Brief Résumé with Most Cited and Recent Publications

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Education:
Ph.D**. (1971)** and M.S. **(1970)** University of California, Berkeley; B. Tech. **(1969** University First Rank Medalist, Highest Hons. & Dist.) I.I.T., Kanpur, India; 1997 IITK Distinguished Alumnus Award; Major Field: Materials Science and Engineering; Minor fields: Electrical Engineering and Solid State Physics

Employment:

2002-	The John C. C. Fan Family Distinguished Chair Professor
1990-	Distinguished University Professor (Materials Science and Engineering, ECE and Physics) and Director of Center for Advanced Materials and Smart Structures
2007-	ORNL Distinguished Guest Scientist
1990-92	National Science Foundation, Division of Materials Research (DMR), Director (The DMR is the largest research division of the NSF with over $300M annual budget funding in Advanced Materials, Nanostructured Materials. Materials Physics, Materials Chemistry, Polymers, MRSEC Centers and many Interdisciplinary Programs across the Foundation)
1983-	North Carolina State University, Professor (MSE, Physics and ECE)
1984-86	Microelectronics Center of North Carolina, Director (MCNC was funded by the State of North Carolina under the Microelectronics Initiative)
1972-84	Oak Ridge National Laboratory, Senior Scientist and Leader of Thin Film and Electron Microscopy Group (Funded by DOE Basic Energy Sciences)
1971-72	Lawrence Berkeley National Laboratory, Research Metallurgist

Honors and Awards:

1) **National Academy of Engineering (NAE Life Member https://www.nae.edu/165651.aspx); National Academy of Inventors (NAI Life Fellow); National Academy of Sciences**, **India (NAS-I Life Member and Fellow, Limited to 100 Foreign Members)**; Materials Research Society (Member and **Inaugural Fellow**); American Physical Society (Life Member and **Fellow**); The Minerals, Metals and Materials Society (TMS Life Member and **Fellow**, **Limited to 100 Members Worldwide**); American Association for the Advancement of Science (AAAS **Fellow**); ASM International (**Fellow**); MRS-I (**Honorary Member**); Bohmische Physical Society (**Fellow**)
2) **Materials Gold Medals:** 1999 **ASM-International Gold Medal** (Highest honor from world's largest materials science and technology society); **2014 TMS Robert Franklin Mehl Gold Medal** and The Institute of Metals Lecture Award (Pinnacle Honor from the World's oldest -152 years old- professional society); **2011 Acta Materialia Gold Medal** and Prize for pioneering contributions and leadership in materials science worldwide, highest materials science prize sponsored by the federation of 33 professional societies.
3) **North Carolina/University Awards:** 2014 North Carolina Science Award (***Highest Civilian Honor of the State of North Carolina***) bestowed by the Honorable Governor of North Carolina, first Materials

Scientist and the sole winner at the Golden Jubilee Celebrations of the North Carolina Awards. (Past winners included seven Nobel Laureates); 2014 O. Max Gardner Award and Prize, (***Highest Honor of the UNC System for the Greatest Scientific Contribution to the Welfare of the Human Race***); 2012 Alexander Holladay Medal (**Highest NC State Faculty Honor**); 2011 Reynolds Prize (**Highest NCSU honor for excellence in research, teaching and extension**). The award of these pinnacle honors in a span of four years is unprecedented in the UNC and North Carolina history.

4) **The Oscars of Innovation: 2019 R&D**-100 Award (Nanodiamonds for Nanosensing and Quantum Computing); **2018 R&D-100 Award** (New Materials Harder than Diamond and Superior High-Temp Superconductor); **2017 R&D-100 Award** (Q-carbon and Diamond Related Materials); **IR-100 Award (1979)** for Laser Diffused p-n Junctions and Solar Cells; **IR-100 Award (1982)** for Novel Supersaturated Semiconductor Alloys; **IR-100 Award (1983)** for New Nanocrystalline Metal-Ceramic Composites.
5) **Other Honors:** 2021 John Goodenough Materials Innovation Lecture; 2023 NanoFlorida Plenary Speaker; 2011 Lee Hsun Lecture Award from the Chinese Academy of Sciences; 2014 TMS Institute of Metals/RF Mehl Lecture Award; 2015 Professor SC Jain Memorial Lecture and Prize; 2015 Emerging Materials Research Prize; 2004 ASM Edward DeMille Campbell Lecture (New Frontiers in Thin Film Growth and Nanomaterials) and Prize; DOE (Div. of Materials Sciences) Award for Outstanding Research (1981); 2011 MRS Acta Gold Medal Symposium (Honoring Professor Narayan); 2005 TMS Symposium on NEW FONTIERS IN THIN FILM GROWTH AND NANOMATERIALS held in honor of Professor Narayan at the 134th TMS Annual Meeting in San Francisco; Journal of Electronic Materials (May 2006 Issue) Published honoring Professor Narayan; 2003 Electronic Products Magazine's "Product of the Year" Award; 1992 NSF Distinguished Service Award; 1997 IIT/K Distinguished Alumnus Award; http://chronicle.com/article/Electronics-Pioneer-Sheds/65783/.
6) **Special Honors and Appointments:**
   NAE Search Committee: Vice Chair (2022-23); Chair (2023-24); Past Chair (2024-25).
   Most Notable People in ORNL history:
   https://en.wikipedia.org/wiki/Oak_Ridge_National_Laboratory.
   Member of CMMRC: Condensed Matter and Materials Research Committee of National Academies (NAS, NAE, and NAM).
   Director of NSF Division of Materials Research: National Science Foundation and NSF Distinguished Service Award (1990-1992*).*
   American Institute of Physics (AIP) Oral History Interviews | Jagdish Narayan https://www.aip.org › niels-bohr-library › oral-histories https://www.aip.org/history-programs/niels-bohr-library/oral-histories/47106
7) **Research Funding (>$40M):** NSF, ARO, DARPA, ONR, AFSOR, ORNL DOE (BES), Kopin Corp., Q-Carbon, LLC, NOV (Houston). Graduated >90 PhDs and Trained >100 Postdocs and Senior Scientists

Important US PATENTS of Professor Narayan (from USPTO Website) (Total: 48)

