References

[1] P. Murphy and S. H. C. Secretariat, "IEA Solar Heating & Cooling Programme," *2010 Annu. Report, April*, 2011.

[2] N. S. Lewis and D. G. Nocera, "Powering the planet: Chemical challenges in solar energy utilization," *Proc. Natl. Acad. Sci.*, vol. 103, no. 43, pp. 15729–15735, 2006.

[3] M. K. Singh, J. Malek, H. K. Sharma, and R. Kumar, "Converting the threats of fossil fuel-based energy generation into opportunities for renewable energy development in India," *Renew. Energy*, vol. 224, p. 120153, 2024.

[4] J. C. Goldemberg, "UN World Energy Assessment Report: Energy and the Challenges of Sustainability," 2003, *United Nations, New York*.

[5] J. Li and N. Wu, "Semiconductor-based photocatalysts and photoelectrochemical cells for solar fuel generation: a review," *Catal. Sci. Technol.*, vol. 5, no. 3, pp. 1360–1384, 2015.

[6] J. Barber, "Photosynthetic energy conversion: natural and artificial," *Chem. Soc. Rev.*, vol. 38, no. 1, pp. 185–196, 2009.

[7] N. S. Lewis, "Powering the planet," *MRS Bull.*, vol. 32, no. 10, pp. 808–820, 2007.

[8] R. F. Service, "Is it time to shoot for the sun?," *Science (80-.).*, vol. 309, no. 5734, pp. 548–551, 2005.

[9] N. S. Lewis *et al.*, "Basic research needs for solar energy utilization. report of the basic energy sciences workshop on solar energy utilization, april 18-21, 2005," DOESC (USDOE Office of Science (SC)), 2005.

[10] V. S. Marakatti and E. M. Gaigneaux, "Recent advances in heterogeneous catalysis for ammonia synthesis," *ChemCatChem*, vol. 12, no. 23, pp. 5838–5857, 2020.

[11] Z. Şen, "Solar energy in progress and future research trends," *Prog. energy Combust. Sci.*, vol. 30, no. 4, pp. 367–416, 2004.

[12] V. Sharma and S. S. Chandel, "Performance and degradation analysis for long term reliability of solar photovoltaic systems: A review," *Renew. Sustain. energy Rev.*, vol. 27, pp. 753–767, 2013.

[13] L. G. Rosa, J. C. G. Pereira, K. Rahmani, G. De Almeida, and L. F. Santos, "Study on the performance of optical lenses under high fluxes of solar radiation," *Appl. Sci.*, vol. 11, no. 11, p. 5174, 2021.

[14] M. Grätzel, “Photoelectrochemical cells,” *Nature*, vol. 414, no. 6861, pp. 338–344, 2001.

[15] A. Fujishima and K. Honda, “Electrochemical photolysis of water at a semiconductor electrode,” *Nature*, vol. 238, no. 5358, pp. 37–38, 1972.

[16] C. Smith, A. K. Hill, and L. Torrente-Murciano, “Current and future role of Haber–Bosch ammonia in a carbon-free energy landscape,” *Energy Environ. Sci.*, vol. 13, no. 2, pp. 331–344, 2020.

[17] S. Verhelst, “Recent progress in the use of hydrogen as a fuel for internal combustion engines,” *Int. J. Hydrogen Energy*, vol. 39, no. 2, pp. 1071–1085, 2014.

[18] B. Zhang, S.-X. Zhang, R. Yao, Y.-H. Wu, and J.-S. Qiu, “Progress and prospects of hydrogen production: Opportunities and challenges,” *J. Electron. Sci. Technol.*, vol. 19, no. 2, p. 100080, 2021.

[19] C. R. Second *et al.*, “Handbook of heterogeneous catalysis,” 2008.

[20] D. K. Barkan and D. K. Buchwald, *Walther Nernst and the transition to modern physical science*. Cambridge University Press, 2011.

[21] H. Schulz, “Short history and present trends of Fischer–Tropsch synthesis,” *Appl. Catal. A Gen.*, vol. 186, no. 1–2, pp. 3–12, 1999.

[22] C. B. B. Farias, R. C. S. Barreiros, M. F. da Silva, A. A. Casazza, A. Converti, and L. A. Sarubbo, “Use of hydrogen as fuel: a trend of the 21st century,” *Energies*, vol. 15, no. 1, p. 311, 2022.

[23] A. J. Bard and M. A. Fox, “Artificial photosynthesis: solar splitting of water to hydrogen and oxygen,” *Acc. Chem. Res.*, vol. 28, no. 3, pp. 141–145, 1995.

[24] X. Li, X. Hao, A. Abudula, and G. Guan, “Nanostructured catalysts for electrochemical water splitting: current state and prospects,” *J. Mater. Chem. A*, vol. 4, no. 31, pp. 11973–12000, 2016.

[25] F. Wang *et al.*, “Recent advances in transition-metal dichalcogenide based nanomaterials for water splitting,” *Nanoscale*, vol. 7, no. 47, pp. 19764–19788, 2015.

[26] M. G. Walter *et al.*, “Solar water splitting cells,” *Chem. Rev.*, vol. 110, no. 11, pp. 6446–6473, 2010.

[27] S. Y. Reece *et al.*, “Wireless solar water splitting using silicon-based semiconductors and earth-abundant catalysts,” *Science (80-.).*, vol. 334, no. 6056, pp. 645–648, 2011.

[28] G. Zhao, K. Rui, S. X. Dou, and W. Sun, “Heterostructures for electrochemical hydrogen evolution reaction: a review,” *Adv. Funct. Mater.*, vol. 28, no. 43, p. 1803291, 2018.

[29] A. Y. Faid and S. Sunde, “Anion exchange membrane water electrolysis from catalyst design to the membrane electrode assembly,” *Energy Technol.*, vol. 10, no. 9, p.

2200506, 2022.

[30] M. Z. Bazant, "Theory of chemical kinetics and charge transfer based on nonequilibrium thermodynamics," *Acc. Chem. Res.*, vol. 46, no. 5, pp. 1144–1160, 2013.

[31] Y.-H. Fang and Z.-P. Liu, "Tafel kinetics of electrocatalytic reactions: from experiment to first-principles," *Acs Catal.*, vol. 4, no. 12, pp. 4364–4376, 2014.

[32] J. Bockris and E. C. Potter, "The mechanism of the cathodic hydrogen evolution reaction," *J. Electrochem. Soc.*, vol. 99, no. 4, p. 169, 1952.

[33] E. Fabbri, A. Habereder, K. Waltar, R. Kötz, and T. J. Schmidt, "Developments and perspectives of oxide-based catalysts for the oxygen evolution reaction," *Catal. Sci. Technol.*, vol. 4, no. 11, pp. 3800–3821, 2014.

[34] T. D. Tran, M. T. T. Nguyen, H. V Le, D. N. Nguyen, Q. D. Truong, and P. D. Tran, "Gold nanoparticles as an outstanding catalyst for the hydrogen evolution reaction," *Chem. Commun.*, vol. 54, no. 27, pp. 3363–3366, 2018.

[35] S. Anantharaj, P. E. Karthik, and S. Kundu, "Self-assembled IrO 2 nanoparticles on a DNA scaffold with enhanced catalytic and oxygen evolution reaction (OER) activities," *J. Mater. Chem. A*, vol. 3, no. 48, pp. 24463–24478, 2015.

[36] A. K. Ranjan, P. K. Jha, P. A. Jha, and P. Singh, "Catalyzing hydrogen production: Exploring plasmonic effects in self-assembled CuO/Cu2O thin films via pulsed laser deposition," *J. Appl. Phys.*, vol. 135, no. 18, 2024.

[37] X. Zou and Y. Zhang, "Noble metal-free hydrogen evolution catalysts for water splitting," *Chem. Soc. Rev.*, vol. 44, no. 15, pp. 5148–5180, 2015.

[38] S.-K. Li, Y.-Y. Pan, M. Wu, F.-Z. Huang, C.-H. Li, and Y.-H. Shen, "Large-scale and green synthesis of octahedral flower-like cupric oxide nanocrystals with enhanced photochemical properties," *Appl. Surf. Sci.*, vol. 315, pp. 169–177, 2014.

[39] A. Ray *et al.*, "Optimization of photoelectrochemical performance in chemical bath deposited nanostructured CuO," *J. Alloys Compd.*, vol. 695, pp. 3655–3665, 2017.

[40] Y. J. Jang *et al.*, "Tree branch-shaped cupric oxide for highly effective photoelectrochemical water reduction," *Nanoscale*, vol. 7, no. 17, pp. 7624–7631, 2015.

[41] X. Zhao, P. Wang, and B. Li, "CuO/ZnO core/shell heterostructure nanowire arrays: synthesis, optical property, and energy application," *Chem. Commun.*, vol. 46, no. 36, pp. 6768–6770, 2010.

[42] A. A. Dubale *et al.*, "Heterostructured Cu 2 O/CuO decorated with nickel as a highly efficient photocathode for photoelectrochemical water reduction," *J. Mater. Chem. A*, vol. 3, no. 23, pp. 12482–12499, 2015.

[43] P. Atkins and J. De Paula, *Elements of physical chemistry*. Oxford University Press, USA, 2013.

[44] T. Butburee *et al.*, "2D porous TiO2 single-crystalline nanostructure demonstrating high photo-electrochemical water splitting performance," *Adv. Mater.*, vol. 30, no. 21, p. 1705666, 2018.

[45] A. Steinfeld, "Solar hydrogen production via a two-step water-splitting thermochemical cycle based on Zn/ZnO redox reactions," *Int. J. Hydrogen Energy*, vol. 27, no. 6, pp. 611–619, 2002.

[46] M. Tayebi and B.-K. Lee, "Recent advances in BiVO4 semiconductor materials for hydrogen production using photoelectrochemical water splitting," *Renew. Sustain. energy Rev.*, vol. 111, pp. 332–343, 2019.

