

AMIT H MUNSHI

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Amit.Munshi@colostate.edu · www.linkedin.com/in/amit-munshi

Expert thin-film researcher with 10 years of experience in interface engineering, materials characterization and advanced process development.

EDUCATION

MAY 2017

DOCTOR OF PHILOSOPHY (Mechanical Engineering), COLORADO STATE UNIVERSITY

Dissertation – Investigation of Processing, Microstructure and Efficiencies of Polycrystalline CdTe Photovoltaic Films and Devices

Advisor – Dr. Walajabad S. Sampath

MAY 2013

MASTER OF SCIENCE (Mechanical Engineering), COLORADO STATE UNIVERSITY

Thesis – Investigation of gold as material for thermal radiation shielding

Advisor – Dr. Walajabad S. Sampath

JUNE 2010

BACHELOR OF ENGINEERING (Automobile Engineering), S.P. UNIVERSITY (INDIA)

Specialization – IC Engines, diagnosis and testing of automotive systems, manufacturing and design of transmission mechanism.

Advisor – Dr. Sudhir K. Gupte

HONORS AND AWARDS

- **Invited Talk** – Materials Research Society (MRS) Spring Meeting 2021
- **2020 Administrative Professional Star Award** at Colorado State University, February 2020. Award announcement transcript from Trish Torres, co-chair awards committee, CSU Administrative Professional Council - *“You were selected as a recipient because of your enthusiasm, continually taking initiatives for team building opportunities, and for your work acquiring materials with limited funding. On behalf of the Administrative Professional Council the committee thanks you for your service to Colorado State University”.*
- **Award Nomination** for *Stuart R. Wenham Young Professional Award* at 47th IEEE Photovoltaics Specialists Conference 2020.
- **Best Poster Award (co-author)** at 46th IEEE Photovoltaics Specialists Conference 2019.
- **Invited Talk** – MRS Spring Meeting 2019 - Progress and Challenges in Absorber and Interface Fabrication of Polycrystalline CdTe Photovoltaics – Invited to submit featured journal paper
- **Best Student Paper Award** at 44th IEEE Photovoltaics Specialists Conference 2017 – Paper invited for publication in Journal of Photovoltaics.
- **Best Poster Award** at 43rd IEEE Photovoltaics Specialists Conference 2016.
- **Invited Talk (co-author)** – IEEE PVSC 2016 – Progress and Challenges with CdTe Cell Efficiencies

- **Best student paper award finalist (co-author)** – at 46th IEEE Photovoltaics Specialists Conference 2019- Analysis of an MZO/CdTe photovoltaic device treated with cadmium bromide
- **Best poster award finalist (co-author, with equal contribution)** – at 45th IEEE Photovoltaics Specialists Conference 2018– Doping CdTe Absorber Cells using Group V Elements
- **Best poster award finalist (co-author)** – at 45th IEEE Photovoltaics Specialists Conference 2018 - 3D Distributions of Chlorine and Sulphur Impurities in a Thin-Film Cadmium Telluride Solar Cell

PATENTS

- Sampath, Walajabad S., **Amit H. Munshi**, Adam H. Danielson, and Kurt L. Barth. *"Doping and passivation for high efficiency solar cells."* U.S. Patent Application 16/404,479 filed November 7, 2019.

Invention Disclosures Submitted –

- **Munshi, Amit H.**, Sampath, Walajabad S., Shah, Akash., and Pandey, Ramesh. "System for controlled co-deposition of complex materials thin-films by thermally isolated sources".
- Shimpi, Tushar M., Sampath, Walajabad., Pandey, Ramesh., **Munshi, Amit H.**, and Barth, Kurt L. "Fabrication of n-type buffer layer doped at appropriate level and paired with p-doped absorber to improve the built-in voltage and thereby increase device performance".
- Papat, Ketul., **Munshi, Amit H.**, Sabino, Roberta M., and KM, Vignesh., "Copper enrichment of titanium and titania surfaces by low temperature process".

RESEARCH EXPERIENCE

MAY 2022 – PRESENT

ASSISTANT RESEARCH PROFESSOR, COLORADO STATE UNIVERSITY

- Laboratory operations and project management
- Student training and mentorship – vacuum systems, thin film fabrication and characterization, solar cell development, scholarly publications
- Grant proposal writing
- Concept development
- Principal investigator for federally funded research programs
- Domestic and international collaborations
- Purchasing and acquisition

NOV 2020 – OCT 2021

RESEARCH SCIENTIST II, COLORADO STATE UNIVERSITY

- Supervise fabrication of high efficiency cadmium telluride solar cells
- Analyze collected device and characterization data
- Experiment design and execution
- Independent grant proposal writing
- Mentoring and supervising undergraduate and graduate students with laboratory operation, device fabrication methods, authoring scholarly publications, and experiment design
- Laboratory management, purchasing, system and equipment development, vacuum systems operation and training
- Supporting various international collaborative projects in the focus areas

MAY 2017 – NOV 2020

RESEARCH SCIENTIST I, COLORADO STATE UNIVERSITY

- Responsibilities – experiment planning, experiment execution, writing publications, drafting proposals
- Project reporting to National Science Foundation and U.S. Department of Energy
- Mentoring graduate and undergraduate students

Graduate students mentored

2021 – Present	Blake Hill , Accelerated Masters Program, Department of Mechanical Engineering, Colorado State University (Advisor – Amit Munshi)
2014 – Present	Anthony Nicholson , Ph.D./Post-Doc Department of Mechanical Engineering, Colorado State University (Advisor – W.S. Sampath)
2017 - Present	Adam Danielson , Ph.D. Department of Mechanical Engineering, Colorado State University (Advisor – W.S. Sampath)
2017 - 2020	Anna Kindvall , M.S. Department of Mechanical Engineering, Colorado State University (Advisor – W.S. Sampath)
2018 Jan – Jun	Kulandai Velu , M.E. Amrita University, India (Intern at Colorado State University, Advisor – W.S. Sampath) – Currently Ph.D. Student at Amrita University, India
2018 - Present	Akash Shah , Ph.D. Department of Mechanical Engineering, Colorado State University (Advisor – W.S. Sampath)
2019 – 2021	Ramesh Pandey , Ph.D. Department of Physics, Colorado State University (Advisor – James Sites)
2020 – Present	Vignesh, K.M. , Ph.D. Department of Mechanical Engineering (Advisor – Ketul Popat)
2020 - 2022	Roberta Sabino , Ph.D. Materials Science and Engineering at School of Advanced materials Discovery, Colorado State University (Advisor – Ketul Popat)
2020 – Present	Zachary Lustig , M.S. Department of Mechanical engineering, Colorado State University (Advisor – W.S. Sampath)

Under-graduate students mentored (Research Experience for Undergraduates)

2019 - 2020	Cody Griffin , B.S. Department of Mechanical Engineering (Advisor – W.S. Sampath)
2019 - 2020	Garrett Robison , B.S. Department of Mechanical Engineering (Advisor – W.S. Sampath)
2019 Jan - Dec	David Miller , B.S. Department of Physics (Advisor – J.R. Sites)
2019 Jan - May	Susan Ossareh , B.S. Department of Mechanical Engineering (Advisor – W.S. Sampath) – Intern at Sandia National Laboratory
2019 Jan - May	Cinta Varghese , B.S. Department of Mechanical Engineering (Advisor – W.S. Sampath)
2019 Jan – May	Kip Ringsrud , B.S. Department of Mechanical Engineering (Advisor – W.S. Sampath)
2018 Jan - Jun	Vivek Manchala , B.E. Amrita University, India (Intern at Colorado State University, Advisor – W.S. Sampath)
2017 May - Dec	Shiva Tarun Reddy , B.E. Amrita University, India (Intern at Colorado State University, Advisor – W.S. Sampath) – Graduated M.S. from Colorado State University
2017 May - Dec	Sreeram Lal – B.E. Amrita University, India (Intern at Colorado State University, Advisor – W.S. Sampath) – Currently Research Fellow – NIMAC at University College Dublin

2021 Nov - Present **Blake Hill**, B.S. Department of Mechanical Engineering
 2022 Apr – Present **Forrest Kuhlmann**, B.S. Department of Mechanical/Biomedical Engineering
 2022 May – **Carrina Morroni**, B.S. Department of Mechanical Engineering
 Present
 2022 May – **Landon Fennell**, B.S. Department of Mechanical Engineering
 Present

- Laboratory (equipment) maintenance
- Purchasing for laboratory supplies
- Hiring of undergraduate student and new prospective students
- Current projects – High efficiency photovoltaic device fabrication using interface passivation and arsenic doping in CdTe-based thin-film devices

FEB 2020 – PRESENT

EXPERT RESEARCH SUPPORT, COLORADO STATE UNIVERSITY

- Controlled copper doping of textured titanium surfaces and titania nanotubes for application in biomedical implant to utilize antimicrobial property of copper alloys
- Precision polishing of titanium surface to form ultra-smooth slippery surface to reduce blood clots in biomedical implants

MAY 2013 – APRIL 2017 (As a Ph.D. Student)

GRADUATE RESEARCH ASSISTANT, COLORADO STATE UNIVERSITY

- Responsibilities – Thin-film device fabrication, materials characterization and photovoltaic device analysis
- Proficient operation of RF sputter systems, sublimation systems, physical vapor deposition systems, electron microscopes
- Experiment planning and execution
- Fabricated over 30,000 small area solar cells
- Demonstrated high efficiency solar cells using CdTe-only ($\eta = 18.7\%$) and $\text{CdSe}_x\text{Te}_{1-x}/\text{CdTe}$ ($\eta = 19.2\%$) devices using a high-speed repeatable process. These are the highest efficiency devices demonstrated by any academic institution.

