Dr. Jeevesh Kumar

Assistant Professor
IIT(ISM) Dhanbad
Dhanbad, Jharkhand, India
826004

jeevesh@iitism.ac.in
+91 8884742131
jeevesh-kumar-727b1879
GoogleScholar

Education

Course	Specialization	University/ Institution	Year
PhD & MTech Res.	2D Materials & Devices	Indian Institute of Science, Bangalore, India	2022
BTech	ECE	National Institute of Technology, Trichy, India	2013

Key Contributions

Jeevesh's key contributions include atomic-level investigations of 2D materials, especially graphene, phosphorene, and transition metal dichalcogenides (TMDs), to address their technological roadblocks and reliability challenges. In computational investigations, he used QuantumATK tools for the density functional theory (DFT) and molecular dynamic (MD) simulations to explore the materials' fundamental properties and contact interfaces. Based on the theoretical finding, he further explored and engineered different materials and their devices using an integrated electrical and optical characterization system. Jeevesh's key findings consist proposal of direct bandgap opening in graphene by creating hydrogenated or fluorinated vacancy patterns [10], and defect-assistance contact resistance engineering of graphene's [2], [4], [29] and TMDs' [1], [16], [17], [18], [26], FETs. He further explored phosphorene's ambient degradation dynamics and degradation stakeholders of the material [5], [15], [27] and devices [6], [24]. He also investigated the thermal evolution of different Raman characteristics of phosphorene [7]. Besides, Jeevesh worked on the various reliability issues of the graphene [11], [12], [25] and TMDs [3], [13], [20], [21], [22], [28] along with their device performance improvement for electronic applications. [8], [9], [23]

Research Publications (Journals & Conferences)

1. **Jeevesh Kumar**, and Mayank Shrivastava. "Role of Chalcogen Defect Introducing Metal-Induced Gap States and Its Implications on Metal-TMDs' Interface Chemistry", ACS Omega, 2023. DOI: 10.1021/acsomega.2c07489

2. Adil Meersha*, **Jeevesh Kumar***, Abhishek Mishra, Harsha B. Variar, and Mayank Shrivastava."Vacancy Assisted Bilayer Graphene Contact for Monolayer Graphene Channel Devices" IEEE Electron Device Letters 44, no. 4 (2023): 666-669. (*Equal contribution). DOI: 10.1109/LED.2023.3250329

3. Ansh, Utpreksh Patbhaje, **Jeevesh Kumar**, Adil Meersha, and Mayank Shrivastava. "Origin of electrically induced defects in monolayer MoS2 grown by chemical vapor deposition." Communications Materials 4, no. 1 (2023): 8. DOI: 10.1038/s43246-023-00333-y

4. **Jeevesh Kumar**, Adil Meersha, Harsha B. Variar, Abhishek Mishra, and Mayank Shrivastava."Carbon Vacancy Assisted Contact Resistance Engineering in Graphene FETs.", IEEE Transactions on Electron Devices 69, no. 4 (2022): 2066-2073. DOI:10.1109/TED.2022.3151033

5. **Jeevesh Kumar**, and Mayank Shrivastava. "First-Principles Molecular Dynamics Insight into the Atomic Level Degradation Pathway of Phosphorene." ACS omega (2022). DOI: 10.1021/acsomega.1c05353

6. **Jeevesh Kumar**, Utpreksh Patbhaje, and Mayank Shrivastava. "Role of Channel Inversion in Ambient Degradation of Phosphorene FETs", IEEE Transactions on Electron Devices 69, no. 6 (2022): 3353-3358. DOI: 10.1109/TED.2022.3171504

7. **Jeevesh Kumar**, Utpreksh Patbhaje, and Mayank Shrivastava. "Breathing Mode's Temperature Coefficient Estimation and Interlayer Phonon Scattering Model of Few-layer Phosphorene", ACS omega 7, no. 48 (2022): 43462-43467. DOI: 10.1021/acsomega.2c03759

8. Hemanjaneyulu, Kuruva, **Jeevesh Kumar**, and Mayank Shrivastava. "Gaps in the Y-Function Method For Contact Resistance Extraction in 2D Few-Layer Transition Metal Dichalcogenide Back-Gated FETs." IEEE Electron Device Letters 43, no. 4 (2022): 635-638. DOI: 10.1109/LED.2022.3149410