[47] R. Siavash Moakhar *et al.*, "Photoelectrochemical water-splitting using CuO-based electrodes for hydrogen production: a review," *Adv. Mater.*, vol. 33, no. 33, p. 2007285, 2021.

[48] O. Khaselev and J. A. Turner, "A monolithic photovoltaic-photoelectrochemical device for hydrogen production via water splitting," *Science (80-.).*, vol. 280, no. 5362, pp. 425–427, 1998.

[49] H. Xu, S. Ouyang, L. Liu, P. Reunchan, N. Umezawa, and J. Ye, "Recent advances in TiO 2-based photocatalysis," *J. Mater. Chem. A*, vol. 2, no. 32, pp. 12642–12661, 2014.

[50] S. Li, P. Zhang, X. Song, and L. Gao, "Photoelectrochemical hydrogen production of TiO2 passivated Pt/Si-nanowire composite photocathode," *ACS Appl. Mater. Interfaces*, vol. 7, no. 33, pp. 18560–18565, 2015.

[51] S. Piskunov *et al.*, "C-, N-, S-, and Fe-doped TiO2 and SrTiO3 nanotubes for visible-light-driven photocatalytic water splitting: prediction from first principles," *J. Phys. Chem. C*, vol. 119, no. 32, pp. 18686–18696, 2015.

[52] A. Kudo, K. Ueda, H. Kato, and I. Mikami, "Photocatalytic O2 evolution under visible light irradiation on BiVO4 in aqueous AgNO3 solution," *Catal. Letters*, vol. 53, no. 3, pp. 229–230, 1998.

[53] Y. Park, K. J. McDonald, and K.-S. Choi, "Progress in bismuth vanadate photoanodes for use in solar water oxidation," *Chem. Soc. Rev.*, vol. 42, no. 6, pp. 2321–2337, 2013.

[54] J. Cheng, L. Wu, and J. Luo, "Cuprous oxide photocathodes for solar water splitting," *Chem. Phys. Rev.*, vol. 3, no. 3, 2022.

[55] J. Fu, J. Yu, C. Jiang, and B. Cheng, "g-C3N4-Based heterostructured photocatalysts," *Adv. Energy Mater.*, vol. 8, no. 3, p. 1701503, 2018.

[56] X. Wang *et al.*, "A metal-free polymeric photocatalyst for hydrogen production from water under visible light," *Nat. Mater.*, vol. 8, no. 1, pp. 76–80, 2009.

[57] R. S. Moakhar *et al.*, "One-pot microwave synthesis of hierarchical C-doped CuO dandelions/g-C3N4 nanocomposite with enhanced photostability for photoelectrochemical water splitting," *Appl. Surf. Sci.*, vol. 530, p. 147271, 2020.

[58] X. Zong *et al.*, “Enhancement of photocatalytic H2 evolution on CdS by loading MoS2 as cocatalyst under visible light irradiation,” *J. Am. Chem. Soc.*, vol. 130, no. 23, pp. 7176–7177, 2008.

[59] C. G. Morales-Guio, S. D. Tilley, H. Vrubel, M. Grätzel, and X. Hu, “Hydrogen evolution from a copper (I) oxide photocathode coated with an amorphous molybdenum sulphide catalyst,” *Nat. Commun.*, vol. 5, no. 1, p. 3059, 2014.

[60] C.-Y. Chiang, J. Epstein, A. Brown, J. N. Munday, J. N. Culver, and S. Ehrman, “Biological templates for antireflective current collectors for photoelectrochemical cell applications,” *Nano Lett.*, vol. 12, no. 11, pp. 6005–6011, 2012.

[61] J. Oh, H. Ryu, W.-J. Lee, and J.-S. Bae, “Improved photostability of a CuO photoelectrode with Ni-doped seed layer,” *Ceram. Int.*, vol. 44, no. 1, pp. 89–95, 2018.

[62] A. Mahmood, F. Tezcan, and G. Kardaş, “Photoelectrochemical characteristics of CuO films with different electrodeposition time,” *Int. J. Hydrogen Energy*, vol. 42, no. 36, pp. 23268–23275, 2017.

[63] A. K. Ranjan, P. A. Jha, P. K. Jha, and P. Singh, “Anisotropic photoconduction in ultrathin CuO: A nonreciprocal system?,” *J. Appl. Phys.*, vol. 132, no. 19, p. 195701, 2022.

[64] J. Mittra *et al.*, “Role of substrate temperature in the pulsed laser deposition of zirconium oxide thin film,” in *Materials Science Forum*, Trans Tech Publ, 2012, pp. 757–761.

[65] K. Nadeem Riaz, N. Yousaf, M. Bilal Tahir, Z. Israr, and T. Iqbal, “Facile hydrothermal synthesis of 3D flower-like La-MoS2 nanostructure for photocatalytic hydrogen energy production,” *Int. J. Energy Res.*, vol. 43, no. 1, pp. 491–499, 2019.

[66] W. H. Bragg and W. L. Bragg, “The reflection of X-rays by crystals,” *Proc. R. Soc. London. Ser. A, Contain. Pap. a Math. Phys. Character*, vol. 88, no. 605, pp. 428–438, 1913.

[67] L. Alexander and H. P. Klug, “Determination of crystallite size with the X-Ray spectrometer,” *J. Appl. Phys.*, vol. 21, no. 2, pp. 137–142, 1950.

[68] S. Loganathan, R. B. Valapa, R. K. Mishra, G. Pugazhenthi, and S. Thomas, “Thermogravimetric analysis for characterization of nanomaterials,” in *Thermal and rheological measurement techniques for nanomaterials characterization*, Elsevier, 2017, pp. 67–108.

[69] B. Chen, H. Chaouki, D. Picard, J. Lauzon-Gauthier, H. Alamdari, and M. Fafard, “Physical property evolution of the anode mixture during the baking process,” *Materials (Basel).*, vol. 14, no. 4, p. 923, 2021.

[70] P. J. Haines, M. Reading, and F. W. Wilburn, “Differential thermal analysis and differential scanning calorimetry,” in *Handbook of thermal analysis and calorimetry*, vol. 1, Elsevier, 1998, pp. 279–361.

[71] G. A. Bogaert, L. Goeman, D. de Ridder, M. Wevers, J. Ivens, and A. Schuermans, “The physical and antimicrobial effects of microwave heating and alcohol immersion on catheters that are reused for clean intermittent catheterisation,” *Eur. Urol.*, vol. 46, no. 5, pp. 641–646, 2004.

[72] D. McMullan, “SEM—past, present and future,” *J. Microsc.*, vol. 155, no. 3, pp. 373–392, 1989.

[73] N. Munir, M. Hanif, D. A. Dias, and Z. Abideen, “The role of halophytic nanoparticles towards the remediation of degraded and saline agricultural lands,” *Environ. Sci. Pollut. Res.*, vol. 28, no. 43, pp. 60383–60405, 2021.

[74] B. J. Inkson, “Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) for materials characterization,” in *Materials characterization using nondestructive evaluation (NDE) methods*, Elsevier, 2016, pp. 17–43.

[75] G. Greczynski and L. Hultman, “A step-by-step guide to perform x-ray photoelectron spectroscopy,” *J. Appl. Phys.*, vol. 132, no. 1, 2022.

[76] F. I. Vilesov, “Photoionization of gases and vapors by vacuum ultraviolet radiation,” *Sov. Phys. Uspekhi*, vol. 6, no. 6, p. 888, 1964.

[77] B. de la Fuente *et al.*, “On the combination of ultraviolet photoelectron spectroscopy with optical absorption studies to investigate Cu2O‖ TiO2 direct Z-scheme junctions with different Cu2O loading,” *Appl. Surf. Sci.*, vol. 657, p. 159796, 2024.

[78] F. J. Giessibl, “Advances in atomic force microscopy,” *Rev. Mod. Phys.*, vol. 75, no. 3, p. 949, 2003.

[79] X. Deng *et al.*, “Application of atomic force microscopy in cancer research,” *J. Nanobiotechnology*, vol. 16, pp. 1–15, 2018.

[80] R. A. Schoonheydt, “UV-VIS-NIR spectroscopy and microscopy of heterogeneous catalysts,” *Chem. Soc. Rev.*, vol. 39, no. 12, pp. 5051–5066, 2010.

[81] B. D. Viezbicke, S. Patel, B. E. Davis, and D. P. Birnie III, “Evaluation of the Tauc method for optical absorption edge determination: ZnO thin films as a model system,” *Phys. status solidi*, vol. 252, no. 8, pp. 1700–1710, 2015.

[82] A. M. Alshehawy, D.-E. A. Mansour, M. Ghali, M. Lehtonen, and M. M. F. Darwish, “Photoluminescence spectroscopy measurements for effective condition assessment of transformer insulating oil,” *Processes*, vol. 9, no. 5, p. 732, 2021.

[83] X. X. Han, R. S. Rodriguez, C. L. Haynes, Y. Ozaki, and B. Zhao, “Surface-enhanced Raman spectroscopy,” *Nat. Rev. Methods Prim.*, vol. 1, no. 1, p. 87, 2021.

[84] N. Elgrishi, K. J. Rountree, B. D. McCarthy, E. S. Rountree, T. T. Eisenhart, and J. L. Dempsey, “A Practical Beginner’s Guide to Cyclic Voltammetry,” *J. Chem. Educ.*, vol. 95, no. 2, pp. 197–206, Feb. 2018, doi: 10.1021/acs.jchemed.7b00361.

[85] R. S. Nicholson, “Theory and Application of Cyclic Voltammetry for Measurement of Electrode Reaction Kinetics.,” *Anal. Chem.*, vol. 37, no. 11, pp. 1351–1355, Oct. 1965, doi: 10.1021/ac60230a016.

[86] A. M. Bond and S. W. Feldberg, “Analysis of Simulated Reversible Cyclic Voltammetric Responses for a Charged Redox Species in the Absence of Added Electrolyte,” *J. Phys. Chem. B*, vol. 102, no. 49, pp. 9966–9974, Dec. 1998, doi: 10.1021/jp9828437.

