

Kunal Jogendra Tiwari

Research Interests: /Thin film science and technology /Semiconductors /Surface science /Charge transport properties /

Professional Experience:

Senior Post Doctoral Researcher, EEBE UPC + IREC Barcelona. **Jan. 2021-June 2023**

- *Established research line focused on exploration of MXene/organic dipoles as charge selective contacts in inorganic compound semiconductors (TRL 3-5).*
- *Demonstrated work function tuning of the $Ti_3C_2T_x$ MXene's through non-conjugated polyelectrolyte organic molecules and used these hetero-assemblies as charge selective contact on c-Si (TRL 3-5).*

Post-Doctoral Researcher **Feb.2019- Dec. 2020**

Fundació Institut de Recerca en Energia de Catalunya (IREC), Barcelona.

- *Demonstration of $Cu_2ZnGeSe_4$ thin film based thin film solar cells with > 6% efficiency (TRL 3-5).*
- *Development of controlled Br_2 based surface etching method for depth dependent defect profiling (TRL 3-5).*

Project Assistant, **Aug.2018- Dec. 2018**

Research Institute SRM Institute of Science and Technology Chennai.

Senior Research Fellow, **May 2016- May 2018**

Research Institute SRM Institute of Science and Technology Chennai.

- *Demonstration of Sb_2Se_3 based thin film solar cells with > 4% efficiency (TRL 3-5).*
- *Collaborated on a project focused on micropatterning of the chalcogenide absorbers (TRL 3-5).*
- *Applied for patents on the process development.*

Junior Research Fellow, **May 2013- May 2016**

Research Institute SRM Institute of Science and Technology Chennai.

- *As a first Ph.D. student, I was founding member of the thin film research laboratory.*
- *Process optimization for synthesis of $Cu_2ZnSnSe_4$, $CuSbSe_2$ and Sb_2Se_3 bulks through mechanical alloying and solid-state synthesis.*
- *Developed novel methodology to obtain thin films of complex compound semiconductors in single step by e-beam evaporation*

Academic Credentials:

Ph.D Physics: SRM Institute of Science and Technology Kattankulathur Chennai, India. **Nov. 2018**

Thesis title: *Growth and Characterization of CZTSe, $CuSbSe_2$ and Sb_2Se_3 thin film for solar cell applications.* | CGPA – 8.0/10

Thesis Supervisor: Prof. P. Malar

M.Sc. Materials Science: College of Engineering Guindy, Anna University Chennai, India. **May 2013**

Thesis title: *Synthesis and Characterization of Multilayer Thin Films for Magnetic Tunnel Junction* | CGPA – 8.0/10

Thesis Supervisor: Prof. R Jayavel, Centre for Nanoscience and Technology Anna University Chennai.

B.Sc. (Phys. Math. Comp. Sci): RTM Nagpur University Nagpur, India. **May 2010**

CGPA – 6/10

Scholarships and Awards:

Best Poster Award: **Nov. 2022**

MXene Symposium at MRS Fall Meeting and Exhibit Boston USA.

Scholarship:

July 2018

Severo Ochoa FunMAT Program to attend the summer school MATERN2018 at Barcelona Spain.

2nd Best Oral Presentation:

Mar. 2014

National Conference on Hierarchically Structured Materials organized by SRM University at Raman Puram Campus, Chennai India.

Scholarship: Inter University Accelerator Centre New Delhi, to attend School on Thin Films.

Dec. 2012

Scholarship: IIT Bombay to attend School for Accelerator Technology and Applications.

Jan. 2012

Membership of Professional Society: MRS USA since 2022.

Peer Review: Regular peer reviewer for different journals such as Advanced Materials, Advanced Materials & Interfaces, Chemistry of Materials, Solar Energy Materials and Solar cells, Solar RRL etc.

Research Output:

Relevant merits:

Total number of peer reviewed research articles: 19

Articles as corresponding author (*): 2

Patents:

Europe: 1 (Published)

Articles as first author: 7

Book Chapter: 1.

India: 3 (2 Granted and 1 published)

Peer Reviewed Articles:

