



Dr. Sadia Muniza Faraz

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A highly committed, hardworking and self-motivated teacher with strong management, leadership and communication skills & rich experience of research. More than twenty-five years of academic experience in teaching, management and assessments at undergraduate and postgraduate levels. More than ten-year research experience in projects, evaluation and review.

Academic Qualification

PhD

Electronic Engineering, NED University of Eng. & Tech., Karachi. (2013). Partial Research carried out at Linköpings University, Linköping, Sweden.

Thesis Title: Physical simulation and characterization of electronic and photonic devices in wide band gap semiconductors

Supervisor: Dr. Qamar-ul-Wahab

Co-Supervisors: Dr. Magnus Willander, Dr. Abdul Qadir

Licentiate

Licentiate of Engineering;

Linköpings Institute of Technology,

Linköping University, Linköping, Sweden (2011)

M. Eng.

Electronic Engineering (Micro System Design). NED University of Eng. & Tech., Karachi. (2006)

B.E

Electrical Engineering,

NED University of Eng. & Tech., Karachi. (1996)

Research Supervision

PhD

2020 Physical Modelling and Simulation of Third Generation Solar cell (ongoing)

2019 Fabrication and Characterization Of Sensitized Photovoltaics (ongoing)

Master Thesis

2022 Artificial intelligence approach for modelling the electrical characteristics of Schottky diode

2021 An Efficient Parameter Extraction Technique for Solar Cell Modules

2018 Power Tracking By Fast and Efficient MPPT Technique for Solar Module under Partial Shading Conditions

2017 Maximum Power Point Tracking Algorithm Based on Particle Swarm Optimization for Photovoltaic System

- 2016 Fabrication and characterization of organic Solar cells Deposition of Graphene through chemical vapor deposition for electronic applications
- 2015 Temperature Dependent Electrical Characterization of Schottky diodes
- 2014 Physical Modelling and Simulation of Au/ZnO Schottky diodes
- 2013 Modeling and Simulation of GaN Schottky diodes using TCAD and comparison to the experimental results
- 2012 Electrical characterization of wideband gap semiconductors

Skills

- Device fabrication processes, thermal evaporation, cleaning, etching, annealing,
- Device modeling and simulation using MicroTec, Minimos-NT, AMPS-1D and TCAD.
- Growth of Nano-structures
- Electrical characterization using Keithley SCS-4200.
- Synthesis and fabrication of Organic Solar cells
- Programming in C-Language, FORTRAN, MATLAB , Verilog HDL, ADS.
- Proficient in MS Office
- Fluent in Urdu, English and basic knowledge of Swedish.

Grants and Funding

- 2021 Co-Principal Investigator for HEC NRPU project titled “Dynamic Analysis of Nanostructured Thin Films for Smart Energy” amounting to Rs. 9.50 million approx.
- 2020 Project Supervisor, “Physical Modelling and Simulation of Third Generation Solar cell” amounting to Rs. 1 million.
- 2019 Project Supervisor, “Fabrication and Characterization of Sensitized Photovoltaics”, amounting to Rs. 1 million
- 2013 Project Supervisor, “Energy Efficient Intelligent Electronic Gas Stove”, NED Alumni Association of Southern California (NEDAASC) funding, amounting to Rs. 20655.
- 2011 HEC Travel grant of Rs. 0.19 million for presenting research paper at 2011-MRS-Fall meeting held in Boston, Massachusetts, USA .
- 2008 PhD funding from NED University Research Fund amounting Rs. 10.125 million approx.

Teaching Experience

PhD Courses:

1. Research Methodologies
2. Characterization Techniques for Semiconductor Materials
3. Electrical Characterization of Semiconductors Devices
4. Nanotechnology
5. Photovoltaic Materials
6. Solar Cell Design
7. Modern Trends in Solar Cell Design

Masters Courses:

1. Light wave Engineering

2. Solid State Materials and Devices
3. High speed semiconductor devices and circuits
4. Hybrid Power Systems
5. Renewable Energy
6. Digital VLSI Design

Undergraduate Courses:

1. VLSI system Design
2. Optoelectronics and Microwave systems
3. Solid State Devices
4. Electronic Devices and Circuits
5. Analog and Digital Electronics
6. Electronics-II
7. Electric Circuits and Machines
8. Programming Languages