9. Hemanjaneyulu, Kuruva, Adil Meersha, **Jeevesh Kumar**, and Mayank Shrivastava. "Unveiling Unintentional Fluorine Doping in TMDs During the Reactive Ion Etching: Root Cause Analysis, Physical Insights, and Solution." IEEE Transactions on Electron Devices 69, no. 4 (2022): 1956-1963. DOI: 10.1109/TED.2022.3152459

10. **Jeevesh Kumar**, Ansh, and Mayank Shrivastava. “Introduction of Near to Far Infrared Range Direct Band Gaps in Graphene: A First Principle Insight.” ACS omega 6, no. 8 (2021): 5619-5626. DOI:10.1021/acsomega.0c06058

11. Mishra, Abhishek, Adil Meersha, N. K. Kranthi, **Jeevesh Kumar**, NS Veenadhari Bellamkonda, Harsha B. Variar, and Mayank Shrivastava. "Unified Mechanism for Graphene FET's Electrothermal Breakdown and Its Implications on Safe Operating Limits." IEEE Transactions on Electron Devices 68, no. 5 (2021): 2530-2537. DOI: 10.1109/TED.2021.3068081

12. **Jeevesh Kumar**, Ansh, and Mayank Shrivastava. “Stone–Wales Defect and Vacancy-Assisted Enhanced Atomic Orbital Interactions Between Graphene and Ambient Gases: A First-Principles Insight.” ACS omega 5, no. 48 (2020): 31281-31288. DOI:10.1021/acsomega.0c04729

13. Ansh, **Jeevesh Kumar**, Gaurav Sheoran and Mayank Shrivastava, “Electrothermal Transport Induced Material Re-Configuration and Performance Degradation of CVD-Grown Monolayer MoS_2 Transistors”, npj 2D Mater Appl 4, 37 (2020). DOI: 10.1038/s41699-020-00171-3

14. Shankar Bhawani, Swati Shikha, Anant Singh, **Jeevesh Kumar**, Ankit Soni, Sayak Dutta Gupta, Srinivasan Raghavan, and Mayank Shrivastava. "Time Dependent Shift in SOA Boundary and Early Breakdown of Epi-Stack in AlGaN/GaN HEMTs Under Fast Cyclic Transient Stress." IEEE Transactions on Device and Materials Reliability 20, no. 3 (2020): 562-569. DOI: 10.1109/TDMR.2020.3007128

15. Andrew E. Naclerio, Dmitri N. Zakharov, **Jeevesh Kumar**, Bridget Rogers, Cary L. Pint, Mayank Shrivastava, and Piran R. Kidambi “Visualizing Oxidation Mechanisms in Few-Layered Black Phosphorus via In Situ Transmission Electron Microscopy”ACS Applied Materials & Interfaces 2020 12 (13), 15844-15854. DOI: 10.1021/acsami.9b21116

16. Ansh, **Jeevesh Kumar**, Gaurav Sheoran, Harsha B. Variar, Ravikesh Mishra, Hemanjaneyulu Kuruva, Adil Meersha, Abhishek Mishra, Srinivasan Raghavan, and Mayank Shrivastava. "Chalcogen-Assisted Enhanced Atomic Orbital Interaction at TMD–Metal Interface and Sulfur Passivation for Overall Performance Boost of 2-D TMD FETs." IEEE Transactions on Electron Devices 67, no. 2 (2020): 717-724. DOI: 10.1109/TED.2019.2958338

17. Ansh, **Jeevesh Kumar**, Gaurav Sheoran, Ravikesh Mishra, Srinivasan Raghavan, and Mayank Shrivastava. "Selective Electron or Hole Conduction in Tungsten Diselenide (WSe2) Field-Effect Transistors by Sulfur-Assisted Metal-Induced Gap State Engineering." IEEE Transactions on Electron Devices 67, no. 1 (2019): 383-388. DOI: 10.1109/TED.2019.2956781

18. Hemanjaneyulu Kuruva, **Jeevesh Kumar**, and Mayank Shrivastava. "MoS_2 doping using potassium iodide for reliable contacts and efficient FET operation." IEEE Transactions on Electron Devices 66, no. 7 (2019): 3224-3228. DOI: 10.1109/TED.2019.2916716

19. Sayak Dutta Gupta, Ankit Soni, Vipin Joshi, **Jeevesh Kumar**, Rudrarup Sengupta, Heena Khand, Bhawani Shankar et al. "Positive Threshold Voltage Shift in AlGaN/GaN HEMTs and E-Mode Operation By $Al_xTi_{1-x}O$ Based Gate Stack Engineering." IEEE Transactions on Electron Devices 66, no. 6 (2019): 2544-2550. DOI: 10.1109/TED.2019.2908960

