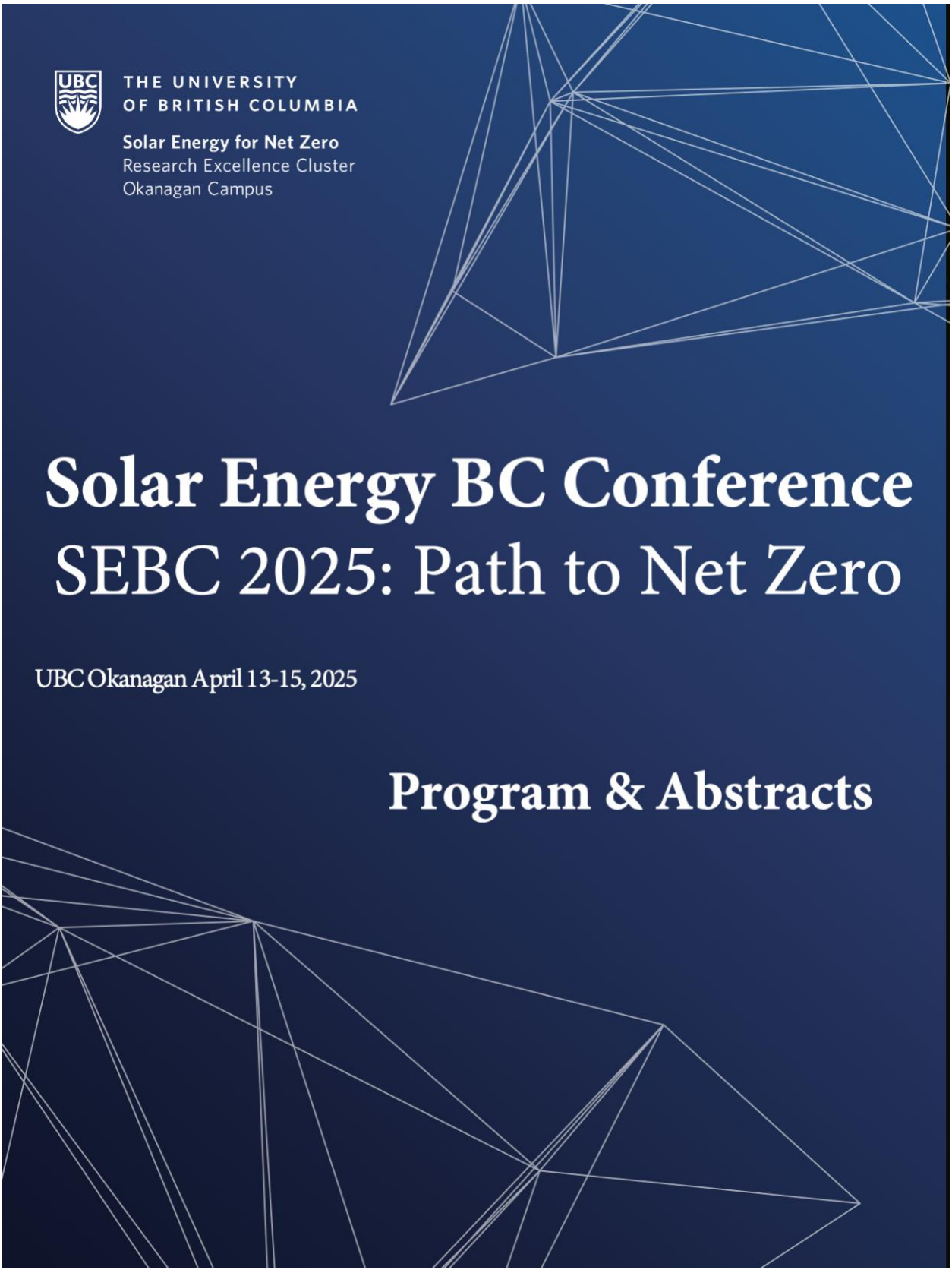
THE UNIVERSITY
OF BRITISH COLUMBIA
Solar Energy for Net Zero
Research Excellence Cluster
Okanagan Campus
Solar Energy BC Conference
SEBC 2025: Path to Net Zero
UBC Okanagan April 13-15, 2025
Program & Abstracts

THE UNIVERSITY OF BRITISH COLUMBIA
Solar Energy for Net Zero
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Conference Program

Sunday, April 13, 2025, (UNC 200)		
Start	End	
17:30	19:30	**Reception and Check-in**
18:00	20:00	**Welcome Dinner Reception**

Monday, April 14, 2025 (UNC 200)			
Start	End		
9:00	9:10	**Opening Remarks** **by Dr. Rehan Sadiq, Provost and Vice-President, Academic, UBC Okanagan**	
Session 1 – Photovoltaics Session Chairs: Dr. Alexander Uhl and Dr. Robert Godin			
9:10	10:00	**Invited Speaker: Dr. Michael Adachi** Simon Fraser University	Flexible Photovoltaic and Optoelectronic Devices Based on Asymmetric Geometry 2D MoS_2
10:00	10:30	**Coffee Break (provided)**	
10:30	10:50	**Dr. Abraha Gidey** University of British Columbia	Room Temperature Synthesis of Ultra-Small SnO_2 Quantum Dots as Charge Transport Layer for Perovskite Solar Cells
10:50	11:10	**Dongyang Zhang** Simon Fraser University	All Scalable Fabrication of Perovskite Solar Cells in Ambient Air
11:10	11:30	**Dr. Pravin Pawar** University of British Columbia	Enhanced Efficiency in Ink-Based $CuIn(S,Se)_2$ Solar Cells via Compositional Engineering and Rear Surface Passivation
11:30	12:20	**Invited Speaker: Dr. Makhsud Saidaminov** University of Victoria	Upscaling Perovskite Solar Cells
12:20	13:30	**Lunch Break (provided)**	
Session 2 – Integration of Solar Energy into Power Systems Session Chairs: Dr. Alexander Uhl and Dr. Robert Godin			
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13:50	14:10	**Abdul-Mubarak Yidana** University of British Columbia	Techno-Economic Assessment of Grid-Tied Photovoltaic Systems in Interior British Columbia
14:10	14:30	**Laurence Lemay** Innergex Renewable Energy Inc.	The Importance of Ecosystems in the Creation of Successful Renewable Energy Projects
14:30	15:45	Panel Discussion: **Maximizing Solar Energy's Impact: Collaborative Pathways to Canada's Net Zero Goals**	

