

REFERENCES

- Aghaei, M., Fairbrother, A., Gok, A., Ahmad, S., Kazim, S., Lobato, K., Oreski, G., Reinders, A., Schmitz, J., Theelen, M., Yilmaz, P., & Kettle, J. (2022). Review of degradation and failure phenomena in photovoltaic modules. *Renewable and Sustainable Energy Reviews*, 159(January). <https://doi.org/10.1016/j.rser.2022.112160>
- Aguilar, O., de Castro, S., Godoy, M. P. F., & Rebello Sousa Dias, M. (2019). Optoelectronic characterization of Zn_{1-x}Cd_xO thin films as an alternative to photonic crystals in organic solar cells. *Optical Materials Express*, 9(9), 3638. <https://doi.org/10.1364/ome.9.003638>
- Ali, A., El-Mellouhi, F., Mitra, A., & Aïssa, B. (2022). Research Progress of Plasmonic Nanostructure-Enhanced Photovoltaic Solar Cells. *Nanomaterials*, 12(5), 788. <https://doi.org/10.3390/nano12050788>
- Ali, L. S., & Abdullah, A. (2011). *Computer Simulation of The Effect of Band Cap Grading of The Cigs Absorber Layer on The Performance of Cds/Cigs Thin Film Solar Cell*.
- Alkhalayfeh, M. A., Aziz, A. A., Pakhuruddin, M. Z., & Katubi, K. M. M. (2022). Plasmonic effects of Au@Ag nanoparticles in buffer and active layers of polymer solar cells for efficiency enhancement. *Materials*, 15(16), 5472.
- Amalathas, A. P., & Alkaisi, M. M. (2019). Nanostructures for light trapping in thin film solar cells. In *Micromachines* (Vol. 10, Issue 9). MDPI AG. <https://doi.org/10.3390/mi10090619>
- Anaraki, H. E., Kermanpur, A., Mayer, M. T., Steier, L., Ahmed, T., Turren-Cruz, S.-H., Seo, J., Luo, J., Zakeeruddin, S. M., & Tress, W. R. (2018). Low-temperature Nb-doped SnO₂ electron-selective contact yields over 20% efficiency in planar perovskite solar cells. *ACS Energy Letters*, 3(4), 773–778.
- Bansal, A., Sekhon, J. S., & Verma, S. S. (2014). Scattering Efficiency and LSPR Tunability of Bimetallic Ag, Au, and Cu Nanoparticles. *Plasmonics*, 9(1), 143–150. <https://doi.org/10.1007/s11468-013-9607-x>
- Barman, B., & Kalita, P. K. (2021). Influence of back surface field layer on enhancing the efficiency of CIGS solar cell. *Solar Energy*, 216, 329–337. <https://doi.org/10.1016/j.solener.2021.01.032>

- Böer, K. W. (2013). Handbook of the physics of thin-film solar cells. In *Handbook of the Physics of Thin-Film Solar Cells*. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-642-36748-9>
- Boukourt, N. E. I., Patanè, S., Hadri, B., & Crupi, G. (2023). Graded Bandgap Ultrathin CIGS Solar Cells (Invited Paper). *Electronics (Switzerland)*, *12*(2). <https://doi.org/10.3390/electronics12020393>
- Chen, W., Kosmas, P., Leeser, M., & Rappaport, C. (2004). An FPGA implementation of the two-dimensional finite-difference time-domain (FDTD) algorithm. *Proceedings of the 2004 ACM/SIGDA 12th International Symposium on Field Programmable Gate Arrays*, 213–222.
- Chopra, K. L., Paulson, P. D., & Dutta, V. (2004). Thin-film solar cells: An overview. *Progress in Photovoltaics: Research and Applications*, *12*(2–3), 69–92. <https://doi.org/10.1002/pip.541>
- Ciddor, P. E. (1996). Refractive index of air: new equations for the visible and near infrared. *Applied Optics*, *35*(9), 1566–1573.