11,189,774 High-temperature carbon-based superconductor: B-doped Q-carbon

11,746,016 Direct conversion of Teflon tape into diamond, Q-carbon, and graphene

11,011,514		DOPING AND FABRICATION OF DIAMOND AND C-BN BASED DEVICE STRUCTURES
10,586,702		Synthesis and processing of novel phase of carbon (Q-carbon)
10,906,104		Systems and methods of fabrication and use of wear-resistant materials
10,566,193	T	Synthesis and processing of Q-carbon, graphene, and diamond
10,529,564	T	Synthesis and processing of novel phase of boron nitride (Q-BN)
10,240,251	T	Synthesis and processing of pure and NV nanodiamonds and other nanostructures for quantum computing and magnetic sensing applications
10,211,049	T	Synthesis and processing of pure and NV nanodiamonds and other nanostructures
10,196,754	T	Conversion of carbon into n-type and p-type doped diamond and structures
8,222,740	T	Zinc oxide based composites and methods for their fabrication
7,994,105	T	Lubricant having nanoparticles and microparticles to enhance fuel efficiency, and a laser synthesis method to create dispersed nanoparticles
7,803,717	T	Growth and integration of epitaxial gallium nitride films with silicon-based devices
7,122,841	T	Bonding pad for gallium nitride-based light-emitting devices
7,105,118	T	Methods of forming three-dimensional nanodot arrays in a matrix
6,955,985	T	Domain epitaxy for thin film growth
6,881,983	T	Efficient light emitting diodes and lasers
6,847,052	T	Light-emitting diode device geometry
6,734,091	T	Electrode for p-type gallium nitride-based semiconductors
6,518,077	T	Method for making optoelectronic and microelectronic devices including cubic ZnMgO and/or CdMgO alloys
6,423,983	T	Optoelectronic and microelectronic devices including cubic ZnMgO and/or CdMgO alloys
5,453,153	T	Zone-melting recrystallization process
5,406,123	T	Single crystal titanium nitride epitaxial on silicon
5,221,411	T	Method for synthesis and processing of continuous monocrystalline diamond thin films
5,208,182	T	Dislocation density reduction in gallium arsenide on silicon heterostructures
5,063,202	T	High transition temperature superconductors

US Patents on Q-carbon and Q-silicon Improve Performance of Lithium-Ion Batteries (Pending):

https://news.ncsu.edu/2023/02/defects-improve-lithium-ion-battery-performance/

(1) **J. Narayan, Q-carbon and Q-silicon anodes to create high-performance batteries, US Patent** D2024-0006 (2023)

(2) **J. Narayan, Discovery of Q-silicon with many outstanding properties and novel applications, US Patent,** D2023-0118 (2023)
(3) **J. Narayan, Laser processing and Q-carbon improving current capacity in lithium ion batteries (LIBs), US Patent** D2022-0043 (2022)
(4) **J. Narayan, Formation of Novel Q-carbon and Q-BN Nanoballs, US Patent** D2021-0283 (2021)

TEN MOST RELEVANT PAPERS:

1. J. Narayan, V.P. Godbole, and C. W. White, **Laser Method for Synthesis and Processing of Continuous Diamond Films on Nondiamond Substrates, SCIENCE** 1991, 252, 416-418. DOI: 10.1126/science.252.5004.416 Highlighted by Ivan Amato ***SCIENCE*** 1991, 252, 375. DOI: 10.1126/science.252.5004.375

2. A. Bhaumik, R. Sachan, S. Gupta, and J. Narayan**, Discovery of High-Temperature Superconductivity (T_c = 55 K) in B-Doped Q-Carbon**, *ACS Nano* 2017, *11*, 11915–11922. https://doi.org/10.1021/acsnano.7b06888

3. J. Narayan, and B. C. Larson, Domain epitaxy: A unified paradigm for thin film growth, Journal of Applied Physics 93 (1), 278-285 (2003). https://doi.org/10.1063/1.1528301

4. J. Narayan, S. Gupta, A. Bhaumik, R. Sachan, F. Cellini, and E. Riedo, **Q-Carbon Harder than Diamond,** MRS Communications 2018, Volume 8, 428 – 436. https://doi.org/10.1557/mrc.2018.35

5. J. Narayan, and A. Bhaumik, **A. Novel Phase of Carbon, Ferromagnetism, and Conversion into Diamond,** J. Appl. Phys. 2015, 118, 215303. https://doi.org/10.1063/1.4936595

6. J. Narayan, P. Joshi, J. Smith, W. Gao, W.J. Weber, and R.J. Narayan, **Q-carbon as a new radiation-resistant material,** Carbon 2021, 186, 253-261. https://doi.org/10.1016/j.carbon.2021.10.006

7. J. Narayan and Bhaumik, **Novel Synthesis and Properties of Pure and NV-Doped Nanodiamonds and Other Nanostructures,** Mater. Res. Lett. 2017, 5(4) 242-250. https://doi.org/10.1080/21663831.2016.1249805

8. RK Singh and J Narayan, **Pulsed-laser evaporation technique for deposition of thin films: Physics and theoretical model,** Physical review B 41 (13), 8843 (1990).
9. H. Conrad and J. Narayan, **On the grain size softening in nanocrystalline materials**, Scripta materialia 42 (11), 1025-1030 (2000).
10. CW White, J Narayan, RT Young, Laser annealing of ion-implanted semiconductors, Science 204 (4392), 461-468 (1979). DOI: 10.1126/science.204.4392.461

MOST CITED from Web of Science (Total >800, Citations >35K, h-index >92, i10 index > 540):

