

Brief Biodata

Name: Dr. Sushil Kumar

Designation:	Chief Scientist & Professor (AcSIR)
DP No. and Name:	4.01 (Photovoltaic Metrology)
DU No. and Name:	4.0 (Advanced Materials & Device Metrology)
Email:	skumar@nplindia.org
Date of Joining CSIR-NPL:	31-01-2000
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Mobile (optional)	



Research Area/ Interest

- Solar Photovoltaic waste & recycling
- Photovoltaic metrology
- Solar cells design & fabrication
- Thin films & Coatings
- Plasma processing & instrumentation

Educational Qualifications

Degree	Subject	University/ Institute	Year
Ph. D	Physics/Electronics Engineering	IIT-BHU (Formerly IT-BHU), Varanasi / NPL, New Delhi	1997
M.Sc	Physics (Electronics)	BHU, Varanasi	1991
B.Sc. (Hons.)	Physics	BHU, Varanasi	1989

Academic / Research Experience

Grade / Post	Institute	Duration		Research Field
		From	To	
Chief Scientist	CSIR-National Physical Laboratory, New Delhi	30-01-2021	Till date	Solar Photovoltaic (PV) waste & recycling, PV metrology, Solar cells design & fabrication
Senior Principal Scientist	CSIR-National Physical Laboratory, New Delhi	31-01-2016	30-01- 2021	PV metrology, Solar cells design & fabrication
Principal Scientist	CSIR-National Physical Laboratory, New Delhi	31-01-2011	30-01-2016	PV metrology, thin film silicon solar cells design & fabrication
Senior Scientist (Scientist-E1)	CSIR-National Physical Laboratory, New Delhi	31-01- 2007	30-01- 2011	Nano/Micro-Crystalline silicon & solar cells, Diamond like coatings, Plasma PECVD instrumentation
Scientist-C	CSIR-National Physical Laboratory, New Delhi	31-01-2003	30-01- 2007	Hard & protective coatings, Diamond like carbon (DLC), Amorphous silicon solar (a-Si:H) cells
BOYSCAST Fellow	Ecole Polytechnique, Palaiseau, FRANCE	01-03- 2002	28-02-2003	Amorphous carbon & its electronic structure
Scientist-B	CSIR-National Physical Laboratory, New Delhi	31-01- 2000	30-01- 2003	Diamond like carbon thin films, a-Si:H solar cells
Research Associate (CSIR)	CSIR-National Physical Laboratory, New Delhi	01-04-1998	30-01 2000	Diamond like nano-composites

No. of Publications

No. of Publications in SCI Journals	No. of Publications in non-SCI Journals	No. of Publications in Conference Proceedings	Books	Total
>100	>10	>100	Book Chapters: 06 Book Edited: 01	>200

Selected Publications (50 Nos.)