1. Eloi Ros Costals, Xavier Francesc Cappela, Thomas Tom, Sergio Giraldo, Marcel Placidi, Cristobal Voz, Joaquim Puigdollers, Edgardo Saucedo, **Kunal Jogendra Tiwari***, Zacharie Jehl Li Kao "Non-covalent Functionalized Schottky Interface at $Ti_3C_2T_x/n$ -Si Van der Waals Heterojunction" (*corresponding author*) 10.26434/chemrxiv-2023-5v7tx.
2. Alex Jimenez-Arguijo, Ivan Cano, Fabien Atlan, Yuancai Gong, **Kunal J. Tiwari**, Marcel Placidi, Joaquim Puigdollers, Zacharie Jehl Li-Kao, Edgardo Saucedo, Sergio Giraldo, Gradient doping in $Cu_2ZnSnSe_4$ by temperature and potential induced defect steering, *Solar Energy*, Vol. 262, 2023, 111883.
3. Thomere, Angélica, Marcel Placidi, Maxim Guc, **Kunal Tiwari**, Robert Fonoll-Rubio, Victor Izquierdo-Roca, Alejandro Perez-Rodriguez, and Zacharie Jehl Li-Kao. "2-step process for 5.4% $CuGaSe_2$ solar cell using fluorine doped tin oxide transparent back contacts." *Progress in Photovoltaics: Research and Applications* 31, no. 5 (2023): 524-535.
4. Jimenez-Arguijo, Alex, Axel Gon Medaille, Alejandro Navarro-Güell, Maykel Jimenez-Guerra, **Kunal J. Tiwari**, Marcel Placidi, Moleko Samuel Mkehlane et al. "Setting the baseline for the modelling of Kesterite solar cells: The case study of tandem application." *Solar Energy Materials and Solar Cells* 251 (2023): 112109.
5. Gon Medaille, Axel, **Kunal J. Tiwari***, Sergio Giraldo, Marcel Placidi, Edgardo Saucedo, and Zacharie Jehl Li-Kao. "Numerical investigation of interface passivation strategies for Sb_2Se_3/CdS solar cells." *Solar RRL* 6, no. 2 (2022): 2100911. (*co-corresponding author*)
6. Andrade-Arvizu, J., Rubio, R.F., Izquierdo-Roca, V., Becerril-Romero, I., Sylla, D., Vidal-Fuentes, P., Li-Kao, Z.J., Thomere, A., Giraldo, S., **K. Tiwari** and Resalati, S., "Controlling the anionic ratio and gradient in kesterite technology." *ACS Applied Materials & Interfaces*, 14(1) (2022), pp.1177-1186.
7. Costals, Eloi Ros, Gerard Masmitjà, Estefania Almache, Benjamin Pusay, **Kunal Tiwari**, Edgardo Saucedo, C. Justin Raj et al. "Atomic layer deposition of vanadium oxide films for crystalline silicon solar cells." *Materials advances* 3, no. 1 (2022): 337-345.
8. Almache-Hernandez, Rosa, Benjamin Pusay, **Kunal Tiwari**, Eloi Ros, Gerard Mastmitja, Ignacio Becerril-Romero, Isidro Martin et al. "Hole Transport Layer based on atomic layer deposited V_2O_x films: Paving the road to semi-transparent CZTSe solar cells." *Solar Energy* 226 (2021): 64-71.
9. Anefnaf, Ikram, Safae Aazou, Y. Sánchez, P. Vidal-Fuentes, R. Fonoll-Rubio, **Kunal J. Tiwari**, S. Giraldo et al. "Insights on the limiting factors of $Cu_2ZnGeSe_4$ based solar cells." *Solar Energy Materials and Solar Cells* 227 (2021): 111106.

10. **Kunal J. Tiwari**, Robert Fonoll Rubio, Sergio Giraldo, Lorenzo Calvo-Barrio, Victor Izquierdo-Roca, Marcel Placidi, Yudania Sanchez, Alejandro Pérez-Rodríguez, Edgardo Saucedo, and Zacharie Jehl Li-Kao. "Defect depth-profiling in kesterite absorber by means of chemical etching and surface analysis." *Applied Surface Science* 540 (2021): 148342.
11. **Kunal J. Tiwari**, Sergio Giraldo, Marcel Placidi, Axel Gon Medaille, Angelica Thomere, Shahabuddin Resalati, Edgardo Saucedo, and Zacharie Jehl Li-Kao. "Feasibility of a full chalcopyrite tandem solar cell: a quantitative numerical approach." *Solar RRL* 5, no. 7 (2021): 2100202.
12. Rajendran, Jagadish, Sivasangari Sathiamoorthy, **Kunal J. Tiwari**, T. S. Suraj, MS Ramachandra Rao, and P. Malar. "Growth of antimony selenide solar absorber on micro textured substrates for efficient light trapping and enhanced optical absorption." *Solar Energy* 211 (2020): 977-987.
13. **Kunal J. Tiwari***, Markus Neuschitzer, Moises Espíndola-Rodríguez, Yudania Sanchez, Zacharie Jehl, Pedro Vidal-Fuentes, Edgardo Saucedo, and Piraviperumal Malar. "Efficient Sb₂Se₃/CdS planar heterojunction solar cells in substrate configuration with (hk0) oriented Sb₂Se₃ thin films." *Solar Energy Materials and Solar Cells* 215 (2020): 110603. (*Corresponding author*)
14. Gupta, Indu, **Kunal J. Tiwari**, P. Malar, and Bhaskar Chandra Mohanty. "Evaluating the role of precursor concentration in facile conformal coating of sub-micrometer thick Cu₂ZnSnS₄ films using non-toxic ethanol-based solutions." *Applied Surface Science* 494 (2019): 795-804.
15. **Kunal J. Tiwari**, Min-Qin Ren, Saumitra Kamalakar Vajandar, Thomas Osipowicz, A. Subrahmanyam, and P. Malar. "Mechanochemical bulk synthesis and e-beam growth of thin films of Sb₂Se₃ photovoltaic absorber." *Solar Energy* 160 (2018): 56-63.
16. **Kunal J. Tiwari**, Vijay Vinod, A. Subrahmanyam, and P. Malar. "Growth and characterization of chalcostibite CuSbSe₂ thin films for photovoltaic application." *Applied Surface Science* 418 (2017): 216-224.
17. **Kunal J. Tiwari**, Raju Chetty, Ramesh Chandra Mallik, and P. Malar. "Solid state synthesis and e-beam evaporation growth of Cu₂ZnSnSe₄ for solar energy absorber applications." *Solar Energy* 153 (2017): 173-180.
18. Sathiamoorthy, Sivasangari, **Kunal J. Tiwari**, G. R. Devi, MS Ramachandra Rao, and P. Malar. "Photoresist template fabrication and template assisted growth for surface patterning of technologically important Cu₂ZnSnSe₄ thin films." *Materials & Design* 127 (2017): 126-133.
19. **Kunal J. Tiwari**, D. S. Prem Kumar, Ramesh Chandra Mallik, and P. Malar. "Ball mill synthesis of bulk quaternary Cu₂ZnSnSe₄ and thermoelectric studies." *Journal of Electronic Materials* 46 (2017): 30-39.