[87] H.-J. Song, M.-H. Seo, K.-W. Choi, M.-S. Jo, J.-Y. Yoo, and J.-B. Yoon, “High-performance copper oxide visible-light photodetector via grain-structure model,” *Sci. Rep.*, vol. 9, no. 1, p. 7334, 2019.

[88] M. Muhibbullah and M. Ichimura, “Fabrication of Photoconductive Copper Oxide Thin Films by the Chemical Bath Deposition Technique,” *Jpn. J. Appl. Phys.*, vol. 49, no. 8R, p. 81102, 2010, doi: 10.1143/JJAP.49.081102.

[89] A. K. Ranjan, P. A. Jha, P. K. Jha, and P. Singh, “Photoconduction in CuO,” *Mater. Today Proc.*, vol. 28, pp. 131–133, 2020.

[90] F. Marabelli, G. B. Parravicini, and F. Salghetti-Drioli, “Optical gap of CuO,” *Phys. Rev. B*, vol. 52, no. 3, pp. 1433–1436, Jul. 1995, doi: 10.1103/PhysRevB.52.1433.

[91] M. Heinemann, B. Eifert, and C. Heiliger, “Band structure and phase stability of the copper oxides Cu${}_{2}$O, CuO, and Cu${}_{4}$O${}_{3}$,” *Phys. Rev. B*, vol. 87, no. 11, p. 115111, Mar. 2013, doi: 10.1103/PhysRevB.87.115111.

[92] C. Zuo and L. Ding, “Solution-Processed Cu2O and CuO as Hole Transport Materials for Efficient Perovskite Solar Cells.,” *Small*, vol. 11, no. 41, pp. 5528–5532, 2015.

[93] T. Eom *et al.*, “Copper oxide buffer layers by pulsed-chemical vapor deposition for semitransparent perovskite solar cells,” *Adv. Mater. Interfaces*, vol. 8, no. 1, p. 2001482, 2021.

[94] R. Hajimammadov *et al.*, “Random networks of core-shell-like Cu-Cu2O/CuO nanowires as surface plasmon resonance-enhanced sensors,” *Sci. Rep.*, vol. 8, no. 1, p. 4708, 2018.

[95] A. Stamatelatos, A. Sousanis, A. G. Chronis, M. M. Sigalas, S. Grammatikopoulos, and P. Poulopoulos, “Analysis of localized surface plasmon resonances in gold nanoparticles surrounded by copper oxides,” *J. Appl. Phys.*, vol. 123, no. 8, 2018.

[96] A. Živković and N. H. de Leeuw, “Exploring the formation of intrinsic p-type and n-type defects in CuO,” *Phys. Rev. Mater.*, vol. 4, no. 7, p. 74606, 2020.

[97] T. Kimura, Y. Sekio, H. Nakamura, T. Siegrist, and A. P. Ramirez, “Cupric oxide as an induced-multiferroic with high-TC,” *Nat. Mater.*, vol. 7, no. 4, pp. 291–294, 2008.

[98] H. Watanabe and Y. Yanase, “Group-theoretical classification of multipole order: Emergent responses and candidate materials,” *Phys. Rev. B*, vol. 98, no. 24, p. 245129,

2018.

[99] W. T. H. Koch, R. Munser, W. Ruppel, and P. Würfel, “Anomalous photovoltage in BaTiO3,” *Ferroelectrics*, vol. 13, no. 1, pp. 305–307, 1976.

[100] S. M. Young and A. M. Rappe, “First principles calculation of the shift current photovoltaic effect in ferroelectrics,” *Phys. Rev. Lett.*, vol. 109, no. 11, p. 116601, 2012.

[101] S. M. Young, F. Zheng, and A. M. Rappe, “First-principles calculation of the bulk photovoltaic effect in bismuth ferrite,” *Phys. Rev. Lett.*, vol. 109, no. 23, p. 236601, 2012.

[102] T. Choi, S. Lee, Y. J. Choi, V. Kiryukhin, and S.-W. Cheong, “Switchable ferroelectric diode and photovoltaic effect in BiFeO3,” *Science (80-.).*, vol. 324, no. 5923, pp. 63–66, 2009.

[103] J. Ahn, G.-Y. Guo, and N. Nagaosa, “Low-frequency divergence and quantum geometry of the bulk photovoltaic effect in topological semimetals,” *Phys. Rev. X*, vol. 10, no. 4, p. 41041, 2020.

[104] J. Liu, F. Xia, D. Xiao, F. J. Garcia de Abajo, and D. Sun, “Semimetals for high-performance photodetection,” *Nat. Mater.*, vol. 19, no. 8, pp. 830–837, 2020.

[105] D. E. Parker, T. Morimoto, J. Orenstein, and J. E. Moore, “Diagrammatic approach to nonlinear optical response with application to Weyl semimetals,” *Phys. Rev. B*, vol. 99, no. 4, p. 45121, 2019.

[106] J. E. Sipe and A. I. Shkrebtii, “Second-order optical response in semiconductors,” *Phys. Rev. B*, vol. 61, no. 8, p. 5337, 2000.

[107] H. Watanabe and Y. Yanase, “Chiral photocurrent in parity-violating magnet and enhanced response in topological antiferromagnet,” *Phys. Rev. X*, vol. 11, no. 1, p. 11001, 2021.

[108] Y. Yang *et al.*, “Y. Yang, C. Peng, D. Zhu, H. Bulijan, J. D. Joannopoulos, B. Zhen, and M. Soljacic, Science 365, 1021–1025 (2019).,” *Science (80-.).*, vol. 365, no. 6457, pp. 1021–1025, 2019.

[109] F. Yang and Y. Li, “Nonreciprocal diffraction of light based on double-transition-assisted photonic Aharonov-Bohm effect,” *Phys. Rev. B*, vol. 94, no. 16, p. 165439, 2016.

[110] T. Holder, D. Kaplan, and B. Yan, “Consequences of time-reversal-symmetry breaking in the light-matter interaction: Berry curvature, quantum metric, and diabatic motion,” *Phys. Rev. Res.*, vol. 2, no. 3, p. 33100, 2020.

[111] K. G. Makris, R. El-Ganainy, D. N. Christodoulides, and Z. H. Musslimani, “Beam dynamics in PT symmetric optical lattices,” *Phys. Rev. Lett.*, vol. 100, no. 10, p. 103904, 2008.

[112] K. Fang, Z. Yu, and S. Fan, "Photonic Aharonov-Bohm effect based on dynamic modulation," *Phys. Rev. Lett.*, vol. 108, no. 15, p. 153901, 2012.

[113] N. A. Estep, D. L. Sounas, J. Soric, and A. Alu, "Magnetic-free non-reciprocity and isolation based on parametrically modulated coupled-resonator loops," *Nat. Phys.*, vol. 10, no. 12, pp. 923–927, 2014.

[114] S. Lannebère, D. E. Fernandes, T. A. Morgado, and M. G. Silveirinha, "Nonreciprocal and non-Hermitian material response inspired by semiconductor transistors," *Phys. Rev. Lett.*, vol. 128, no. 1, p. 13902, 2022.

[115] E. Li, B. J. Eggleton, K. Fang, and S. Fan, "Photonic Aharonov–Bohm effect in photon–phonon interactions," *Nat. Commun.*, vol. 5, no. 1, p. 3225, 2014.

[116] K. Fang, Z. Yu, and S. Fan, "Experimental demonstration of a photonic Aharonov-Bohm effect at radio frequencies," *Phys. Rev. B—Condensed Matter Mater. Phys.*, vol. 87, no. 6, p. 60301, 2013.

[117] Y. Yanase, "Magneto-electric effect in three-dimensional coupled zigzag chains," *J. Phys. Soc. Japan*, vol. 83, no. 1, p. 14703, 2014.

[118] J. Tauc, "Optical properties and electronic structure of amorphous Ge and Si," *Mater. Res. Bull.*, vol. 3, no. 1, pp. 37–46, 1968.

[119] J. Tauc, R. Grigorovici, and A. Vancu, "Optical properties and electronic structure of amorphous germanium," *Phys. status solidi*, vol. 15, no. 2, pp. 627–637, 1966.

[120] F. Urbach, "The long-wavelength edge of photographic sensitivity and of the electronic absorption of solids," *Phys. Rev.*, vol. 92, no. 5, p. 1324, 1953.

[121] E. Burstein, "Anomalous optical absorption limit in InSb," *Phys. Rev.*, vol. 93, no. 3, p. 632, 1954.

[122] T S Moss, "The Interpretation of the Properties of Indium Antimonide," *Proc. Phys. Soc. Sect. B*, vol. 67, no. 10, p. 775, 1954, doi: 10.1088/0370-1301/67/10/306.

[123] S. R. Morrison and S. R. Morrison, *Electrochemistry at semiconductor and oxidized metal electrodes*, vol. 126. Springer, 1980.

[124] U. Sharma, U. K. Kailash Veerappan, P. K. Jha, P. A. Jha, and P. Singh, "Bandgap and electrochemical engineering for disordered LaFeO3," *J. Appl. Phys.*, vol. 131, no. 2, 2022.

[125] M. Kumar, P. A. Jha, P. K. Jha, and P. Singh, *Hysteric photo-conduction and negative differential resistance in cesium lead bromide*, (2020). doi: 10.1063/5.0012202.

[126] N. F. Mott and R. W. Gurney, "Electronic processes in ionic crystals," *(No Title)*, 1940.

[127] K. C. Kao, *Dielectric phenomena in solids*. Elsevier, 2004.

[128] M. A. Lampert, "Simplified theory of space-charge-limited currents in an insulator with

traps," *Phys. Rev.*, vol. 103, no. 6, p. 1648, 1956.

[129] H. Nassar *et al.*, "Nonreciprocity in acoustic and elastic materials," *Nat. Rev. Mater.*, vol. 5, no. 9, pp. 667–685, 2020.