- Cousse, J. (2021). Still in love with solar energy? Installation size, affect, and the social acceptance of renewable energy technologies. *Renewable and Sustainable Energy Reviews*, *145*, 111107. <https://doi.org/10.1016/J.RSER.2021.111107>
- Dambhare, M. v., Butey, B., & Moharil, S. v. (2021). Solar photovoltaic technology: A review of different types of solar cells and its future trends. *Journal of Physics: Conference Series*, *1913*(1). <https://doi.org/10.1088/1742-6596/1913/1/012053>
- Dubey, A., Adhikari, N., Mabrouk, S., Wu, F., Chen, K., Yang, S., & Qiao, Q. (2018). A strategic review on processing routes towards highly efficient perovskite solar cells. *Journal of Materials Chemistry A*, *6*(6), 2406–2431.
- Garcia, M. A. (2011). Surface plasmons in metallic nanoparticles: Fundamentals and applications. In *Journal of Physics D: Applied Physics* (Vol. 44, Issue 28). <https://doi.org/10.1088/0022-3727/44/28/283001>
- Gezgin, Y., & Kılıç, H. Ş. (2020). An improvement on the conversion efficiency of Si/CZTS solar cells by LSPR effect of embedded plasmonic Au nanoparticles. *Optical Materials*, *101*. <https://doi.org/10.1016/j.optmat.2020.109760>

- Ghosh, S., Yasmin, S., Ferdous, J., & Saha, B. B. (2022). Numerical Analysis of a CZTS Solar Cell with MoS₂ as a Buffer Layer and Graphene as a Transparent Conducting Oxide Layer for Enhanced Cell Performance. *Micromachines*, *13*(8). <https://doi.org/10.3390/mi13081249>
- Green, M. A., Emery, K., Hishikawa, Y., Warta, W., & Dunlop, E. D. (2015). Solar cell efficiency tables (Version 45). *Progress in Photovoltaics: Research and Applications*, *23*(1), 1–9. <https://doi.org/https://doi.org/10.1002/pip.2573>
- Greffet, J.-J. (2012). Introduction to surface plasmon theory. In *Plasmonics: From Basics to Advanced Topics* (pp. 105–148). Springer.
- Guo, Z., Chen, Y., Wang, Y., Jiang, H., & Wang, X. (2020). Advances and challenges in metallic nanomaterial synthesis and antibacterial applications. In *Journal of Materials Chemistry B* (Vol. 8, Issue 22, pp. 4764–4777). Royal Society of Chemistry. <https://doi.org/10.1039/d0tb00099j>
- Harish, K. K., Nagasamy, V., Himangshu, B., & Anuttam, K. (2018). Metallic Nanoparticle: A Review. *Biomed J Sci & Tech Res*, *4*(2). <https://doi.org/10.26717/BJSTR.2018.04.001011>
- Hasheminassab, S. M. S., Imanieh, M., Kamali, A., Emamghorashi, S. A., & Hassanhosseini, S. (2021). Influence of the Shape and Size of Ag Nanoparticles on the Performance Enhancement of CIGS Solar Cells: the Role of Surface Plasmons. *Plasmonics*, *16*(1), 273–282. <https://doi.org/10.1007/s11468-020-01280-x>
- Heidarzadeh, H., & Tavousi, A. (2021). Design of an LSPR-Enhanced Ultrathin CH₃NH₃PbX₃ Perovskite Solar Cell Incorporating Double and Triple Coupled Nanoparticles. *Journal of Electronic Materials*, *50*(4), 1817–1826. <https://doi.org/10.1007/s11664-020-08612-x>
- Hepp, J. (2020). Development of visualization and quantification techniques of local material failures in PV.
- Hepp, J., Vetter, A., Hofbeck, B., Sultan, U., Hauch, J. A., Camus, C., & Brabec, C. J. (2020). Quantitative Analysis of the Separate Influences of Material Composition and Local Defects on the V_{oc} of PV Devices: An Exemplary Study on CIGS. *IEEE journal of photovoltaics*, *10*(3), 898-904.
- Hossain, N., Islam, M. A., Chowdhury, M. A., & Alam, A. (2022). Advances of nanoparticles employment in dental implant applications. *Applied Surface Science Advances*, *12*, 100341.