Book Chapter:

1. **Kunal J. Tiwari**, Sergio Giraldo, Marcel Placidi, Zacharie Jehl Li-Kao, and Edgardo Saucedo. "Recent Advances in the Kesterite-Based Thin Film Solar Cell Technology: Role of Ge." *Recent Advances in Thin Film Photovoltaics* (2022): 41-66.

Conference Proceedings:

1. **Kunal J. Tiwari**, Eloi Ros Costals, Yuancai Gong, Sergio Giraldo, Marcel Placidi, Cristobal Voz, Joaquim Puigdollers, Edgardo Saucedo, and Zacharie Jehl Li Kao. "Detailed Investigation on Organic Dipole Functionalized Interface between 2D Ti₃C₂T_x and Quasi-1D Sb₂Se₃." In *244th ECS Meeting (October 8-12, 2023)*. ECS, 2023.
2. Jimenez, Alex, Alejandro Navarro, Sergio Giraldo, **Kunal Jogendra Tiwari**, Marcel Placidi, Lorenzo Calvo-Barrio, Joaquim Puigdollers, Edgardo Saucedo, and Zacharie Jehl Li-Kao. "Which potential for Kesterite absorbers in tandem solar cells: a quantitative modelling approach." In *2022 IEEE 49th Photovoltaics Specialists Conference (PVSC)*, pp. 0284-0284. IEEE, 2022.
3. Salem, Mohamed Ould, **Kunal Tiwari**, Robert Fonoll, Sergio Giraldo, Marcel Placidi, Yudania Sanchez, Victor Izquierdo-Roca et al. "Wide bandgap CIGSe solar cells on transparent substrates above 10% efficiency." In *2021 IEEE 48th Photovoltaic Specialists Conference (PVSC)*, pp. 1389-1392. IEEE, 2021.
4. **Kunal J. Tiwari**, Alex Jimenez, Sergio Giraldo, Marcel Placidi, Lorenzo Calvo-Barrio, Robert Fonoll-Rubio, Victor Izquierdo-Roca et al. "Bromine etching of kesterite thin films: perspectives in depth defect profiling and device performance improvement." In *2021 IEEE 48th Photovoltaic Specialists Conference (PVSC)*, pp. 1348-1351. IEEE, 2021.
5. Giraldo, Sergio, **Kunal J. Tiwari**, Ikram Anefnaf, Robert Fonoll, Yudania Sánchez, Zacharie Jehl Li-Kao, Victor Izquierdo-Roca et al. "Effect of alkali doping strategies on the performance of wide band gap Cu₂ZnGeSe₄ thin film solar cells." In *2020 47th IEEE Photovoltaic Specialists Conference (PVSC)*, pp. 0732-0735. IEEE, 2020.