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15:45	16:00	**Transition Time:** Attendees relocate to poster session in EME building	
16:00	18:00	**Poster Session (EME Foyer, ground floor)**	
		Davis Kurdyla University of British Columbia	Electrodeposition of Conductive Metal-organic Framework Thin Films
		Dongyang Zhang Simon Fraser University	All Scalable Fabrication of Perovskite Solar Cells in Ambient Air
		Elnaz Ghahremani Rad University of British Columbia (presented by Dr. Abraha Gidey)	Advancing Operational Stability of Inverted Perovskite Solar Cells by Utilizing Parylene-C Encapsulation
		Katherine Latosinsky University of British Columbia	Solution-Processed Perovskite-Chalcogenide Tandem Solar Cells
		Shahrukh Hossain Rian University of British Columbia	Feasibility of Solar in The City of Kelowna - A Socio-Techno-Economic Analysis of Solar Photovoltais in Interior BC
		Sandali Rukshila Walgama University of British Columbia	Solar Energy for Enhancing EV Sustainability: Smart EV Charging Integration in Solar-Powered Net-Zero Energy Buildings
		Dr. Pravin Pawar University of British Columbia	Enhanced Efficiency in Ink-Based $CuIn(S, Se)_2$ Solar Cells via Compositional Engineering and Rear Surface Passivation
		Tim Webster University of British Columbia	Coating of Thin Films for Solar Water Splitting Using Custom Built 3-Axis Spray Coater

Tuesday, April 15, 2025 (UNC 200)			
Start	End		
Session 3 – Solar Fuels and Catalysis Session Chairs: Dr. Alexander Uhl and Dr. Robert Godin			
9:30	10:50	**Invited Speaker: Dr. Jeff Waren** Simon Fraser University	Lessons from Carbon Dioxide Reduction Molecular Electrocatalyst Designs: Where can we go from here?
10:20	11:20	**Coffee Break (provided)**	
10:50	11:40	**Dr. Eva Nichols** University of British Columbia	Complex Chemistry at the Interface: Altering CO Binding Modes Through Bimetallic Cooperativity
11:20	12:00	**Dr. Haritham Khan** University of British Columbia	Solution-Processed, Molecular Catalyst-Decorated Chalcopyrites for Highly Efficient Solar-driven CO_2 Reduction Reaction
11:40	13:00	**Dr. Muhammad Ashraf** University of British Columbia	Selective Photoelectrochemical Reforming of Biomass Intermediates Catalyzed by In-Situ Fabricated C_3N_3 Electrode on Cu Foil
12:00	13:30	**Lunch Break (provided)**	
13:00	13:50	**Dr. Alexandra Tavasoli** University of British Columbia	Challenges Facing the Scale-up and Commercialization of Solar-Driven Chemical Processes

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13:30	14:10	**Dr. Peter Ohemeng** University of British Columbia	The Development of Hybrid Systems Composed of Carbon Nitride (CN_x) and First-Row Transition Metals for Photocatalytic CO_2 Reduction (CO_2RR) and Electrochemical Nitrogen Reduction Reaction (eNRR).
13:50	14:30	**Davis Kurdyla** University of British Columbia	Electrodeposition of Conductive Metal-Organic Framework Thin Films
14:10	14:50	**Dr. Mahboob Alam** University of British Columbia	An Economical Zn-CO_2 Energy Storage Device Using a Bismuth-Based Electrocatalyst as Cathode
14:30	15:00	**Sutripto Khasnabis** University of British Columbia	Exploring Spatial and Temporal Charge Carrier Dynamics in Carbon Nitride using Transient Absorption Microscopy
14:50	15:10	**Break**	
15:00	16:00	**Awards Ceremony & Farewell**	
15:10	16:00	**Lab Tours**	

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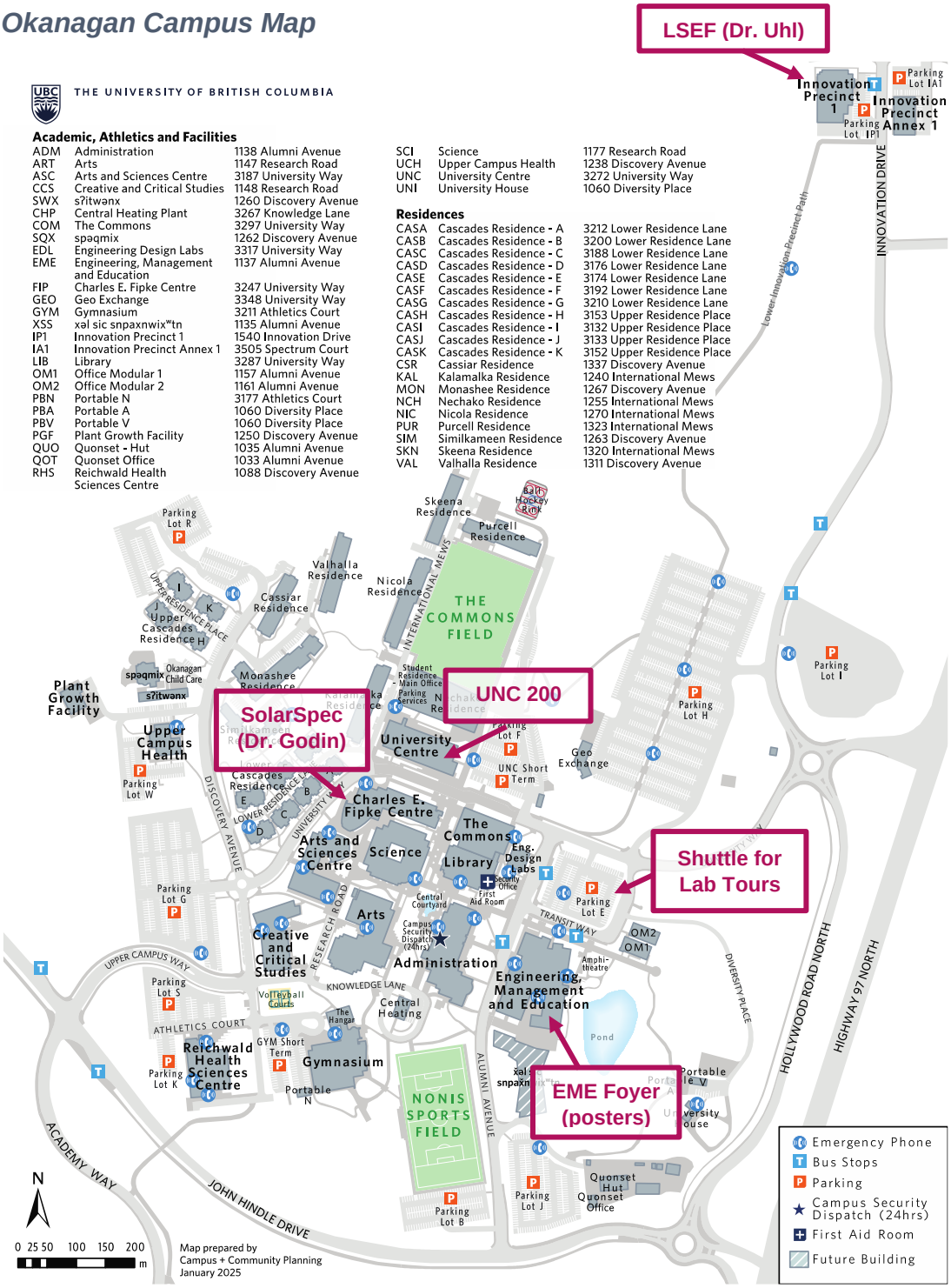
UBC Okanagan Campus Map