1) III–nitrides: Growth, characterization, and properties, SC Jain, M Willander, J Narayan, RV Overstraeten, Journal of Applied Physics 87 (3), 965-1006 (2000)
2) Pulsed-laser evaporation technique for deposition of thin films: Physics and theoretical model, RK Singh, J Narayan, Physical review B 41 (13), 8843 (1990)
3) Domain epitaxy: A unified paradigm for thin film growth, J Narayan, BC Larson, Journal of Applied Physics 93 (1), 278-285 (2003)
4) Optical and structural properties of MgZnO epitaxial alloys
AK Sharma, J Narayan, JF Muth, CW Teng, C Jin, A Kvit, RM Kolbas,, Applied Physics Letters 75 (21), 3327-3329 (1999)
5) On the grain size softening in nanocrystalline materials, H Conrad, J Narayan, Scripta materialia 42 (11), 1025-1030 (2000)
6) Excitonic structure and absorption coefficient measurements of ZnO single crystal epitaxial films deposited by pulsed laser deposition, JF Muth, RM Kolbas, AK Sharma, S Oktyabrsky, J Narayan, Journal of Applied Physics 85 (11), 7884-7887 (1999)
7) ZnO:Co-based diluted magnetic semiconducting thin films, S Ramachandran, A Tiwari, J Narayan, Applied Physics Letters 84 (25), 5255-5257 (2004)
8) Electrical properties of transparent and conducting Ga doped ZnO, V Bhosle, A Tiwari, J Narayan, Journal of Applied Physics 100 (3), 033713(2006)
9) Theoretical model for deposition of superconducting thin films using pulsed laser evaporation technique, RK Singh, OW Holland, J Narayan, Journal of applied physics 68, 233-247(1990)
10) Epitaxial growth of TiN films on (100) silicon substrates by laser physical vapor deposition
J Narayan, P Tiwari, X Chen, R Chowdhury, T Zheleva, Applied physics letters 61, 1290 (1992)
11) Structural, optical and magnetic properties of diluted magnetic semiconducting Zn1− xMnxO films, A Tiwari, C Jin, A Kvit, D Kumar, JF Muth, J Narayan, Solid State Communications 121 (6-7), 371-374 (2002)
12) Metallic conductivity and metal-semiconductor transition in Ga-doped ZnO, V Bhosle, A Tiwari, J Narayan, Applied Physics Letters 88 (3), 032106 (2006)
13) Ferromagnetism in Co doped : Observation of a giant magnetic moment with a high Curie temperature, A Tiwari, VM Bhosle, S Ramachandran, N Sudhakar, J Narayan, S Budak,, Applied physics letters 88 (14), 142511 (2006)
14) Laser annealing of boron-implanted silicon, RT Young, CW White, GJ Clark, J Narayan, WH Christie, M Murakami, Applied Physics Letters 32 (3), 139-141 (1978)
15) Defects and interfaces in epitaxial ZnO heterostructures, J Narayan, K Dovidenko, AK Sharma, S Oktyabrsky, Journal of Applied Physics 84 (5), 2597-2601 (1998)
16) Dislocation–twin interactions in nanocrystalline fcc metals, YT Zhu, XL Wu, XZ Liao, J Narayan, LJ Kecskés, SN Mathaudhu, Acta Materialia 59 (2), 812-821(2011)
17) Room temperature ferromagnetism in ZnO:Cu thin films, D Chakraborti, J Narayan, JT Prater, Applied Physics Letters 90 (6), 062504 (2007)
18) Formation of thin superconducting films by the laser processing method, J Narayan, N Biunno, R Singh, OW Holland, O Auciello, Applied physics letters 51 (22), 1845-1847 (1987)
19) Refractive indices and absorption coefficients of MgZnO alloys, CW Teng, JF Muth, MJ Bergmann, HO Everitt, AK Sharma, C Jin, Applied Physics Letters 76 (8), 979-981 (2000)
20) *In situ* processing of epitaxial Y-Ba-Cu-O high T_c superconducting films on (100) $SrTiO_3$ and (100) YS-ZrO_2 substrates at 500–650 °C, RK Singh, J Narayan, AK Singh, J Krishnaswamy

Applied physics letters 54 (22), 2271-2273 (1989)
21) Phase transition and critical issues in structure-property correlations of vanadium oxide
J Narayan, VM Bhosle, Journal of Applied Physics 100 (10), 103524 (2006)
22) Epitaxial growth of AlN thin films on silicon (111) substrates by pulsed laser deposition
RD Vispute, J Narayan, H Wu, K Jagannadham, Journal of applied physics 77, 4724 (1995)
23) Laser method for synthesis and processing of continuous diamond films on nondiamond substrates, J Narayan, VP Godbole, CW White, Science 252 (5004), 416-418 (1991)
24) Effect of oxygen annealing on Mn doped ZnO diluted magnetic semiconductors, S Ramachandran, J Narayan, JT Prater, Applied Physics Letters 88 (24), 242503 (2006)
25) Interface structures during solid-phase-epitaxial growth in ion implanted semiconductors and a crystallization model, J Narayan, Journal of Applied Physics 53 (12), 8607-8614 (1982)
26) High quality epitaxial aluminum nitride layers on sapphire by pulsed laser deposition
RD Vispute, H Wu, J Narayan, Applied physics letters 67 (11), 1549-1551 (1995)
27) Gallium-doped zinc oxide films as transparent electrodes for organic solar cell applications
V Bhosle, JT Prater, SR Forrest, J Narayan, Journal of Applied Physics 102 (2), 023501 (2007)
28) Structural characteristics of AlN films deposited by pulsed laser deposition and reactive magnetron sputtering: A comparative study, K Jagannadham, AK Sharma, Q Wei, R Kalyanraman, J Narayan, Journal of Vacuum Science & Technology A 16 (5 …} (1998)
29) Laser annealing of ion-implanted semiconductors, CW White, J Narayan, RT Young, Science 204 (4392), 461-468 (1979)
30) Thin-film deposition by a new laser ablation and plasma hybrid technique, J Krishnaswamy, A Rengan, J Narayan, K Vedam, CJ McHargue, Applied physics letters 54 (24), 2455 (1989)
31) Aluminum nitride films on different orientations of sapphire and silicon, K Dovidenko, S Oktyabrsky, J Narayan, M Razeghi, Journal of Applied Physics 79 (5), 2439-2445(1996)
32) Subsurface heating effects during pulsed laser evaporation of materials, RK Singh, D Bhattacharya, J Narayan, Applied physics letters 57 (19), 2022-2024 (1990)
33) Low-temperature resistivity minima in colossal magnetoresistive La 0.7 Ca 0.3 MnO 3 thin films, D Kumar, J Narayan, RK Singh, AK Majumdar, Physical Review B 65 (9), 094407 (2002)
34) Epitaxial growth in large-lattice-mismatch systems, T Zheleva, K Jagannadham, J Narayan Journal of applied physics 75 (2), 860-871 (1994)
35) Nondestructive depth profiling by spectroscopic ellipsometry, K Vedam, PJ McMarr, J Narayan, Applied physics letters 47 (4), 339-341 (1985)
36) Spectroscopic ellipsometry: A new tool for nondestructive depth profiling and characterization of interfaces, PJ McMarr, K Vedam, J Narayan, Journal of applied physics 59 (3), 694 (1986)
37) Novel cubic ZnxMg1− xO epitaxial heterostructures on Si (100) substrates, J Narayan, AK Sharma, C Jin, JF Muth, OW Holland, Solid state communications 121 (1), 9-13 (2001)
38) A novel method for simulating laser-solid interactions in semiconductors and layered structures, RK Singh, J Narayan, Materials Science and Engineering: B 3 (3), 217-230 (1989)
39) Ion implantation damage and annealing in germanium, OW Holland, BR Appleton, J Narayan, Journal of Applied Physics 54 (5), 2295-2301(
40) *p-n* junction formation in boron-deposited silicon by laser-induced diffusion
J Narayan, RT Young, RF Wood, WH Christie, Applied Physics Letters 33 (4), 338-340 (1978)
41) A new mechanism for field-assisted processing and flash sintering of materials
J Narayan, Scripta Materialia 69 (2), 107-111 (2013)