TEACHING EXPERIENCE

JAN 2020 (SPRING 2020, SUMMER 2021, FALL 2021)

INSTRUCTOR, COLORADO STATE UNIVERSITY

- Instructor for **Introduction to Engineering Materials (MECH 331)** –
 - 4 credit including course lectures and laboratory
 - Teaching properties, characteristics and behavior of engineering materials
 - Preparing exams, homework and quiz, supervise grading
 - Maintain parallel progress between class lectures and laboratory experiments
 - Development and implementation of new hands-on teaching laboratories

GRADUATE TEACHING ASSISTANT, COLORADO STATE UNIVERSITY

- Teaching Assistant for **Manufacturing Processes (MECH 200)** –
 - Teaching and supervising machine shop with lathe, milling machines, electric saws, welding equipment, molding and casting of metals.

- Grading homework assignments, projects and exams.
- Student and equipment safety during laboratory sessions in machine shop
- Teaching Assistant for **Engineering Design I (MECH 201)** –
 - Conducting 4 laboratory session where students used Creo Parametric to learn perspectives, constraints in mechanical design and GD&T.
 - Worked with the supervising professor (Prof. Sakurai) in preparing grading rubrics
 - Grading homework assignments, exams and final projects.
- Teaching Assistant for **Engineering Design II (MECH 202)** –
 - Teaching project management and project scheduling.
 - Teach a class of over 100 students while serving as a graduate teaching assistant
 - Grading projects, homework assignments and exams
 - Organizing final project and competition for the class.

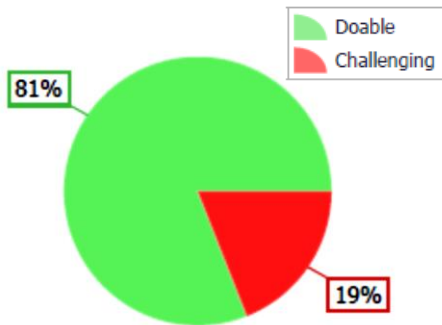
2014 – PRESENT (As a GRA and Research Scientist I)

VISITING LECTURER FOR SPECIALITY TOPICS, COLORADO STATE UNIVERSITY

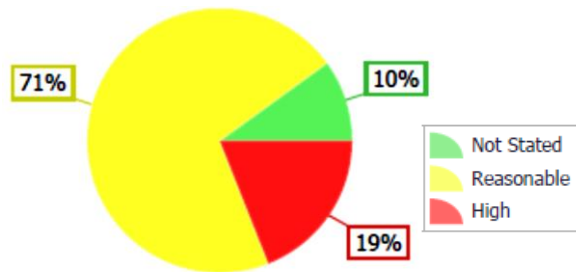
- Teach ME431 (Metals and Alloys) and ME575 (Solar and Alternate Energies) as a substitute for Prof. W.S. Sampath in his absence.
 - *Topics covered* – Basics of solar energy, thin-film fabrication, characterization of engineering materials, materials failure mechanisms and identification, and advanced materials characterization methods

MECH331 (Introduction to Engineering Materials)

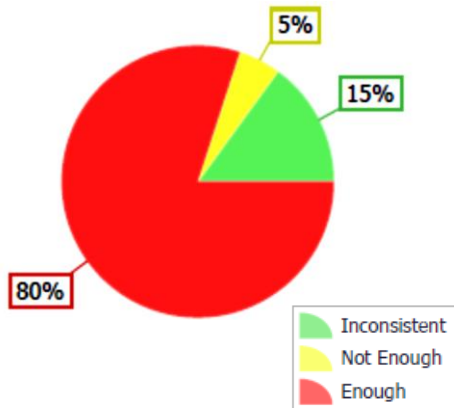
COURSE WORKLOAD RATING –



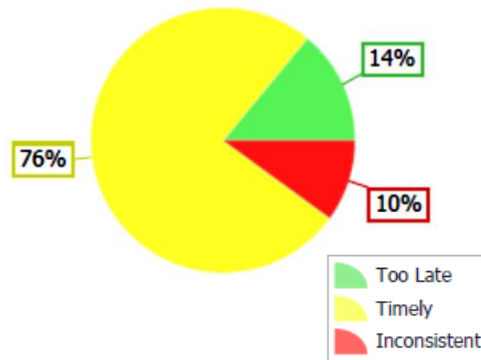
INSTRUCTOR’S EXPECTATIONS RATING -



INSTRUCTOR FEEDBACK –



INSTRUCTOR'S FEEDBACK TIMELY –



"I honestly would not change a thing. Dr Munshi nailed it on all these strengths. I was nervous in the beginning as he is a new to teaching and this is one of our hardest classes, but Dr Munshi did an excellent job."

"I was worried going into this class as it is considered one of our hardest. Dr Munshi made this one of my favorite classes."

"Dr Munshi nailed it this semester. I was nervous in the beginning as he is a new to teaching and this is considered one of our hardest classes, but Dr Munshi did an excellent job and turned Materials in to one of my favorite classes."

"Dr Munshi always had interesting extras to add to the lectures, whether it was a material sample, demonstration, or video about a subject. This goes a long way to understanding difficult material."

"Instructor is primarily concerned with students actually learning the information rather than just doing it for a grade."

"I liked Dr. Munshi's lectures. He provided real world examples and demonstrations to keep things interesting and engaging. Second half of the semester he provided an ample amount of youtube lectures, which was helpful for me."

"The instruction was great, and very helpful. Gave me a desire to learn more about materials."

"He wanted us to learn as much of the material as concretely and in depth as possible."

INDUSTRIAL EXPERIENCE

NOV 2021 – MARCH 2022

CHIEF RESEARCH & DEVELOPMENT OFFICER, TOLEDO SOLAR INC.

- Development of thin film photovoltaics research infrastructure.
- 330,000 sq feet, 180 MW solar panel manufacturing capacity plant management.
- Oversee OSHA compliance.

- Design and develop computerized integration of data from various production and testing department and automate analysis of collected data.
- Manufacturing equipment upgrade design.
- Investor relations.
- Project management and 6-sigma process control for manufacturing.
- Product failure investigation, UL certification of solar panel for commercialization, reliability testing, and manufacturing equipment commissioning.
- Research, development, and integration of advanced technologies for manufacturing.
- Plant maintenance scheduling, supervision, employee safety, and calibration of production systems (sensors and actuators).

MAY 2012 – JULY 2013 (Internship during M.S. and Ph.D.)

ENGINEERING MATERIALS FAILURE ANALYST, WOODWARD GOVERNERS INC.

- Identify the causes for failure of engineering parts under test condition and occasionally in the field.
- I handled multiple projects and identified failure causes for several engineering parts which included fatigue fractures, chlorine induced corrosions and cavitation.
- Served on a team of over 15 engineers and project managers for development of a new product and material selection.

MAY 2011 – AUGUST 2011 (Internship during M.S.)

SUMMER DESIGN ENGINEERING INTERN, COLORADO STATE UNIVERSITY

- As an engineering intern at the Energy Institute (then Engines and Energy Conversion Laboratory - EECL) I was hired to work on a project named SEED (Small Engines for Economic Development).
- Design and development of a small engine combined with a lightweight water pump to be used for irrigation by farmers in developing countries such as Bangladesh, China and India.
- Major challenges were to make the product light weight to allow one person to carry the unit on their shoulder to the farm while maintaining a low cost.