- Jangjoy, A., Bahador, H., & Heidarzadeh, H. (2019). Design of an ultra-thin silicon solar cell using Localized Surface Plasmonic effects of embedded paired nanoparticles. *Optics Communications*, 450, 216–221. <https://doi.org/10.1016/j.optcom.2019.06.007>
- Jošt, M., Köhnen, E., Al-Ashouri, A., Bertram, T., Tomšič, Š., Magomedov, A., Kasparavicius, E., Kodalle, T., Lipovšek, B., Getautis, V., Schlatmann, R., Kaufmann, C. A., Albrecht, S., & Topič, M. (2022). Perovskite/CIGS Tandem Solar Cells: From Certified 24.2% toward 30% and beyond. *ACS Energy Letters*, 7(4), 1298–1307. https://doi.org/10.1021/ACSENERGYLETT.2C00274/SUPPL_FILE/NZ2C00274_SI_001.PDF
- Kaelin, M., Rudmann, D., & Tiwari, A. N. (2004). Low cost processing of CIGS thin film solar cells. *Solar Energy*, 77(6), 749–756. <https://doi.org/10.1016/J.SOLENER.2004.08.015>
- Khan, I., Saeed, K., & Khan, I. (2019). Nanoparticles: Properties, applications and toxicities. In *Arabian Journal of Chemistry* (Vol. 12, Issue 7, pp. 908–931). Elsevier B.V. <https://doi.org/10.1016/j.arabjc.2017.05.011>
- Kinsey, G. S. (2021). Solar cell efficiency divergence due to operating spectrum variation. *Solar Energy*, 217, 49–57. <https://doi.org/10.1016/j.solener.2021.01.024>
- Kovacic, M., Krc, J., Lipovsek, B., Chen, W. C., Edoff, M., Bolt, P. J., van Deelen, J., Zhukova, M., Lontchi, J., Flandre, D., Salomé, P., & Topic, M. (2019). Light management design in ultra-thin chalcopyrite photovoltaic devices by employing optical modelling. *Solar Energy Materials and Solar Cells*, 200, 109933. <https://doi.org/10.1016/J.SOLMAT.2019.109933>
- Lawrence, K., Al-Jamal, M., Kohli, I., & Hamzavi, I. (2016). Principles and Practice of Photoprotection.
- Lee, J.-Y., Peumans, P., Schaadt, D. M., Feng, B., & Yu, E. T. (2010). *OCIS codes: (250.5403) Plasmonics; (290.4020) Mie theory.*
- Licht, C., Peiró, L. T., & Villalba, G. (2015). Global Substance Flow Analysis of Gallium, Germanium, and Indium: Quantification of Extraction, Uses, and Dissipative Losses within their Anthropogenic Cycles. *Journal of Industrial Ecology*, 19(5), 890–903. <https://doi.org/10.1111/JIEC.12287>
- Lin, L., & Ravindra, N. M. (2020). CIGS and perovskite solar cells-an overview. *Emerging Materials Research*, 9(3), 812–824. <https://doi.org/10.1680/jemmr.20.00124>

- Loubat, A., Eypert, C., Mollica, F., Bouttemy, M., Naghavi, N., Lincot, D., & Etcheberry, A. (2017). Optical properties of ultrathin CIGS films studied by spectroscopic ellipsometry assisted by chemical engineering. *Applied Surface Science*, 421, 643–650. <https://doi.org/10.1016/j.apsusc.2016.10.037>
- Low, F. W., & Lai, C. W. (2018). Recent developments of graphene-TiO₂ composite nanomaterials as efficient photoelectrodes in dye-sensitized solar cells: A review. *Renewable and Sustainable Energy Reviews*, 82, 103–125.