[130] Ş. K. Özdemir, S. Rotter, F. Nori, and L. Yang, "Parity–time symmetry and exceptional points in photonics," *Nat. Mater.*, vol. 18, no. 8, pp. 783–798, 2019.

[131] C. Caloz, A. Alu, S. Tretyakov, D. Sounas, K. Achouri, and Z.-L. Deck-Léger, "Electromagnetic nonreciprocity," *Phys. Rev. Appl.*, vol. 10, no. 4, p. 47001, 2018.

[132] S. U. M. Khan, M. Al-Shahry, and W. B. Ingler Jr, "Efficient photochemical water splitting by a chemically modified n-TiO2," *Science (80-.).*, vol. 297, no. 5590, pp. 2243–2245, 2002.

[133] J. Feng *et al.*, "Non-oxide semiconductors for artificial photosynthesis: progress on photoelectrochemical water splitting and carbon dioxide reduction," *Nano Today*, vol. 30, p. 100830, 2020.

[134] L. Pan *et al.*, "Cu2O photocathodes with band-tail states assisted hole transport for standalone solar water splitting," *Nat. Commun.*, vol. 11, no. 1, p. 318, 2020.

[135] Y. Wang *et al.*, "Current understanding and challenges of solar-driven hydrogen generation using polymeric photocatalysts," *Nat. Energy*, vol. 4, no. 9, pp. 746–760, 2019.

[136] L. Li *et al.*, "Visible light driven hydrogen production from a photo-active cathode based on a molecular catalyst and organic dye-sensitized p-type nanostructured NiO," *Chem. Commun.*, vol. 48, no. 7, pp. 988–990, 2012.

[137] E. Amouyal, "Photochemical production of hydrogen and oxygen from water: A review and state of the art," *Sol. Energy Mater. Sol. Cells*, vol. 38, no. 1–4, pp. 249–276, 1995.

[138] J. A. Seabold and K.-S. Choi, "Efficient and stable photo-oxidation of water by a bismuth vanadate photoanode coupled with an iron oxyhydroxide oxygen evolution catalyst," *J. Am. Chem. Soc.*, vol. 134, no. 4, pp. 2186–2192, 2012.

[139] J. A. Seabold and K.-S. Choi, "Effect of a cobalt-based oxygen evolution catalyst on the stability and the selectivity of photo-oxidation reactions of a WO3 photoanode," *Chem. Mater.*, vol. 23, no. 5, pp. 1105–1112, 2011.

[140] J. Jia *et al.*, "Solar water splitting by photovoltaic-electrolysis with a solar-to-hydrogen efficiency over 30%," *Nat. Commun.*, vol. 7, no. 1, p. 13237, 2016.

[141] S. Wang, G. Liu, and L. Wang, "Crystal facet engineering of photoelectrodes for photoelectrochemical water splitting," *Chem. Rev.*, vol. 119, no. 8, pp. 5192–5247, 2019.

[142] J. Zhang *et al.*, "Boosting photocatalytic water splitting by tuning built-in electric field at phase junction," *J. Mater. Chem. A*, vol. 7, no. 17, pp. 10264–10272, 2019.

[143] J. Joy, J. Mathew, and S. C. George, “Nanomaterials for photoelectrochemical water splitting–review,” *Int. J. Hydrogen Energy*, vol. 43, no. 10, pp. 4804–4817, 2018.

[144] A. G. Tamirat, J. Rick, A. A. Dubale, W.-N. Su, and B.-J. Hwang, “Using hematite for photoelectrochemical water splitting: a review of current progress and challenges,” *Nanoscale horizons*, vol. 1, no. 4, pp. 243–267, 2016.

[145] Y. Tachibana, L. Vayssieres, and J. R. Durrant, “Artificial photosynthesis for solar water-splitting,” *Nat. Photonics*, vol. 6, no. 8, pp. 511–518, 2012.

[146] C. Jiang, S. J. A. Moniz, A. Wang, T. Zhang, and J. Tang, “Photoelectrochemical devices for solar water splitting–materials and challenges,” *Chem. Soc. Rev.*, vol. 46, no. 15, pp. 4645–4660, 2017.

[147] S. Chen, T. Takata, and K. Domen, “Particulate photocatalysts for overall water splitting,” *Nat. Rev. Mater.*, vol. 2, no. 10, pp. 1–17, 2017.

[148] C. S. Tan *et al.*, “> 10% solar-to-hydrogen efficiency unassisted water splitting on ALD-protected silicon heterojunction solar cells,” *Sustain. Energy Fuels*, vol. 3, no. 6, pp. 1490–1500, 2019.

[149] Z. Wang, R. R. Roberts, G. F. Naterer, and K. S. Gabriel, “Comparison of thermochemical, electrolytic, photoelectrolytic and photochemical solar-to-hydrogen production technologies,” *Int. J. Hydrogen Energy*, vol. 37, no. 21, pp. 16287–16301, 2012.

[150] D. Kang *et al.*, “Printed assemblies of GaAs photoelectrodes with decoupled optical and reactive interfaces for unassisted solar water splitting,” *Nat. Energy*, vol. 2, no. 5, pp. 1–5, 2017.

[151] E. Khorashadizade *et al.*, “Alkali metal cation incorporation in conductive TiO2 nanoflakes with improved photoelectrochemical H2 generation,” *ChemElectroChem*, vol. 7, no. 7, pp. 1699–1706, 2020.

[152] B. Bazri, E. Kowsari, N. Seifvand, and N. Naseri, “RGO-α-Fe2O3/β-FeOOH ternary heterostructure with urchin-like morphology for efficient oxygen evolution reaction,” *J. Electroanal. Chem.*, vol. 843, pp. 1–11, 2019.

[153] S. Wang, P. Chen, Y. Bai, J. Yun, G. Liu, and L. Wang, “New BiVO4 dual photoanodes with enriched oxygen vacancies for efficient solar-driven water splitting,” *Adv. Mater.*, vol. 30, no. 20, p. 1800486, 2018.

[154] N. P. Dharmarajan *et al.*, “Bio-inspired supramolecular self-assembled carbon nitride nanostructures for photocatalytic water splitting,” *Adv. Mater.*, vol. 36, no. 2, p. 2306895, 2024.

[155] P. Kumar *et al.*, “Multifunctional carbon nitride nanoarchitectures for catalysis,” *Chem. Soc. Rev.*, vol. 52, no. 21, pp. 7602–7664, 2023.

[156] S. Masudy-Panah, R. Siavash Moakhar, C. S. Chua, A. Kushwaha, and G. K. Dalapati,

"Stable and efficient CuO based photocathode through oxygen-rich composition and Au–Pd nanostructure incorporation for solar-hydrogen production," *ACS Appl. Mater. Interfaces*, vol. 9, no. 33, pp. 27596–27606, 2017.

[157] C. Cheng, K. R. Gustavsen, and K. Wang, "Plasmon-induced visible light absorption arising from edge-interfaces of titanium-oxides nanocomposites," *Opt. Mater. (Amst).*, vol. 113, p. 110847, 2021.

[158] J. E. Saal, S. Kirklin, M. Aykol, B. Meredig, and C. Wolverton, "Materials design and discovery with high-throughput density functional theory: the open quantum materials database (OQMD)," *Jom*, vol. 65, pp. 1501–1509, 2013.

[159] S. Kirklin *et al.*, "The Open Quantum Materials Database (OQMD): assessing the accuracy of DFT formation energies," *npj Comput. Mater.*, vol. 1, no. 1, pp. 1–15, 2015.

[160] J. Pike, S.-W. Chan, F. Zhang, X. Wang, and J. Hanson, "Formation of stable Cu2O from reduction of CuO nanoparticles," *Appl. Catal. A Gen.*, vol. 303, no. 2, pp. 273–277, 2006.

[161] B. Maack and N. Nilius, "Morphological and kinetic insights into Cu2O–CuO oxidation," *Phys. status solidi*, vol. 257, no. 1, p. 1900365, 2020.

[162] F. Wu, S. Banerjee, H. Li, Y. Myung, and P. Banerjee, "Indirect phase transformation of CuO to Cu2O on a nanowire surface," *Langmuir*, vol. 32, no. 18, pp. 4485–4493, 2016.

[163] S. Wu, Y. Chen, and S. Gao, "Plasmonic photocatalysis with nonthermalized hot carriers," *Phys. Rev. Lett.*, vol. 129, no. 8, p. 86801, 2022.

[164] S. A. Lee and S. Link, "Chemical interface damping of surface plasmon resonances," *Acc. Chem. Res.*, vol. 54, no. 8, pp. 1950–1960, 2021.

[165] P. K. Jain, "Taking the heat off of plasmonic chemistry," 2019, *ACS Publications*.

[166] J. Li, Z. Lou, and B. Li, "Engineering plasmonic semiconductors for enhanced photocatalysis," *J. Mater. Chem. A*, vol. 9, no. 35, pp. 18818–18835, 2021.

[167] E. Kazuma and Y. Kim, "Mechanistic studies of plasmon chemistry on metal catalysts," *Angew. Chemie Int. Ed.*, vol. 58, no. 15, pp. 4800–4808, 2019.

[168] C. Zhang, F. Jia, Z. Li, X. Huang, and G. Lu, "Plasmon-generated hot holes for chemical reactions," *Nano Res.*, vol. 13, pp. 3183–3197, 2020.

[169] J. Theerthagiri *et al.*, "Fundamentals and comprehensive insights on pulsed laser synthesis of advanced materials for diverse photo-and electrocatalytic applications," *Light Sci. Appl.*, vol. 11, no. 1, p. 250, 2022.

[170] T. Ito, H. Yamaguchi, T. Masumi, and S. Adachi, "Optical properties of CuO studied by spectroscopic ellipsometry," *J. Phys. Soc. Japan*, vol. 67, no. 9, pp. 3304–3309, 1998.