Academic Duties / Volunteering/Memberships

- Member Senate, NEDUET
- Member Board of Faculties (BOF), Faculty of Electrical and Computer Engineering (ECE), NEDUET
- Member of Board of Studies (BOS), Dept. of Electronic Eng. NED.
- Member Board of Studies (BOS), Institute of Industrial Electronic Engineering (IIEE), Karachi.
- Member Board of Review (BOR), Audit Department, NED University.
- Member National Curriculum Revision Committee (NCRC) of Higher Education Commission (HEC), Pakistan
- Acting Oman I.T. Chair (20th Jan-11th Feb, 2014)
- Expert Member in Selection Board DHA Suffa University, Karachi
- In-charge Electronics Design Center, Dept. of Electronic Eng. NED.
- Proposals reviewer for HEC, National Research Program for Universities (NRPU), CPEC- Collaborative Research Grant(CRG), Local Challenge Fund(LCF), Grand Challenge Fund (GCF)
- Proposal reviewer for Sind HEC.
- External examiner (Master's Thesis) for Mehran University of Engineering & Technology, Jamshoro,
- Expert, Charter Inspection and Evaluation Committee (CIEC), Sind HEC, for monitoring and evaluating Bachelor of Engineering program.
- Reviewer for International/National journals and conferences
- Proposal reviewer for "Pakistan – United States Science and Technology Cooperation Program (USAID)
- Member Local Council of Institution of Engineers Pakistan (IEP) 2016 – 2018.
- Member Central Council of Institution of Engineers Pakistan (IEP) 2016 - 2018.
- Member Pakistan Engineering Council (PEC)
- Faculty Head of Green Electronics Society, Electronic Eng. Dept.
- Member Curriculum Revision Committee, Electronic Eng. Dept.
- Member Post Graduate Admission Committee, Electronic Eng. Dept. NED.

Honors

1. HEC approved PhD Supervisor.
2. Received certificate of award and cash prize on a journal paper from NED Alumni Association of Southern California USA (NEDAASC)-2013

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3. Received a funding of Rs. 10 million for PhD research work from NED University Research Fund -2008.
 4. Best teacher awards received from Dept. of Electronic Engineering, NED University of Engineering & Technology, Karachi, Pakistan from 2001-2005.
 5. 99.6 percentile among approx.35,000 candidates appeared in Higher School Certificate examinations (HSC - 12th grade) in the year 1990.
 6. 99.96 percentile among approx. 50,000 candidates appeared in Secondary School Certificate Examination (SSC-10th grade) in the year 1988.
 7. Received President Talent Scholarship for two years 1987-1988 for being amongst top 50 students in President Talent Scholarship Examination.
 8. Passed the Merit Scholarship Examination and received Scholarship for three years 1984-86 from Board of Secondary Education Karachi.
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Invited Talks / Conference Presentations

- 2021 Presented research work on “Voltage and Frequency Dependent Electrical Characteristics and Interface State Density of Ni/ZnO Schottky Diodes”, online in The 49th International School and Conference on the Physics of Semiconductors (Jaszowiec-2021), Warsaw, Poland, September 1-10, 2021

Keynote Speaker to give talk on “Modelling and Simulation of Eco- Friendly Solar Cells Sensitized by Natural Dyes”, International Conference on Energy, Water & Environment (ICEWE-2021), held at University of Engineering & Technology (UET), Lahore, Pakistan. 31st March, 2021.

Invited Speaker to give a talk on “Modelling and Simulation of Electrical Characteristics of Dye Sensitized Solar Cells” in 9th International Conference on semiconductor Materials and Nano-Devices (9th ICSMAND-2021), Khawaja Fareed University of Engineering & Information Technology(KFUEIT), Rahim Yar Khan. 1-2 April, 2021

- 2020 Invited Speaker to give a talk on “Impedance Spectroscopy and Photovoltaic Properties of Metallic and Natural Dyes based Dye Sensitized Solar Cells” in 8th International Conference on semiconductor Materials and Nano-Devices (8th ICSMAND-2020), Khawaja Fareed University of Engineering & Information Technology, Rahim Yar Khan. 9th -10th March, 2020

Invited Speaker to give a talk on “Impedance Spectroscopy and Photovoltaic properties of Metallic and Natural Dyes based Dye Sensitized Solar Cells”, in International Conference On Nanomaterials & Nanotechnology (MSNANO-2020), Government College University Faisalabad, 3rd – 5th March, 2020