- McPeak, K. M., Jayanti, S. V., Kress, S. J. P., Meyer, S., Iotti, S., Rossinelli, A., & Norris, D. J. (2015). Plasmonic films can easily be better: Rules and recipes. *ACS Photonics*, 2(3), 326–333. <https://doi.org/10.1021/ph5004237>
- Memon, N., Naich, M. R., Pathan, A. Z., Mirjat, B. A., & Faiz, M. (2019). Computational Investigations on CZTS Thin-Film Layers Adopting Grating Structures. *SSRG International Journal of Electronics and Communication Engineering*, 6(8), 38–43.
- Mirzaei, M., Hasanzadeh, J., & Abdolazadeh Ziabari, A. (2021). Significant Efficiency Enhancement in Ultrathin CZTS Solar Cells by Combining Al Plasmonic Nanostructures Array and Antireflective Coatings. *Plasmonics*, 16(4), 1375–1390. <https://doi.org/10.1007/s11468-021-01379-9>
- Mirzaei, M., Hasanzadeh, J., & Ziabari, A. A. (2020). Efficiency Enhancement of CZTS Solar Cells Using Al Plasmonic Nanoparticles: The Effect of Size and Period of Nanoparticles. *Journal of Electronic Materials*, 49(12), 7168–7178. <https://doi.org/10.1007/s11664-020-08524-w>
- Muldarisnur, M., Fahendri, F., Perdana, I., Abdullah, Z., & Yusfi, M. (2023). Light absorption enhancement in organic solar cell using non-concentric Ag:SiO₂ core-shell nanoparticles. *Communications in Science and Technology*, 8(1), 50–56. <https://doi.org/10.21924/cst.8.1.2023.1076>
- Nair, A. T., Anoop, C. S., Vinod, G. A., & Reddy, V. S. (2020). Efficiency enhancement in polymer solar cells using combined plasmonic effects of multi-positional silver nanostructures. *Organic Electronics*, 86, 105872.
- Naseri Taheri, A., & Kaatuzian, H. (2015). Applications of Nano-Scale Plasmonic Structures in Design of Stub Filters — A Step Towards Realization of Plasmonic Switches (p. 26). <https://doi.org/10.5772/59877>

- Ninomiya, S., & Adachi, S. (1995). Optical properties of wurtzite CdS. *Journal of Applied Physics*, 78(2), 1183–1190.
- Niu, G., Guo, X., & Wang, L. (2015). Review of recent progress in chemical stability of perovskite solar cells. *Journal of Materials Chemistry A*, 3(17), 8970–8980.
- Okorieimoh, C. C., Norton, B., & Conlon, M. (2020). Long-Term durability of solar photovoltaic modules. *Sustainable Ecological Engineering Design: Selected Proceedings from the International Conference of Sustainable Ecological Engineering Design for Society (SEEDS) 2019*, 317–325.
- Olaimat, M. M., Yousefi, L., & Ramahi, O. M. (2021). Using plasmonics and nanoparticles to enhance the efficiency of solar cells: review of latest technologies. *Journal of the Optical Society of America B*, 38(2), 638. <https://doi.org/10.1364/josab.411712>
- Ouédraogo, S., Zougmore, F., Ndjaka, J. M., & Harold Langford, C. (2013). Numerical Analysis of Copper-Indium-Gallium-Diselenide-Based Solar Cells by SCAPS-1D. *International Journal of Photoenergy*, 2013. <https://doi.org/10.1155/2013/421076>
- Parisi, A., Pernice, R., Rocca, V., Curcio, L., Stivala, S., Cino, A., Cipriani, G., di Dio, V., Galluzzo, G., Miceli, R., & Busacca, A. (2015). Graded Carrier Concentration Absorber Profile for High Efficiency CIGS Solar Cells. *International Journal of Photoenergy*, 2015, 1–9. <https://doi.org/10.1155/2015/410549>
- Petryayeva, E., & Krull, U. J. (2011). Localized surface plasmon resonance: Nanostructures, bioassays and biosensing-A review. In *Analytica Chimica Acta* (Vol. 706, Issue 1, pp. 8–24). <https://doi.org/10.1016/j.aca.2011.08.020>
- Philip E. Ciddor. (1996). Refractive index of air: new equations for the visible and near infrared. *Applied Optics*.