[171] Y. K. Saurabh, P. A. Jha, P. K. Dubey, P. K. Jha, and P. Singh, “Bandgap engineering in TiO2/rGO 1D photonic metasurfaces as broadband solar absorber,” *J. Appl. Phys.*, vol. 131, no. 2, 2022.

[172] P. Giannozzi *et al.*, “QUANTUM ESPRESSO: a modular and open-source software project for quantum simulations of materials,” *J. Phys. Condens. matter*, vol. 21, no. 39, p. 395502, 2009.

[173] P. Giannozzi *et al.*, “Advanced capabilities for materials modelling with Quantum ESPRESSO,” *J. Phys. Condens. matter*, vol. 29, no. 46, p. 465901, 2017.

[174] P. Giannozzi *et al.*, “Quantum ESPRESSO toward the exascale,” *J. Chem. Phys.*, vol. 152, no. 15, 2020.

[175] S. L. Dudarev, G. A. Botton, S. Y. Savrasov, C. J. Humphreys, and A. P. Sutton, “Electron-energy-loss spectra and the structural stability of nickel oxide: An LSDA+ U study,” *Phys. Rev. B*, vol. 57, no. 3, p. 1505, 1998.

[176] P. R. West, S. Ishii, G. V Naik, N. K. Emani, V. M. Shalaev, and A. Boltasseva, “Searching for better plasmonic materials,” *Laser Photon. Rev.*, vol. 4, no. 6, pp. 795–808, 2010.

[177] J. Hao, L. Zhou, and M. Qiu, “Nearly total absorption of light and heat generation by plasmonic metamaterials,” *Phys. Rev. B—Condensed Matter Mater. Phys.*, vol. 83, no. 16, p. 165107, 2011.

[178] D. Ziemkiewicz and S. Zielińska-Raczyńska, “Copper plasmonics with excitons,” *Phys. Rev. B*, vol. 106, no. 20, p. 205404, 2022.

[179] A. Živković, A. Roldan, and N. H. De Leeuw, “Density functional theory study explaining the underperformance of copper oxides as photovoltaic absorbers,” *Phys. Rev. B*, vol. 99, no. 3, p. 35154, 2019.

[180] A. S. Zoolfakar, R. A. Rani, A. J. Morfa, A. P. O’Mullane, and K. Kalantar-Zadeh, “Nanostructured copper oxide semiconductors: a perspective on materials, synthesis methods and applications,” *J. Mater. Chem. c*, vol. 2, no. 27, pp. 5247–5270, 2014.

[181] Y. Deng, A. D. Handoko, Y. Du, S. Xi, and B. S. Yeo, “In situ Raman spectroscopy of copper and copper oxide surfaces during electrochemical oxygen evolution reaction: identification of CuIII oxides as catalytically active species,” *Acs Catal.*, vol. 6, no. 4, pp. 2473–2481, 2016.

[182] D. M. R. De Rooij, “Electrochemical methods: fundamentals and applications,” *Anti-Corrosion Methods Mater.*, vol. 50, no. 5, 2003.

[183] D. Shoup and A. Szabo, “Chronoamperometric current at finite disk electrodes,” *J. Electroanal. Chem. Interfacial Electrochem.*, vol. 140, no. 2, pp. 237–245, 1982.

[184] P. S. Joshi and D. S. Sutrave, “A brief study of cyclic voltammetry and electrochemical analysis,” *Int. J. ChemTech Res.*, vol. 11, no. 9, p. 77, 2018.

[185] A. M. Appel and M. L. Helm, "Determining the overpotential for a molecular electrocatalyst," 2014, *ACS Publications*.

[186] M. Xue, Y. Wei, and G. Liu, "Facile hydrothermal preparation of edge-oriented Cu2MoS4 as an efficient electrocatalyst for hydrogen evolution reaction," *Mater. Lett.*, vol. 256, p. 126663, 2019.

[187] S. Zheng, Y. Fu, L. Zheng, Z. Zhu, G. Yu, and D. Yang, "Polypyrrole encapsulating TiB2 as newly-emerged electrocatalyst for highly boosted hydrogen evolution reaction," *Ceram. Int.*, vol. 45, no. 17, pp. 23298–23303, 2019.

[188] G. Kaur, G. R. Chaudhary, and U. Batra, "Investigating affordable cobalt based metallosurfactant as an efficient electrocatalyst for hydrogen evolution reaction," *J. Colloid Interface Sci.*, vol. 562, pp. 598–607, 2020.

[189] D. Zhang, R. Ding, Y. Tang, L. Ma, and Y. He, "Stable Co/N-doped carbon nanotubes as catalysts for oxygen reduction," *ACS Appl. Nano Mater.*, vol. 5, no. 7, pp. 10026–10035, 2022.

[190] K. Qu, Y. Zheng, Y. Jiao, X. Zhang, S. Dai, and S. Qiao, "Polydopamine-inspired, dual heteroatom-doped carbon nanotubes for highly efficient overall water splitting," *Adv. Energy Mater.*, vol. 7, no. 9, p. 1602068, 2017.

[191] T.-W. Lin, C.-J. Liu, and C.-S. Dai, "Ni3S2/carbon nanotube nanocomposite as electrode material for hydrogen evolution reaction in alkaline electrolyte and enzyme-free glucose detection," *Appl. Catal. B Environ.*, vol. 154, pp. 213–220, 2014.

[192] L. Qu, Z. Zhang, H. Zhang, H. Zhang, and S. Dong, "Transformation from graphitic C3N4 to nitrogen-boron-carbon ternary nanosheets as efficient metal-free bifunctional electrocatalyst for oxygen reduction reaction and hydrogen evolution reaction," *Appl. Surf. Sci.*, vol. 448, pp. 618–627, 2018.

[193] J. Ahmed *et al.*, "rGO supported NiWO4 nanocomposites for hydrogen evolution reactions," *Mater. Lett.*, vol. 240, pp. 51–54, 2019.

[194] G. Hu *et al.*, "Enhanced electrocatalytic activity of WO3@ NPRGO composite in a hydrogen evolution reaction," *Appl. Surf. Sci.*, vol. 463, pp. 275–282, 2019.

[195] H. Zheng *et al.*, "Decorating cobalt phosphide and rhodium on reduced graphene oxide for high-efficiency hydrogen evolution reaction," *J. Energy Chem.*, vol. 34, pp. 72–79, 2019.

[196] D. B. Kayan, D. Koçak, and M. İlhan, "Electrocatalytic hydrogen production on GCE/RGO/Au hybrid electrode," *Int. J. Hydrogen Energy*, vol. 43, no. 23, pp. 10562–10568, 2018.

[197] K. S. Bhat, H. C. Barshilia, and H. S. Nagaraja, "Porous nickel telluride nanostructures as bifunctional electrocatalyst towards hydrogen and oxygen evolution reaction," *Int. J. Hydrogen Energy*, vol. 42, no. 39, pp. 24645–24655, 2017.

[198] Y.-S. Li *et al.*, "Three 2D polyhalogenated Co (II)-based MOFs: Syntheses, crystal structure and electrocatalytic hydrogen evolution reaction," *J. Solid State Chem.*, vol. 281, p. 121052, 2020.

[199] H. Nady, M. M. El-Rabiei, G. M. Abd El-Hafez, and A. M. Fekry, "Electrochemical determination of niobium cathode as an efficient electrocatalyst for hydrogen generation in acidic media," *Int. J. Hydrogen Energy*, vol. 46, no. 42, pp. 21785–21795, 2021.

[200] J. O. M. Bockris, I. A. Ammar, and A. Huq, "The mechanism of the hydrogen evolution reaction on platinum, silver and tungsten surfaces in acid solutions," *J. Phys. Chem.*, vol. 61, no. 7, pp. 879–886, 1957.

[201] B. JO'M and S. Srinivasan, "Elucidation of the mechanism of electrolytic hydrogen evolution by the use of HT separation factors," *Electrochim. Acta*, vol. 9, no. 1, pp. 31–44, 1964.

[202] A. J. Appleby, "Oxygen reduction studies at smooth pre-reduced ruthenium and rhodium electrodes in 85% orthophosphoric acid," *J. Electroanal. Chem. Interfacial Electrochem.*, vol. 27, no. 3, pp. 335–345, 1970.

[203] N. Pentland, J. Bockris, and E. Sheldon, "Hydrogen evolution reaction on copper, gold, molybdenum, palladium, rhodium, and iron: mechanism and measurement technique under high purity conditions," *J. Electrochem. Soc.*, vol. 104, no. 3, p. 182, 1957.

[204] J. R. McKone, B. F. Sadtler, C. A. Werlang, N. S. Lewis, and H. B. Gray, "Ni–Mo nanopowders for efficient electrochemical hydrogen evolution," *ACS Catal.*, vol. 3, no. 2, pp. 166–169, 2013.

[205] D. Merki, H. Vrubel, L. Rovelli, S. Fierro, and X. Hu, "Fe, Co, and Ni ions promote the catalytic activity of amorphous molybdenum sulfide films for hydrogen evolution," *Chem. Sci.*, vol. 3, no. 8, pp. 2515–2525, 2012.

[206] S. Cobo *et al.*, "A Janus cobalt-based catalytic material for electro-splitting of water," *Nat. Mater.*, vol. 11, no. 9, pp. 802–807, 2012.

[207] S. L. Wang *et al.*, "Two-dimensional C/TiO2 heterogeneous hybrid for noble-metal-free hydrogen evolution," *ACS Catal.*, vol. 7, no. 10, pp. 6892–6900, 2017.

[208] X. Hao, J. Zhou, Z. Cui, Y. Wang, Y. Wang, and Z. Zou, "Zn-vacancy mediated electron-hole separation in ZnS/g-C3N4 heterojunction for efficient visible-light photocatalytic hydrogen production," *Appl. Catal. B Environ.*, vol. 229, pp. 41–51, 2018.

