

## Roger J. Narayan

### 1. Professional Preparation

Ph.D., 1996-2002, North Carolina State University, Materials Science and Engineering

M.D., 1996-2001, Wake Forest University, Medicine

B.A., 1994-1996, North Carolina State University, Chemistry (Summa Cum Laude)

### 2. Appointments

2021-present, Distinguished Professor, Department of Biomedical Engineering, University of North Carolina-Chapel Hill and North Carolina State University

2009-2021, Professor, Department of Biomedical Engineering, University of North Carolina-Chapel Hill and North Carolina State University

2006-present, Associate Member of the Faculty, Department of Materials Science and Engineering, North Carolina State University

2005-2009, Associate Professor, Department of Biomedical Engineering, University of North Carolina-Chapel Hill and North Carolina State University

2003-2005, Assistant Professor, Bioengineering Program and School of Materials Science and Engineering, Georgia Institute of Technology

### 3. Publications/Patents

1. Doraiswamy A, Jin C, Narayan RJ, Mageswaran P, Mente P, Modi R, Auyeung R, Chrisey DB, Ovsianikov A, Chichkov B. Two photon induced polymerization of organic-inorganic hybrid biomaterials for microstructured medical devices. *Acta biomaterialia*. 2006 May 1;2(3):267-75 (222 citations)

2. Nguyen AK, Gittard SD, Koroleva A, Schlie S, Gaidukeviciute A, Chichkov BN, Narayan RJ. Two-photon polymerization of polyethylene glycol diacrylate scaffolds with riboflavin and triethanolamine used as a water-soluble photoinitiator. *Regenerative medicine*. 2013 Nov;8(6):725-38 (75 citations)

3. Nguyen AK, Narayan RJ. Two-photon polymerization for biological applications. *Materials Today*. 2017 Jul 1;20(6):314-22. (92 citations)

4. Boehm RD, Miller PR, Daniels J, Stafslie S, Narayan RJ. Inkjet printing for pharmaceutical applications. *Materials Today*. 2014 Jun 1;17(5):247-52 (130 citations)

5. Doraiswamy A, Dunaway TM, Wilker JJ, Narayan RJ. Inkjet printing of bioadhesives. *Journal of Biomedical Materials Research Part B: Applied Biomaterials: An Official Journal of The Society for Biomaterials, The Japanese Society for Biomaterials, and The Australian Society for Biomaterials and the Korean Society for Biomaterials*. 2009 Apr;89(1):28-35 (53 citations)

6. Miller PR, Skoog SA, Edwards TL, Lopez DM, Wheeler DR, Arango DC, Xiao X, Brozik SM, Wang J, Polsky R, Narayan RJ. Multiplexed microneedle-based biosensor array for characterization of metabolic acidosis. *Talanta*. 2012 Jan 15;88:739-42 (108 citations)

7. Miller PR, Xiao X, Brener I, Burckel DB, Narayan R, Polsky R. Microneedle-based transdermal sensor for on-chip potentiometric determination of K<sup>+</sup>. *Advanced healthcare materials*. 2014 Jun;3(6):876-81 (107 citations)

8. Miller PR, Gittard SD, Edwards TL, Lopez DM, Xiao X, Wheeler DR, Monteiro-Riviere NA, Brozik SM, Polsky R, Narayan RJ. Integrated carbon fiber electrodes within hollow polymer microneedles for transdermal electrochemical sensing. *Biomicrofluidics*. 2011 Mar 30;5(1):013415 (97 citations)

9. Doraiswamy A, Narayan RJ, Harris ML, Qadri SB, Modi R, Chrisey DB. Laser microfabrication of hydroxyapatite-osteoblast-like cell composites. *Journal of Biomedical Materials Research Part A*. 2007 Mar 1;80(3):635-43 (71 citations)

10. Skoog SA, Elam JW, Narayan RJ. Atomic layer deposition: medical and biological applications. *International materials reviews*. 2013 Feb 1;58(2):113-29 (53 citations).