- R. E. Treharne, A. Seymour-Pierce, K. Durose, K. Hutchings, S. Roncallo, & D. Lane. (2011). Optical design and fabrication of fully sputtered CdTe/CdS solar cells. *Journal of Physics: Conference Series*.
- Ranabhat, K., Patrikeev, L., Revina, A. A. evna, Andrianov, K., Lapshinsky, V., & Sofronova, E. (2016). An introduction to solar cell technology. *Journal of Applied Engineering Science*, 14(4), 481–491. <https://doi.org/10.5937/jaes14-10879>

- Rehman, Q., Khan, A. D., Khan, A. D., Noman, M., Ali, H., Rauf, A., & Ahmad, M. S. (2019). Super absorption of solar energy using a plasmonic nanoparticle based CdTe solar cell. *RSC Advances*, 9(59), 34207–34213.
- Rosenblatt, G., Simkhovich, B., Bartal, G., & Orenstein, M. (2020). Nonmodal Plasmonics: Controlling the Forced Optical Response of Nanostructures. *Physical Review X*, 10(1). <https://doi.org/10.1103/PhysRevX.10.011071>
- Royanian, S., Abdolazadeh Ziabari, A., & Yousefi, R. (2020). Efficiency Enhancement of Ultra-thin CIGS Solar Cells Using Bandgap Grading and Embedding Au Plasmonic Nanoparticles. *Plasmonics*, 15(4), 1173–1182. <https://doi.org/10.1007/s11468-020-01138-2>
- Salhi, B. (2022). The Photovoltaic Cell Based on CIGS: Principles and Technologies. In *Materials* (Vol. 15, Issue 5). MDPI. <https://doi.org/10.3390/ma15051908>
- Saliba, M., Correa-Baena, J., Grätzel, M., Hagfeldt, A., & Abate, A. (2018). Perovskite solar cells: from the atomic level to film quality and device performance. *Angewandte Chemie International Edition*, 57(10), 2554–2569.
- Sim, J.-K., Um, D.-Y., Kim, J.-W., Kim, J.-S., Jeong, K.-U., & Lee, C.-R. (2018). Improvement in the performance of CIGS solar cells by introducing GaN nanowires on the absorber layer. <https://doi.org/10.1016/j.jallcom.2018.11.297>
- Sobhani, F., Heidarzadeh, H., & Bahador, H. (2020). Efficiency enhancement of an ultra-thin film silicon solar cell using conical-shaped nanoparticles: similar to superposition (top, middle, and bottom). *Optical and Quantum Electronics*, 52(9). <https://doi.org/10.1007/s11082-020-02487-2>
- Song, M., Bouhelier, A., Bramant, P., Sharma, J., Dujardin, E., Zhang, D., & Colas-des-Francis, G. (2011). Imaging symmetry-selected corner plasmon modes in penta-twinned crystalline Ag nanowires. *ACS Nano*, 5(7), 5874–5880.
- Sui, F., Pan, M., Wang, Z., Chen, M., Li, W., Shao, Y., Li, W., & Yang, C. (2020). Quantum yield enhancement of Mn-doped CsPbCl₃ perovskite nanocrystals as luminescent down-shifting layer for CIGS solar cells. <https://doi.org/10.1016/j.solener.2020.05.070>
- Susumu Ninomiya, & Sadao Adachi. (1995). Optical properties of wurtzite CdS. *Journal of Applied Physics*, 78.

- Treharne, R. (2011). RF magnetron sputtering of transparent conducting oxides and CdTe/CdS solar cells (Doctoral dissertation, Durham University).
- Urbieto, M., Barbry, M., Zhang, Y., Koval, P., Sánchez-Portal, D., Zabala, N., & Aizpurua, J. (2018). Atomic-Scale Lightning Rod Effect in Plasmonic Picocavities: A Classical View to a Quantum Effect. *ACS Nano*, *12*(1), 585–595. <https://doi.org/10.1021/acsnano.7b07401>
- Widén, J., & Munkhammar, J. (2019). Solar Radiation Theory. In *Solar Radiation Theory*. Uppsala University. <https://doi.org/10.33063/diva-381852>
- Wolfgang S. M. Werner, Kathrin Glantschnig, & Claudia Ambrosch-Draxl. (2009). Optical Constants and Inelastic Electron-Scattering Data for 17 Elemental Metals. *Journal of Physical and Chemical Reference Data*.