CONSULTATION EXPERIENCE

FEB 2015 – PRESENT

EXPERT WITNESS, MEDICAL IMPLANTS FAILURE

- Analysis of failure mode for medical implants during its service life in patients' body
- Microscopic characterization of failed surfaces to verify failure mechanism
- Preparing expert witness reports for legal arguments and proceedings

DEC 2021 – PRESENT

FEASIBILITY INVESTIGATION, NAVAJO NATIVE AMERICAN RESERVATION

- Site visit for potential off-grid stand alone energy solutions for underprivileged minority families
- Interview with families to identify the pain points, expected solutions, available resources, etc.
- Identification of user needs and effective as well as affordable solutions
- Preparing simplified system diagrams, identifying suitable vendors, etc.
- Reporting findings for projected performance, system cost, phased installation, etc.

TEHCNICAL EXPERTISE

- **Thin-film fabrication and interface engineering**
 - Sublimation and closed-space sublimation of semiconductors for photovoltaic application
 - Defect passivation and activation of photovoltaic thin-films
 - RF and DC sputter deposition of thin films
 - Physical vapor deposition for deposition for electrical contacts
 - Metal Organic Chemical Vapor Deposition and Chemical Bath Deposition
 - Plasma and chemical etching for surface and interface preparation
 - Vacuum system design, operation and maintenance
- **Computational simulation and programming**
 - R script for statistical analysis of data
 - Machine learning using Python
 - Synopsys QyantumATK – DFT modeling, molecular dynamics simulations and Monte Carlo Adaptive Modeling
 - SCAPS 1-D semiconductor interface modeling
- **Electron microscopy and X-ray methods (SEM, TEM/HRTEM, EDS, XPS)**
 - Specimen preparation for electron microscope imaging using Dual Beam FIB
 - Secondary electron and back-scatter electron imaging with SEM
 - Bright field, dark field and high angle annular dark field electron imaging using TEM
 - Image analysis to understand film morphology
 - Energy dispersive X-ray spectroscopy (EDS) for elemental mapping and composition
 - SIMS, ICP, CL, SCM and SKPM data analysis and interpretation
 - Cross-section transmission electron microscope imaging for grain structure and defects
 - High-resolution transmission electron microscopy for interface and defect analysis
 - XPS compositional analysis
 - Argon ion etching and depth profiling using XPS
- **Focused Ion Beam (Gallium Ion-Electron Dual-beam)**
 - Ultra-thin electron transparent TEM sample fabrication (<60 nm cross section) for TEM and HRTEM imaging
 - Specimen preparation for thin-film cross-section composition analysis using EDS
 - Specimen preparation for cross-section EBSD analysis
- **Electrical measurement and analysis**
 - Current density v/s voltage (JV),
 - Quantum efficiency (EQE),
 - Capacitance v/s voltage (CV) and Capacitance v/s frequency (CF) measurement and data analysis
 - Time Resolved and low-temperature photoluminescence
- **Computer aided designing, manufacturing and analysis (CAD, CAM, CFD, FEA)**
 - Company certified PTC (ProEngineer Wildfire) Creo engineer
 - Computation fluid dynamics analysis using Ansys and Workbench
 - Finite Element Analysis using Abaqus
- **Machining**
 - Lathe and milling - steel, brass, aluminum, wood, graphite and acrylic
 - Welding – SMAW, GTAW, MIG
- **Certifications –**
 - Acumen Academy: Human Centered Design

- AIGPE Six Sigma White Belt

RESEARCH ACTIVITIES

Google Scholar Profile

Key Words – Amit Munshi CdTe

Citations – 1014

h-index – 15

i10 index – 19

Research gate profile –

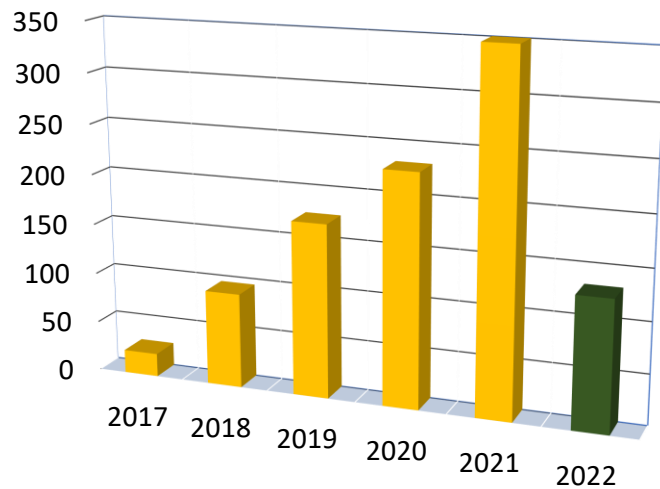
Rating – 26.46

Total research interest – 542.9

recommendations – 45

Reads – 7,026

PROGRESS IN CITATION BY YEAR



Source: <https://scholar.google.com/citations?user=aQ2uIa/AAAA&hl=en>

As of 07/30/22

Demonstration of High Research Impact –

- At 2019 IEEE Photovoltaics Specialists Conference, **over 85%** of the 40 published manuscripts in this field cited my research.
- At European Materials Research Society Spring 2020 meeting, I was a author/co-author for **8 out of 10** oral presentations in this field of research, remaining 2 also cited my research.

PEER REVIEWED JOURNAL PUBLICATIONS

1. Fiducia, Thomas, Ashley Howkins, Ali Abbas, Budhika Mendis, Amit Munshi, Kurt Barth, Walajabad Sampath, and John Walls. "Selenium passivates grain boundaries in alloyed CdTe solar cells." *Solar Energy Materials and Solar Cells* 238 (2022): 111595. **[Impact Factor – 7.26]**
2. Jiang, C-S., David Albin, Marco Nardone, K. J. Howard, A. Danielson, A. Munshi, T. Shimpi et al. "Electrical potential investigation of reversible metastability and irreversible degradation of CdTe solar cells." *Solar Energy Materials and Solar Cells* 238 (2022): 111610. **[Impact Factor – 7.26]**
3. Shah, Akash, Ramesh Pandey, Anthony Nicholson, Zach Lustig, Ali Abbas, Adam Danielson, John Walls, Amit Munshi, and Walajabad Sampath. "Understanding the Role of CdTe in Polycrystalline CdSe_xTe_{1-x}/CdTe-Graded Bilayer Photovoltaic Devices." *Solar RRL* 5, no. 11 (2021): 2100523. **[Impact Factor – 8.62]**
4. Pandey, Ramesh, Akash Shah, Amit Munshi, Tushar Shimpi, Pascal Jundt, Jinglong Guo, Robert F. Klie, Walajabad Sampath, and James R. Sites. "Mitigation of J–V distortion in CdTe solar cells by Ga-doping of MgZnO emitter." *Solar Energy Materials and Solar Cells* 232 (2021): 111324. **[Impact Factor – 7.26]**
5. Guo, Jinglong, Ramesh Pandey, Amit Munshi, Walajabad Sampath, and Robert Klie. "Electric field mapping in CdSeTe solar cell using 4D-STEM." *Microscopy and Microanalysis* 27, no. S1 (2021): 2196-2198. **[Impact Factor – 3.41]**
6. Shah, Akash, Anthony P. Nicholson, Thomas AM Fiducia, Ali Abbas, Ramesh Pandey, Junliang Liu, Chris Grovenor, John M. Walls, Walajabad S. Sampath, and Amit H. Munshi. "Understanding the copassivation effect of Cl and Se for CdTe grain boundaries." *ACS Applied Materials & Interfaces* 13, no. 29 (2021): 35086-35096. **[Impact Factor – 9.23]**

