


# Report on attending **Materials Today Conference 2023 (MATA 2023)** in Singapore (2-5 August 2023) and **Invited Talk and Visit of different laboratories of Solar Energy Research Institute (SERI), UKM, Malaysia** (6-10, August 2023)


Dr. Syed Farid Uddin Farhad presented two papers on BCSIR-approved R&D projects (PA-24 and PA-26) at MATA 2023 Conference, in Singapore.



**Bandgap Engineering of Bismuth-based Photoelectrode Materials for Self-sustained Photoelectrochemical Generation of Hydrogen**

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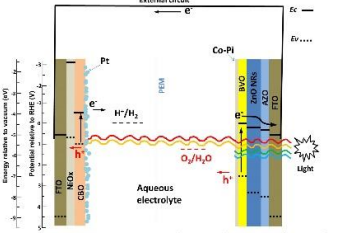
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### INTRODUCTION

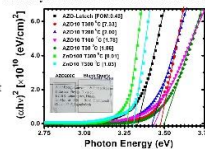
- Photoelectrochemical (PEC) devices for Solar Fuels (e.g., H<sub>2</sub>)
- Ecofriendly Bi-based photoelectrode materials such as BiVO<sub>4</sub> (BVO) and CuBi<sub>2</sub>O<sub>4</sub> (CBO) for attaining high solar-to-hydrogen (STH) efficiency<sup>1</sup>
- BVO ( $\mu_c \sim 10^{-2}$  cm<sup>2</sup>/V.s; L<sub>n</sub> ~ 100 nm)<sup>2</sup>: Are suitable band alignment and the radial junction with n-type electrodes needed?

#### Bismuth-based metal oxide photoelectrodes for self-sustained PEC devices<sup>1</sup>



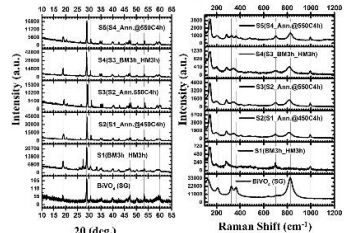
FTO: Fluorine-doped Tin Oxide  
 NiOx: Nickel oxide  
 AZO: Al-doped ZnO electrode  
 ZnO NRs: ZnO Nanorod arrays  
 Co-Pi: cobalt-phosphate co-catalyst  
 PEM: Proton exchange membrane

ZnO layers with tunable features for BVO

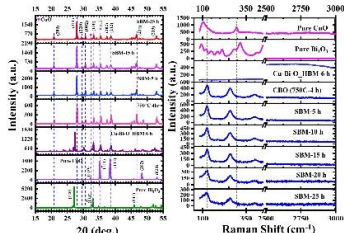


### RESULTS AND DISCUSSION

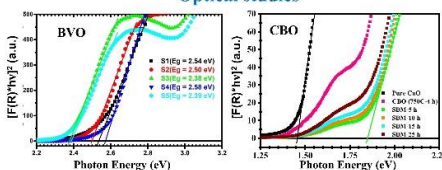
#### Phase pure (BVO)<sup>3</sup>



#### Phase pure (CBO)<sup>4</sup>

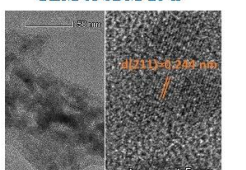


#### Optical studies



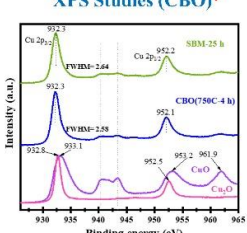
➤ Direct and tunable bandgap

#### TEM of SBM-25 h



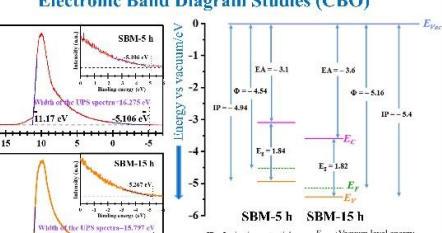
\*TEM → Transmission electron microscopy

#### XPS Studies (CBO)<sup>4</sup>



➤ No existence of secondary phases!

#### Electronic Band Diagram Studies (CBO)



➤ p-type nature is confirmed!