THE UNIVERSITY OF BRITISH COLUMBIA
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Abstracts

Session 1: Photovoltaics

Session Chairs: Dr. Alexander Uhl and Dr. Robert Godin

Monday, April 14, 2025 (UNC 200)

09:00 AM – 10.00 AM

Flexible Photovoltaic and Optoelectronic devices based on Asymmetric Geometry 2D MoS_2

M.M. Adachi*, A. Abnavi, R. Ahmadi, H. Ghanbari
School of Engineering Science, Simon Fraser University, 8888 University Dr., Burnaby, BC, Canada

Abstract

Multi-layered transition metal dichalcogenides (TMDs) (e.g. MoS_2, $MoSe_2$, etc.) are two dimensional semiconductors that have gained interest for flexible optoelectronic and photovoltaic applications due to a number of reasons including having a suitable bandgap for solar cells, ultra-high absorption coefficient, and high mechanical flexibility. However, the performance of TMD based devices has been limited due to difficulty of achieving reliable doping in TMDs. Here, we discuss an alternative method to achieve high diode rectification (~10^5) in 2D MoS_2 based on asymmetric geometries. The device efficiently collects photogenerated carriers and showed a photovoltaic power conversion efficiency of 3.16% and open-circuit voltage of 0.43V, and a high retention of photovoltaic performance after 5000 bending cycles. The asymmetric geometry MoS_2 devices also exhibited switchable photovoltaic effect induced by light intensity which can facilitate bidirectional photosensors and optoelectronic logic gates. The simple fabrication process and efficient charge collection show promise for ultra-thin flexible photovoltaic devices.

*Presenter

10:30 AM – 10:50 AM

Room Temperature Synthesis of Ultra-small SnO_2 Quantum Dot as Charge Transport Layer for Perovskite Solar Cells

Abraha Gidey Tadese**, Elnaz Ghahremani Rad, Alexander R. Uhl*
Laboratory for Solar Energy and Fuels (LSEF), School of Engineering, The University of British Columbia, Kelowna V1V1V7, Canada

Abstract

Quantum dots (QDs) are a subject of great interest in materials science, spectroscopy, sensors, biological imaging, diagnostics, and photovoltaics. SnO_2 QDs have garnered significant attention as ETLs in PSCs due to their exceptional optoelectronic properties such as wide bandgap, good electron mobility, high thermal stability, and compatibility with solution processing techniques. Despite the advancements in SnO_2 QDs ETLs, the conventional synthesis strategy of SnO_2 QDs mainly relies on complex processes, high-temperature processing, and toxic reagents with environmental and PSCs stability concerns. To address these issues, we report a room-temperature solution-processable strategy using environmentally friendly chemical facilitator and solvent to synthesize ultra-small SnO_2 QDs. We analyzed the SnO_2 QDs ink chemistry, morphological, crystallographic, electronic, and optoelectronic characteristics of SnO_2 QD thin films to optimize precursors for depositing phase-pure SnO_2 QDs. The as-synthesized SnO2 QDs ETLs achieved enhanced PSCs device stability and photovoltaic performance outperforming those traditional SnO2 QDs ETLs, offering a pathway to stable, efficient, reproducible, large-scale, and flexible PSCs/tandem PSCs processed at low temperatures.

Key word: Quantum dots, SnO_2, chemical facilitator, electron transporting layer, optoelectronics, perovskite solar cells

*Corresponding author: alexander.uhl@ubc.ca

**Presenter

10:50 AM – 11:10 AM

All Scalable Fabrication of Perovskite Solar Cells in Ambient Air

Dongyang Zhang
Simon Fraser University

Abstract

As the world moves toward net-zero carbon emissions, the demand for clean and renewable energy is rapidly increasing. Photovoltaic (PV) technology plays an important role in reducing reliance on fossil fuels and cutting greenhouse gas emissions. Among new PV technologies, halide perovskite solar cells stand out for their high efficiency, low cost, and flexible processing, making them a strong candidate for future solar energy solutions. By 2025, perovskite solar cells have reached 27% efficiency in lab-scale devices, comparable to silicon solar cells. However, largescale production still requires low-cost and scalable manufacturing methods. In this presentation, I will share our group's recent progress on ambient-processed, antisolvent-free, and scalable perovskite solar cells using MAPbI3 and MAPbI3 compositions. I will first discuss the ink optimization of MAPbI3 perovskite solar cell using non-halide lead precursors, demonstrating its application on both rigid and flexible substrates.[1,2] Afterwards, I will introduce passivation strategies for both the hole and electron transport interfaces in the corresponding devices. Then, I will focus on FAPbI3, discussing how small-ion doping improves stability and device performance. I will also introduce scalable film deposition techniques used for doping concentration screening.3 By the end, I will highlight our latest work on scalable fabrication of wide-bandgap perovskites using green solvents for tandem solar cells.[4]

References

1. Ahmed, Y., Thrithamarassery Gangadharan, D., Kokaba, M. R., Yeddu, V., Awais, M., Zhang, D., …. & Saidaminov, M. I. (2023). All-Scalable CH3NH3PbI3 Perovskite Solar Cells Fabricated in Ambient Air. Solar RRL, 7(15), 2300288.
2. Kokaba, M. R., Ahmed, Y., Yeddu, V., Zhang, D., Moazzezi, P., Kamraninejad, V., ... & Saidaminov, M. I. (2024). Enhanced Particle-to-Particle Interaction of Tin Oxide Electron Transporter Layer for Scalable Flexible Perovskite Solar Cells. Solar RRL, 8(7), 2301013.
3. Zhang, D., Khasnabis, S., Wang, W., Yeddu, V., Moradi, S., Awais, M., ... & Saidaminov, M. I. (2024). Cadmium-Doping Slows Trap Emptying in Ambient-Air Blade-Coated Formamidinium Lead Iodide Perovskite Solar Cells. Advanced Energy Materials, 14(17), 2303858.
4. Duan, C., Gao, H., Xiao, K., Yeddu, V., Wang, B., Lin, R., ... & Tan, H. (2024). Scalable fabrication
of wide-bandgap perovskites using green solvents for tandem solar cells. Nature Energy, 1-11.