1. "Diamond like carbon films grown by very high frequency (100MHz)-PECVD technique" by Sushil Kumar, P.N. Dixit, D. Sarangi and R. Bhattacharyya, Appl. Phys. Lett. 69, 49(1996).
2. "A possible solution to the problem of high builtup stresses in Diamond-like carbon films" by Sushil Kumar, P.N. Dixit, D. Sarangi and R. Bhattacharyya, J. Appl. Phys. 85, 3866(1999).
3. "High rate deposition of Diamond like Carbon films by VHF-PECVD at 100 MHz" by Sushil Kumar, P.N. Dixit, D. Sarangi and R. Bhattacharyya, J. Appl. Phys. 93, 6361 (2003).
4. "Correlation of residual stress with optical absorption edge in diamond like carbon films" by Sushil Kumar, P.N. Dixit, O.S. Panwar and R. Bhattacharyya, Diamond and Related Materials. 12, 1576 (2003).
5. "Field-enhanced electrical transport mechanisms in amorphous carbon films" by C. Godet, Sushil. Kumar and V. Chu, Philosophical Magazine 83, 3351 (2003).
6. "Electronic transport in amorphous carbon nitride (a-C:N:H) and carbon oxide (a-C:O:H) films, Sushil Kumar and C. Godet, Solid State Communications 130, 331(2004).
7. "High-field transport in amorphous carbon and carbon nitride films", by Sushil Kumar, C. Godet, A. Goudovskikh, J.P. Kleider, G. Adamopoulos and V. Chu, J. Non Crystalline Solids 338-340, 349(2004).
8. "High pressure growth of nanocrystalline silicon films" by Sushil Kumar, Jhuma Gope, Aravind Kumar, A. Parashar, C.M.S.Rauthan, and P.N. Dixit, Journal of Nanosci. & Nanotechnol. Vol. 8, No. 8, pp 4211-4217 (2008).
9. "Formation of Y and T nano junctions in boron nitride thin films" by Sushil Kumar, A. Parashar, C.M.S. Rauthan, S.K. Singhal, P.N. Dixit, B.P. Singh and R. Bhattacharyya, Journal of Nanosci. & Nanotechnol. Vol. 8, No. 7 , pp 3526-3531 (2008).
10. "Fabrication of low cost integrated micro-capillary electrophoresis analytical chip for chemical analysis" by G.S. Viridi, R.K. Chutani, P.K. Rao and Sushil Kumar, Sensors and Actuators B: Chemical 128, 422–426, (2008) & Erratum 134, 352, (2008).
11. High pressure condition of $\text{SiH}_4+\text{Ar}+\text{H}_2$ plasma for deposition of hydrogenated nanocrystalline silicon films by A. Parashar, Sushil Kumar, P.N. Dixit, Jhuma Gope, C.M.S. Rauthan and S.A. Hashmi. Solar Energy Mater. & Solar Cells 92, 1199-1204 (2008).
12. "Effect of power on the growth of nanocrystalline silicon films" by Sushil Kumar, P.N. Dixit, and C.M.S. Rauthan, J. Phys.: Condens. Matter. 20, 335215(2008).
13. "Amorphous and nanocrystalline Silicon made by varying deposition pressure in PECVD process" by Jhuma Gope, Sushil Kumar, A. Parashar, P.N. Dixit, C.M.S. Rauthan, O.S. Panwar, D.N. Patel and S.C. Agarwal, J. Non-Crystalline Solids 335, 2228-2232 (2009).
14. "Properties of nitrogen diluted hydrogenated amorphous carbon (n-type a-C:H) films and their realization in n-type a-C:H/p-type crystalline silicon heterojunction diodes" by Sushil Kumar, Neeraj Dwivedi, C.M.S. Rauthan, and O.S. Panwar, Vacuum 84, 882-889(2010).
15. "Influence of argon dilution on growth and properties of hydrogenated nanocrystalline silicon films" by A. Parashar , Sushil Kumar, Jhuma Gope , C.M.S. Rauthan , P.N. Dixit and S.A. Hashmi, Solar Energy Mater. & Solar Cells 94, 892(2010).
16. "RF power density dependence phase formation in hydrogenated silicon films" A. Parashar, Sushil Kumar, Jhuma Gope, C. M. S. Rauthan, S. A. Hashmi, P. N. Dixit, J. Non-Cryst. Solid 356, 1774-1778 (2010).
17. "Nano indentation measurements on nitrogen incorporated diamond-like carbon coatings" by Neeraj Dwivedi, Sushil Kumar, CMS Rauthan and O.S. Panwar, Applied Physics A 102, 225-230 (2011).
18. "Field emission, morphological and mechanical properties of variety of diamond-like carbon thin films by N. Dwivedi, Sushil Kumar, Hitendra K. Malik, Ravi K Tripathi, and O. S. Panwar, Applied Physics A, 105, 417-425 (2011).
19. "Nanostructured Titanium/Diamond-like Carbon Multilayer Films: Deposition, Characterization and Applications" by Neeraj Dwivedi, Sushil Kumar and Hitendra Malik, Applied Materials & Interfaces Vol. 3, No. 11, pp 4268-4278 (2011).
20. "Studies of pure and nitrogen incorporated hydrogenated amorphous carbon films and their possible role in the development of efficient amorphous silicon solar cells", Neeraj Dwivedi, Sushil Kumar and Hitendra Malik, J. Appl. Phys. 111, 014908 (2012).