- Wu, Y., Zhang, C., Estakhri, N. M., Zhao, Y., Kim, J., Zhang, M., Liu, X. X., Pribil, G. K., Alù, A., Shih, C. K., & Li, X. (2014). Intrinsic optical properties and enhanced plasmonic response of epitaxial silver. *Advanced Materials*, *26*(35), 6106–6110. <https://doi.org/10.1002/adma.201401474>
- Yang, Z. L., Li, Q. H., Ruan, F. X., Li, Z. P., Ren, B., Xu, H. X., & Tian, Z. Q. (2010). FDTD for plasmonics: Applications in enhanced Raman spectroscopy. *Chinese Science Bulletin*, *55*(24), 2635–2642. <https://doi.org/10.1007/s11434-010-4044-0>
- Yassin, H., El-Batawy, Y., Soliman, E., Yassin, H. M., El-Batawy, Y. M., & Soliman, E. A. (2022). *Enhancement of Plasmonic Photovoltaics with Pyramidal Nanoparticles*. <https://doi.org/10.21203/rs.3.rs-2226576/v1>
- Yorulmaz, M., Hoggard, A., Zhao, H., Wen, F., Chang, W. S., Halas, N. J., Nordlander, P., & Link, S. (2016). Absorption Spectroscopy of an Individual Fano Cluster. *Nano Letters*, *16*(10), 6497–6503. <https://doi.org/10.1021/acs.nanolett.6b03080>
- Yousefi, R., Ziabari, A. A., Royanian, S., & Ghoreishi, S. S. (2020). Performance Improvement of Ultrathin CIGS Solar Cells Using Al Plasmonic Nanoparticles: The Effect of the Position of Nanoparticles. In *Islamic Azad University Journal of Optoelectrical Nanostructures Autumn* (Vol. 5, Issue 4)
- Yu, P., Yao, Y., Wu, J., Niu, X., Rogach, A. L., & Wang, Z. (2017). Effects of Plasmonic Metal Core-Dielectric Shell Nanoparticles on the Broadband Light Absorption Enhancement in Thin Film Solar Cells. *Scientific Reports*, *7*(1). <https://doi.org/10.1038/s41598-017-08077-9>

- Zarerasouli, P., Bahador, H., & Heidarzadeh, H. (2022). Performance improvement of an ultra-thin film solar cell based on optimized CIGS (Cu(In_{1-x}, Ga_x)Se₂) using appropriate plasmonic nanoparticles. *Optical Materials*, 131. <https://doi.org/10.1016/j.optmat.2022.112729>
- Zarerasouli, P., Bahador, H., & Heidarzadeh, H. (2023). Design of an efficient ultra-thin film Cu(In,Ga)Se₂ solar cell, using plasmonic cluster back reflectors. *Solar Energy*, 261, 1–6. <https://doi.org/10.1016/j.solener.2023.06.001>
- Zhang, J., Zhang, L., & Xu, W. (2012). Surface plasmon polaritons: Physics and applications. In *Journal of Physics D: Applied Physics* (Vol. 45, Issue 11). <https://doi.org/10.1088/0022-3727/45/11/113001>
- Zhang, Y., Min, C., Dou, X., Wang, X., Urbach, H. P., Somekh, M. G., & Yuan, X. (2021). Plasmonic tweezers: for nanoscale optical trapping and beyond. In *Light: Science and Applications* (Vol. 10, Issue 1). Springer Nature. <https://doi.org/10.1038/s41377-021-00474-0>
- Zhu, R., Zhang, Z., & Li, Y. (2019). Advanced materials for flexible solar cell applications. In *Nanotechnology Reviews* (Vol. 8, Issue 1, pp. 452–458). De Gruyter. <https://doi.org/10.1515/ntrev-2019-0040>