11:10 AM – 11:30 AM

Enhanced Efficiency in Ink-Based $CuIn(S,Se)_2$ Solar Cells via Compositional Engineering and Rear Surface Passivation

Pravin S. PAWAR**, Alexander R. UHL*
Laboratory for Solar Energy & Fuels (LSEF), School of Engineering, The University of British Columbia, Kelowna, V1V 1V7, Canada

Abstract

Ink-based $CuIn(S,Se)_2$ (CISSe) thin-film solar cells (TFSCs) present a promising low-cost and scalable alternative to conventional photovoltaic (PV) technologies. This study integrates two critical advancements to enhance the power conversion efficiency (PCE) of solution-processed CISSe devices. First, compositional engineering of molecular inks, utilizing a N, N-dimethylformamide–thiourea (DMF–TU) based deposition route, enables fine control over absorber composition, leading to optimized stoichiometric films with large grain sizes (~2 μm) and smooth surfaces. These improvements yield a PCE of 13.2%, reaching 70% of the Shockley–Queisser limit open-circuit voltage (V_{OC} = 526 mV at 1.01 eV bandgap). Second, a novel rear surface passivation approach addresses recombination losses at the Mo/CISSe interface in submicron absorber layers. Atomic layer deposition of an Al_2O_3 passivation layer with nanosized point contacts significantly reduces rear interface recombination, increasing minority carrier lifetimes and boosting V_{OC} by 59 mV. As a result, a record active area PCE of 14.2% is achieved for a submicron-thick (0.75 μm) CISSe absorber layer-based solar cell device. These findings demonstrate that ink-based CISSe PV's can achieve competitive efficiencies through tailored absorber composition and advanced interface engineering, paving the way for their broader adoption in cost-effective solar energy solutions.

Keywords: chalcogenides, CISSe, solution process, photovoltaics, solar cells

*Corresponding author: alexander.uhl@ubc.ca

**Presenter

11:30 AM – 12:20 PM

Upscaling Perovskite Solar Cells

Makhsud Saidaminov
University of Victoria, 3800 Finnerty Rd., Victoria BC V8P 5C2

Abstract

In this talk, I will present our latest advancements in scaling up perovskite photovoltaics. I will begin by discussing our high-throughput screening approach for optimizing perovskite thin-film compositions[1], followed by their integration into solar mini-modules using scalable fabrication techniques and environmentally friendly solvents[2]. If time permits, I will also highlight our progress in automating the synthesis of centimeter-scale perovskite single crystals with consistently high crystallinity[3] and their application in the development of sensitive X-ray detectors[4].

(1) Communications Materials, 2022. 3, 13
(2) Nature Energy, 2024, https://doi.org/10.1038/s41560-024-01672-x
(3) ACS Energy Letters 2024, 9, 271
(4) Nature Synthesis, 2024, 3, 1212

Session 2: Integration of Solar Energy into Power Systems

Session Chairs: Dr. Alexander Uhl and Dr. Robert Godin

1:30 PM – 1:50 PM

Agrivoltaics: Shaping the Future of Solar and Agriculture

Jeremy Dresner
Pathfinder Clean Energy (PACE) Canada Development

Abstract

Agrivoltaics combine solar energy production with farming, offering a way to grow food and generate clean power on the same land. This session will introduce agrivoltaics, highlight how they improve community support and deliver broader environmental, agricultural, and economic benefits, and discuss the challenges facing wider adoption in Canada. We'll also explore why the future looks bright for agrivoltaics as a key part of Canada's clean energy transition.

1:50 PM – 2:10 PM

Techno-Economic Assessment of Grid-Tied Photovoltaic Systems in Interior British Columbia

Amandine A. Drew[2], A.M.Yussif Yidana[1], Sunil Suresh[3], Noah McIntosh[1], Christopher Paul[1],
Alexander R. Uhl[1]
[1]Laboratory for Solar Energy and Fuels (LSEF), School of Engineering, The University of British Columbia, Kelowna V1V1V7, Canada
[2]Carbon Engineering, 37322 Galbraith Road, Squamish, B.C., V8B 0A2
[3]Hasselt University, imo-imomec, Martelarenlaan 42, 3500 Hasselt, Belgium, Imec, imo-imomec, Thor Park 8320, 3600 Genk, Belgium, EnergyVille, imo-imomec, Thor Park 8320, 3600 Genk, Belgium

Abstract

In British Columbia (BC), solar energy is increasingly critical in diversifying electricity infrastructures traditionally dominated by low-cost hydroelectric resources. However, the economic viability of rooftop photovoltaic (PV) systems, especially those exceeding local net-metering thresholds, remains uncertain. This study assesses the techno-economic feasibility of a 153.30 kWp rooftop PV system installed on student residences in Kelowna, BC. System performance data collected from July to December 2023 was validated using simulation tools PVsyst and PVSol. A comprehensive economic evaluation was conducted, calculating the Levelized Cost of Electricity (LCOE) and assessing financial viability both with and without applicable policy incentives. Simulation outputs closely matched measured performance data, demonstrating minimal deviation. The PV system offset approximately 17% of the buildings' annual electricity demand, exporting less than 1% of its generated power to the grid and eliminating the requirement for battery storage. The calculated LCOE was found to be 9.25¢/kWh, close to the provincial commercial rate of 8.36¢/kWh in 2024. Incorporating a 30% Investment Tax Credit (ITC) reduced the LCOE to 6.60¢/kWh, shortening the payback period from 20.9 to 15.6 years. The results confirm the economic and technical feasibility of deploying large-scale rooftop PV systems in BC, even in the absence of traditional net-metering incentives. Effective policy measures such as ITCs significantly enhance economic viability, underscoring the importance of targeted incentives in transitioning to diversified renewable energy solutions.

2:10 PM – 2:30 PM

The Importance of Eco-systems in the Creation of Successful Renewable Energy Projects

Laurence Lemay
Innergex Renewable Energy Inc.

Abstract

There are key enabling conditions that support the successful development of renewable projects in B.C. including, but not limited to, collaboration with Indigenous partners, long-term community engagement, regulatory and financial frameworks, and the role of equity partnerships in advancing energy transition goals. In todays' context and highly matrixed environment, constructive and beneficial ecosystems combined with a relentless focus on synergies are needed to build successful renewable energy projects. This presentation will discuss the various conditions and components of these ecosystems and their role in generating collaborative pathways.