20. **Jeevesh Kumar**, Hemanjaneyulu, Kuruva, Harsha B. Variar, Utpreksh Patbhaje, and Mayank Shrivastava. “Atomic-level Insight and Quantum Chemistry of Ambient Reliability Issues of the TMDs Devices” In 2023 IEEE International Reliability Physics Symposium (IRPS), IEEE, 2023. DOI: 10.1109/IRPS48203.2023.10118245

21. Utpreksh Patbhaje, Rupali Verma, **Jeevesh Kumar**, Ansh, and Mayank Shrivastava, "Unveiling Field Driven Performance Unreliabilities Governed by Channel Dynamics in MoSe2 FETs", In 2023 IEEE International Reliability Physics Symposium (IRPS), IEEE, 2023. DOI: 10.1109/IRPS48203.2023.10117743

22. Rupali Verma, Utpreksh Patbhaje, **Jeevesh Kumar**, Anand Kumar Rai, and Mayank Shrivastava, "OFF State Reliability Challenges of Monolayer WS2 FET Photodetector: Impact on the Dark and Photo-illuminated state", In 2023 IEEE International Reliability Physics Symposium (IRPS), IEEE, 2023. DOI: 10.1109/IRPS48203.2023.10117978

23. Asif A. Shah, **Jeevesh Kumar**, Aadil Bashir Dar and Mayank Shrivastava, "Unveiling Root Cause of Defect Assisted Filamentation and Implication on Resistive Switching in MoS2 Atomristor”, In 2023 IEEE Electron Devices Technology and Manufacturing (EDTM), IEEE, 2023. DOI: 10.1109/EDTM55494.2023.10102955

24. **Jeevesh Kumar**, Utpreksh Patbhaje, and Mayank Shrivastava. “Unveiling Additional Ambient Degradation Issues of Phosphorene FETs under Laser Exposer and Positive Gate Bias”, In 2022 IEEE international conference on emerging electronics (ICEE). IEEE, 2022. DOI: 10.1109/ICEE56203.2022.10118342

25. **Jeevesh Kumar**, and Mayank Shrivastava. “Are Argon and Nitrogen Gases Really Inert to Graphene Devices?” In 2022 Device Research Conference (DRC), pp. 1-2. IEEE, 2022. DOI: 10.1109/DRC55272.2022.9855822

26. **Jeevesh Kumar**, Ansh, Hemanjaneyulu Kuruva, and Mayank Shrivastava. "Defect Assisted Metal-TMDs Interface Engineering: A First Principle Insight." In 2020 Device Research Conference (DRC), pp. 1-2. IEEE, 2020. DOI: 10.1109/DRC50226.2020.9135158

27. **Jeevesh Kumar**, *et al*. "Physical Insights into Phosphorene Transistor Degradation Under Exposure to Atmospheric Conditions and Electrical Stress." In 2020 IEEE International Reliability Physics Symposium (IRPS), pp. 1-4. IEEE, 2020. DOI: 10.1109/IRPS45951.2020.9129123

28. Ansh, Ansh, Gaurav Sheoran, **Jeevesh Kumar**, and Mayank Shrivastava. "First Insights into Electro-Thermal Stress Driven Time-Dependent Permanent Degradation Failure of CVD Monolayer MoS2 Channel." In 2020 IEEE International Reliability Physics Symposium (IRPS), pp. 1-4. IEEE, 2020. DOI: 10.1109/IRPS45951.2020.9129173

29. **Jeevesh Kumar**, Adil Meersha, and Mayank Shrivastava. "A First Principle Insight into Defect Assisted Contact Engineering at the Metal-Graphene and Metal-Phosphorene Interfaces." In 2019 International Conference on Simulation of Semiconductor Processes and Devices (SISPAD), pp. 1-4. IEEE, 2019. DOI: 10.1109/SISPAD.2019.8870396

Conference Presentation

1. *A First Principle Insight into Defect Assisted Band Gap Creation in Graphene*, Graphene Week Conference, Helsinki, Finland, September, 2019
2. *A First Principle Insight into Defect Engineering at the Metal-Graphene and Metal-Phosphorene Interfaces*, Graphene Week Conference, Helsinki, Finland, September, 2019
3. *A Deep Insight into Defect Engineering at the Metal-Graphene and Metal-Phosphorene Interfaces*, Graphene 2019 Conference, Rome, Italy, June, 2019