Narayan's most recent Publications:

1) Synthesis and novel properties of Q-silicon, Narayan, J., Sahoo, S., Joshi, N., and Narayan, R. (2023) Materials Research Letters, 11, 688 ***DOI:*** **10.1080/21663831.2023.2224396**

2) **Discovery of double helix of screw dislocations: a perspective,** Narayan, J. (2021), MATERIALS RESEARCH LETTERS, 11. https://doi.org/10.1080/21663831.2021.1973131

3) Dislocation does the twist with a double helix, Discovery of Double Helix by J. Narayan Highlighted MRS Bulletin 47, 651-652 (2022).

4) **Atomic-Scale Insights on Large-Misfit Heterointerfaces in LSMO/MgO/c-Al2O3,** Mandal, S., Gupta, A. K., Beavers, B. H., Singh, V., Narayan, J., & Sachan, R. (2021), CRYSTALS, 12. https://doi.org/10.3390/cryst11121493

5) Khosla, N., Narayan, J., Narayan, R., Sun, X. G., & Paranthaman, M. P. (2023). Nanosecond Laser Annealing of NMC 811 Cathodes for Enhanced Performance. *Journal of The Electrochemical Society*. https://iopscience.iop.org/article/10.1149/1945-7111/acc27d/meta

6) Khosla, N., Narayan, J., Narayan, R., Sun, X.-G., & Paranthaman, M. P. (2023). Microstructure and defect engineering of graphite anodes by pulsed laser annealing for enhanced performance of lithium-ion batteries. CARBON, 205, 214–225. https://doi.org/10.1016/j.carbon.2023.01.009

7) Narayan, J., & Narayan, R. (2022). Discovery of Double Helix and Impact on Nanoscale to Mesoscale Crystalline Structures. ACS OMEGA, 7(29), 25853–25859. https://doi.org/10.1021/acsomega.2c03501

8) Riley, P. R., Yang, K.-H., Liu, Y., Skoog, S. A., Narayan, J., & Narayan, R. J. (2022, June 21). Effect of oxygen and fluorine plasma surface treatment of silicon-incorporated diamond-like carbon coatings on cellular responses of mouse fibroblasts. INTERNATIONAL JOURNAL OF APPLIED CERAMIC TECHNOLOGY, Vol. 6. https://doi.org/10.1111/ijac.14107

9) Joshi, P., Shukla, S., Gupta, S., Riley, P. R., Narayan, J., & Narayan, R. (2022). Excimer Laser Patterned Holey Graphene Oxide Films for Nonenzymatic Electrochemical Sensing. ACS APPLIED MATERIALS & INTERFACES, 14(32), 37149–37160. https://doi.org/10.1021/acsami.2c09096

10) Gupta, S., Joshi, P., Sachan, R., & Narayan, J. (2022). Fabricating Graphene Oxide/h-BN Metal Insulator Semiconductor Diodes by Nanosecond Laser Irradiation. NANOMATERIALS, 12(15). https://doi.org/10.3390/nano12152718

11) Khosla, N., & Narayan, J. (2022). Fabrication of Q-Carbon Nanostructures, Diamond and Their Composites with Wafer-Scale Integration. CRYSTALS, 12(5). https://doi.org/10.3390/cryst12050615

12) Riley, P. R., Joshi, P., Khosla, N., Narayan, R. J., & Narayan, J. (2022). Formation of Q-carbon with wafer scale integration. CARBON, 196, 972–978. https://doi.org/10.1016/j.carbon.2022.06.003

13) Cui, Z., Khosla, N., Lai, T., Narayan, J., & Manthiram, A. (2022, December 27). Laser-Assisted Surface Lithium Fluoride Decoration of a Cobalt-Free High-Voltage Spinel LiNi0.5Mn1.5O4 Cathode for Long-Life Lithium- Ion Batteries. ACS APPLIED MATERIALS & INTERFACES, Vol. 12. https://doi.org/10.1021/acsami.2c18918

14) Joshi, P., Riley, P. R., Denning, W., Shukla, S., Khosla, N., Narayan, J., & Narayan, R. (2022, January 13). Laser-patterned carbon coatings on flexible and optically transparent plastic substrates for advanced biomedical sensing and implant applications. JOURNAL OF MATERIALS CHEMISTRY C, Vol. 1. https://doi.org/10.1039/d1tc05176h

15) Narayan, J., Joshi, P., Smith, J., Gao, W., Weber, W. J., & Narayan, R. J. (2022). Q-carbon as a new radiation-resistant material. CARBON, 186, 253–261. https://doi.org/10.1016/j.carbon.2021.10.006

16) Narayan, J., & Khosla, N. (2022). Self-organization of amorphous Q-carbon and Q-BN nanoballs. CARBON, 192, 301–307. https://doi.org/10.1016/j.carbon.2022.03.003

17) Self-organization of amorphous Q-carbon and Q-BN nanoballs, J Narayan, N Khosla, Carbon 192, 301-307 (2022)

18) Spin Engineering of VO_2 Phase Transitions and Removal of Structural Transition, A Moatti, G Mineo-Foley, S Gupta, R Sachan, J Narayan, ACS Applied Materials & Interfaces 14 (10), 12883-12892 (2022)

19) DOUBLE HELIX DISCOVERY IMPACTS MATERIALS SYNTHESIS FROM NANOSCALE TO MESOSCALE, J Narayan, Advanced Materials & Processes 180 (1), 24-28 (2022)

20) Doping and fabrication of diamond and C-BN based device structures, J Narayan, US Patent 11,011,514 (2021)

21) Riley, P. R., & Narayan, R. J. (2021). Recent advances in carbon nanomaterials for biomedical applications: A review. *Current Opinion in Biomedical Engineering*, *17*, 100262.