7. Pandey, Ramesh, Amit Munshi, Tushar Shimpi, Akash Shah, Alexandra Bothwell, Darius Kuciauskas, and James R. Sites. "CdTe-Based Solar Cells with Variations in Mg Concentration in the MgZnO Emitter." *Solar RRL* 5, no. 7 (2021): 2100126. **[Impact Factor – 8.62]**
8. Guo, J., Sharma, **A., Munshi, A.**, Reich, C., Danielson, A., Sampath, W., . . . Klie, R. (2020). Study of Arsenic Doped CdSeTe Solar Cells Using Transmission Electron Microscopy. *Microscopy and Microanalysis*, 26(S2), 1232-1234. doi:10.1017/S1431927620017420. **[Impact Factor – 3.41]**
9. Shah, Akash., **Munshi, Amit H.**, Nicholson, Anthony P., Thiyaagrajan, Aanand., Pozzoni, Umberto M. and Sampath, Walajabad S.; "Atomistic modeling of energy band alignment in CdSeTe surfaces." *Applied Surface Science* (2020): 148762. **[Impact Factor – 6.71]**
10. Pandey, Ramesh, Tushar Shimpi, **Amit Munshi**, and James R. Sites. "Impact of Carrier Concentration and Carrier Lifetime on MgZnO/CdSeTe/CdTe Solar Cells." *IEEE Journal of Photovoltaics* 10, no. 6 (2020): 1918-1925. **[Impact Factor – 3.73]**
11. Mathews, Ian, Sai Nithin Reddy Kantareddy, Zhe Liu, **Amit Munshi**, Kurth Barth, Walajabad Sampath, Tonio Buonassisi, and Ian Peters. "Analysis of CdTe photovoltaic cells for ambient light energy harvesting." *Journal of Physics D: Applied Physics* (2020). ***Equal contribution – Device fabricated by me enabled this research [Impact Factor – 3.16]**
12. Samoilenko, Yegor, Gavin Yeung, **Amit H. Munshi**, Ali Abbas, Carey L. Reich, Michael Walker, Matthew O. Reese et al. "Stable magnesium zinc oxide by reactive Co-Sputtering for CdTe-based solar cells." *Solar Energy Materials and Solar Cells* 210 (2020): 110521. **[Impact Factor – 6.01]**
13. Misra, Sudhajit, Jeffery A. Aguiar, Sophia Gardner, Xiahan Sang, Raymond R. Unocic, **Amit Munshi**, Walajabad Sampath, Chris S. Ferekides, and Michael A. Scarpulla. "Cadmium Selective Etching in CdTe Solar Cells Produces Detrimental Narrow-gap Te in Grain Boundaries." *ACS Applied Energy Materials* (2020). **[Impact Factor – 15.00]**
14. *Fiducia, Thomas AM, Budhika G. Mendis, Kexue Li, Chris RM Grovenor, ***Amit H. Munshi**, Kurt Barth, Walajabad S. Sampath et al. "Understanding the role of selenium in defect passivation for highly efficient selenium-alloyed cadmium telluride solar cells." *Nature Energy* 4, no. 6 (2019): 504. **[Impact Factor – 54.00] *Equal contribution**
15. *Fiducia, Thomas AM, Kexue Li, ***Amit H. Munshi**, Kurt Barth, Walajabad S. Sampath, Chris RM Grovenor, and John M. Walls "3D Imaging of Selenium and Chlorine Distributions in Highly Efficient Selenium-Graded Cadmium Telluride Solar Cells" *IEEE Journal of Photovoltaics*, (2019); doi: 10.1109/JPHOTOV.2019.2955313. **[Impact Factor – 3.74] *Equal contribution**
16. *Jinglong Guo, Arun Mannodi-Kanakkithodi, Faitih G. Sen, Eric Schwenker, E.S. Bernard, ***Amit Munshi**, W. Sampath, Maria K. Y. Chan and Robert F. Klie. "Effect of selenium and chlorine co-passivation in polycrystalline CdSeTe devices." *Applied Physics Letters* 115, 153901 (2019). **[Impact Factor – 3.52] *Equal contribution**
17. Bittau, Francesco, Shridhar Jagdale, Christos Potamialis, Jake W. Bowers, John M. Walls, **Amit H. Munshi**, Kurt L. Barth, and Walajabad S. Sampath. "Degradation of Mg-doped zinc oxide buffer layers in thin film CdTe solar cells." *Thin Solid Films* (2019): 137556. **[Impact Factor – 1.94]**

18. *Guo, Jinglong, Fatih G. Sen, Arun Mannodi-Kannakithodi, Edward S. Barnard, W. Sampath, ***Amit Munshi**, Maria KY Chan, and Robert F. Klie. "Study of Effects of Cl and Se in CdSeTe Solar Cells Using Scanning Transmission Electron Microscopy." *Microscopy and Microanalysis* 25, no. S2 (2019): 2150-2151. [**Impact Factor – 2.67**] ***Equal contribution**
19. **Munshi, Amit H.**, Jason M. Kephart, Ali Abbas, Adam Danielson, Guillaume G  linas, Jean-Nicolas Beaudry, Kurt L. Barth, John M. Walls, and Walajabad S. Sampath. "Effect of CdCl₂ passivation treatment on microstructure and performance of CdSeTe/CdTe thin-film photovoltaic devices." *Solar Energy Materials and Solar Cells* 186 (2018): 259-265. [**Impact Factor – 6.01**]
20. **Munshi, Amit H.**, Nikhil Sasidharan, Subin Pinkayan, Kurt L. Barth, W. S. Sampath, and Weerakorn Ongsakul. "Thin-film CdTe photovoltaics–The technology for utility scale sustainable energy generation." *Solar Energy* 173 (2018): 511-516. [**Impact Factor – 4.67**]
21. Berg, Morgann, Jason M. Kephart, **Amit Munshi**, Walajabad S. Sampath, Taisuke Ohta, and Calvin Chan. "Local electronic structure changes in polycrystalline CdTe with CdCl₂ treatment and air exposure." *ACS applied materials & interfaces* 10, no. 11 (2018): 9817-9822. [**Impact Factor – 8.45**]
22. Kephart, Jason M., Anna Kindvall, Desiree Williams, Darius Kuciauskas, Pat Dippo, **Amit Munshi**, and W. S. Sampath. "Sputter-deposited oxides for interface passivation of CdTe photovoltaics." *IEEE Journal of Photovoltaics* 8, no. 2 (2018): 587-593. [**Impact Factor – 3.74**]
23. **Munshi, Amit H.**, Jason M. Kephart, Ali Abbas, Tushar M. Shimpi, Kurt L. Barth, John M. Walls, and Walajabad S. Sampath. "Polycrystalline CdTe photovoltaics with efficiency over 18% through improved absorber passivation and current collection." *Solar Energy Materials and Solar Cells* 176 (2018): 9-18. [**Impact Factor – 6.01**]
24. **Munshi, Amit H.**, Jason Kephart, Ali Abbas, John Raguse, Jean-Nicolas Beaudry, Kurt Barth, James Sites, John Walls, and Walajabad Sampath. "Polycrystalline CdSeTe/CdTe absorber cells with 28 mA/cm₂ short-circuit current." *IEEE Journal of Photovoltaics* 8, no. 1 (2017): 310-314. [**Impact Factor – 3.74**]
25. Shimpi, Tushar M., Jason M. Kephart, Drew E. Swanson, **Amit H. Munshi**, Walajabad S. Sampath, Ali Abbas, and John M. Walls. "Effect of the cadmium chloride treatment on RF sputtered Cd_{0.6}Zn_{0.4}Te films for application in multijunction solar cells." *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films* 34, no. 5 (2016): 051202. [**Impact Factor – 1.72**]
26. **Munshi Amit** and Walajabad Sampath. "CdTe photovoltaics for sustainable electricity generation." *Journal of Electronic Materials* 45, no. 9 (2016): 4612-4619. [**Impact Factor – 1.68**]

CONFERENCE PROCEEDINGS – POSTERS/ORALS/ABSTRACTS

1. Pandey, Ramesh, Akash Shah, **Amit Munshi**, Pascal Jundt, Tushar Shimpi, Darius Kuciauskas, and James Sites. "Transparent MgO for back-contact passivation of CdTe-based solar cells." In *2021 IEEE 48th Photovoltaic Specialists Conference (PVSC)*, pp. 1163-1165. IEEE, 2021.
2. Jundt, Pascal, Ramesh Pandey, **Amit Munshi**, and James Sites. "Transparent Buffer Layer for Back Surface Passivation in CdTe Photovoltaics." In *2021 IEEE 48th Photovoltaic Specialists Conference (PVSC)*, pp. 1614-1618. IEEE, 2021.