- 2019 Invited Speaker to give a talk on “Fabrication and Characterization of Oxide Semiconductor based Electronic Devices” in 7th International Conference on semiconductor Materials and Nano-Devices (7th ICSMAND-2019), Khawaja Fareed University of Engineering & Information Technology, Rahim Yar Khan. February 25-27, 2019

Invited Speaker to give a talk on “Physical Modeling and Simulation of Nanostructure Electronic Devices”, in Ist International Conference on Advances in Theoretical and Applied Physics -2019, Government College Women University, Faisalabad, 19th February, 2019

Invited Speaker to give a talk on “Fabrication and Characterization of Oxide Semiconductor based Electronic Devices” in 7th International Conference on semiconductor Materials and Nano-Devices (7th ICSMAND-2019), Khawaja Fareed University of Engineering & Information Technology, Rahim Yar Khan. February 25-27, 2019

- 2018 Invited Speaker to give a talk on “Fabrication and Photoelectrical characterization of Natural Dye Sensitized Solar cells”, in 2018 -Photonics Symposium and National Engineering Convention & Optics Olympiad (NECOO’2018), Ghulam Ishaq Khan Institute (GIKI) of Engineering Sciences and Technology. Topi, KPK, Pakistan, 30st March – 1st -April, 2018.
- Invited Speaker to give a talk on “Fabrication and Photoelectrical Characterization of Natural Dye Sensitized Solar cells”, in International Conference On Nanomaterials & Nanotechnology (MSNANO-2018), Government College University Faisalabad, February 19-20, 2018
- Invited Speaker to give a talk on “Synthesis, Fabrication and Characterization of Third Generation Solar Cells” in 6th International Conference on Semiconductor Materials and Nano-Devices (6th ICSMAND-2018), The Islamia University of Bahawalpur, Pakistan, February 15-17, 2018
- 2015 Guest speaker to give a talk on “The Science of Life Management” in Evolver-Personality Development Program powered by Enroute at Institute of Business Administration (IBA), Karachi, July 10, 2015.
- Speaker to give a talk on “Projects on Green Electronics”, in a Seminar on “Journey from Imagination to Implementation” organized by Green Electronics Society, Dept. of Electronic Engg. NED University, February 12, 2015.
- Speaker to give a talk on “Environment Friendly Electronics” in a Seminar to mark the 45th Anniversary of Earth Day, organized by Women Engineers Committee and Environment Committee of the Institution of Engineers Pakistan (IEP), Karachi Chapter, April 25, 2015.
- 2014 Invited speaker to give a talk on “Final Year Engineering Project Selection, Planning and Management” at Hamdard Institute of Engineering & Technology (HIET), Hamdard University, Karachi, Pakistan, Sept.24, 2014.
- Guest Speaker to give a talk on “Criteria, selection and requirements of Final year Project (FYP)” in “INFUSE, FYP-Pedia from A to Z” organized by Institute for Electrical and Electronics Engineers (IEEE), NED University Students Branch, August 5, 2014
- 2013 Invited Speaker to give a talk on Electronic and Photonic Devices in Wide Bandgap Semiconductors in National Workshop on Advanced Electronics: Device Design & Process Characterization, International Islamic University, Islamabad, December 2 - 3, 2013
- Invited Speaker to give a talk on Electrical Characterization of Interface States Density in Wide Bandgap Semiconductor Devices in 3rd - International Conference on Semiconductor Materials & Nano-Devices, Bahawalpur, Pakistan, April 22 – 24, 2013.
- 2011 Presented paper in 14th IEEE International Multi-topic Conference (INMIC 2011), Sir Syed University of Engineering & Technology, Karachi, Pakistan, December 22-24, 2011.
- Presented paper in Material Research Society (MRS-2011) fall meeting, Boston, Massachusetts, USA. November 28- December 2, 2011.
- Presented paper in European Material Research Society (E-MRS-2011) fall meeting, Warsaw, Poland, September 19-23, 2011.
- 2009 Presented paper in The 2nd International Conference on Multi-functional Materials and Structures Qingdao, China, , October 09-12, 2009.
- 2008 Talk on EDA tools, Dept. Of Electronic Engineering, NED University Karachi, August 30, 2008.