22) Riley, P. R., Joshi, P., Azizi Machekposhti, S., Sachan, R., Narayan, J., & Narayan, R. J. (2021). Enhanced Vapor Transmission Barrier Properties via Silicon-Incorporated Diamond-Like Carbon Coating. *Polymers*, *13*(20), 3543.

23) Joshi, P., Riley, P. R., Mishra, R., Azizi Machekposhti, S., & Narayan, R. (2022). Transdermal Polymeric Microneedle Sensing Platform for Fentanyl Detection in Biofluid. *Biosensors*, *12*(4), 198.

24) Joshi, P., Riley, P. R., Denning, W., Shukla, S., Khosla, N., Narayan, J., & Narayan, R. (2022). Laser-patterned carbon coatings on flexible and optically transparent plastic

substrates for advanced biomedical sensing and implant applications. *Journal of Materials Chemistry C*.

25) . Narayan, J., Joshi, P., Smith, J., Gao, W., Weber, W. J., & Narayan, R. J. (2022). Q-carbon as a new radiation-resistant material. *Carbon*, *186*, 253-261.

26) Joshi, P., Riley, P. R., Denning, W., Shukla, S., Khosla, N., Narayan, J., & Narayan, R. (2022). Laser-patterned carbon coatings on flexible and optically transparent plastic substrates for advanced biomedical sensing and implant applications. *Journal of Materials Chemistry C*.

27) Joshi, P., Riley, P. R., Mishra, R., Azizi Machekposhti, S., & Narayan, R. (2022). Transdermal Polymeric Microneedle Sensing Platform for Fentanyl Detection in Biofluid. *Biosensors*, *12*(4), 198.

Selected Recent Archival Journal Papers with Q-carbon and Q-BN Discoveries:

(1) B-doped Q-carbon has a new record for BCS high-temperature superconductivity with T_c over 55K and going higher, and carries record critical current density in the presence of magnetic field (superconducting qubits and Majorana Fermion based devices):

1. Bhaumik, A.; Sachan, R.; Narayan, J. High-Temperature Superconductivity in Boron-Doped Q-Carbon. *ACS Nano* **2017**, *11*, 5351–5357.
2. Bhaumik, A.; Sachan, R.; Gupta, S.; Narayan, J. Discovery of High-Temperature Superconductivity (T c = 55 K) in B-Doped Q-Carbon. *ACS Nano* **2017**, *11*, 11915–11922.
3. Bhaumik, A.; Sachan, R.; Narayan, J. A Novel High-Temperature Carbon-Based Superconductor: B-Doped Q-Carbon. *J. Appl. Phys.* **2017**, *122*, 45301.
4. Bhaumik, A.; Sachan, R.; Narayan, J. Magnetic Relaxation and Three-Dimensional Critical Fluctuations in B-Doped Q-Carbon – a High-Temperature Superconductor. *Nanoscale* **2018**, 10, 12665–12673.
5. Narayan, J.; Bhaumik, A.; Sachan, R. High Temperature Superconductivity in Distinct Phases of Amorphous B-Doped Q-Carbon. *J. Appl. Phys*. **2018**, 123, 135304.
6. Narayan, J.; Sachan, R.; Bhaumik, A. Search for near Room-Temperature Superconductivity in B-Doped Q-Carbon. *Mater. Res. Lett*. **2019**, 7, 164–172.
7. Sachan, R.; Hatchtel, J.; Bhaumik, A.; Moatti, A.; Prater, J.; Idrobo, J.; and Narayan, J. Emergence of shallow energy levels in B-doped Q-carbon: A high-temperature superconductor. Acta Materialia **2019,** 174, 153-159.
8. Bhaumik, Anagh, and Jagdish Narayan. "Structure–property correlations in phase-pure B-doped Q-carbon high-temperature superconductor with a record T c= 55 K." ***Nanoscale***, 2019,**11**, 9141-9154

(2) Pure (undoped) Q-carbon is ferromagnetic with robust RTFM and extraordinary Hall Effect (biocompatible magnetic devices and sensors):

1. Narayan, J.; Bhaumik, A. Novel Phase of Carbon, Ferromagnetism, and Conversion into Diamond. *J. Appl. Phys.* **2015**, *118*, 215303.
2. Bhaumik, A.; Nori, S.; Sachan, R.; Gupta, S.; Kumar, D.; Majumdar, A. K.; Narayan, J. Room-Temp Ferromagnetism and Extraordinary Hall Effect in Nanostructured Q-Carbon: Implications for Potential Spintronic Devices. *ACS Appl. Nano Mater.* **2018**, *1*, 807–819.

(3) Q-carbon is harder (tougher and more adherent) than diamond (cutting tools and coatings):