[209] S. Zhang *et al.*, "MoS2 quantum dot growth induced by S vacancies in a ZnIn2S4 monolayer: atomic-level heterostructure for photocatalytic hydrogen production," *ACS Nano*, vol. 12, no. 1, pp. 751–758, 2018.

[210] W. Yuan *et al.*, "Laminated hybrid junction of sulfur-doped TiO2 and a carbon substrate derived from Ti3C2 MXenes: toward highly visible Light-driven photocatalytic hydrogen evolution," *Adv. Sci.*, vol. 5, no. 6, p. 1700870, 2018.

[211] N. Meng, J. Ren, Y. Liu, Y. Huang, T. Petit, and B. Zhang, "Engineering oxygen-containing and amino groups into two-dimensional atomically-thin porous polymeric carbon nitrogen for enhanced photocatalytic hydrogen production," *Energy Environ. Sci.*, vol. 11, no. 3, pp. 566–571, 2018.

[212] B. Lin *et al.*, "Preparation of 2D/2D g-C3N4 nanosheet@ ZnIn2S4 nanoleaf heterojunctions with well-designed high-speed charge transfer nanochannels towards high-efficiency photocatalytic hydrogen evolution," *Appl. Catal. B Environ.*, vol. 220, pp. 542–552, 2018.

[213] D. Tilgner and R. Kempe, "A Plasmonic Colloidal Photocatalyst Composed of a Metal–Organic Framework Core and a Gold/Anatase Shell for Visible-Light-Driven Wastewater Purification from Antibiotics and Hydrogen Evolution," *Chem. Eur. J.*, vol. 23, no. 13, pp. 3184–3190, 2017.

[214] Z. Guan, Z. Xu, Q. Li, P. Wang, G. Li, and J. Yang, "AgIn5S8 nanoparticles anchored on 2D layered ZnIn2S4 to form 0D/2D heterojunction for enhanced visible-light photocatalytic hydrogen evolution," *Appl. Catal. B Environ.*, vol. 227, pp. 512–518, 2018.

[215] W.-T. Chen, V. Jovic, D. Sun-Waterhouse, H. Idriss, and G. I. N. Waterhouse, "The role of CuO in promoting photocatalytic hydrogen production over TiO2," *Int. J. Hydrogen Energy*, vol. 38, no. 35, pp. 15036–15048, 2013.

[216] H. Song, S. Luo, H. Huang, B. Deng, and J. Ye, "Solar-driven hydrogen production: recent advances, challenges, and future perspectives," *ACS Energy Lett.*, vol. 7, no. 3, pp. 1043–1065, 2022.

[217] S. Trasatti, "Work function, electronegativity, and electrochemical behaviour of metals: II. Potentials of zero charge and 'electrochemical' work functions," *J. Electroanal. Chem. Interfacial Electrochem.*, vol. 33, no. 2, pp. 351–378, 1971.

[218] A. Pecherskaya and V. Stender, "Potentials of the evolution of hydrogen in acid solutions," *Zh. Fiz. Khim*, vol. 24, pp. 856–859, 1950.

[219] E. Demir, S. Akbayrak, A. M. Önal, and S. Özkar, "Nanoceria-supported ruthenium (0) nanoparticles: highly active and stable catalysts for hydrogen evolution from water," *ACS Appl. Mater. Interfaces*, vol. 10, no. 7, pp. 6299–6308, 2018.

[220] T. Biegler and R. Parsons, "Anomalous faradaic impedance of the nickelocene-nickelocinium system in acetonitrile," *J. Electroanal. Chem. Interfacial Electrochem.*, vol. 27, no. 2, pp. 314–319, 1970.

[221] S. Trasatti, "Work function, electronegativity, and electrochemical behaviour of metals: III. Electrolytic hydrogen evolution in acid solutions," *J. Electroanal. Chem. Interfacial Electrochem.*, vol. 39, no. 1, pp. 163–184, 1972.

[222] A. T. Petrenko, "EFFECT OF SURFACE ACTIVE SUBSTANCES ON THE HYDROGEN OVERVOLTAGE ON TITANIUM," 1962, *MEZHDUNARODNAYA*

KNIGA 39 DIMITROVA UL., 113095 MOSCOW, RUSSIA.

[223] V. I. Bystrov and L. I. KRISHMALIK, “KINETICS OF HYDROGEN EVOLUTION ON SILVER IN PHOSPHATE BUFFER SOLUTIONS,” *Elektrokhimiya*, vol. 3, no. 12, pp. 1499–1501, 1967.

[224] Y. Li *et al.*, “Cobalt phosphate-modified barium-doped tantalum nitride nanorod photoanode with 1.5% solar energy conversion efficiency,” *Nat. Commun.*, vol. 4, no. 1, p. 2566, 2013.

[225] W. Luo *et al.*, “Solar hydrogen generation from seawater with a modified BiVO4 photoanode,” *Energy Environ. Sci.*, vol. 4, no. 10, pp. 4046–4051, 2011.

[226] C.-F. Chi, Y.-L. Lee, and H.-S. Weng, “A CdS-modified TiO2 nanocrystalline photoanode for efficient hydrogen generation by visible light,” *Nanotechnology*, vol. 19, no. 12, p. 125704, 2008.

[227] Y. Pihosh *et al.*, “Photocatalytic generation of hydrogen by core-shell WO3/BiVO4 nanorods with ultimate water splitting efficiency,” *Sci. Rep.*, vol. 5, no. 1, p. 11141, 2015.

[228] J. Zhao *et al.*, “Enhancement of solar hydrogen evolution from water by surface modification with CdS and TiO2 on porous CuInS2 photocathodes prepared by an electrodeposition–sulfurization method,” *Angew. Chemie Int. Ed.*, vol. 53, no. 44, pp. 11808–11812, 2014.

[229] Y.-H. Chiu, T.-H. Lai, M.-Y. Kuo, P.-Y. Hsieh, and Y.-J. Hsu, “Photoelectrochemical cells for solar hydrogen production: Challenges and opportunities,” *APL Mater.*, vol. 7, no. 8, 2019.

[230] M. Z. Iqbal and S. Siddique, “Recent progress in efficiency of hydrogen evolution process based photoelectrochemical cell,” *Int. J. Hydrogen Energy*, vol. 43, no. 46, pp. 21502–21523, 2018.

[231] K. Kalyanasundaram, “Photoelectrochemical cell studies with semiconductor electrodes—A classified bibliography (1975–1983),” *Sol. Cells*, vol. 15, no. 2, pp. 93–156, 1985.

[232] A. Khlyustova, N. Sirotkin, T. Kusova, A. Kraev, V. Titov, and A. Agafonov, “Doped TiO 2: the effect of doping elements on photocatalytic activity,” *Mater. Adv.*, vol. 1, no. 5, pp. 1193–1201, 2020.

[233] A. M. Ibrahim, M. S. Abdel-wahab, M. A. K. Elfayoumi, and W. Z. Tawfik, “Highly efficient sputtered Ni-doped Cu2O photoelectrodes for solar hydrogen generation from water-splitting,” *Int. J. Hydrogen Energy*, vol. 48, no. 5, pp. 1863–1876, 2023.

[234] X. Chen, S. Shen, L. Guo, and S. S. Mao, “Semiconductor-based photocatalytic hydrogen generation,” *Chem. Rev.*, vol. 110, no. 11, pp. 6503–6570, 2010.

[235] M. F. R. Samsudin, R. Bashiri, N. M. Mohamed, Y. H. Ng, and S. Sufian, “Tailoring

the morphological structure of BiVO4 photocatalyst for enhanced photoelectrochemical solar hydrogen production from natural lake water," *Appl. Surf. Sci.*, vol. 504, p. 144417, 2020.

[236] G. Kaur, V. R. Satsangi, S. Dass, and R. Shrivastav, "3D-nano-hetero-structured n/n junction, CuO/Ru–ZnO thin films, for hydrogen generation with enhanced photoelectrochemical performances," *Int. J. Hydrogen Energy*, vol. 45, no. 41, pp. 21051–21067, 2020.

[237] X. Gao, Y. Du, and X. Meng, "Cupric oxide film with a record hole mobility of 48.44 cm2/Vs via direct–current reactive magnetron sputtering for perovskite solar cell application," *Sol. Energy*, vol. 191, pp. 205–209, 2019.

[238] P. K. Samal, L. Sharma, and A. Halder, "Enhanced photoelectrochemical hydrogen evolution by 2D nanoleaf structured CuO," *J. Appl. Phys.*, vol. 127, no. 19, 2020.

[239] H. Zhang *et al.*, "Dynamic traction of lattice-confined platinum atoms into mesoporous carbon matrix for hydrogen evolution reaction," *Sci. Adv.*, vol. 4, no. 1, p. eaao6657, 2018.

[240] K. Jiang *et al.*, "Single platinum atoms embedded in nanoporous cobalt selenide as electrocatalyst for accelerating hydrogen evolution reaction," *Nat. Commun.*, vol. 10, no. 1, p. 1743, 2019.

[241] S. Deng *et al.*, "Directional construction of vertical nitrogen-doped 1T-2H MoSe2/graphene shell/core nanoflake arrays for efficient hydrogen evolution reaction," *Adv. Mater.*, vol. 29, no. 21, p. 1700748, 2017.

[242] D. Kong, H. Wang, Z. Lu, and Y. Cui, "CoSe2 nanoparticles grown on carbon fiber paper: an efficient and stable electrocatalyst for hydrogen evolution reaction," *J. Am. Chem. Soc.*, vol. 136, no. 13, pp. 4897–4900, 2014.

[243] J. Xie *et al.*, "Atomically-thin molybdenum nitride nanosheets with exposed active surface sites for efficient hydrogen evolution," *Chem. Sci.*, vol. 5, no. 12, pp. 4615–4620, 2014.

[244] D. Gao *et al.*, "Metallic Ni 3 N nanosheets with exposed active surface sites for efficient hydrogen evolution," *J. Mater. Chem. A*, vol. 4, no. 44, pp. 17363–17369, 2016.