POSTER SESSION PRESENTATIONS

Monday, April 14, 2025 (EME Foyer at ground floor)

Electrodeposition of Conductive Metal-organic Framework Thin Films

Davis Kurdyla
The University of British Columbia, Kelowna, V1V 1V7, Canada

Abstract

Many key environmental crises arise from the oxidative transformation of chemicals into small molecule waste or byproducts. Examples include the oxidation of ammonia fertilizer into nitrate waste and the oxidation of carbonaceous fuels to carbon dioxide, among others. In this space, metal-organic frameworks (MOFs) are a promising platform for the adsorption and catalytic reduction of small molecules, owing to their varied pore size, tunable chemical functionality, and ultrahigh surface area. Furthermore, conductive, electrocatalytically active MOFs offer to accomplish these reactions powered by clean energy and without stoichiometric reductants. Such a system, however, requires a well-defined electrode-MOF composite through which charge transfer can take place. We investigate electrodeposition as a general strategy to incorporate MOFs as thin films onto conductive substrates and characterize their morphological and electrochemical properties, using techniques ranging from electron microscopy and x-ray diffraction to electrochemical quartz crystal microbalance and alternating current voltammetry. Insights gained from these systems inform the design of more active and selective heterogeneous electrocatalysts.

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All Scalable Fabrication of Perovskite Solar Cells in Ambient Air

Dongyang Zhang
Simon Fraser University

Abstract

As the world moves toward net-zero carbon emissions, the demand for clean and renewable energy is rapidly increasing. Photovoltaic (PV) technology plays an important role in reducing reliance on fossil fuels and cutting greenhouse gas emissions. Among new PV technologies, halide perovskite solar cells stand out for their high efficiency, low cost, and flexible processing, making them a strong candidate for future solar energy solutions. By 2025, perovskite solar cells have reached 27 % efficiency in lab-scale devices, comparable to silicon solar cells. However, largescale production still requires low-cost and scalable manufacturing methods. In this presentation, I will share our group's recent progress on ambient-processed, antisolvent-free, and scalable perovskite solar cells using $MAPbI_3$ and $FAPbI_3$ compositions. I will first discuss the ink optimization of $MAPbI_3$ perovskite solar cell using non-halide lead precursors, demonstrating its application on both rigid and flexible substrates.[1,2] Afterwards, I will introduce passivation strategies for both the hole and electron transport interfaces in the corresponding devices. Then, I will focus on $FAPbI_3$, discussing how small-ion doping improves stability and device performance. I will also introduce scalable film deposition techniques used for doping concentration screening.[3] By the end, I will highlight our latest work on scalable fabrication of wide-bandgap perovskites using green solvents for tandem solar cells.[4]

References

1. Ahmed, Y., Thrithamarassery Gangadharan, D., Kokaba, M. R., Yeddu, V., Awais, M., Zhang, D., …. & Saidaminov, M. I. (2023). All-Scalable CH3NH3PbI3 Perovskite Solar Cells Fabricated in Ambient Air. Solar RRL, 7(15), 2300288.
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Advancing Operational Stability of Inverted Perovskite Solar Cells by Utilizing Parylene-C Encapsulation

Elnaz Ghahremani Rad, Abraha T. Gidey**, and Alexander R. Uhl*
Laboratory for Solar Energy and Fuels (LSEF), School of Engineering, University of British Columbia, Okanagan (UBCO), Campus
Laboratory for Solar Energy & Fuels (LSEF), School of Engineering, The University of British Columbia, Kelowna, V1V 1V7, Canada

Abstract

Following advancements to increase the efficiency of perovskite solar cells, the current emphasis is mainly on enhancing their operational stability. Various methods of encapsulation have been employed to safeguard perovskite solar cells from environmental factors and preserve their efficiency. Recent research studies have primarily focused on using organic/inorganic multilayers to create a more robust barrier against the degradation of perovskite solar cells. However, the commercial feasibility of employing inorganic materials might be limited due to their high-cost fabrication process and low flexibility. The encapsulation techniques using polymers stand out for their versatility in material selection and functionality, making them suitable for manufacturing flexible devices. Polymers efficiently act as encapsulants, preventing the infiltration of water and oxygen into the perovskite layer while also inhibiting the release of perovskite composition. One such polymer, parylene-C, offers cost-effective extrinsic protection against environmental harm, mainly humidity and oxygen, to uphold the performance and reliability of perovskite solar cells. In our study, we utilized a multilayer deposition of parylene-C with a high light and low water vapor transmission rate, uniformly applied across the surface of the perovskite solar cells. To assess the operational stability of these devices, we employed ISOS-D1 and D2 protocols including conditions such as ambient/ambient and 85℃/ambient, pertaining to temperature/relative humidity. The obtained results underscore the durability of parylene-C coated perovskite solar cells compared to their unencapsulated counterparts.

** presenter

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Solution-Processed Perovskite-Chalcogenide Tandem Solar Cells

Katherine Latosinsky*, Pravin Pawar, Elnaz Ghahremani Rad, Abraha T. Gidey, Alexander R. Uhl*
Laboratory for Solar Energy & Fuels (LSEF), School of Engineering, The University of British Columbia, Kelowna, V1V 1V7, Canada

Abstract

Tandem solar cells based on perovskite and chalcogenide CI(G)S absorbers show promise for a new generation of low-cost, high-efficiency, lightweight photovoltaic technologies. A key advantage of both materials is the ability to fabricate thin films using solution-based processes, which can significantly reduce manufacturing costs and increase material throughput. While record efficiencies for four-terminal perovskite-CI(G)S tandem solar cells have now exceeded 29%, high-efficiency research devices rely on costly vacuum-processed CI(G)S absorber layers and atomic-layer-deposited SnO_x buffer layers, which are barriers to future commercialization. This work proposes an architecture for four-terminal tandem solar cells based on solution-processed perovskite and CI(G)S absorbers. It also adapts recent advances in perovskite-silicon tandems to replace the SnO_x layer with a scalable carbon-based electron transport layer that can be fabricated using thermal deposition or solution processing techniques. The expected optoelectronic performance of these devices is discussed, along with preliminary results from device fabrication.

*Corresponding author: alexander.uhl@ubc.ca

*Presenter

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Feasibility of Solar in The City of Kelowna- A Socio-techno-economic analysis of Solar Potential in Interior BC

Shahrukh Hossain Rian*, Abdul-Mubarak Yussif Yidana, Alexander R. Uhl
Laboratory for Solar Energy & Fuels (LSEF), School of Engineering, The University of British Columbia, Kelowna, V1V 1V7, Canada