Patents:

• Europe:

- Zacharie Jehl, Marcel Placidi, Sergio Munoz Giraldo, **Kunal Tiwari**, Ignacio Becerril, Alejandro Lopez Garcia, Alejandro Perez Rodriguez, Alfredo Blazquez Matinez, Yudania, Sanche Gonzalez, Edgardo, Saucedo Silva; EP 3799134A1; EP19382837; Bifacial Solar Module Spain. 30/09/2019. IREC (**Status:Published**)

India:

- Piraviperumal Malar, Sivasangri Sathyamoorthy, **Kunal J. Tiwari**; 201841007926; Process for Developing an Intermittently Textured Substrate Coated with A Film of Antimony Triselenide; India; 16/08/2019, SRM Institute of Science and Technology India. (**Status: Granted**)
- Piraviperumal Malar and **Kunal J. Tiwari**; 46/2017; A Single Step Process For The Preparation Of $\text{Cu}_2\text{ZnSnSe}_4$ Thin Films; India, 17/11/2017; SRM Institute of Science and Technology India. (**Status: Granted**)
- Piraviperumal Malar, Sivasangri Sathyamoorthy, **Kunal J. Tiwari**; 6642/CHE/2015; A Solar Radiation Absorbing Layer for Thin-film Solar Cells with Enhanced Absorption and A Method to Manufacture the Same; India; 16/06/2017; SRM Institute of Science and Technology India. (**Status: Under Examination**)

Selected Presentations at Conferences:

1. “Enhancing the performance of CZGSe thin film solar cells through short oxidative surface etching and KCN etching of the absorber.” Zacharie Jehl, **Kunal J. Tiwari**, Sergio Giraldo, Edgardo Saucedo, Marcel Placidi, oral Presentation at 31st IMRC, Cancun Mexico 13-18th Aug. 2023.
2. “Tunable MXenes Carrier Selective Contact for Kesterite and Sb_2Se_3 -based Photovoltaic Devices” **Kunal J. Tiwari**, Eloi Ros Costals, Serge Giraldo, Thomas Tom, Joachim Puigdollers, Edgardo Saucedo, Zacharie Jehl Li-Kao, oral presentation at ICMAT Singapore 26th-30th June 2023
3. “Molecular Dipole Assisted Tuning of Work Function in $\text{Ti}_3\text{C}_2\text{T}_x/\text{n-Si}$ and $\text{Ti}_3\text{C}_2\text{T}_x/\text{p-Sb}_2\text{Se}_3$ Heterojunctions” **Kunal J. Tiwari**, Eloi Ros Francesc X. Capella, Sergio Giraldo, Pablo Ortega, Joaquim Puigdollers, Edgardo Saucedo Zacharie Jehl Li Kao; MRS fall meeting and exhibit 27th Nov.-2nd Dec. 2022 Boston (Poster Presentation). [*Awarded with the symposium “Best Poster Award” at MRS 2022 Fall Meeting.*](#)
4. “Bromine etching of kesterite thin films: perspectives in depth defect profiling and device performance improvement” **Kunal J. Tiwari**, Alex Jimenez, Sergio Giraldo, Zacharie Jehl Li-Kao; Oral Presentation 2021 IEEE 48th Photovoltaic Specialists Conf. Remote
5. “Study of the Effect of Alkali Doping on the Performance of Emerging Wide Band Gap Absorber $\text{Cu}_2\text{ZnGeSe}_4$ based Thin Film Solar Cells” **Kunal J. Tiwari**, S. Giraldo, I. Anefnaf, Y. Sánchez, Z. Jehl Li-Kao, R. Fonoll, V. Izquierdo-Roca, E. Saucedo Oral Presentation 10th European Kesterite Workshop, Uppsala (Sweden), Nov. 20-22, 2019.
6. “Tailoring doping of efficient Sb_2Se_3 solar cells in substrate configuration by low temperature post deposition selenization process”; **Kunal J. Tiwari**, [...], Edgardo Saucedo, Piraviperumal Malar; Poster Presentation 7th World Conference on Photovoltaic Energy Conversion (WCPEC-7) June 2018, Hawaii.

Future Research Direction:

Since Jan. 2021, my research focus has been exploration of 2D MXene’s as a charge selective contact and engineering of functional interfaces in optoelectronic devices using hybrids of MXene/organic dipoles. I am developing methods to adapt MXene-based charge selective contacts for use in chalcogenide-based optoelectronic devices. Although MXene has been consistently explored as a charge selective contact or additive in ETL/HTL for organic or perovskite-based thin film solar cell technology, its exploration for chalcogenides remains limited and scarcely explored. The main reason may be the different processing of the absorber layer compared to the low-temperature synthesis used in organic or perovskite technology. To fully realize the potential of MXene in chalcogenide-based optoelectronic device technology, both the processing of MXene and the synthesis of functional chalcogenide materials and devices must be tackled simultaneously. Given my extensive experience in the synthesis of complex chalcogenide compound semiconductors, I am confident of my ability to propose new concepts and synthesis routes to carry out this challenging research.