1. Narayan, J.; Gupta, S.; Bhaumik, A.; Sachan, R.; Cellini, F.; Riedo, E. Q-Carbon Harder than Diamond. *MRS Commun.* 8, 428 (**2018**).
2. Narayan, J.; Bhaumik, A. Q-Carbon Discovery and Formation of Single-Crystal Diamond Nano- and Microneedles and Thin Films. *Mater. Res. Lett.* **2016**, *4*, 118–126.
3. Narayan, J.; Bhaumik, A. Research update: Direct conversion of amorphous carbon into diamond at ambient pressures and temperatures in air. *APL Mater.* **2015**, *3*, 100702.
4. Gupta, S.; Bhaumik, A.; Sachan, R.; Narayan, J. Structural Evolution of Q-Carbon and Nanodiamonds. *JOM **2018**, 70*, 1–6.
5. Bhaumik, A.; Narayan, J. Synthesis and Characterization of Quenched and Crystalline Phases: Q-Carbon, Q-BN, Diamond and Phase-Pure c-BN. *JOM* **2018**, *70*, 456–463.
6. Gupta, S.; Sachan, R.; Bhaumik, A.; Narayan, J. Undercooling driven growth of Q-carbon, diamond and Graphite. *MRS Communications* **2018,** *8* (2), 533-540.
7. Gupta, S.; Sachan, R.; Bhaumik, A.; Narayan, J. Enhanced mechanical properties of Q-carbon nanocomposites by nanosecond pulsed laser annealing. *Nanotechnology* **2018,** *29* (45), 45LT02.
8. Sachan, Ritesh, Siddharth Gupta, and Jagdish Narayan. "Nonequilibrium Structural Evolution of Q-Carbon and Interfaces." ACS Applied Materials & Interfaces 12.1 (2019): 1330-1338.
9. Joshi, Pratik, Siddharth Gupta, Ariful Haque, and Jagdish Narayan. "Fabrication of ultrahard Q-carbon nanocoatings on AISI 304 and 316 stainless steels and subsequent formation of high-quality diamond films." Diamond and Related Materials 104 (2020): 107742.
10. A. Haque, S. Gupta, and J. Narayan, "Characteristics of diamond deposition on Al2O3, diamondlike carbon and Q-carbon," ACS Applied Electronic Materials 2, 1323-1334 (2020).
11. Narayan, J., S. Gupta, R. J. Sachan, A. Niebroski, and P. Pant. "Formation of Q-carbon and diamond coatings on WC and steel substrates." Diamond and Related Materials 98 (2019): 107515.
12. Sachan, Ritesh, Anagh Bhaumik, Punam Pant, John Prater, and Jagdish Narayan. "Diamond film growth by HFCVD on Q-carbon seeded substrate." Carbon 141 (2019): 182-189.
13. S. Gupta and J. Narayan, "Direct conversion of Teflon into nanodiamond films," MATER. RES. LETT., VOL. 8, NO. 11, 408–416 (2020). https://doi.org/10.1080/21663831.2020.1778111

(4) Q-carbon exhibits record field emission due to negative electron affinity (field emission displays and contactless electric motors):

1. Haque, A.; Narayan, J. Electron Field Emission from Q-Carbon. *Diam. Relat. Mater.* **2018**, *86*, 71–78.
2. Haque, A.; Narayan, J. Stability of Electron Field Emission in Q-Carbon. *MRS Commun.* **2018**, *8* (3), 1343–1351.

(5) Q-carbon is electrochromic (smart windows):

Bhaumik, A.; Narayan, J. Electrochromic Effect in Q-Carbon. *Appl. Phys. Lett*. **2018**, 112, 223104.

(6) Q-carbon is most radiation resistant (nuclear, space and coating applications):

J. Narayan, P. Joshi, J. Smith, W. Gao, W.J. Weber, and R.J. Narayan, "Q-carbon as a new radiation-resistant material," Carbon 186, 253-261 (2021).

(7) N-type and p-type doping with dopant concentrations far higher than Thermodynamic solubility limits (diamond integrated circuits and high-power devices):

1. Narayan, J.; Bhaumik, A.; Gupta, S.; Haque, A.; Sachan, R. Progress in Q-Carbon and Related Materials with Extraordinary Properties. *Mater. Res. Lett.* **2018**, *6*, 353–364.
2. S. Gupta, R. Sachan, and J. Narayan, "Nanometer-thick hexagonal BN films for 2-D field-effect transistors," ACS Applied Nano Materials 3, 7930-41 (2020).

(8) Formation of NV and SiV nanodiamonds and thin films (RT quantum technologies, including quantum computing, quantum sensing and quantum communication):

1. Narayan, J.; Bhaumik, A. Novel Synthesis and Properties of Pure and NV-Doped Nanodiamonds and Other Nanostructures. *Mater. Res. Lett.* **2017, 5(4) 242-250.**.
2. Bhaumik, A.; Sachan, R.; Narayan, J. Tunable Charge States of Nitrogen-Vacancy Centers in Diamond for Ultrafast Quantum Devices. *Carbon N. Y.* **2019**, 142, 662–672.
3. S. Gupta, R. Sachan, and J. Narayan, " Scale-up of Q-carbon and nanodiamonds by pulsed laser annealing," Diamond and Related materials 99, 107531 (2019).

(9) Direct conversion of carbon fibers and nanotubes into diamond fibers (Field emission displays and contactless and frictionless motors):

1. Narayan, J.; Bhaumik, A.; Sachan, R.; Haque, A.; Gupta, S.; Pant, P. Direct Conversion of Carbon Nanofibers and Nanotubes into Diamond Nanofibers and the Subsequent Growth of Large-Sized Diamonds. *Nanoscale* **2019,** 11, 2238–2248
2. Haque, A.; Sachan, R.; Narayan, J. Synthesis of diamond nanostructures from carbon nanotube and formation of diamond-CNT hybrid structures," Carbon **2019**, 150, 388-395.
3. Bhaumik, Anagh, and Jagdish Narayan. "Direct conversion of carbon nanofibers into diamond nanofibers using nanosecond pulsed laser annealing." *Physical Chemistry Chemical Physics* 21.13 (2019): 7208-7219.
4. Narayan, J.; Bhaumik, A.; Haque, A. Pseudo-topotactic growth of diamond nanofibers. *Acta Mater.* **2019,** 178, 179-185.

(10) Macrodiamonds for jewelry and diamond needles (field emission and drug delivery):

1. Sachan, R.; Bhaumik, A.; Pant, P.; Prater, J.; Narayan, J. Diamond Film Growth by HFCVD on Q-Carbon Seeded Substrate. *Carbon* **2019**, *141*, 182–189.
2. Haque, A.; Pant, P.; Narayan, J. Large-Area Diamond Thin Film on Q-Carbon Coated Crystalline Sapphire by HFCVD. *J. Cryst. Growth* **2018**, *504*, 17–25.
3. Bhaumik, A.; Narayan, J. Nano to micro diamond formation by nanosecond laser annealing. J. Appl. Phys. **126**, 125307 (2019); https://doi.org/10.1063/1.5118890

(10) Parallel results from h-BN conversion into Q-BN and c-BN, c-BN and diamond composites, and Q-silicon:

1. Narayan, J.; Bhaumik, A. Research update: Direct conversion of h-BN into pure c-BN at ambient temperatures and pressures in air. *APL Mater.* **2016**, *4*, 020701.
2. Narayan, J.; Bhaumik, A. Discovery of Q-BN and Direct Conversion of h-BN into c-BN and Formation of Epitaxial c-BN/Diamond Heterostructures. *MRS Adv.* **2016**, *1*, 2573–2584.
3. Narayan, J.; Bhaumik, A.; Xu, W. Direct Conversion of h-BN into c-BN and Formation of Epitaxial c-BN/diamond Heterostructures. *J. Appl. Phys.* **2016**, *119*, 185302.