3. Shah, Akash, Ramesh Pandey, Anthony P. Nicholson, Tushar Shimpi, Walajabad S. Sampath, and **Amit H. Munshi**. "First principles guided device fabrication of arsenic doped CdTe photovoltaics." In *2021 IEEE 48th Photovoltaic Specialists Conference (PVSC)*, pp. 1527-1529. IEEE, 2021.
4. **Amit H. Munshi**, Carey L. Reich, Adam H. Danielson, Ramesh Pandey, Darius Kuciauskas, Jinglong Guo, Siming Li, Akash Shah, Santosh Swain, Tushar M. Shimpi, Tawfeeq K. Al-Hamdi, Kelvin G. Lynn, Robert F. Klie and Walajabad S. Sampath. "Arsenic Doping of Polycrystalline CdSeTe Devices for Microsecond Life-times with High Carrier Concentrations." In *2020 IEEE 47th Photovoltaic Specialists Conference (PVSC)*, IEEE, 2020. **[Extended Oral Panel Discussion, Chalcogenide PV Roadmap and Area 2 Featured Conference Highlights]**
5. Tushar Shimpi, Carey Reich, Adam Danielson, **Amit Munshi**, Anna Kindvall, Ramesh Pandey, Kurt Barth and Walajabad Sampath. "Influence of Process Parameters and Absorber Thickness on Efficiency of Polycrystalline CdSeTe/CdTe Thin Film Solar Cells." In *2020 IEEE 47th Photovoltaic Specialists Conference (PVSC)*, IEEE, 2020. **[Extended 30 minute oral presentation]**
6. Darius Kuciauskas, David Albin, John Moseley, Siming Li, Patrik Scajev, Carey Reich, **Amit H. Munshi**, Adam Danielson, Walajabad Sampath and Chungho Lee. "Microsecond Carrier Lifetimes in polycrystalline CdSeTe Heterostructures and in CdSeTe Thin Film Solar Cells." In *2020 IEEE 47th Photovoltaic Specialists Conference (PVSC)*, IEEE, 2020. **[Oral Presentation]**
7. Onno, Arthur, Adam Danielson, Carey Reich, Anna Kindvall, William Weigand, **Amit Munshi**, Siming Li, Darius Kuciauskas, Walajabad Sampath, and Zachary Holman. "Calculation of the thermodynamic voltage limit of CdSeTe solar cells." In *2020 47th IEEE Photovoltaic Specialists Conference (PVSC)*, pp. 0535-0537. IEEE, 2020.
8. Adam Danielson, Darius Kuciasukas, Carey Reich, Siming Li, Arthur Onno, William Weigand, Anna Kindvall, **Amit Munshi**, Zachary Holman and Walajabad Sampath. "CdSe_xTe_{1-x}/CdTe Devices with Reduced Interface Recombination Through Novel Back Contacts and Group-V Doping." In *2020 IEEE 47th Photovoltaic Specialists Conference (PVSC)*, IEEE, 2020.
9. Thomas Fiducia, Ashley Howkins, Ali Abbas, Budhika Mendis, **Amit Munshi**, Kurt Barth, Walajabad Sampath and John M. Walls. "TEM-based Cathodoluminescence of a Selenium-alloyed CdTe Solar Cell." In *2020 IEEE 47th Photovoltaic Specialists Conference (PVSC)*, IEEE, 2020.
10. Torabi, Aida, Claudia Beck, **Amit Munshi**, Carey Reich, Walajabad Sampath, and Taylor Harvey. "Cathodoluminescence measurement of high bandgap CdTe-based devices." *Bulletin of the American Physical Society* 65 (2020).
11. **Amit H Munshi**, Adam H Danielson, Santosh Swain, Carey L Reich, Tushar M Shimpi, Seth W McPherson, Kelvin G Lynn, Darius Kuciauskas, Andrew Ferguson, Jinglong Guo, Robert Klie, Walajabad S Sampath. "Doping CdSe_xTe_{1-x}/CdTe Graded Absorber Films with Arsenic for Thin-Film Photovoltaics." In *2019 IEEE 46th IEEE Photovoltaics Specialists Conference, Chicago*. IEEE, 2019. **[Oral Presentation]**
12. Anna E. Kindvall, **Amit H. Munshi**, Tushar M. Shimpi, Adam H. Danielson, Walajabad S. Sampath.. "Effect of Process Temperature and Copper Doping on the Performance of ZnTe:Cu Back Contacts in CdTe Photovoltaics." In *2019 IEEE 46th IEEE Photovoltaics Specialists Conference, Chicago*. IEEE, 2019. **[Best Poster Presentation Award]**

13. **Amit Munshi**, Jason Kephart, Ali Abbas, Thomas Fiducia, Adam Danielson, Carey Reich, Tushar Shimpi, John Walls, Walajabad Sampath." Progress and Challenges in Absorber and Interface Fabrication of Polycrystalline CdTe Photovoltaics." *Materials Research Society Spring Meeting 2019*. **[Invited Talk, invited to submit manuscript to Journal of Materials Research as a featured article]**
14. William Weigand, Carey Reich, **Amit Munshi**, Arthur Onno, Adam Danielson, Walajabad Sampath, Zachary Holman."P-Type Hydrogenated Amorphous Silicon—A Hole-Selective Contact to Cadmium Telluride Based Solar Cells." *Materials Research Society Spring Meeting 2019*. **[Oral Presentation]**
15. Arthur Onno, **Amit Munshi**, Adam Danielson, Carey Reich, William Weigand, Salman Manzoor, Jason Yu, Walajabad Sampath, Darius Kuciauskas, Zachary Holman." Diagnosing Recombination and Resistive Losses in Thin-Film Chalcogenide Solar Cells Using a Silicon-Inspired Characterization Platform." *Materials Research Society Spring Meeting 2019*. **[Oral Presentation]**
16. Jinglong Guo, Fatih G. Sen, Arun Mannodi-Kannakithodi, Edward S. Barnard, Walajabad S. Sampath, **Amit Munshi**, Moon Kim, Maria K. Y. Chan, Robert F. Klie. "Study of Se and Cl segregation in polycrystalline CdSeTe" In *2019 IEEE 46th IEEE Photovoltaics Specialists Conference, Chicago*. IEEE, 2019. **[Oral Presentation]**
17. Thomas A. M. Fiducia, Kexue Li, **Amit H. Munshi**, Kurt Barth, Walajabad S. Sampath, Chris R. M. Grovener, John M. Walls. "3D Imaging of Selenium Distributions in High Efficiency Selenium-Graded Cadmium Telluride Solar Cells." In *2019 IEEE 46th IEEE Photovoltaics Specialists Conference, Chicago*. IEEE, 2019. **[Oral Presentation]**
18. Kholoud Alajmi, Dhruv Patel, **Amit Munshi**, Walajabad Sampath, Roseanne Warren, M.A. Scarpulla "Capacitance Spectroscopies on FTO/MZO/CdSeTe Thin Film Solar Cells" In *2019 IEEE 46th IEEE Photovoltaics Specialists Conference, Chicago*. IEEE, 2019.
19. Dhruv Patel, Kholoud Alajmi, Abdul Shaik, **Amit Munshi**, Walajabad Sampath, Dragica Vasileska, Roseanne Warren, M.A. Sarpulla "Observation of Current Voltage Hysteresis in Air Exposed FTO/MZO/CdSeTe/Te Thin Film Solar Cells" In *2019 IEEE 46th IEEE Photovoltaics Specialists Conference, Chicago*. IEEE, 2019.
20. Rachael C. Greenhalgh, Vincent Tsai, Ali Abbas, Vladislav Kornienko, Tom A. M. Fiducia, Mustafa Togay, Kexue Li, Chris Grovener, Adam Danielson, **Amit H. Munshi**, Kurt L. Barth, Walajabad S. Sampath, Jake W. Bowers, John M. Walls. "Analysis of an MZO/CdTe photovoltaic device treated with cadmium bromide" In *2019 IEEE 46th IEEE Photovoltaics Specialists Conference, Chicago*. IEEE, 2019. **[Best Paper Award Finalist]**
21. Adam H. Danielson, **Amit H. Munshi**, Arthur Onno, William Weigand, Anna Kindvall, Carey Reich, Zhengshan J. Yu, Jianwei Shi, Zachary Holman, Walajabad Sampath, Darius Kuciauskas, Ali Abbas, John M. Walls "Sputtered Aluminum Oxide and p+ Amorphous Silicon Back-contact for Improved Hole Extraction in Polycrystalline CdSe_xTe_{1-x} and CdTe Photovoltaics." In *2019 IEEE 46th IEEE Photovoltaics Specialists Conference, Chicago*. IEEE, 2019. (Oral Presentation)
22. **Munshi, Amit H.**, Adam H. Danielson, Kurt L. Barth, Guillaume Gélinas, Jean-Nicolas Beaudry, and W. S. Sampath. "Advanced Co-sublimation of Low Bandgap CdSe_xTe_{1-x} Alloy to Achieve Higher Short-Circuit Current." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC)(A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 0148-0152. IEEE, 2018.