21. "Oxygen modified diamond-like carbon as a window layer for amorphous silicon solar cells" by Neeraj Dwivedi, Sushil Kumar, Sukhbir Singh and Hitendra Malik, *Solar Energy* 86, 220-230 (2012).
22. "Mechanical and structural properties of RF magnetron sputter deposited silicon carbide films for MEMS applications" by Atul Vir Singh, Sudhir Chandra, Sushil Kumar, G. Bose, *Journal of Micromechanics & Microengineering* 22(2), 025010 (2012).
23. "Investigation of radio frequency plasma for the growth of diamond like carbon films" by Ishpal, Sushil Kumar, Neeraj Dwivedi and C. M.S. Rauthan, *Physics of Plasmas* 19, 033515 (2012).
24. Band gap optimization of p-i-n layers of a-Si:H by computer aided simulation for development of efficient solar cell, Sukhbir Singh, Sushil Kumar and Neeraj Dwivedi, *Solar Energy*, Vol. 86, No. 5, pp. 1470-1476, (2012).
25. "Cost effective deposition system for nitrogen incorporated diamond-like carbon coatings" Sushil Kumar, Neeraj Dwivedi and M. K. Dalai, *Plasma Processes and Polymers* 9, 890-903 (2012).
26. "Superhard Behaviour, Low Residual Stress and Unique Structure in Diamond-Like Carbon Films by Simple Bilayer Approach: Deposition and Characterizations" by Neeraj Dwivedi, Sushil Kumar, and Hitendra Malik, *J. Appl. Phys* 102, 023518 (2012).
27. Structural and Electronic Characterization of Nanocrystalline Diamond-Like Carbon Thin Films" Author(s): Neeraj Dwivedi, Sushil Kumar, R. K Tripathi, J David Carey, Hitendra K Malik, M. K Dalai., *Applied Materials & Interfaces* 5, 5309 (2012) .
28. "Photoconductivity and Characterization of Nitrogen Incorporated Hydrogenated Amorphous Carbon Thin Films", by Neeraj Dwivedi, Sushil Kumar, J. David Carey, Hitendra Malik, and Govind, *J. Appl. Phys.* 112, 113706 (2012).
29. Strange hard characteristic of hydrogenated diamond like carbon thin films deposited by PECVD process", by Neeraj Dwivedi, Sushil Kumar and Hitendra Malik, *Appl. Phys. Lett.* 102, 011917(2013).
30. "Simulation approach for optimization of device structure and thickness of HIT solar cells to achieve ~ 27 % efficiency" by Neeraj Dwivedi, Sushil Kumar, Atul Bisht, Kamlesh Patel and S. Sudhakar, *Solar Energy* 88, 31-41 (2013).
31. "Influence of Silver Incorporation on the Structural and Electrical Properties of Diamond-Like Carbon Thin Films" by Neeraj Dwivedi, Sushil Kumara, J. David Carey, R. K. Tripathia, Hitendra K. Malik and M. K. Dalai, *ACS Applied Materials & Interfaces* 5(7), 2725-2732 (2013).
32. Optimization of Band Gap, Thickness and Carrier Concentrations for the Development of Efficient Microcrystalline Silicon Solar Cells: A Theoretical Approach" by Mansi Sharma, Sushil Kumar, Neeraj Dwivedi, Sucheta Juneja, A.K. Gupta, S. Sudhakar and Kamlesh Patel, *Solar Energy* 97, 176-185 (2013).
33. "Numerical simulations for high efficiency HIT solar cells using microcrystalline silicon as emitter and back surface field (BSF) layers", by Arti Rawat, Mansi Sharma, Deepika Chodhary, S. Sudhakar and Sushil Kumar, *Solar Energy* Vol 110, P 691-703 (2014).
34. "Structurally Driven Enhancement of Resonant Tunneling and Nano-mechanical Properties in Diamond-like Carbon Superlattices" by Neeraj Dwivedi, Ross McIntosh, Chetna Dhand, Sushil Kumar, Hitendra K. Malik, Somnath Bhattacharyya, *ACS Applied Materials & Interfaces*, 7, 20726-20735 (2015).
35. "Anomalous Electron Transport in Metal/Carbon Multijunction Devices by Engineering of the Carbon Thickness and Selecting Metal Layer" Neeraj Dwivedi, Chetna Dhand, Ishpal Rawal, Sushil Kumar and Hitendra Malik, Rajamani Lakshminarayanan, *Journal of Applied Physics* 121, 225101 (2017).
36. "Structural composition and thermal stability of extracted EVA from silicon solar modules waste; Chitra, Dheeraj Sah, Kaplana Lodhi, Chander Kant, Parveen Saini, Sushil Kumar *Solar Energy*, 211, 74-81 (2020).
37. "Solution Processable High Performance Multi Wall Carbon Nanotube-Heterojunctions, Neeraj Dwivedi, Chetna Dhand, Erik C. Anderson, Rajeev Kumar, Baochen Liao, Reuben J. Yeo, Raju Khan, J. David Carey, M. S. M. Saifullah, Sushil Kumar, Hitendra K. Malik, S. A. R. Hashmi, A. K. Srivastava, Subramanian K. R. S. Sankaranarayanan, Rolf Stangl, Shubham Duttgupta, *Adv. Electron. Mater.*, 6(11), 2000617(2020).
38. "Effect of Power on Crystallinity and Opto-Electronic Properties of Silicon Thin Films Grown Using VHF PECVD Process", Sucheta Juneja and Sushil Kumar, *Silicon* 13, 3927-3940 (2021).
39. "Sub-nano Crystalline Silicon Thin Films as Active Layer in Solar Cells", Mansi Sharma, Deepika Chaudhary, S. Sudhakar and Sushil Kumar, *Silicon*. 13, 1–7 (2021).
40. Anomalous Characteristics of Nanostructured Hydrogenated Carbon Thin Films, Neeraj Dwivedi, Chetna Dhand, Rajeev Kumar, Kalpana Lodhi, Jeet Vishwakarma, Ritesh Kumar Gupta, Pradip Kumar, S. A. R. Hashmi, Satanand Mishra, Hitendra K. Malik, Sushil Kumar, A. K. Srivastava; *Materials Chem. & Phy.* 262, 124316 (2021).
41. The rise of carbon materials for field emission, Neeraj Dwivedi, Chetna Dhand, J David Carey, Erik C Anderson, Rajeev Kumar, AK Srivastava, Hitendra K Malik, MSM Saifullah, Sushil Kumar, Rajamani Lakshminarayanan, Seeram Ramakrishna, Charanjit S Bhatia, Aaron Danner, *Journal*