[245] M. A. Lukowski, A. S. Daniel, F. Meng, A. Forticaux, L. Li, and S. Jin, "Enhanced hydrogen evolution catalysis from chemically exfoliated metallic MoS2 nanosheets," *J. Am. Chem. Soc.*, vol. 135, no. 28, pp. 10274–10277, 2013.

[246] A. Boudjemaa, S. Boumaza, M. Trari, R. Bouarab, and A. Bouguelia, "Physical and photo-electrochemical characterizations of α-Fe2O3. Application for hydrogen production," *Int. J. Hydrogen Energy*, vol. 34, no. 10, pp. 4268–4274, 2009.

[247] D. Voiry *et al.*, "Enhanced catalytic activity in strained chemically exfoliated WS2 nanosheets for hydrogen evolution," *Nat. Mater.*, vol. 12, no. 9, pp. 850–855, 2013.

[248] B. Hinnemann *et al.*, "Biomimetic hydrogen evolution: MoS2 nanoparticles as catalyst for hydrogen evolution," *J. Am. Chem. Soc.*, vol. 127, no. 15, pp. 5308–5309, 2005.

[249] D. R. Cummins *et al.*, "Efficient hydrogen evolution in transition metal dichalcogenides via a simple one-step hydrazine reaction," *Nat. Commun.*, vol. 7, no. 1, p. 11857, 2016.

[250] S. Wang *et al.*, "Molybdenum-carbide-modified nitrogen-doped carbon vesicle encapsulating nickel nanoparticles: a highly efficient, low-cost catalyst for hydrogen evolution reaction," *J. Am. Chem. Soc.*, vol. 137, no. 50, pp. 15753–15759, 2015.

[251] L. Liao *et al.*, "A nanoporous molybdenum carbide nanowire as an electrocatalyst for hydrogen evolution reaction," *Energy Environ. Sci.*, vol. 7, no. 1, pp. 387–392, 2014.

[252] X. Yan, L. Tian, M. He, and X. Chen, "Three-dimensional crystalline/amorphous Co/Co3O4 core/shell nanosheets as efficient electrocatalysts for the hydrogen evolution reaction," *Nano Lett.*, vol. 15, no. 9, pp. 6015–6021, 2015.

[253] M. Zhang *et al.*, "Enhanced light harvesting and electron-hole separation for efficient photocatalytic hydrogen evolution over Cu7S4-enwrapped Cu2O nanocubes," *Appl. Catal. B Environ.*, vol. 246, pp. 202–210, 2019.

[254] M. Nazim, A. A. P. Khan, A. M. Asiri, and J. H. Kim, "Exploring rapid photocatalytic degradation of organic pollutants with porous CuO nanosheets: synthesis, dye removal, and kinetic studies at room temperature," *ACS omega*, vol. 6, no. 4, pp. 2601–2612, 2021.

[255] A. Cots, P. Bonete, and R. Gómez, "Improving the stability and efficiency of CuO photocathodes for solar hydrogen production through modification with iron," *ACS Appl. Mater. Interfaces*, vol. 10, no. 31, pp. 26348–26356, 2018.

[256] S. Masudy-Panah, R. Katal, N. D. Khiavi, E. Shekarian, J. Hu, and X. Gong, "A high-performance cupric oxide photocatalyst with palladium light trapping nanostructures and a hole transporting layer for photoelectrochemical hydrogen evolution," *J. Mater. Chem. A*, vol. 7, no. 39, pp. 22332–22345, 2019.

[257] A. E. Nogueira, J. A. Oliveira, G. T. S. T. da Silva, and C. Ribeiro, "Insights into the role of CuO in the CO2 photoreduction process," *Sci. Rep.*, vol. 9, no. 1, p. 1316, 2019.

[258] Y. Zhang *et al.*, "Effect of CuO–ZnO catalyst layer on proton-conducting electrochemical cell reactor for CO2 reduction reaction," *Int. J. Hydrogen Energy*, vol. 49, pp. 766–779, 2024.

[259] Y. Yang, D. Xu, Q. Wu, and P. Diao, "Cu2O/CuO bilayered composite as a high-efficiency photocathode for photoelectrochemical hydrogen evolution reaction," *Sci. Rep.*, vol. 6, no. 1, p. 35158, 2016.

[260] L. Sun *et al.*, "Nitrogen-doped carbon-coated CuO-In2O3 p–n heterojunction for remarkable photocatalytic hydrogen evolution," *Adv. Energy Mater.*, vol. 9, no. 48, p. 1902839, 2019.

[261] K. T. Fountaine, H. J. Lewerenz, and H. A. Atwater, “Efficiency limits for photoelectrochemical water-splitting,” *Nat. Commun.*, vol. 7, no. 1, p. 13706, 2016.

[262] M. A. Dar, Y. S. Kim, W. B. Kim, J. M. Sohn, and H. S. Shin, “Structural and magnetic properties of CuO nanoneedles synthesized by hydrothermal method,” *Appl. Surf. Sci.*, vol. 254, no. 22, pp. 7477–7481, 2008.

[263] U. Holzwarth and N. Gibson, “The Scherrer equation versus the’Debye-Scherrer equation’,” *Nat. Nanotechnol.*, vol. 6, no. 9, p. 534, 2011.

[264] N. Topnani, S. Kushwaha, and T. Athar, “Wet synthesis of copper oxide nanopowder,” *Int. J. green Nanotechnol. Mater. Sci. Eng.*, vol. 1, no. 2, pp. M67–M73, 2010.

[265] B. Djamila, L. S. Eddine, B. Abderrhmane, A. Nassiba, and A. Barhoum, “In vitro antioxidant activities of copper mixed oxide (CuO/Cu2O) nanoparticles produced from the leaves of Phoenix dactylifera L,” *Biomass Convers. Biorefinery*, vol. 14, no. 5, pp. 6567–6580, 2024.

[266] Y. Sun, S. Gao, F. Lei, and Y. Xie, “Atomically-thin two-dimensional sheets for understanding active sites in catalysis,” *Chem. Soc. Rev.*, vol. 44, no. 3, pp. 623–636, 2015.

[267] J. Xie *et al.*, “Controllable disorder engineering in oxygen-incorporated MoS2 ultrathin nanosheets for efficient hydrogen evolution,” *J. Am. Chem. Soc.*, vol. 135, no. 47, pp. 17881–17888, 2013.

[268] J. Zhang, J. Wang, Y. Fu, B. Zhang, and Z. Xie, “Sonochemistry-synthesized CuO nanoparticles as an anode interfacial material for efficient and stable polymer solar cells,” *Rsc Adv.*, vol. 5, no. 36, pp. 28786–28793, 2015.

[269] Ç. Oruç and A. Altındal, “Structural and dielectric properties of CuO nanoparticles,” *Ceram. Int.*, vol. 43, no. 14, pp. 10708–10714, 2017.

[270] M. E. Güldüren, D. İskenderoğlu, H. Güney, S. M. Karadeniz, M. Acar, and E. Gür, “Structural, optical, and H2 gas sensing analyses of Cr doped CuO thin films grown by ultrasonic spray pyrolysis,” *Int. J. Hydrogen Energy*, vol. 48, no. 54, pp. 20804–20814, 2023.

[271] S. K. Shinde, D. P. Dubal, G. S. Ghodake, and V. J. Fulari, “Hierarchical 3D-flower-like CuO nanostructure on copper foil for supercapacitors,” *RSC Adv.*, vol. 5, no. 6, pp. 4443–4447, 2015.

[272] M. Vaseem, A.-R. Hong, R.-T. Kim, and Y.-B. Hahn, “Copper oxide quantum dot ink for inkjet-driven digitally controlled high mobility field effect transistors,” *J. Mater. Chem. C*, vol. 1, no. 11, pp. 2112–2120, 2013.

[273] H. Xing, E. Lei, Z. Guo, D. Zhao, X. Li, and Z. Liu, “Exposing the photocorrosion mechanism and control strategies of a CuO photocathode,” *Inorg. Chem. Front.*, vol. 6, no. 9, pp. 2488–2499, 2019.

[274] D. Devadoss, A. Asirvatham, A. Kujur, G. Saaron, N. Devi, and S. J. Mary, "Green synthesis of copper oxide nanoparticles from Murraya koenigii and its corrosion resistivity on Ti-6Al-4V dental alloy," *J. Mech. Behav. Biomed. Mater.*, vol. 146, p. 106080, 2023.

[275] U. Sharma, V. Pawar, and P. Singh, "Charge particle dynamics and electrochemical behaviour of SrTiO3-δ as anode material for IT-SOFC applications," *Int. J. Hydrogen Energy*, vol. 52, pp. 1278–1289, 2024.

[276] S. Tajik *et al.*, "Nanostructured mixed transition metal oxides for high performance asymmetric supercapacitors: facile synthetic strategy," *Int. J. Hydrogen Energy*, vol. 42, no. 17, pp. 12384–12395, 2017.

[277] Y. Xie and H. Du, "Electrochemical capacitance of a carbon quantum dots–polypyrrole/titania nanotube hybrid," *Rsc Adv.*, vol. 5, no. 109, pp. 89689–89697, 2015.

[278] S. K. Shinde *et al.*, "Using chemical bath deposition to create nanosheet-like CuO electrodes for supercapacitor applications," *Colloids Surfaces B Biointerfaces*, vol. 181, pp. 1004–1011, 2019.

[279] J. S. Shaikh, R. C. Pawar, N. L. Tarwal, D. S. Patil, and P. S. Patil, "Supercapacitor behavior of CuO–PAA hybrid films: Effect of PAA concentration," *J. Alloys Compd.*, vol. 509, no. 25, pp. 7168–7174, 2011.

[280] S. Bilgin, Ü. Alver, F. Erdemir, and A. Çanakçı, "Effect of fuel type on pseudocapacitance behaviour of CuO nanoparticles synthesized by solution combustion method," *Bull. Mater. Sci.*, vol. 45, no. 4, p. 240, 2022.