### SYNTHESIS

- Raw materials: BVO (V<sub>2</sub>O<sub>5</sub>·Bi<sub>2</sub>O<sub>3</sub>) and CBO (CuO·Bi<sub>2</sub>O<sub>3</sub>)
- Ball mill derived solid-state reactions

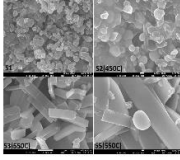
Compositional Variation & Bandgap (CBO)

Sample	Bi <sub>2</sub> O <sub>3</sub>	CuO	λ <sub>g</sub>
CBO-50C-1h	1.56	1.98	2.14
SBM-5 h	1.52	1.96	2.14
SBM-15 h	1.50	2.01	2.12
SBM-25 h	1.48	2.12	2.09
SBM-30 h	1.43	2.12	1.94

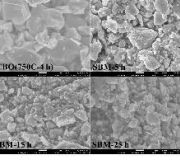
Industrially scalable facile synthesis & processing

### Morphological Studies

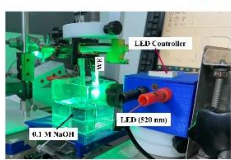
BVO



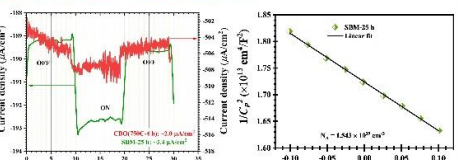
CBO



➤ Grain size and shape variation with milling duration



\*WE → Working Electrode



N<sub>s</sub> = 4.50 × 10<sup>19</sup> cm<sup>-3</sup>

### REFERENCES

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- Kim and J.S. Lee, *Adv. Mater.*, 2019, 1806938.
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### CONCLUSIONS

- Successful synthesis of phase pure BVO and CBO materials.
- Direct and tunable bandgap: BVO (2.58 to 2.38 eV); CBO (1.84 to 1.74 eV) for PEC devices.
- PEC performance of drop-casted SBM-CBO/FTO showed its suitability for H<sub>2</sub> production.

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## Zinc Sulfide Nanocrystals Decorated Vertically Aligned ZnO Nanorods on Wide Bandgap Seed Layers for Lead-free Perovskite Solar Cells

Syed Farid Uddin Farhad<sup>1,2,3\*</sup>, Nazmul Islam Turvir<sup>1,2,3</sup>, Md. Nur Amin Bitu<sup>1,3</sup>, Md. Al Mamun<sup>4</sup>, Md. Saiful Islam<sup>1,3</sup>, Md. Saiful Quddus<sup>2,3</sup>, Mohammad Moniruzzaman<sup>2,3</sup>

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<sup>3</sup>Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka 1205, Bangladesh

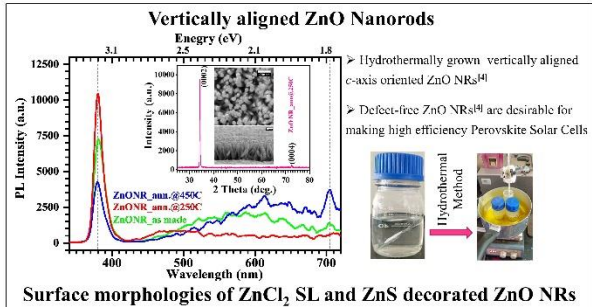
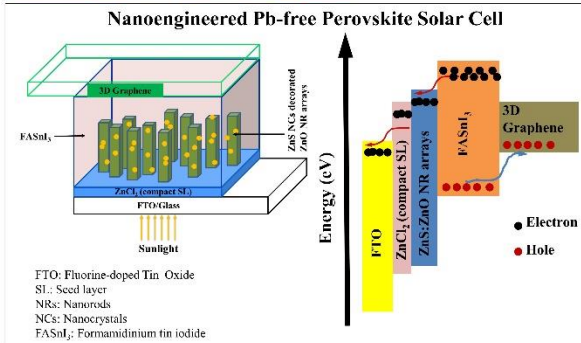
<sup>4</sup>Atomic Energy Center, Bangladesh Atomic Energy Commission (BAEC), Bangladesh

