A. Desai, N. Adhikari, and A. B. Kaul, "Tungsten disulfide nanodispersions for inkjet printing and semiconducting devices," *MRS Advances,* vol. 2, issue 60 (Electronics and Photonics), pp. 3697-3702, 2017.

3. N. Adhikari, A. S. Bandyopadhyay, and A. B. Kaul "Nanoscale charge transport properties of perovskite solar cells with 2D materials for stable performance,"oral presentation, Solar Technologies Symposium, NanoTech 2017 Conference & Expo (part of Techconnect World Innovation Conference & Expo), National Harbor, MD May, 2017.

STUDENT RECOGNITIONS

Ridwan Hossain (PhD candidate): 1st place in Graduate Student Expo, University of Texas, El Paso, Fall 2017