[281] D. C. Iwueke *et al.*, "A novel chemical preparation of Ni (OH) 2/CuO nanocomposite thin films for supercapacitive applications," *J. Mater. Sci. Mater. Electron.*, vol. 26, pp. 2236–2242, 2015.

[282] V. D. Patake, S. S. Joshi, C. D. Lokhande, and O.-S. Joo, "Electrodeposited porous and amorphous copper oxide film for application in supercapacitor," *Mater. Chem. Phys.*, vol. 114, no. 1, pp. 6–9, 2009.

[283] Z. Endut, M. Hamdi, and W. J. Basirun, "Pseudocapacitive performance of vertical copper oxide nanoflakes," *Thin Solid Films*, vol. 528, pp. 213–216, 2013.

[284] X. Guo *et al.*, "CuO/Pd composite photocathodes for photoelectrochemical hydrogen evolution reaction," *Int. J. Hydrogen Energy*, vol. 39, no. 15, pp. 7686–7696, 2014.

[285] F. M. Meresht, E. S. Iranizad, A. Bayat, and M. N. Liavali, "Synthesis of binder-free fluffy anemone-like MoS2 for electrocatalytic hydrogen evolution: A Mott-schottky study," *Int. J. Hydrogen Energy*, vol. 45, no. 53, pp. 28696–28705, 2020.

[286] A. J. Bard, L. R. Faulkner, and H. S. White, *Electrochemical methods: fundamentals and applications*. John Wiley & Sons, 2022.

[287] M. Patel, H.-S. Kim, D. B. Patel, and J. Kim, "CuO photocathode-embedded

semitransparent photoelectrochemical cell," *J. Mater. Res.*, vol. 31, no. 20, pp. 3205–3213, 2016.

[288] E. L. Tsege *et al.*, "Scalable and inexpensive strategy to fabricate CuO/ZnO nanowire heterojunction for efficient photoinduced water splitting," *J. Mater. Sci.*, vol. 53, no. 4, pp. 2725–2734, 2018.

[289] C.-J. Chen *et al.*, "Molybdenum tungsten disulfide with a large number of sulfur vacancies and electronic unoccupied states on silicon micropillars for solar hydrogen evolution," *ACS Appl. Mater. Interfaces*, vol. 12, no. 49, pp. 54671–54682, 2020.

[290] S. Masudy-Panah *et al.*, "Nanocrystal engineering of sputter-grown CuO photocathode for visible-light-driven electrochemical water splitting," *ACS Appl. Mater. Interfaces*, vol. 8, no. 2, pp. 1206–1213, 2016.

[291] S. R. Qutb, W. Z. Tawfik, S. I. El-Dek, M. R. Hussein, and M. S. Abdel-wahab, "Superior photoelectrodes of nanostructured Mo-doped CuO thin film for green hydrogen generation from photoelectrochemical water-splitting," *Int. J. Hydrogen Energy*, vol. 76, pp. 190–201, 2024.

[292] C.-Y. Chiang, M.-H. Chang, H.-S. Liu, C. Y. Tai, and S. Ehrman, "Process intensification in the production of photocatalysts for solar hydrogen generation," *Ind. Eng. Chem. Res.*, vol. 51, no. 14, pp. 5207–5215, 2012.

[293] A. S. Bangwal *et al.*, "Compositional effect on oxygen reduction reaction in Pr excess double perovskite Pr1+ xBa1-xCo2O6-δ cathode materials," *Int. J. Hydrogen Energy*, vol. 45, no. 43, pp. 23378–23390, 2020.

[294] J. Zhu and M. Zäch, "Nanostructured materials for photocatalytic hydrogen production," *Curr. Opin. Colloid Interface Sci.*, vol. 14, no. 4, pp. 260–269, 2009.

[295] T. M. Gür, S. F. Bent, and F. B. Prinz, "Nanostructuring materials for solar-to-hydrogen conversion," *J. Phys. Chem. C*, vol. 118, no. 37, pp. 21301–21315, 2014.

[296] W.-F. Chen *et al.*, "Highly active and durable nanostructured molybdenum carbide electrocatalysts for hydrogen production," *Energy Environ. Sci.*, vol. 6, no. 3, pp. 943–951, 2013.

[297] A. Mehta *et al.*, "Band gap tuning and surface modification of carbon dots for sustainable environmental remediation and photocatalytic hydrogen production–A review," *J. Environ. Manage.*, vol. 250, p. 109486, 2019.

[298] L. Yang *et al.*, "A surface modification resultant thermally oxidized porous g-C3N4 with enhanced photocatalytic hydrogen production," *Appl. Catal. B Environ.*, vol. 204, pp. 335–345, 2017.

[299] L. L. Rusevich *et al.*, "Effects of Al doping on hydrogen production efficiency upon photostimulated water splitting on SrTiO3 nanoparticles," *J. Phys. Chem. C*, vol. 126, no. 50, pp. 21223–21233, 2022.

[300] V. Kumaravel, S. Mathew, J. Bartlett, and S. C. Pillai, “Photocatalytic hydrogen production using metal doped TiO2: A review of recent advances,” *Appl. Catal. B Environ.*, vol. 244, pp. 1021–1064, 2019.

[301] K. Deng *et al.*, “Surface engineering of defective and porous Ir metallene with polyallylamine for hydrogen evolution electrocatalysis,” *Adv. Mater.*, vol. 34, no. 18, p. 2110680, 2022.

[302] X. Chen, Y. Li, and S. Shen, “Surface-and interface-engineered heterostructures for solar hydrogen generation,” *J. Phys. D. Appl. Phys.*, vol. 51, no. 16, p. 163002, 2018.

[303] E. Arulkumar, S. S. Shree, and S. Thanikaikarasan, “Structure, morphology, composition, optical properties of CuO/NiO nanocomposite for electrochemical energy storage devices,” *Results Chem.*, vol. 6, p. 101087, 2023.

[304] K. Sivula, “Mott–Schottky analysis of photoelectrodes: sanity checks are needed,” 2021, *ACS Publications*.

[305] J. Wang, W. Cui, Q. Liu, Z. Xing, A. M. Asiri, and X. Sun, “Recent progress in cobalt-based heterogeneous catalysts for electrochemical water splitting,” *Adv. Mater.*, vol. 28, no. 2, pp. 215–230, 2016.

List of Publications

International Journals:

1. Anisotropic photoconduction in ultrathin CuO: A nonreciprocal system?, **Ashish K. Ranjan**, Priyanka A. Jha, Pardeep K. Jha, and Prabhakar Singh, *Journal of Applied Physics* 132, 195701 (2022)

2. Catalyzing Hydrogen Production: Exploring Plasmonic Effects in Self-Assembled CuO/Cu_2O Thin Films via Pulsed Laser Deposition, **Ashish K. Ranjan**, Pardeep K. Jha, , Priyanka A. Jha and Prabhakar Singh, *Journal of Applied Physics* 135, 184902 (2024)

3. CuO nanoparticles for Enhanced Photoelectrochemical HER activity, **Ashish K. Ranjan**, Prabhakar Singh, *International Journal of Hydrogen energy* (Accepted).

4. Bandgap tuning for transition metal oxides via PEGylation, Priyanka. A. Jha, Jay N. Mishra, Gargi, Harinder K., **Ashish K. Ranjan**, Pardeep K. Jha , Prabhakar Singh, Journal of Physics D: Applied Physics (under review).

5. Effect of bandgap tuning on photoelectrochemical behavior of $Cu_{1-x}Ni_xO$, **Ashish K. Ranjan**, Prabhakar Singh (To be communicated).

Papers Published as Conference Proceedings:

1. Photoconduction in CuO, **Ashish K. Ranjan**, Priyanka A. Jha, Pardeep K. Jha, and Prabhakar Singh, *Materials Today: Proceedings* 28 (2020) 131–133
2. Structural and photo-conduction studies of NiO as a hole transport material for perovskite solar cells, **Ashish K. Ranjan**, Priyanka A. Jha, Pardeep K. Jha, and Prabhakar Singh, *Materials Today: Proceedings* 68 (2022) 2768–2771

National/International (Conference/Workshop/Webinar) Presentations:

1. Participated in the Continuing Education Program (CEP) course on **"Perovskite Solar Cells"** during October 15-16, 2019 at IIT Bombay, INDIA.
2. Participated and presented a poster in the **"3rd International Conference on Solar Energy Photovoltaics"** during December 19-21, 2019 at KIIT Bhubaneswar, INDIA.
3. Participated and presented a poster in the **"International Conference on Advanced Materials and Nanotechnology (AMN-2020)"** during February 20-22, 2019 at JIIT Noida, INDIA.
4. Participated in E-International Symposium on **"Synthesis and Characterization of Smart Materials and Their Potential Applications"** during 14-17 June, 2020 at GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY, NEW DELHI.
5. Attended online workshop on **"Rietveld Refinement"** Method during September 22-24, 2020 organized online by UGC-DAE Consortium for Scientific Research, Mumbai.
6. Participated in webinar on **"Atomistic Modelling and Simulation of Materials"** organized by Dept. of Metallurgical and Materials Engineering on 30-31 May, 2021 at IIT Kharagpur, INDIA .

7. Participated and oral presented in the **"International conference on Energy Materials and Devices (ICEMD-2022)"** during January 11-12, 2022 at MMV BHU, INDIA.

8. Participated and presented a poster in the **"International Union of Materials Research Society-International conference in Asia (IUMRS-ICA 2022)"** during December 19-23, 2022 at IIT Jodhpur, INDIA.

9. Visited IITRAM, Ahmedabad for one month **DFT training**.

10. Participated and oral presented in the **"Materials Grand Meeting (MRM2024/IUMRS-ICA)"** during December 11-16, 2023 organized by Materials Research Society of Japan at Kyoto, JAPAN.

11. Participated and presented a poster in the **"International Conference on Materials – Advance in Materials Innovation (ICM 2024)"** during September 25-27, 2024 at Basel, Switzerland.