4. Narayan, J.; Bhaumik, A. Fundamental Discovery of Q-Phases and Direct Conversion of Carbon into Diamond and h-BN into c-BN. In; Springer, Cham, 2017; pp. 219–228.
5. Narayan, J.; Bhaumik, A., Narayan, R. Discovery of Q-phases and Direct Conversion of Carbon into Diamond and h-BN into c-BN, Advanced materials & processess, 2016, 174, pp. 24-30.
6. Bhaumik, A.; Narayan, J. Formation and Characterization of Nano- and Microstructures of Twinned Cubic Boron Nitride. *Phys. Chem. Chem. Phys*. **2019,** 21, 1700–1710.
7. Narayan, J..; Sahoo, S.; Joshi, N.; Narayan, R. Synthesis and novel properties of Q-silicon, Materials Research Lett 2023, 11, pp688-696.

(12) Non equilibrium pulsed laser Processing of graphene (G, GO, RGO) and h-BN based devices

(1) Gupta, Siddharth, and Jagdish Narayan. "Reduced Graphene Oxide/Amorphous Carbon p–n Junctions: Nanosecond Laser Patterning." *ACS applied materials & interfaces* 11.27 (2019): 24318.
(2) S. Gupta, R. Sachan, and J. Narayan, "Nanometer-thick hexagonal BN films for 2-D field-effect transistors," ACS Applied Nano Materials 3, 7930-41 (2020).
(3) Gupta, S.; Narayan, J. Non-equilibrium processing of ferromagnetic heavily reduced graphene oxide. *Carbon* **2019**, 153, 663-673 DOI: https://doi.org/10.1016/j.carbon.2019.07.064.
(4) Bhaumik, Anagh, and Jagdish Narayan. "Reduced Graphene Oxide-Nanostructured Silicon Photosensors with High Photoresponsivity at Room Temperature." *ACS Applied Nano Materials* 2.4 (2019): 2086-2098.
(5) Bhaumik, A.; Narayan, J. Conversion of p to n-type reduced graphene oxide by laser annealing at room temperature and pressure. *J. Appl. Phys.* **2017,** *121* (12), 125303.
(6) Bhaumik, A.; Narayan, J. Wafer scale integration of reduced graphene oxide by novel laser processing at room temperature in air. *J. Appl. Phys.* **2016,** *120* (10), 105304.
(7) Zkria, Abdelrahman, Ariful Haque, Mohamed Egiza, Eslam Abubakr, Koki Murasawa, Tsuyoshi Yoshitake, and Jagdish Narayan. "Laser-induced structure transition of diamond-like carbon coated on cemented carbide and formation of reduced graphene oxide." MRS Communications 9,(2019): 910
(8) J. Narayan et al. Formation of self-organized nano- and micro-diamond rings, Materials Research Letters 9, 300-307(2021).
(9) J. Narayan et al. Laser Processing of Continuous and Adherent Diamond Films on Sapphire and Glass, Carbon 176, 558-568 (2021).
(10) Joshi, Pratik; Riley, Parand; Gupta, Siddharth; Narayan, Roger ; Narayan, J., "Liquid phase regrowth of <110> oriented nanodiamond film by UV laser annealing of PTFE to generate dense CVD microdiamond film," Diamond and Related Materials 8, 108481 (2021).
(11) Joshi, P., Riley, P., Gupta, S., Narayan, R. J., & Narayan, J., "Advances in laser-assisted conversion of polymeric and graphitic carbon into nanodiamond films," NANOTECHNOLOGY 32, 432011. https://doi.org/10.1088/1361-6528/ac1097 (2021).

Selected Special Lectures

1) **2023 NanoFlorida Chief Plenary Speaker**
2) **2021 John Goodenough Materials Innovation Lecture**

3) **Invited Colloquia: MIT (10/30/2018); Harvard (10/31/2018); Princeton (10/23/2017); ORNL (11/14/2019); USC Lyman lecture (2018); Distinguished Lectures UCF (2018); Michigan State (2018)**
4) **2022 TMS Plenary Invited Talk, San Diego, March 19-23, 2023**
5) **Plenary Invited Talk at 2021 and 2022 TMS Annual Meetings (Virtual)**
6) **Invited Talk at the 2021 MRS Fall Meeting, Boston**
7) **Plenary Invited Talks on Discoveries of Q-carbon and Q-BN**, 2020 TMS Annual Meeting in San Diego; 2018 TMS Annual Meeting in Phoenix; 2017 TMS Annual Meeting in San Diego
8) **J. Narayan , Plenary Invited Talk, 2017 MRS Fall Meeting, Boston**
9) **Invited Colloquia: MIT (10/30/2018); Harvard (10/31/2018); Princeton (10/23/2017); ORNL (11/14/2019); USC Lyman lecture (2018);** Distinguished Lectures UCF (2018); Michigan State (2018)
10) **2016 MRS Spring Meeting,** March 28-April 1, Phoenix, Invited Talk on Discovery of Q-carbon and Q-BN and Direct Conversion of Carbon into Diamond and h-BN into c-BN (Invited Lecture Recorded by MRS and Paper Published in MRS Advances
11) **2015 SC Jain Memorial Lecture and Prize,** Plenary Talk at the 2015 IWPSD (International Workshop on Physics of Semiconductor Devices, Dec 7-10, IISc, Bangalore, India
12) **2015 MRS Fall Meeting,** November 29-December 4, Invited Talk on Discovery of Q-carbon and Direct Conversion of Carbon into Diamond
13) **2015 MRS Spring Meeting,** April 6-10, Invited Talk on Defects and Interfaces in Oxide Thin Film Heterostructures.
14) **2014 MRS Spring Meeting,** San Francisco, April 20-25, 2014: Plenary Talk (in Symposium K) on Novel Two-dimensional Multifunctional Nanostructured Materials), Invited Talk VV on Tuning of electrical and magnetic Properties of nanostructured oxides, and Invited Talk FFF on Holistic approach to training and mentoring of next-generation materials scientists.
15) **Plenary Invited Talk on Frontiers in Nanomaterials and Impact on Nanotechnology at The 2014 Pan American Materials Conference, ABM, July 21-25, Sao Paulo, Brazil.**
16) **The 2014 TMS (The Materials Society) Institute of Metals Lecture on the Frontiers in Thin Film Epitaxy and Novel Nanostructured Materials**
17) **The 2012 Lee Hsun Award Lecture,** July 20, 2012, Shenyang, China, Sponsored by Chinese Academy of Sciences, IMR and Shenyang National Laboratory Frontiers in Nanostructured Materials
18) **Plenary Keynote Speaker,** ICCE-20, Twentieth Annual International Conference on Composites and Nanoengineering, July 22-28, 2012, Beijing, China.Title: Frontiers of Nanostructured Materials and Nanocomposites
19) **2014 Mehl Medal from the Brazilian ABM-TMS** and presented plenary keynote talk at its 69th Annual ABM-TMS Meeting in Sao Paulo, July 20-24, 2014.
20) **2014 The Institute of Metals Lecture Award of TMS on Frontiers in Thin Epitaxy and Novel Nanostructured Materials** at the TMS Annual Meeting in San Diego, California, Feb 16-20, 2014.
21) **2014 TMS International Symposium** on Frontiers in Nanostructured Electronic and Structural Materials and Their applications, TMS Annual Meeting in San Diego, California, Feb 16-20, 2014.
22) **2011 MRS Forum: 2011 MRS Spring Meeting**, San Francisco, April 25-30, 2011. Acta Materialia Gold Medal Forum: Frontiers in **Thin Film Epitaxy and Nanostructured Materials** (Honoring Professor Narayan); **Journal of Materials Research Volume 28, 2013** devoted to Narayan's research