23. Abbas, A., **A. Munshi**, K. L. Barth, W. S. Sampath, G. D. West, and J. M. Walls. "Investigation of localized Phase Changes using High Resolution Electron Back-Scatter Diffraction in Thin Film Cadmium Telluride Photovoltaic Material with High Lattice Defect Densities." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC)(A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 1692-1696. IEEE, 2018.
24. **Munshi, Amit H.**, Adam H. Danielson, Anna Kindvall, Kurt Barth, and Walajabad Sampath. "Investigation of Sputtered Oxides and p+ Back-contact for Polycrystalline CdTe and CdSeTe Photovoltaics." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC) (A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 3009-3012. IEEE, 2018.
25. **Munshi, Amit H.**, Jason M. Kephart, C. Reich, Davis R. Hemenway, Tushar M. Shimpi, Ali Abbas, Kevan C. Cameron et al. "Advanced co-sublimation hardware for deposition of graded ternary alloys in thin-film applications." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC)(A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 0842-0845. IEEE, 2018.
26. Fiducia, Thomas AM, **Amit H. Munshi**, Kurt Barth, Daniela Proprentner, Geoffrey West, Walajabad S. Sampath, and John M. Walls. "Defect Tolerance in as-deposited Selenium-alloyed Cadmium Telluride Solar Cells." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC)(A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 0127-0130. IEEE, 2018.
27. Danielson, Adam, **Amit Munshi**, Anna Kindvall, Santosh Kumar Swain, Kurt Barth, Kelvin Lynn, and Walajabad Sampath. "Doping CdTe Absorber Cells using Group V Elements." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC)(A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 0119-0123. IEEE, 2018. **[Best Poster Presentation Finalist]**
28. Greenhalgh, R. C., Ali Abbas, **A. H. Munshi**, Tushar M. Shimpi, Kurt L. Barth, Walajabad S. Sampath, Jake W. Bowers, and J. M. Walls. "Activation of thin film CdTe solar cells using a cadmium bromide treatment." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC)(A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 2990-2993. IEEE, 2018.
29. Nicholson, Anthony P., **Amit H. Munshi**, Umberto Pozzoni, and Walajabad S. Sampath. "First Principles Approach to CdTe/Te Interface Band Alignment Using Density Functional Theory and Nonequilibrium Green's Function." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC)(A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 1932-1936. IEEE, 2018.
30. Kindvall, Anna, **Amit Munshi**, Tushar Shimpi, Adam Danielson, and Walajabad S. Sampath. "Copper-Doped Zinc Telluride Thin-Films as a Back Contact for Cadmium Telluride Photovoltaics." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC) (A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 2994-2997. IEEE, 2018.
31. Fiducia, Thomas AM, Kexue Li, **Amit H. Munshi**, Kurt Barth, Walajabad S. Sampath, Chris Grovenor, and John M. Walls. "Large Area 3D Elemental Mapping of a MgZnO/CdTe Solar Cell with Correlative EBSD Measurements." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC) (A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 1702-1706. IEEE, 2018.
32. Danielson, Adam, **Amit Munshi**, Drew Swanson, Jennifer Drayton, Giray Kartopu, Kurt Barth, Stuart Irvine, and Walajabad Sampath. "MOCVD Deposition of Group V Doped CdTe in Sublimated CdTe and CdSeTe Devices." In *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC) (A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, pp. 0153-0156. IEEE, 2018.

33. Fiducia, Thomas AM, Kexue Li, **Amit H. Munshi**, Kurt Barth, Walajabad S. Sampath, Chris RM Grovenor, and John M. Walls. "3D Distributions of Chlorine and Sulphur Impurities in a Thin-Film Cadmium Telluride Solar Cell." *MRS Advances* 3, no. 56 (2018): 3287-3292. **[Best Poster Presentation Finalist]**
34. **Munshi, Amit**, Piotr M. Kaminski, Ali Abbas, Shiva T. Reddy, Sreeram Chandralal, Michael Walls, and Walajabad S. Sampath. "Characterization of CdTe photovoltaic devices passivated using hydrogen plasma." In *2017 IEEE 44th IEEE Photovoltaics Specialists Conference, Portland*. IEEE, 2017. (2017).
35. **Munshi, Amit H.**, Jason Kephart, Ali Abbas, John Raguse, Jean-Nicolas Beaudry, Kurt Barth, James Sites, John Walls, and Walajabad Sampath. "Polycrystalline CdSeTe/CdTe absorber cells with 28 mA/cm² short-circuit current." In *2017 IEEE 44th IEEE Photovoltaics Specialists Conference, Portland*. IEEE, 2017. (2017). **[Best Paper Award – Invited for publication in IEEE Journal of Photovoltaics]**
36. Sites, James, **Amit Munshi**, Jason Kephart, Drew Swanson, and W. S. Sampath. "Progress and challenges with CdTe cell efficiency." In *2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC)*, pp. 3632-3635. IEEE, 2016. **[Invited Talk]**
37. **Munshi, Amit H.**, Jason M. Kephart, Ali Abbas, Tushar M. Shimpi, Kurt Barth, John M. Walls, and Walajabad S. Sampath. "Effect of varying deposition and substrate temperature on sublimated CdTe thin-film photovoltaics." In *2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC)*, pp. 0465-0469. IEEE, 2016. **[Best Poster Presentation Award]**
38. Reich, Carey, Drew Swanson, Tushar Shimpi, Jennifer Drayton, **Amit Munshi**, Ali Abbas, and Walajabad Sampath. "Passivation of a Cd_{1-x}Mg_xTe absorber for application in a tandem cell." In *2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC)*, pp. 0487-0491. IEEE, 2016.
39. Dangate, Milind, **Amit Munshi**, W. S. Sampath, Olga V. Boltalina, Steven H. Strauss, C. Saravanan, and Shantikumar Nair. "Investigation of organic small molecules and polymer compounds for CdTe back contact." In *2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC)*, pp. 1438-1442. IEEE, 2016.
40. Abbas, Ali, D. Swanson, **Amit Munshi**, Kurt L. Barth, Walajabad S. Sampath, G. D. West, Jake W. Bowers, Piotr M. Kaminski, and J. M. Walls. "The effect of a post-activation annealing treatment on thin film CdTe device performance." In *2015 IEEE 42nd Photovoltaic Specialist Conference (PVSC)*, pp. 1-6. IEEE, 2015.
41. Swanson, Drew E., Ali Abbas, **Amit H. Munshi**, Jennifer A. Drayton, John M. Raguse, Russell M. Geisthardt, James R. Sites, and Walajabad S. Sampath. "Incorporation of Cd_{1-x}Mg_xTe as an electron reflector for cadmium telluride photovoltaic cells." *MRS Online Proceedings Library Archive* 1771 (2015): 133-138.
42. **Munshi Amit**, Ali Abbas, John Raguse, Kurt Barth, Walajabad S. Sampath, and J. M. Walls. "Effect of varying process parameters on CdTe thin film device performance and its relationship to film microstructure." In *2014 IEEE 40th Photovoltaic Specialist Conference (PVSC)*, pp. 1643-1648. IEEE, 2014.

SYNERGISTIC ACTIVITIES

- **IEEE Photovoltaics Specialists Conference 2022** – Co-Area Chair for Area 2: Chalcogenide Thin-Film Solar Cells for sub-area Absorber Preparation and Material Properties
- **IEEE Photovoltaics Specialists Conference 2021** – Sub-Area Chair for Area 2: Chalcogenide Thin-Film Solar Cells for sub-area Absorber Preparation and Material Properties

- Co-organizer **E-MRS (European Materials Research Society) 2021 spring meeting** in Strasbourg, France for Chalcogenide Thin-Film Solar Cells Symposium.
- Co-organizer **E-MRS (European Materials Research Society) 2020 spring meeting** in Strasbourg, France for Chalcogenide Thin-Film Solar Cells Symposium.
- Co-organizer **Virtual Chalcogenide PV Conference** attended by over 500 participants aimed at encouraging scholarly discussion in light of several cancelled conferences due to COVID-19 pandemic.
- **Materials Research Society Spring Meeting 2019** – Session Chair for Area ES20.11: Module Fabrication and Stability
- **IEEE Photovoltaics Specialists Conference 2019** - Session Chair for Area 2: Interfaces and Contact Layers in Thin Film PV
- **IEEE Photovoltaics Specialists Conference 2019** - Session Chair for Area 2: Fabrication and Degradation of CIGSe
- **IEEE Photovoltaics Specialists Conference 2019** – Organizer and sub-area Chair for Area 2
- **IEEE Photovoltaics Specialists Conference 2017** - Session Chair for Area 2: Interfaces and Contact Layers in Thin Film PV