Abstract

With the growing change of global temperature, the looming threat of climate change is slowly becoming more and more a current issue rather than a near future issue. Fossil fuels used day-to-day to power our infrastructure and economy are causing severe environmental changes that are contributing to these increasingly drastic weather events. The City of Kelowna, being one of the most rapidly developing cities in Canada, the power demand to meet this need and living up to the promise of net zero emissions, adapting clean energy is a must. This, coupled with high solar irradiance that graces the Okanagan region makes solar the prime candidate among the alternate clean energy sources. This research project aims to gauge the feasibility of Solar in Kelowna, on a residential, community and utility scale. This is a multi-layer project starting with two crucial pillars – understanding the public opinion and eagerness to adapting solar and investigate true potential of solar by means of cutting-edge research incorporating simulation and live data. With primary focus on this, a market research study survey is planned to be launched. The survey with its specifically chosen questions will probe into the public mindset on important policies, eagerness and factors that will drive not only this project but also the utility companies and governments to review and plan its next steps. The survey can pinpoint gaps in the policies and factor out reasons that hinder people from investing in cleaner energy. Partnered with the City of Kelowna, and the cities prime utility company, FortisBC, the survey can look into the heart of the problem and not just observe it but potentially provide a solution to the question at hand. On the other hand, parallelly the actual potential of Solar in a residential scale must be calculated. Will the potential be feasible to offset the City's growing peak demands, will the system be profitable for the people deciding to invest in solar – these are very important questions that must be researched religiously. One of the biggest advantages of the project is the VEDA Student housing PV installation. It is the largest solar installation in the city and Interior BC with a 152 kWp nameplate capacity serving as a living lab that provides crucial data for analyzing solar potential in the region.
With this twin approach, gauging the public opinion and calculating actual solar potential on a residential scale, can pave the way for Kelowna to lead the Net zero emissions goals in the province. The project also aims to review policies, building codes and revive dormant solar projects using the survey data and results from the extensive simulation work. With this socio-techno-economical analysis, this research hopes to contribute to the growing changes to fight climate change and ensure a better, cleaner world for the generations to come.

* presenter

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Solar Energy for Enhancing EV Sustainability: Smart EV Charging Integration in Solar-Powered Net-Zero Energy Buildings

Sandali Walgama[1*], Kasun Hewage[1], Ezzeddin Bakhtavar[2], Ahmed Aboyosef[1], Rehan Sadiq[1]
1 School of Engineering, University of British Columbia (Okanagan Campus), 1137 Alumni Avenue, Kelowna, BC V1V 1V7, Canada
2 School of Engineering and Computer Science, Laurentian University, 935 Ramsey Lake Rd, Sudbury, Ontario P3E 2C6, Canada

Abstract

The transportation sector, responsible for approximately 23% of global fossil fuel emissions, must transition to low-emission alternatives. Electric vehicles (EVs) are a key solution, but their sustainability depends on the energy mix used for charging. Smart EV charging has emerged as an effective strategy for load management, while integrating it with solar-powered net-zero energy buildings (NZEBs) can maximize renewable energy utilization and improve demand management. However, concerns remain about long-term impacts such as battery degradation and maintenance. This study evaluates and compares the life cycle sustainability of conventional and smart EV charging in solar-integrated NZEBs using a comprehensive sustainability score, incorporating Life Cycle Assessment, Life Cycle Cost Assessment, and Social Life Cycle Assessment. Energy simulations via Design Builder and MATLAB-based genetic algorithms to optimize smart charging were applied for a case study in British Columbia, Canada. Over a 20-year simulation period, uni-directional and bi-directional smart charging reduce grid energy consumption by nearly 70% compared to regular charging while significantly minimizing peak energy exchanges with the grid. Solar energy usage increases by 131% with uni-directional smart charging and 139% with bi-directional smart charging. The bi-directional smart charging further enhances solar utilization by 3.6% and reduces grid dependence by 2.2% compared to uni-directional smart charging. Results show that smart charging—especially bi-directional—outperforms conventional methods across environmental, economic, and social dimensions, with sustainability score improvements of 9% and 10% for uni- and bi-directional smart charging, respectively. These findings underscore the potential of smart EV charging and solar-powered NZEBs integration as a key enabler of sustainable transportation.

*presenter

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Enhanced Efficiency in Ink-Based $CuIn(S,Se)_2$ Solar Cells via Compositional Engineering and Rear Surface Passivation

Pravin S. PAWAR**, Alexander R. UHL*
Laboratory for Solar Energy & Fuels (LSEF), School of Engineering, The University of British Columbia, Kelowna, V1V 1V7, Canada

Abstract

Ink-based $CuIn(S,Se)_2$ (CISSe) thin-film solar cells (TFSCs) present a promising low-cost and scalable alternative to conventional photovoltaic (PV) technologies. This study integrates two critical advancements to enhance the power conversion efficiency (PCE) of solution-processed CISSe devices. First, compositional engineering of molecular inks, utilizing a N, N-dimethylformamide–thiourea (DMF–TU) based deposition route, enables fine control over absorber composition, leading to optimized stoichiometric films with large grain sizes (~2 μm) and smooth surfaces. These improvements yield a PCE of 13.2%, reaching 70% of the Shockley–Queisser limit open-circuit voltage (V_{OC} = 526 mV at 1.01 eV bandgap). Second, a novel rear surface passivation approach addresses recombination losses at the Mo/CISSe interface in submicron absorber layers. Atomic layer deposition of an Al_2O_3 passivation layer with nanosized point contacts significantly reduces rear interface recombination, increasing minority carrier lifetimes and boosting V_{OC} by 59 mV. As a result, a record active area PCE of 14.2% is achieved for a submicron-thick (0.75 μm) CISSe absorber layer-based solar cell device. These findings demonstrate that ink-based CISSe PV's can achieve competitive efficiencies through tailored absorber composition and advanced interface engineering, paving the way for their broader adoption in cost-effective solar energy solutions.

Keywords: chalcogenides, CIS, solution process, photovoltaics, solar cells

** presenter

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Coating of Thin Films for Solar Water Splitting Using Custom Built 3-Axis Spray Coater

Tim Webster**, Alexander R. Uhl*
Laboratory for Solar Energy & Fuels (LSEF), School of Engineering, The University of British Columbia, Kelowna, V1V 1V7, Canada

Abstract

The looming effects of climate change have led to high demand for the efficient production of clean energy and fuels, both of which may be produced by rapidly advancing solar technologies. Uniform, high throughput deposition of thin film materials is essential for long term application of thin film solar technologies to produce high efficiency green energy and fuels. This poster presents the design process and applications of an autonomous three-axis spray coating system for manufacturing various thin films for producing solar energy and clean fuels. This custom-built project allows for the investigation of various materials with a wide range of applications, particularly photocatalysts for solar water splitting through the Hydrogen Evolution Reaction (HER). By adjusting various parameters such as flow rate, spray pressure, and bed temperature, various properties of the deposited film are easily adjusted and compared for optimization of the material. Additionally, multiple combinations of materials can be mixed during the deposition itself, to rapidly test the effects of varying material compositions.

Keywords: Solar Fuels, Spray Pyrolysis, Photocatalysts, Hydrogen evolution reaction

*Corresponding Author, email: alexander.uhl@ubc.ca

** presenter

Tuesday, April 15, 2025 (UNC 200)

Session 3: Solar Fuels and Catalysis

Session Chairs: Dr. Alexander Uhl and Dr. Robert Godin

9:30 AM – 10:20 AM

Lessons from Carbon Dioxide Reduction Molecular Electrocatalyst Designs: Where can we go from here?