- of Materials Chemistry C 9(8), 2620-2659 (2021).
42. "Numerical Simulation for Optimization of Ultra-thin n-type AZO and TiO₂ Based Textured p-type c-Si Heterojunction Solar Cells", Chandan Yadav and Sushil Kumar, Silicon 14, 4291-4299 (2022).
 43. "Solar photovoltaic quality control and waste management in India", Sushil Kumar, PV Magazine, (Opinion & Analysis), 2 July 2021.
 44. Efficiency measurement of organic solar cells using apex calibration facility at CSIR-National Physical Laboratory by Sushil Kumar, K.M.K. Srivatsa, S. Sudhakar, Preetam Singh, Pankaj Kumar, Ramil Bhardwaj, Rajiv Kumar Singh, Chander Kant, Shailesh N. Sharma, Vidyanand Singh, P. Pratap, Sanjay Kumar Srivastava, Vandana, C.M.S. Rauthan, Ashish Agarwal, Parag Sharma, V.K. Jaiswal, T. John, D. Shivagan and D.K. Aswal, Applied Solar Energy, 57(4) (2021).
 45. "Numerical simulation of novel designed perovskite/silicon heterojunction solar cell" Chandan Yadav and Sushil Kumar, Optical Materials 123, 111847 (2022).
 46. "Efficiency measurement of organic solar cells : Step by step protocol to be followed", Mehak Ahuja, Samya Naqvi, Amit Kumar, Rachana Kumar, Rajiv Singh, Sushil Kumar, MAPAN, 37, 311–318 (2022).
 47. "Extraction and Analysis of Recovered Silver and Silicon from Laboratory Grade Waste Solar Cells", Dheeraj Sah, Chitra, Kaplana Lodhi, Chander Kant, Sushil Kumar, Silicon (10.1007/s12633-022-01715-6) (2022).
 48. "Boron induced crystallization: an alternate way to crystallize amorphous silicon films." Sucheta Juneja, Sushil Kumar, Silicon 151, DOI 10.1007/s12633-022-01738-z (2022).
 49. "Recovery and Analysis of Valuable Materials from a Discarded Crystalline Silicon Solar Module", Dheeraj Sah, Chitra and Sushil Kumar, Solar Energy Materials and Solar Cells 246, 111908 (2022).
 50. "Recovery and analysis of polymeric layers from waste solar modules by chemical route", Chitra, Dheeraj Sah, Parveen Siani and Sushil Kumar, Solar Energy 244, 31-39 (2022).