Skills and Expertise

Simulation Skills & Tools	Density Functional Theory (DFT), Molecular Dynamics (MD), QuantumATK, VASP.
Device Processing	2D material back gated FETs using exfoliation to the lift-off process flow, Ebeam lithography (Raith Pioneer), RIE (Oxford), Ebeam evaporator (TECPORT).
Device & Material Characterization	DC & Pulse Measurements (Keithley 4200), Raman Spectroscopy & Photoluminescence (Horiba LabRam HR), Atomic Force Microscopy (Park NX10 AFM Systems), Thermoreflectance (Microsanj).
Soft Skills & Languages	UNIX, MATLAB, Verilog HDL, Shell, Python, C.

Research Work

- **Explored bandgap creation technique in graphene using DFT computational investigation [10]**
  - Carbon vacancy can open bandgap in graphene.
  - The vacancy can also generate unwanted trap states and ambient oxidation sites.
  - A hydrogenated or fluorinated vacancy pattern removes the trap states and oxidation sites, thus creating a direct bandgap in graphene.
  - The proposed patterns are thermally stable, feasible and reliable in ambient conditions.
  - QuantumATK computational tool was used in all the investigations.

- **Vacancy-assisted contact resistance engineering in graphene FETs [2], [4]**
  - DFT & NEGF revealed that carbon vacancy could reduce the contact resistance of the graphene-metal interface.
  - QuntumATK was used in the DFT and NEGF simulations.
  - Carbon vacancies were created in the contact region of graphene FETs before metal deposition using different processing methods.
  - The achieved contact resistance was as low as $\sim$78 $\Omega.\mu m$ and $\sim$36 $\Omega.\mu m$ for monolayer and bilayer graphene contact, respectively.

Research Work (continued)

- **Unveiled atomic-level degradation pathway of phosphorene and its stakeholders [5], [6]**
  - QuantumATK tool was used for all the DFT and MD simulations.
  - The explored results were further verified using electrical and optical characterizations.
  - Oxygen is the real killer of phosphorene.
  - Water molecules, oxygen partial pressure, and gate bias help the degradation reaction.
  - Phosphorus vacancy acts as an epicenter for the degradation.
  - Laser light also assists the degradation by etching the degraded surface oxide.
- **Raman breathing mode of phosphorene and its thermal properties [7]**
  - Horiba LabRam HR Raman instrument was used for all the investigations.
  - The Raman breathing mode is the signature of identifying phosphorene's thin flake for FET applications.
  - The modes follow three-phonon and four-phonon scattering processes at low and high temperatures, respectively.
  - The Raman shift's instrumental error can be mitigated by capturing the average of stokes and anti-stokes lines.
- **Explored metal-TMDs interactions and the role of chalcogen defects [1]**
  - QuantumATK was used in all the computational investigations.
  - Au, Cr, Ni, and Pd metals were considered in the analysis.
  - The study was done for MoS_2, $MoSe_2$, WS_2, and WSe_2.
  - Chalcogen vacancy can reduce the contact resistance of all the investigated TMDs-metal combinations.
  - Pd has the potential to offer p-type contact with all the investigated TMDs. .

Employment History

JUN, 2022 – OCT, 2023 — **Research Associate I** in Nanoelectronics team, *MSD Lab*, DESE, IISc, Bangalore, India.

JUN, 2013 – JUN, 2016 — **ASIC Digital Design Engineer I & II** in USB team, *Solution Group*, Synopsys, Bangalore, India.

Selected Awards and Honors

2009 — **ABCDEF scholarship**, by Abundant Cauvery Delta Education Foundation.
2016 — **Ph.D Research Fellowship**, by Council of Scientific and Industrial Research (CSIR), Govt. of India.
2019 — **Student Grant**, Graphene Week Conference, 2019.
2022 — **Student Grant**, Graphene Week Conference, 2022.

Technical Committees & Professional Organizations

2019–Present — **Student Member**, IEEE EDS Bangalore Chapter.

References

Prof. Mayank Shrivastava
Associate Professor,
Indian Institute of Science,
Bangalore, India
mayank@iisc.ac.in
+91 80 2293 2732
homepage

Prof. Piran Kidambi
Assistant Professor,
Vanderbilt University,
Nashville, USA
piran.kidambi@vanderbilt.edu
+1 615 343 7466
homepage

Er. Chandrashekar B U
Principal Engineer,
Solutions Group, Synopsys,
Bangalore, India
cbu@synopsys.com
+91 9902555991
homepage