PEER REVIEW AND EVALUATION

- Journal of Solar Energy Materials and Solar Cells (2017, 2018, 2019, 2020)
- Journal of Solar Energy (2018, 2019, 2020)
- IEEE Journal of Photovoltaics (2018, 2019)
- Journal of Thin-Solid Films (2019)
- Journal of Vacuum Science and Technology (2018, 2019)
- Ph.D. Dissertation Evaluator – Visvesvaraya Technological University, Karnataka, India (2018)
- American Institute of Physics Advances (2019)
- Photonics Technology Letters (2019)
- IEEE Photovoltaics Specialists Conference abstract evaluation (2019,2020)
- European Materials Research Society (EMRS) abstract evaluation (2020)
- Solid State Communications (2020)
- Journal of Applied Energy (2020)
- Environmental Pollution (2020)
- Journal of Applied Sciences (2020)
- Recent Progress in Materials (2020)
- International Journal of Technology, Policy and Management (2020)
- MDPI Sustainability (2021)
- Journal of Applied Surface Science (2021)

RESEARCH PROPOSALS AND FUNDING

- Concluded projects –
 - NSF AIR-RA – **Major Contributor** - *Advanced Thin-Film Photovoltaics for Sustainable Energy*. Contributions include experiment execution, data analysis and reporting.
Total Budget – US \$1.2M over 3 years. **Project successfully concluded July 2019.**

- U.S. Department of Energy, Solar Energy Technology Office (SETO) - **Co-Principal investigator** – *High Lifetime and Mobility CdTe Alloys by Co-Sublimation*.
Total Budget - US \$189,000. **Project successfully concluded June 2019**.
- Three National Science Foundation Research Experience for Undergraduate (REU) supplements including two for diversity students. Contributions include mentoring undergraduate students, managing hours in laboratory and reporting.
Total Budget – US \$24k for 1 year.
- Ongoing projects -
 - U.S. Department of Energy Solar Energy Technology Office – **Senior Personal**: *Doping of CdTe and CdSeTe for higher efficiency*. Contributions include experiment planning, experiment execution, data analysis, reporting to DOE and results publications.
Total Budget – US \$937K over 3 years.
 - U.S. Department of Energy Solar Energy Technology Office – **Senior Personal** (subcontract, Arizona State University lead): *Diagnosing and overcoming recombination and resistive losses in non-silicon solar cells using a silicon-inspired characterization platform*. Contributions include experiment planning, experiment execution, data analysis, reporting to DOE and results publications.
Total Budget – US \$1.47M, **CSU Budget** – US \$375K for 3 years.
 - National Science Foundation Industry/University Cooperative Research Center for Next Generation Photovoltaics – **Senior Personal**. Research lead on 2-3 annual projects since 2013 focused on materials characterization and process development. Contributions include experiment planning and execution, data analysis, quarterly reporting, biannual presentation to NSF and Industrial Advisory Board, annual project reporting and research publications.
Annual Budget – US \$350K per year.
- Past proposals –
 - **Co-principal Investigator** (Subcontract, University of Nevada at Las Vegas lead) - U.S. Department of Energy Solar Energy Technology Office : *Maximizing Long Term Power Output for Thin-film Photovoltaics: Metastability and long-term degradation in CdTe and CdSeTe solar cells: Quantification of interface and bulk degradation*.
 - **Principal Investigator** (Subcontract, Arizona State University lead) - U.S. Department of Energy Solar Energy Technology Office : Transparent back-contact and interface development in CdTe solar cells for bifacial and tandem cell applications.
 - National Science Foundation Research Experience for Undergraduate (REU) supplement for one student.
 - **Senior personal** (Subcontract, University of Illinois at Chicago lead) - U.S. Department of Energy Solar Energy Technology Office : Advanced characterization of interfaces and defects in polycrystalline thin-film photovoltaics.
 - **Senior personal** (Subcontract, Colorado School of Mines lead) - U.S. Department of Energy Solar Energy Technology Office : Thin-film transistor fabrication and its integration into modules to allow active control of reverse bias damage due to shadowing.
 - **Principal investigator** - U.S. Department of Energy, Solar Energy Technology Office (SETO) – Low Band-gap Sb_2Se_3 for Tandem Application with Thin-Film CdTe – Proposal Encouraged
 - **Principal investigator** (sub-contract) - U.S. Department of Energy, Solar Energy Technology Office (SETO) - Advanced Buffer Layers for CdTe-based Solar Cells - Proposal Encouraged
 - **Principal investigator** (sub-contract) - U.S. Department of Energy, Solar Energy Technology Office (SETO) – Maximizing Long Term Power Output for Thin-film Photovoltaics: Quantification of Interface and Bulk Degradation Mechanisms vis In-Situ Stress Analyses - Proposal Encouraged.

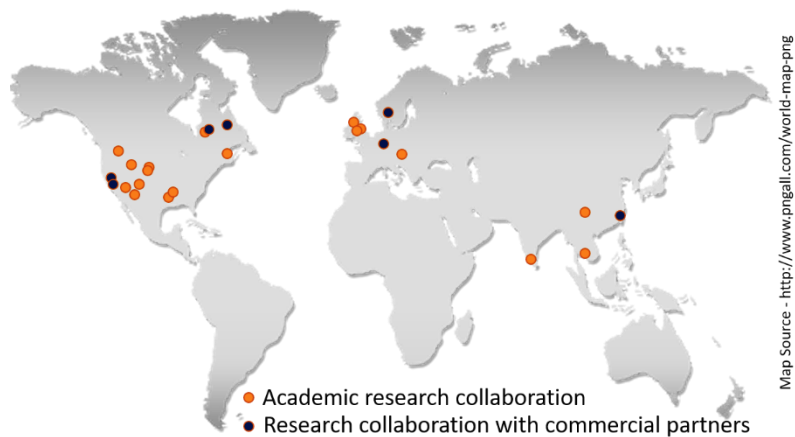
- National Science Foundation Designing Materials to Revolutionize and Engineer our Future (DMREF) – **Co-principal Investigator:** *(working title) Fundamental understanding of antimony chalcogenides and their interfaces for clean energy applications – establishing a theory-modeling-preparation-characterization cycle.*
Proposed budget – US \$1.8M over 4 years.

CURRENT RESEARCH INTERESTS

- Development of low cost thin-film photovoltaics with advanced device architecture, and materials and interface engineering
- Copper enrichment of titanium and titania nano-tubes surface for biomedical application
- First principle computation modeling of advanced materials, surfaces, and interfaces
- Monte Carlo and Molecular Dynamics modeling to simulate material growth and behavior prediction
- Development of Machine Learning using Python for academic materials research

ACTIVE RESEARCH COLLABORATIONS

- **University of Utah, US**
 - Prof. Michael Scarpulla
- **Arizona State University, US**
 - Prof. Zachary Holman
 - Prof. Richard King
- **University of Chicago at Illinois, US**
 - Prof. Robert Klie
- **Texas A&M University, US**
 - Prof. Russ Porter
 - Prof. Taylor Harvey
- **University of Texas at Austin, US**
 - Prof. Brian Korgel
- **University of Toledo, US**
 - Prof. Adam Philips
- **Colorado School of Mines, US**
 - Prof. Colin Wolden
- **University of Nevada at Las Vegas, US**
 - Prof. Shubhra Bansal
- **Sanida National Laboratories, US**
 - Dr. Morgann Berg



- **First Solar Inc., US**
 - Dr. Markus Gloeckler
 - Dr. Gang Xiong
 - Dr. Chungho Lee
- **Reel Solar Inc., US**
 - Dr. Hsiao Kuo-Jui
- **National Renewable Energy Laboratory, US**
 - Dr. Darius Kuciauskas
 - Dr. Dave Albin
 - Dr. Wyatt Metzger
- **Washington State University at Pullman, US**
 - Late Prof. Kelvin Lynn
 - Prof. John McCloy
- **Massachusetts Institute of Technology, US**
 - Prof. Ian Marius Peters
- **Synopsys QuantumATK, Denmark**
 - Dr. Umberto Pozzoni
- **5N Plus Inc., Canada**
 - Dr. Jean-Nicholas Beaudry
 - Dr. Gulliaume Gélinas
- **Loughborough University, UK**
 - Prof. John Walls
 - Prof. Jake Bowers
- **University of Liverpool, UK**
 - Prof. Ken Durose
- **University of Oxford, UK**
 - Prof. Chris Grovenor
- **Chinese Academy of Sciences, China**
 - Prof. Xiangxin Liu
- **CTF Solar GmbH, Germany**
 - Dr. Bastian Siepchen
- **Asian Institute of Technology, Thailand**
 - Prof. Weerakorn Ongsakul
 - Prof. Subin Pinkayan
- **Advanced Solar Power, China**
 - Dr. Xuanzhi Wu