Invited speaker: Jeffrey J. Warren
Department of Chemistry, Simon Fraser University, 8888 University Drive, Burnaby BC V5A1S6

Abstract

Molecular electrocatalysts continue to serve as a promising and intriguing testbed for renewable energy technologies. The ability to precisely modify the environments of active sites is a key component of our ongoing interest in these systems. Ultimately, the detailed insights into reaction mechanisms enabled by the tuning of active sites provides a path forward for the design and implementation of new systems. Our research team has been designing, synthesizing, and investigating the electrochemistry of metalloporphyrins, metallophthalocyanines, and metal diimine coordination complexes. This presentation will summarize recent examples from our laboratory, encompassing all of those classes of catalysts. With respect to metalloporphyrins, we have investigated specific catalyst designs to interrogate the importance of proton transfer reactions to activated (reduced) intermediates. In work on metallophthalocyanines, we have explored how molecular charge can be leveraged to facilitate CO_2 binding, activation, and reduction to CO and CH_3OH. Finally, for rhenium(I) diimine complexes, we compare a newly studied complex that features a cation next to the metal site with recent literature examples. Overarching lessons from our research efforts and forward-looking ideas also will be discussed.

Corresponding author: jjwarren@sfu.ca

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10:50 AM – 11:20 AM

Complex Chemistry at the Interface: Altering CO Binding Modes Through Bimetallic Cooperativity

Dr. Eva Nichols
The University of British Columbia, Kelowna V1V1V7, Canada.

Abstract

Metal surfaces are widely studied for electrocatalytic conversion of small molecules related to energy transformations and sustainability. The properties of these surfaces can be tuned by forming self-assembled monolayers (SAMs) with highly customizable molecules that can in turn impart tailored properties to the surface. In the context of solar energy catalysis, incorporation of such molecules to the surface of a metal or semiconductor (photo)electrode can alter the ability to stabilize various catalytic intermediates/transition states and in some cases can alter the coordination modes of critical small molecules at the surface. This talk will showcase one such system that features a family of related metal complexes that form SAMs on a gold surface, thereby giving rise to possible bimetallic interactions at the interface. I will discuss methods used to characterize these complex SAMs, as well as indications based on surface-enhanced infrared spectroscopy that these coordination complexes alter the binding mode and degree of activation of adsorbed carbon monoxide.

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11:20 AM – 11:40 AM

Solution-processed, Molecular Catalyst-Decorated Chalcopyrites for Highly Efficient Solar-driven CO_2 Reduction Reaction

Ela Nurlaela[1], Haritham Khan[1**], Andrew Jewlal[2], Cameron Kellet[2], Monika Stolar[2], Curtis P. Berlinguette[2], Alexander R. Uhl[1*]
[1]Laboratory for Solar Energy and Fuels (LSEF), School of Engineering, University of British Columbia, Okanagan (UBCO), Campus
[2] Department of Chemistry, The University of British Columbia, Vancouver (UBCV), Campus

Abstract

Efficient solar-driven CO_2 conversion into valuable chemical energy presents a promising solution to solar energy intermittency and GHG-driven climate change. The photoelectrochemical (PEC) CO_2 reduction reaction (CO_2RR) offers a promising route for sustainable fuel and chemical production. Here, we report a highly efficient aqueous PEC CO_2RR system utilizing a solution-processed $CuIn(S,Se)_2$ (CIS) photocathode decorated with molecular co-catalysts. To enhance charge separation and catalytic efficiency, and the product selectivity, we modified the CIS thin film with a buffer layer and a linker, enabling robust anchoring of the co-catalyst. The optimized CIS-based photocathode achieved an impressive current density and high Faradaic efficiency (FE) for CO under 1-sun light illumination. This study underscores the advantages of molecular catalyst integration with solution-processed photocathodes and paves the way for scalable PEC CO_2 conversion technologies.

Keywords: PEC CO_2 RR, solution-processed, molecular catalyst, photocathode

*Corresponding author: alexander.uhl@ubc.ca
** Presenter

11:40 AM – 12:00 PM

Selective Photoelectrochemical Reforming of Biomass Intermediates Catalyzed by In-Situ Fabricated C_3N_4 Electrode on Cu Foil

Muhammad Ashraf
Department of Chemistry, The University of British Columbia, 3247 University Way, Kelowna, BC, V1V 1V7 Canada

Abstract

This study presents the in-situ fabrication of carbon nitride (C_3N_3) based photoanodes on copper (Cu) foil substrates for the photoreforming of hydroxymethylfurfural (HMF). The fabricated photoanodes efficiently convert the lignocellulosic biomass intermediate, HMF, into 2,5-furandicarboxylic acid (FDCA) and green hydrogen (H_2) fuel through a photoelectrochemical process. FDCA is a promising platform chemical for producing biodegradable plastics, such as polyethylene furanoate (PEF). The Cu foil serves three key functions in this system: (i) acting as a catalyst for Ullmann polymerization to synthesize the C_3N_3 photocatalyst, (ii) coordinating with the C_3N_3 framework to selectively convert HMF into FDCA, and (iii) providing a conductive substrate for in-situ fabrication of the C_3N_3/Cu photoanode. This innovative process produces FDCA and H_2 fuel under ambient conditions with single sunlight irradiation, utilizing holes generated during water splitting to drive the oxidation of HMF and electrons to enhance H_2 production. The C_3N_3/Cu photoanode demonstrated exceptional performance, achieving 85% HMF conversion and high Faradaic efficiency with 20 mM HMF and 1 M KOH electrolyte at a cell voltage of 1.20–1.60 V. Furthermore, the photoanode maintained stability for over 80 hours under experimental conditions. Density functional theory (DFT) calculations reveal that Cu intercalation induces significant charge redistribution, enhancing selectivity and improving the photocatalytic hydrogen evolution reaction (HER) performance.

Corresponding author: Muhammad.ashraf@ubc.ca

1:00 PM – 1:30 PM

Challenges Facing the Scale-up and Commercialization of Solar-driven Chemical Processes

Dr. Alexandra Tavasoli

The Laboratory of Future Industry (LoFI), School of Engineering, University of British Columbia, Okanagan (UBCO), Campus

Abstract

Solar-driven chemical processes, such as those used for producing solar fuels, offer a promising pathway toward sustainable energy and industrial decarbonization. However, scaling these technologies from lab-scale demonstrations to industrial application has a number of significant engineering and commercialization challenges. This talk will explore key barriers, including material limitations, system design, and economic viability. Related issues that influence new technology commercialization, like infrastructure integration, policy support, and market competitiveness will also be discussed. By examining recent advancements and real-world case studies, this presentation aims to highlight potential collaborative research pathways for accelerating the commercialization of solar-driven chemical processes.