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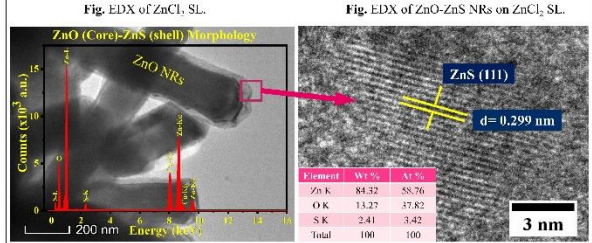
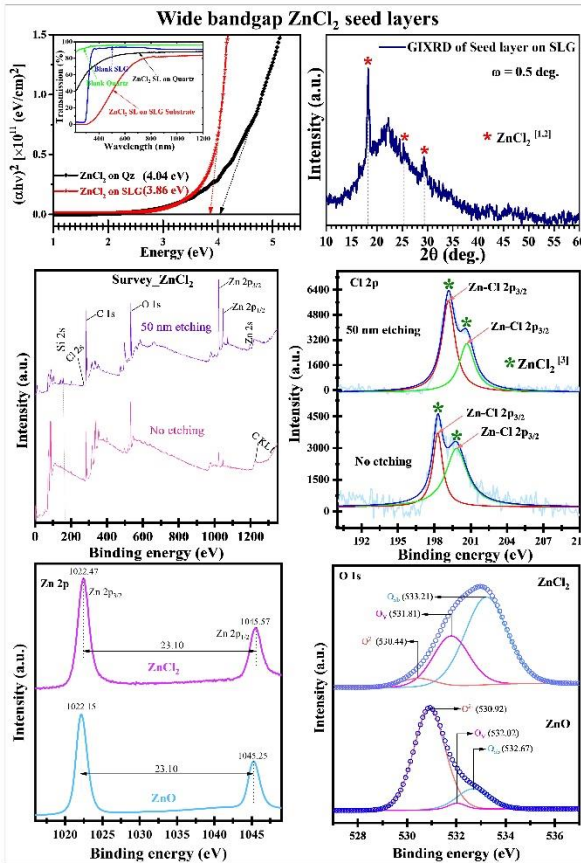
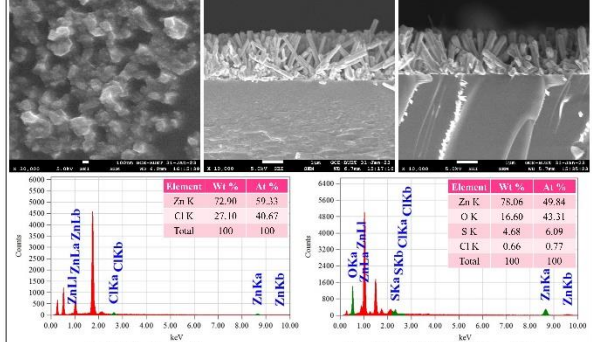


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### Surface morphologies of ZnCl<sub>2</sub> SL and ZnS decorated ZnO NRs



### Conclusions

- Highly transparent and wide bandgap (>3.8 eV) ZnCl<sub>2</sub> seed layers were synthesized.
- The GIXRD and XPS analyses further confirmed the successful formation of ZnCl<sub>2</sub>.
- Vertically aligned c-axis oriented ZnO NRs were synthesized on the ZnCl<sub>2</sub> SL.
- Conformal coating of ZnO NR with ultra-thin ZnS NCs could be promising to fabricate high-performance Pb-free Perovskite solar cells.