23) **2011 MS&T Meeting**, Columbus, Ohio, October 17-20, 2011. **International Symposium on Advances in Nanostructured Materials and Applications** (Honoring Narayan). **Acta Materialia (Elsevier), Special Volume 61 (8) of Acta Materialia devoted to this Symposium**

24) **Invited Talk: 2012 MRS Fall Meeting,** November 25-30, 2012, Boston, MA

Title: Designing Novel Nanostructured Materials with Improved Properties.

25) **Chair: MRS Forum (Honoring Prof. Mildred Dresselhaus of MIT),** 2012 MRS Fall Meeting, November 25-30, 2012, Boston

Selected News Items on Narayan's Discoveries

Discovery of Q-silicon with Extraordinary Properties:

IEEE Spectrum: https://spectrum.ieee.org/silicon-quantum-computing
https://phys.org/news/2023-06-quantum-boost-discovery-q-silicon.html

https://newatlas.com/materials/q-silicon-magnetic-spintronic-quantum-computers/

https://news.ncsu.edu/2023/06/quantum-computing-could-get-boost-from-discovery-of-q-silicon/

Discovery of Double Helix of Screw Dislocations:

MRS Bulletin **volume 47**, pages651–652 (2022)
https://link.springer.com/article/10.1557/s43577-022-00395-2

Discoveries Q-carbon and Diamond Related Materials:

Materials Research Society: http://www.materials360online.com/newsDetails/60077

NSF Science 360: http://news.science360.gov/archives/20160205

IEEE Spectrum on c-BN: http://spectrum.ieee.org/nanoclast/semiconductors/materials/cheap-cubic-boron-nitride-for-power-transistors-and-switches

Christian Science Monitor:
http://www.csmonitor.com/Science/2015/1203/A-replacement-for-diamonds-Scientists-discover-Q-carbon

Newsweek: http://www.newsweek.com/scientists-create-material-stronger-diamonds-400777

NBC: http://www.nbcnews.com/tech/innovation/scientists-create-substance-harder-diamond-n473476

NY Times: http://www.nytimes.com/2015/12/03/science/q-carbon-harder-than-diamond.html?_r=1

Discovery:
http://news.discovery.com/tech/nanotechnology/new-form-of-carbon-is-harder-than-diamonds-151203.htm

Fox News:
http://www.foxnews.com/tech/2015/12/02/scientists-discover-new-form-carbon-harder-than-diamonds.html

Smithsonian:

http://www.smithsonianmag.com/science-nature/weird-new-type-carbon-harder-brighter-than-diamond-180957433/?no-ist

CNN: http://www.cnn.com/2015/12/01/tech/super-diamond-q-carbon-scientists-laser/

Popular Science: http://www.popsci.com/new-form-carbon-is-harder-than-diamonds-and-glows

Gizmodo: http://gizmodo.com/theres-a-new-form-of-carbon-thats-harder-than-diamond-1745437658

Forbes:
http://www.forbes.com/sites/ericmack/2015/11/30/scientists-create-new-kind-of-diamond-at-room-temperature/

ITV:
https://www.youtube.com/watch?v=vFyCGf0XcA4
https://www.dropbox.com/s/wm04naodo4w214l/Jay%20Narayan%2012-29%20Edited.mpg?dl=0

Independent Q-carbon Confirmation:

Formation of Q-carbon by adjusting sp^3 content in diamond-like carbon films and laser energy density of pulsed laser annealing

Hiroki Yoshinaka [a], Seiko Inubushi [b], Takanori Wakita [b], Takayoshi Yokoya [b], Yuji Muraoka [b,*] **Carbon 167, 504-511 (2020).**

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Heavy boron doping in superconducting carbon materials
By: Sakai, Yuki; Chelikowsky, James R.; Cohen, Marvin L.
PHYSICAL REVIEW MATERIALS Volume: 4 Issue: 5 Article Number: 054801 Published: MAY 4 2020

Role of atomic coordination on superconducting properties of boron-doped amorphous carbon
By: Sakai, Yuki; Chelikowsky, James R.; Cohen, Marvin L.
PHYSICAL REVIEW MATERIALS Volume: 3 Issue: 8 Article Number: 084802 Published: AUG 7 2019

Magnetism in amorphous carbon
By: Sakai, Yuki; Chelikowsky, James R.; Cohen, Marvin L.
PHYSICAL REVIEW MATERIALS Volume: 2 Issue: 7 Article Number: 074403 Published: JUL 13 2018

Simulating the effect of boron doping in superconducting carbon
By: Sakai, Yuki; Chelikowsky, James R.; Cohen, Marvin L.
PHYSICAL REVIEW B Volume: 97 Issue: 5 Article Number: 054501 Published: FEB 1 2018