Patents

- European Patent No. # EP 2398933 B1, Granted on Aug. 07, 2013:
Title: "Process to deposit diamond like carbon as protective coating on inner surface of a shaped object" Inventor: Sushil Kumar, P.N. Dixit and C.M.S. Rauthan.
- US Patent No. # US 8586151 B2, Granted on Nov. 19, 2013:
Title: "Process for the preparation of photoluminescent nanostructured silicon thin films using radio frequency plasma discharge" Inventor: Sushil Kumar, P.N. Dixit and C.M.S. Rauthan.
- Taiwan Patent No. # TW I450320 B Granted on Aug. 21, 2014:
Title: "A process for the preparation of photo luminescent nanostructured silicon thin films", Inventor: Sushil Kumar, P.N. Dixit and C.M.S. Rauthan.
- European Patent No. # EP 2589680 B1, Granted on Dec. 24, 2014:
Title: "Apparatus for the deposition of diamondlike carbon as protective coating on an inner surface of a shaped object", Inventor: Sushil Kumar, P.N. Dixit and C.M.S. Rauthan.
- Japan Patent No. # 5795266, Granted on 21 August 2015,
Title: "Process to deposit diamond like carbon as protective coating on inner surface of a shaped object", Inventor: Sushil Kumar, P.N. Dixit and C.M.S. Rauthan.
- Indian Patent No. # 270971, Granted on 28 Jan. 2016,
Title: "An Process to deposit diamond like carbon as protective coating on inner surface of a shaped object" , Inventor: Sushil Kumar, P.N. Dixit and C.M.S. Rauthan
- US Patent No. # US 9260781 B2, Granted on Feb. 16, 2016
Title: "Process to deposit Diamond like carbon as surface of a shaped object", Inventor: Sushil Kumar, P.N. Dixit and C.M.S. Rauthan
- Korean Patent No. # 10-1660557, Granted on 21 September 2016,
Title: "Process to Deposit Diamond Like Carbon as Protective Coating on Inner Surface of a Shaped Object", Inventor: Sushil Kumar, P.N. Dixit and C.M.S. Rauthan
- Patent Application: 0162NF2022 (Filed)
Title: A scalable and environment friendly process for the recycling of pharmaceutical blister packaging for recovery of metallic & polymeric fractions and their exploitation for technological application". Inventors: Parveen Saini, Anuj, Neha, and Sushil Kumar
- Patent Application: 0137NF2022 (Filed)
Title: "Ionic-asymmetric aliphatic diamine terminated rylene dicarboximide organic electronic materials" Inventors: Rachana Kumar, Samya Naqvi, Mehak Ahuja, Komal Bhardwaj, Rajiv K. Singh, Asit Patra and Sushil Kumar.