- Dr. Jie Zhou
- **Oak Ridge National Laboratory**
 - Dr. Sudhajit Misra
- **Amrita University, India**
 - Prof. Balashankar Nair

RESEARCH PROJECTS PURSUED (Since 2010)

- **Gold thin-film mirrors for high temperature radiation shielding application**
 - M.S. Thesis – Colorado State University (Funding – National Science Foundation)
 - Gold is an excellent infrared reflector but on exposure at higher temperatures it breaks down into islands as the stresses are released rendering them unusable.
 - In this project several alloying combinations were tested to overcome the breakdown of these films
 - Using a thin layer of indium between the quartz substrate and gold thin film allows exposure of these films to over 650°C for over 800 hours without the loss of reflective properties.
- **Cavitation in aluminum cooling element**
 - Internship Project – Woodward Inc.
 - Cooling element in a large IC engine had regular failures in certain regions of the world.
 - The failure mode was identified as a combination of corrosion from hard water and cavitation caused by vibrations and flow pattern of the cooling water.
 - The problem was later resolved by altering the design to reduce cavitation.
- **Material failure in titanium hip implant**
 - Patient vs implant manufacturer – Expert witness
 - A patient had a first revision surgery during which the titanium hip implant broke while walking.
 - Manufacturer claimed that the patient fell which lead to the failure and therefore they were not liable.
 - Analysis showed it was a fatigue fracture and calculations showed that a fall would not be able to generate force enough to break the implant, therefore, it was a manufacturing defect.
 - Manufacturer accepted out-of-court settlement – monetary compensation and cost of second revision surgery.
- **Exploring relationship between processing conditions, device performance and film microstructure in CdTe photovoltaics**
 - Ph.D. Dissertation – Colorado State University (Funding – National Science Foundation)
 - Goal of the project was to identify the effect of deposition material, glass substrate and passivation treatment on the microstructure and photovoltaic device performance.
 - Study substantially furthered the understanding of CdCl₂ passivation treatment in CdTe solar cells.
 - Improved understanding led to increase in conversion efficiency from 12% to 18.7% (externally verified and certified) which was the highest efficiency device at the time by any academic laboratory worldwide.
- **Introduction of Mg_xZn_{1-x}O to replace CdS as the more transparent n-type window layer**
 - Ph.D. Research – Colorado State University (Funding – National Science Foundation and U.S. Department of Energy)

- CdS was traditionally used by researchers worldwide as the n-type window layer in CdTe solar cells.
- CdS is a strong absorber of blue light which caused parasitic absorption that reduced the maximum short-circuit current.
- Replacing CdS with $Mg_xZn_{1-x}O$ enhanced current collection and device power conversion efficiency.
- **Formation of Te-rich back contact using pure Te evaporation**
 - Ph.D. Research – Colorado State University (Funding – National Science Foundation)
 - Te-rich back surface layer was traditionally created by etching the back surface using a bromine-methanol solution, but this method had to be highly controlled to avoid preferential etching of grain boundaries and often had detrimental effect.
 - In our study etching was replaced 30-40 nm of pure Te that resulted in a highly repeatable process.
 - This process has been replicated by several research groups and is part of regular baseline process.
- **Selenium alloying of CdTe for bandgap engineering**
 - Post-doctoral research – Colorado State University (Funding – National Science Foundation and U.S. Department of Energy)
 - Selenium alloying of CdTe makes a lower bandgap $CdSe_xTe_{1-x}$. Such alloy leads to higher current collection but lower voltage by itself.
 - I identified a bilayer configuration of $CdSe_xTe_{1-x}$ with CdTe where higher current collection was achieved from lower bandgap $CdSe_xTe_{1-x}$ while voltage deficit was eliminated by higher bandgap CdTe.
 - This was the first demonstration of electron reflector effect in polycrystalline CdTe-based photovoltaics. (manuscript in progress)
- **Al_2O_3 surface passivation of polycrystalline CdTe-based photovoltaics**
 - Post-doctoral research – Colorado State University (research currently in progress; Funding – U.S. Department of Energy)
 - Efficiency of CdTe photovoltaics is limited by voltage deficit of over 300 mV which is the major limiting factor keeping the technology from achieving the Shockley-Queisser limit.
 - Interface passivation is an important process step that has been identified to be critical in overcoming such deficit in polycrystalline silicon photovoltaics.
 - I demonstrated for the first time that a thin enough Al_2O_3 layer can passivate the surface and yet charged carrier can be tunneled through it.
 - A carrier recombination lifetime of over 10 ns was considered unrealistic with polycrystalline CdTe; this study demonstrated carrier recombination lifetime of over 620 ns.
- **Arsenic doping of CdTe-based photovoltaics**
 - Post-doctoral research – Colorado State University (research currently in progress; Funding – U.S. Department of Energy)
 - Copper has been traditionally used as a dopant in CdTe based photovoltaics. Copper as a dopant has two major limitations –
 - High mobility of copper makes devices more susceptible to shunting if not controlled.
 - Doping over $1E17\text{ cc}^{-1}$ is necessary for high efficiency; doping with copper over $1E15\text{ cc}^{-1}$ has several fundamental challenges.
 - Arsenic doping was successfully incorporated by depositing doped source charge under over pressure of cadmium that creates appropriate vacancy sites for arsenic to occupy.
 - Efficiency over 2.5 μs and efficiency over 17% has been achieved using this approach and is currently making progress – Project target 24% record efficiency with single junction.

- **Gallium doping of $Mg_xZn_{1-x}O$ window layer**
 - Post-doctoral research – Colorado State University (research currently in progress; Funding – National Science Foundation and U.S. Department of Energy)
 - $Mg_xZn_{1-x}O$ was found to have a photodoping effect which meant that part of the improvement in efficiency would be induced in an uncontrolled manner when exposed to blue photons.
 - This is detrimental since in field operation when the operating temperature of the panels reach over 60°C, this effect diminishes and therefore requires to be addressed.
 - To eliminate this doping of this material with gallium has been studied and is moving towards optimization. Improvement in device efficiency is also consistently observed.

- **Low bandgap Sb_2Se_3 based photovoltaics for tandem cell application**
 - Post-doctoral research – Colorado State University (research currently in progress; Funding – U.S. Department of Energy)
 - $CdSe_xTe_{1-x}/CdTe$ has an effective bandgap of 1.4 eV. This project aims to use a lower bandgap Sb_2Se_3 with a bandgap of 1.1 eV to make the bottom cell in a four terminal tandem structure.
 - To further lower the bandgap of Sb_2Se_3 up to 0.7 eV alloying it with Te to form a ternary alloy is planned.
 - Anticipated efficiency of this structure is over 28% and the processes being used are viable for commercial scalability.

- **Machine Learning for materials engineering**
 - Post-doctoral research – Colorado State University (research currently in progress; not yet funded)
 - Since I started my graduate research in the field of thin film photovoltaics, I have fabricated over 70,000 solar cells and with my entire research group combined there are over 120,000 cells fabricated.
 - Aim of this project is to use processing parameters and device performance data in a database to use machine learning models to predict the likely processing conditions that would lead to next improvements.
 - The machine learning models are being developed using Python.

- **Density Functional Theory modeling using Synopsis QuantumATK**
 - Post-doctoral research – Colorado State University (ongoing research; Funding – National Science Foundation and U.S. Department of Energy)
 - Semiconductor device performance is highly dependent on the conditions of the interfaces and passivation of the defects at the surfaces.
 - This method uses first principle *ab initio* approach to identify effects of interfacial characteristics such as grain orientations, defects, interface relaxation, etc.
 - This method has been very effective in explaining behaviors of films that were not fully understood earlier.

- **Copper enrichment of titanium and titania nano-tubes surfaces for biomedical applications**
 - Post-doctoral research – Colorado State University (ongoing research; not yet funded)
 - Biocompatibility and hemocompatibility are two key properties for biomaterials that encounter blood. Titanium and titania are highly biocompatible, but introduction of antimicrobial properties is highly desirable.
 - The purpose of this work is to make the surfaces copper rich while maintaining the surface texture that enhances its hemocompatibility.

- Similar work as been done using different methods however these methods are highly control sensitive and expensive. In this work we have used a novel low temperature, inexpensive processing approach.
- Antimicrobial efficacy of copper has been studied and contact of copper to microorganisms such as bacteria leads to disturbance in integrity of their membranes eventually causing their annihilation.