Workshops, Courses and Trainings

Workshops, Courses and Trainings Conducted

- 2022 Conducted faculty training on “Uniform OBE framework”, 21st March, 2022.
- 2020 Conducted faculty training on “Learning Management System: G-suite: Google Classroom”, at Dept. of Electronic Eng. NED University on 12th May, 2020.
- Conducted students training on “Outcome Based Education” at Dept. of Electronic Engg. NED University on 10th December, 2020.
- 2018 Conducted faculty training on “Rubric Design for Psychomotor Domain Courses” at Dept. of Electronic Eng. NED University on 12th June, 2018.
- Conducted faculty training on “Rubric Design for Affective Domain Courses” at Dept. of Electronic Eng. NED University on 13th June, 2018.
- Conducted workshop on “Fabrication of Dye-Sensitized Solar Cells (DSSC)” organized by Green Electronics Society, Dept. of Electronic Eng. NED University on August, 9, 2018.
- 2016 Conducted workshop on “Fabrication of Dye-Sensitized Solar Cells (DSSC)” organized by Green Electronics Society, Dept. of Electronic Eng. NED University on March 10-11th, 2016
- 2015 Conducted a workshop on “Fabrication of Dye-Sensitized Solar Cells (DSSC)” organized by Green Electronics Society, Dept. of Electronic Eng. NED University on March 24th, 2015

Workshops, Courses and Trainings Organized

- 2018 Organized a Workshop on “Engineering Applications of Digital Microscopy”, conducted by Leica Microsystems, on Wednesday, 3rd January, 2018.
- 2017 Organized a seminar on “Internship Drive- A Gateway to Industry”, by Green Electronics Society, Dept. of Electronic Engineering, on 13th March, 2017.
- 2015 Organized a training course on “Programming and Interfacing of Arduino Uno”, at Dept. Of Electronic Engineering, 17th Dec. – 23 Dec, 2015.
- Organized a seminar in collaboration with Energy Wise (pvt).ltd. on “Energy Auditing & Conservation”, by Green Electronics Society, Dept. of Electronic Engineering, NED University, October 12th, 2015.
- Organized hands on “Refresher Training of Laboratory Equipment” for the faculty of Electronics Dept, NED, 20th and 21st May, 2015.

Organized a training course on “Project Design and Implementation, using FPGA”, at dept. Of Electronic Engineering, 16th May – 13 June, 2015.

Organized a Half Day seminar on “Journey from Imagination to Implementation”, Dept. of Electronic Engineering, NED University, February 12, 2015.

Trainings Received

2021 Half day QEC training on “Development of SAR assessment report as per HEC guidelines for PhD program”, at NED University on 14th October, 2021.

Half day training on “Assessment of Self-Assessment reports of PhD program as per HEC guidelines”, at NED University on 15th October, 2021.

2020 Half day QEC Training, “OBE Based students evaluation”, at NED University on 9th January, 2020.

2019 Three months training, “Higher Education Teacher’s Training 2019”, at NED University from 1st October – 31st December, 2019.

Half day training on “Higher education curriculum Design (OBE Based)”, at NED University on 26th April and 3rd May, 2019.

Half day training on “Assessment of SAR as per HEC criteria”, at NED University on 14th June, 2019.

Half day training on “G-suite: Google Classroom”, at NED University on 16th July, 2019.

2016 Two days International Research Workshop “How to Combine Multiple Research Methods-Practical Triangulation”, Organized by Research Centre for Training & Development (RCTD), held on 29-30 Jan, 2016

2009 Received a 2 weeks training on modelling and simulation using TCAD, at Advanced Engineering Research organization(AERO), Hasan Abdal, Pakistan, February 2009.