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1:30 PM – 1:50 PM

The Development of Hybrid Systems Composed of Carbon Nitride (CNx) and First-Row Transition Metals for Photocatalytic CO_2 Reduction (CO_2 RR) and Electrochemical Nitrogen Reduction Reaction (eNRR).

Peter Ohemeng
The University of British Columbia

Abstract

To address issues of high energy consumption and carbon emission, researchers today have intensified efforts into developing alternative green industrial methods. In this work, we synthesized organic-inorganic hybrid systems made of carbon nitride (CN_x) and first-row transition elements for photocatalytic CO_2 RR and electrocatalytic NRR. The easy tunability and facile synthesis of CN_x as a metal free organic semiconductor material makes it a good candidate to be used in this context. Through an amide linkage, an iron quaterpyridine (Feqpy) molecular cocatalyst is attached to CN_x scaffold to obtain the photocatalyst. The synthesized hybrid material delivers 38.8 nmol g^{-1} h^{-1} of carbon monoxide (CO) in acetonitrile using triethanol amine (TEOA) as hole scavenger and proton source, with high selectivity (> 90 %) after 21 hours of irradiation under simulated solar. The apparent quantum yield (AQY) of the reaction is about 0.03 %. Similarly, a hybrid material composed of CN_x, and manganese (Mn) metal is synthesized via a simple solid-liquid state approach for electrocatalytic nitrogen reduction reaction using N_2 gas as substrate. The electrocatalyst shows an outstanding performance with NH_3 production rate of 80.807 µg h^{-1} cm^{-2} and a Faraday efficiency of 92 %. Preliminary characterization information of the synthesized materials (both photocatalyst and electrocatalyst) is obtained by spectroscopic measurements including Fourier transform infrared spectroscopy (FTIR), ultraviolet-visible diffuse reflectance spectroscopy (UV-vis DRS), and photoluminescence (PL) measurements. Overall, this work presents an alternative approach to design advanced photocatalytic and electrocatalytic systems based on CN_x.

1:50 PM – 2:10 PM
Electrodeposition of Conductive Metal-organic Framework Thin Films

Davis Kurdyla
The University of British Columbia

Abstract

Many key environmental crises arise from the oxidative transformation of chemicals into small molecule waste or byproducts. Examples include the oxidation of ammonia fertilizer into nitrate waste and the oxidation of carbonaceous fuels to carbon dioxide, among others. In this space, metal-organic frameworks (MOFs) are a promising platform for the adsorption and catalytic reduction of small molecules, owing to their varied pore size, tunable chemical functionality, and ultrahigh surface area. Furthermore, conductive, electrocatalytically active MOFs offer to accomplish these reactions powered by clean energy and without stoichiometric reductants. Such a system, however, requires a well-defined electrode-MOF composite through which charge transfer can take place. We investigate electrodeposition as a general strategy to incorporate MOFs as thin films onto conductive substrates and characterize their morphological and electrochemical properties, using techniques ranging from electron microscopy and x-ray diffraction to electrochemical quartz crystal microbalance and alternating current voltammetry. Insights gained from these systems inform the design of more active and selective heterogeneous electrocatalysts.

2:10 PM – 2:30 PM
An Economical Zn-CO_2 Energy Storage Device Using a Bismuth Based Electrocatalyst as Cathode

Mahboob Alam[a], Jia Xu[b], Evan J. Hansen[b], Ela Nuraela[a], Li, Tao[b], Alexander R. Uhl[a], Jian Liu[b]
[a] Laboratory for Solar Energy and Fuels (LSEF), School of Engineering, The University of British Columbia, Kelowna, V1V 1V7 Canada
[b] School of Engineering, Faculty of Applied Science, The University of British Columbia, Kelowna, British Columbia, V1V 1V7, Canada

Abstract

Zn-CO_2 batteries are gaining more attention due to their promising technology for utilizing green house gas (GHG) CO_2 and generating electricity simultaneously, whereas a big challenge is to develop efficient electrocatalysts towards CO_2 reduction (CO_2RR). However, current electrocatalyst face multiple obstacles such as carbon containing products (C^{2+}) and in-efficient cost. Herein, we developed a single bismuth based electrocatalyst rich with nitrogen and carbon matrix (Bi-SAs/NC). The H-type cell coupled with *in-situ* Gas Chromatography (GC) was used to assess the electrochemical performance of Bi-SAs/NC in 0.5 M $KHCO_3$ under CO_2RR conditions. No notable gaseous products were observed a part from hydrogen (H_2). Moreover, *ex-situ* Nuclear Magnetic Resonance (NMR) confirmed the presence of small hydrocarbons, such as, formic acid (HCOOH), ethane-diol ($CH_3CH(OH)_2$), and acetic acid (CH_3COOH) at very low faradaic efficiency. Furthermore, we fabricated a Zn-CO_2 system using Bi-SAs/NC as cathode and Zn foil as anode. The device+ showed exceptional performance with a high current density of 14 mA cm^{-2} and peak power density of 3.8 mW cm^{-2}. The long-term charge and discharge cycling of the Zn-CO_2 device sustains its operation for 67 hours at 0.5 mA cm^{-2} accentuating its stability and durability.

Keywords: Zn-CO_2 battery, Electrochemical reduction of CO_2, Zinc battery, Energy storage

2:30 PM – 2:50 PM

Exploring Spatial and Temporal Charge Carrier Dynamics in Carbon Nitride Using Transient Absorption Microscopy

Sutripto Khasnabis, Robert Godin
The University of British Columbia, Kelowna, British Columbia, V1V 1V7, Canada

Abstract

Solar energy conversion to produce Hydrogen using photocatalysis is a promising route for sustainable energy production. However, polymeric photocatalysts, such as carbon nitride (CN_x), suffers from poor charge carrier dynamics, which limits their efficiency. Transient Absorption Spectroscopy (TAS) is routinely used to explore these dynamics, which reveals insights regarding properties such as charge carrier lifetimes and trapping. However, conventional TAS measurements typically rely on large probe sizes (millimeters to centimeters), which average out spatial heterogeneities at smaller scales. To overcome this limitation, a home-built Transient Absorption Microscopy (TAM) setup was developed to study single CN_x particles with probe beams that allowed micron level spatial resolution. For the first time, µs–s carrier dynamics were explored within individual CN_x particles, revealing significant heterogeneity in trapped charge density across particles and in lifetimes within a single particle, spatially. Additionally, this study investigates the spatial effects of Pt deposition on slow carrier dynamics the TAM setup. Pt deposition was found to extend charge half-lives by at least threefold and increase heterogeneity, with a preference for binding in areas with the lowest lifetimes. These findings suggest that local environments independently influence charge trapping at different timescales. Spatiotemporally resolved TAM offers a powerful approach to understanding and optimizing photocatalyst design for improved solar energy conversion efficiency.