Current Activities

Presently heading Photovoltaic Metrology Section of CSIR-NPL towards development of primary & secondary standards for solar cells; development of waste management technologies such as recycling of waste solar modules, plastic wastes and other electronic wastes for their societal applications; silicon based hetero-junction solar cells covering basic and applied research spanning from wafer based silicon photovoltaic technology, thin film to latest concepts such as organic and perovskites, organic/inorganic heterostructures based solar cells.

Honour(s)/Award(s)/ Fellowship(s)

- Member of national committee for the formation on white paper on green initiatives in solar PV in marine sector (Ministry of Ports, Shipping and Waterways, Govt. of India), 2022.
- Member of Task Force for setting up project of manufacturing solar cells and modules at Central Electronics Ltd., A Govt. of India Enterprise (10 Feb 2021-09 Feb 2024).
- Member Governing Council of National Institute of Solar Energy (NISE), Ministry of New & Renewable Energy (MNRE), Govt. of India, (15 Jan. 2021- 14 Jan.2024)
- Member of core expert panel for solar energy research and development: Applied Research Solar Stream, Department of Science and Technology (DST), Govt. of India, 2020.
- Technical Review Committee Member of DST, Govt. of India for "IEST Solar PV HUB" for Five Years (August 2018 – July 2023).
- Member of Board of Studies, University School of Basic and Applied Sciences, Guru Govind Singh Indraprastha University, New Delhi for two Years (September 2019 – August 2021)
- Editorial Board Member, Indian Journal of Pure & Applied Physics (IJPAP) (2022-2025)
- Guest Editor of Vacuum, Elsevier (Special Issue, Volume 152, June 2018)
- Certificate of Outstanding Contribution in Reviewing, Thin Solid Films (Elsevier), April 2017
- Springer & Indian Vacuum Society (IVS) Best Paper Presentation award conferred at 17th International Conference on Thin Films 2017
- "Outstanding Scientist Award" (In Science / Thin Films) by Venus International Foundation, Chennai, 2015
- Guest Editor Journal of Nano Materials (Special Issue: Functional Nanomaterials for Electronics, Optoelectronics, and Bioelectronics, 2015)
- Editor of Journal of Nano Materials (Hindwai Publishing Corporation,) [During 2013-15]
- Editor of ISST-Journal of Applied Physics (India) (Since 2010)
- Optical Society of India Best Poster Award conferred at 30th Symposium on optics and Opto-Electronics 2005
- Young Scientist Award (In Physical Sciences), CSIR, INDIA, 2003.
- BOYSCAST Fellowship, Department of Science and Technology (DST), Govt. of India, 2002.
- IEEE (India) EDS & MTT Chapter Best Poster Award conferred at 10th International Workshop on Physics of Semiconductor Device 1999

Contributions to AcSIR

- Professor (Honorary) (04 Sept. 2020 to till date), Academy of Scientific & Innovative Research (AcSIR), Ghaziabad [An Institution of National Importance, by Act of Parliament]
- Associate Professor (Honorary) (28 March 2014 to 03 Sept. 2020), AcSIR Ghaziabad
- Course coordinator & faculty for Thin Film Physics & Technology
- Supervision Ph.D students (6 Nos. Perusing, 5 Nos. Completed)
- Member of Doctoral Advisory Committees (DAC) for students

Membership of Professional Societies/ Institutions

- Solar Energy Society of India
- Material Society of India
- Society of Vacuum Coaters, USA
- Metrology Society of India

Any other Information

Industrial Experience: Fabrication of Amorphous Silicon Solar Modules (1 ft X1 ft and 3ft x 1 ft) through in-line-process (Glass-in to Module-out) and its Characterization at M/s B.H.E.L., Gurgaon, Haryana, India. (Six Months, during 1995)