Publications

- [1] **S. M. Faraz**, Z. Tajwar, Q. Wahab, A. Ulyashin, R. Yakimova, “Voltage and frequency Dependent Electrical Characteristics and Interface State Density of Ni/ZnO Schottky Diodes”, *ACTA Physica Polonica A*, Vol. 141, No. 2, pp. 99-104, **2022**. <https://doi.org/10.12693/APhysPolA.141.99>
- [2] B. Shaikh, **S. M. Faraz**, S. R.U. N. Jafri, S.U.Ali, “Self-Localization of Mobile Robot Using Map Matching Algorithm”, *Journal Of Engineering and Applied Sciences*, Vol. 40, no. 1, pp.69-77, **2021**. <https://dx.doi.org/10.17582/journal.jeas/40.1.69.77>
- [3] S.R.U.N. Jafri, Y. Rehman, **S. M. Faraz**, "Development of Georeferenced 3D Point Cloud in GPS Denied Environments using Backpack Laser Scanning System", *Elektronika Ir Elektrotechnika*, Vol.27, No. 6, pp. 25-34, **2021**.<https://doi.org/10.5755/j02.eie.29063>
- [4] **S. M. Faraz**, S.R.U.N. Jafri, H. R. Khan, W. Shah, N. H. Alvi, Q. Wahab, O. Nur, "Effect of annealing temperature on the interface state density of n-ZnO nanorod/p-Si heterojunction diodes." *Open Physics*, Vol. 19, no. 1, 467-476, **2021**. <https://doi.org/10.1515/phys-2021-0053>

- [5] **S. M. Faraz**, S.R.U.N. Jafri, Z. Tajvar, N. H. Alvi, Q. Wahab, O. Nur, "Effect of annealing atmosphere on the diode behaviour of ZnO/Si Heterojunction", *Elektronika Ir Elektrotechnika*, Vol. 27, No. 4, pp. 49 -54, **2021**. <https://doi.org/10.5755/j02.eie.28723>
- [6] **S. M. Faraz**, M. Mazhar, W. Shah, H. Noor, Z. H. Awan, M. H. Sayyad, "Comparative study of Impedance Spectroscopy and Photovoltaic properties of Metallic and Natural Dye based Dye Sensitized Solar Cells", *Physica B: Condensed Matter*, 602, 412567, **2021**. <https://doi.org/10.1016/j.physb.2020.412567>
- [7] **S. M. Faraz**, W. Shah, N. U. H. Alvi, O. Nur, and Q. U. Wahab, "Electrical Characterization of Si/ZnO Nanorod PN Heterojunction Diode," *Advances in Condensed Matter Physics*, vol. 2020, pp. 1–9, **2020**. <https://doi.org/10.1155/2020/6410573>
- [8] S. Moin, **S.M. Faraz**, "Simulation based IV Characteristics Analysis of GaAs and InP Solar Cell", The 8th IEEE International Symposium on Next-Generation Electronics (ISNE-2019), Zhengzhou, China, Oct 9-10, **2019**. DOI: 10.1109/ISNE.2019.8896687
- [9] H. Shumail, **S. M. Faraz**, "Physical Modelling and Simulation of Au/ZnO Schottky diode", 2018 IEEE International Conference on Semiconductor Electronics (ICSE), Kuala Lumpur, Malaysia, August 14-17, **2018**. <https://doi.org/10.1109/smelec.2018.8481294>
- [10] S.Masood, M. Mazhar, **S. M. Faraz**, Synthesis of Graphene Ink For Electrodes Of Organic Solar Cell", International Conference on Emerging Trends In Telecommunication and Electronic Engineering IC(TE)2, NED University, Karachi, Pakistan, February 27-28, **2018**.
- [11] M. Mazhar, H. Sayyad and **S. M. Faraz**, "Anthocyanin based Photosensitizer for Natural Dye-Sensitized Solar Cells", 2017 2nd International Electrical Engineering Conference (IEEC 2017), organized by The Institution of Engineers, Pakistan, May. 12-13, **2017**.
- [12] M. Mazhar, H. Mazia Ada, H. A. Siddiqui, and **S. M. Faraz**, "Fabrication of Dye Sensitized Solar Cells Using Natural Dyes", 19th IEEE International Multi-Topic Conference (INMIC 2016) Air University Islamabad, Pakistan, December 5-6, **2016**. <https://ieeexplore.ieee.org/abstract/document/7840148>
- [13] M. Mazhar, H. Mazia Ada, U. Hani, H. A. Siddiqui, and **S. M. Faraz**, "Synthesis of Dye Sensitized Solar Cells Using Natural Resources", 1st International Electrical Engineering Congress, organized by The Institution of Engineers, Pakistan, May 13- 14, **2016**.
- [14] **S. M. Faraz**, O. Nur, M. Willander and Q. Wahab, "Interface states density of Au/n-ZnO nanorods Schottky diodes", *IOP Conf. Ser.: Mater. Sci. Eng.*, vol. 34, pp. 012006, **2012**. <https://doi.org/10.1088/1757-899x/34/1/012006>
- [15] M. Asghar, F. Iqbal, **S.M. Faraz**, V. Jokubavicius, Q. Wahab, M. Syvajarvi, "Study of deep level defects in doped and semi-insulating n-6H-SiC epilayers grown by sublimation method", *Physica B: Condensed Matter*, vol. 407, no.15, pp. 3038, **2012**. DOI: <https://doi.org/10.1016/j.physb.2011.08.036>
- [16] M. Asghar, F. Iqbal, **S. M. Faraz**, V. Jokubavicius, Q. Wahab, M. Syväjärvi, "Characterization of deep level defects in sublimation grown p-type 6H-SiC epilayers by deep level transient spectroscopy" *Physica B: Condensed Matter*, Vol. 407, no.15, pp. 3041, **2012**. DOI: <https://doi.org/10.1016/j.physb.2011.08.085>