### References

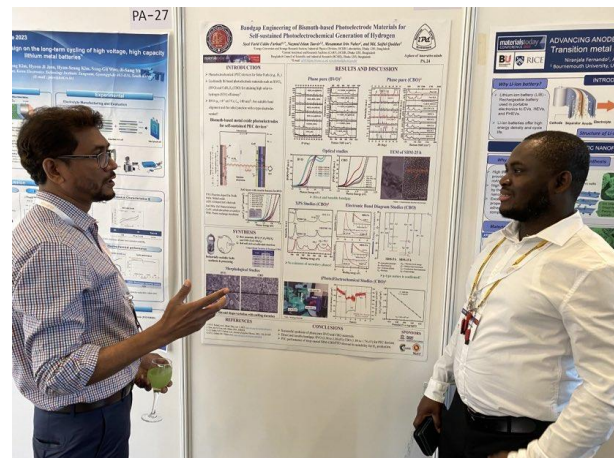
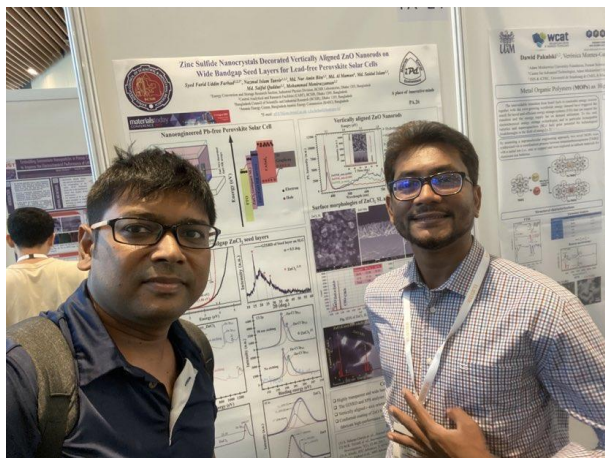
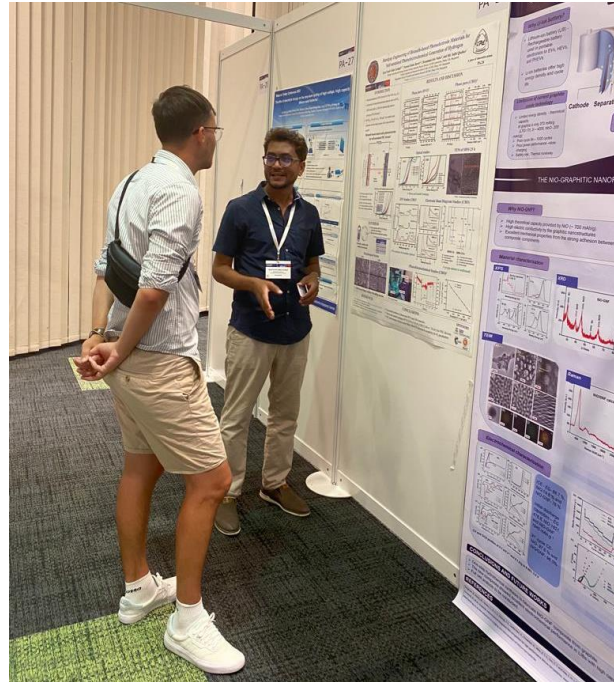
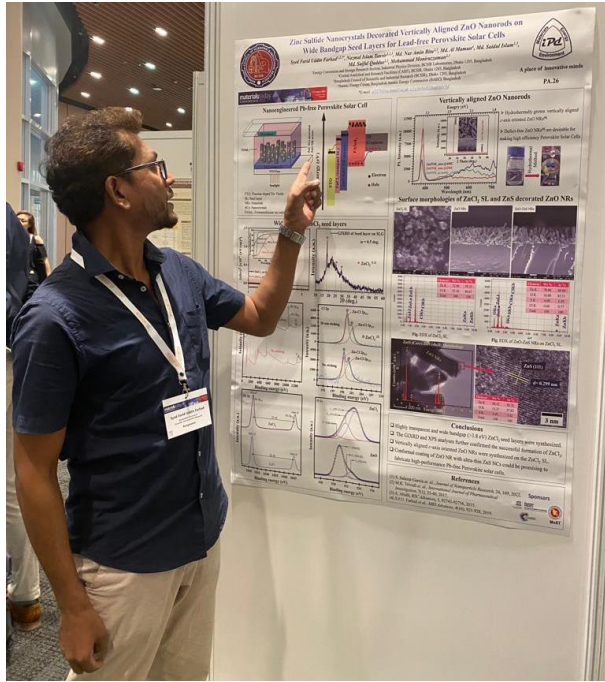
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Poster presentation on 2 - 4 August 2023 Singapore Expo Drive, Singapore

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Prof. Dr. Adib Ibrahim, Director, SERI, University Kebangsaan Malaysia (UKM) invited Dr. Farhad to deliver a lecture (~2 hours) on the Research Scopes and current R&D activities of Industrial Physics Division (IPD), BCSIR Laboratories, Dhaka 1205 for potential collaborative research works and Researchers/Students short/long term visit for fostering mutual benefits. Some photographs taken during his invited talk are given below.



Science for Life



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### Ecofriendly and Nanostructured Metal Oxide Materials for Solar Cells and Solar Fuels

**Dr. Syed Farid Uddin Farhad**  
Industrial Physics Division  
BCSIR Laboratories, Dhaka, Bangladesh

<b>Invited Talk</b> 9 August 2023	<b>Venue</b> SERI, UKM, Malaysia
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IPD *A place of innovative minds*Dr. S. F.U. Farhad



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Open floor discussions with SERI's research faculties for potential research collaborations and joint Postgraduate/Ph.D. student(s) supervision.



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Visits of different laboratories of UKM institutes for exploring research scopes and facilities