- [17] **S. M. Faraz**, N. H. Alvi, A. Henry, O. Nur, M. Willander and Q. Wahab, “Annealing effects on electrical and optical properties of n-ZnO/p-Si heterojunction diodes”, *Advanced Materials Research*, vol. 324, pp 233, Aug. **2011**. DOI: <https://doi.org/10.4028/www.scientific.net/AMR.324.233>
- [18] **S. M. Faraz**, N. H. Alvi, A. Henry, O. Nur, M. Willander, Q. Wahab, “Post fabrication annealing effects on electrical and optical characteristics of n-ZnO nanorods/p-Si heterojunction diodes”, Techconnect World 2011, Nanotech Conference, June 13-16, 2011, Boston, Massachusetts, USA. NSTI-Nanotech **2011**, Vol.2, pp. 68, 2011. ISBN: 978-1-4398-7139-3.
- [19] **S. M. Faraz**, M. Willander and Q. Wahab, “Current Transport Studies and Extraction of Series Resistance of Pd/ZnO Schottky Diode”, 14th IEEE International Multitopic Conference (INMIC 2011), Karachi, Pakistan, December 22-24, **2011**, : <https://doi.org/10.1109/inmic.2011.6151472>
- [20] **S. M. Faraz**, V. Khranovskyy, R. Yakimova, A. Ulyashin and Q. Wahab, “Temperature dependent current transport in Schottky diodes of nano structured ZnO grown on Si by magnetron sputtering”, Proceedings 2011 IEEE Regional Symposium of Micro & Nano Electronics, Kota Kinabalu, Malaysia, Sept. 28-30, **2011**. pp. 48, ISBN: 978-1-61284-846-4. DOI: 10.1109/RSM.2011.6088289
- [21] Hadia Noor, P. Klason, **S. M. Faraz**, O. Nur, Q. Wahab, M. Willander, and M. Asghar, “Influence of background concentration induced field on the emission rate signatures of an electron trap in zinc oxide Schottky devices”, *J. Appl. Phys.*, vol.107, no. 10, pp.103717, May **2010**. DOI: <https://doi.org/10.1063/1.3428426>
- [22] H. Ashraf, M. Imran Arshad, **S. M. Faraz**, Q. Wahab, P. R. Hageman and M. Asghar, “Study of electric field enhanced emission rates of an electron trap in *n*-type GaN grown by hydride vapor phase epitaxy”, *J. Appl. Phys.*, vol.108, no. 10, pp.103708, Nov. **2010**. DOI: <https://doi.org/10.1063/1.3499669>
- [23] **S. M. Faraz**, H. Ashraf, M. Imran Arshad, P. R. Hageman, M. Asghar and Q. Wahab, “Interface state density of free-standing GaN Schottky diodes”, *Semicond. Sci. Technol.* vol. 25, no.9, pp. 095008, Sept. **2010**. DOI: <https://doi.org/10.1088/0268-1242/25/9/095008>
- [24] **S. M. Faraz**, Hadia noor, M. Asghar, M. Willander, Q. Wahab, “Modeling and simulations of Pd/n-ZnO Schottky diode and its comparison with measurements”, *Advanced Materials Research*, vol. 79-82, pp. 1317, Aug.**2009**. DOI: <https://doi.org/10.4028/www.scientific.net/AMR.79-82.1317>