#### 4. Research Leadership

1. PI for "Matrix-Assisted Pulsed Laser Evaporation of Dry Product Vaccine" Bill & Melinda Gates Foundation and Kenan Institute for Engineering, Technology & Science 10/2021-9/2023 (Total amount \$370,000)
2. NC State PI for "Microneedle-based delivery platforms for SARS-CoV-2" Fast Funding for COVID-19 Science 9/2021-8/2022 (Total amount \$27,000)
3. Lead PI for "Evaluation of a microneedle-based technology for point-of-care detection of infection biomarkers" Military Infectious Diseases Research Program 2/2020-1/2024 (Total amount \$4,084,541)
4. PI for "Light integrated novel multimodal microscale biosystem" National Science Foundation 7/2020-6/2022 (Total amount \$170,000)
5. PI for "Laser-based layer-by-layer nanomanufacturing of water insoluble drug-loaded thin films" National Science Foundation 5/2018-5/2022 (Total amount \$258,939)
6. PI for "Emergency treatment of synthetic opioid overdose" National Institutes of Health 4/2018-3/2022 (Total amount \$373,940)
7. PI for "IRES Track I: US-South Korea Collaborative Training Program on Advances in Medical 3D Printing" National Science Foundation (6/2021-5/2024) (Total amount \$299,999)
8. PI for "NCSU-RTI collaboration on multi-pollutant exposure monitor that measures real-time total PM and PM species" NCSU Center for Human Health and the Environment 2019 Pilot Award 3/2020-2/2022 (Total amount \$37,875)
9. PI for "NITRic Oxide Gas thErapy to treat coronavirus iNfection (NITROGEN)" North Carolina Biotechnology Center 11/2020-5/2022 (Total amount \$20,000)
10. PI for "Matrix-assisted pulsed laser evaporation of dry product vaccine" William R. Kenan, Jr. Institute for Engineering, Technology & Science 10/2021-9/2022 (Total amount \$100,000)
11. PI for "Stability of three-dimensional printed polymers under gamma irradiation" 2020 NC Space Grant 6/2020-5/2022 (Total amount \$20,000)
12. PI for "Innovation in polymers for additive manufacturing" Eastman University Engagement Fund 12/2021 (Total amount \$3,000)
13. PI for "Use of diamond-like carbon coatings to reduce leachables from biomedical metal alloys" National Science Foundation 8/2018-7/2022 (Total amount \$99,999)
14. PI for "Physico-chemical characterization and in vitro biological evaluation of 3d printed ceramics" National Science Foundation 9/2020-8/2022 (Total amount \$100,000)
15. PI for "Microneedles for real-time biochemical sensing" RTI International 8/2019-8/2022 (Total amount \$107,204)
16. Chief Investigator "E" for "Improving clinical outcomes of antimicrobial resistant infections with a drug free intervention" National Health and Medical Research Council (Australia) 2021-2025 (Total amount \$999,581)
17. PI for "Use of thin films to reduce leachable contamination" National Institute for Innovation in Manufacturing Biopharmaceuticals 9/2018-3/2021 (Total amount \$1,102,685)
18. PI for "Preliminary Results: Reducing the burden for people living with type 1 diabetes" NCSU Adelaide Grant Program 7/2018-6/2019 (Total amount \$10,000)
19. PI for "Biodegradable microneedle-based transdermal treatment of cutaneous leishmaniasis" National Institutes of Health 4/2016-3/2019 (Total amount \$413,404)
20. PI for "Minimally invasive biosensors for detecting flavivirus infection" National Science Foundation 8/2016-1/2019 (Total amount \$80,000)
21. PI of "US-Australia planning visits for UNC-NCSU-Queensland partnership on novel materials and devices for transdermal sensors" National Science Foundation 7/2014-6/2019 (Total amount \$49,500)
22. PI for "Science Saturday program on space biology, materials and medicine", NC Space Grant 3/2010-6/2018 (Total amount \$11,562)

23. PI for “Innovative printing approach for transdermal drug delivery” National Science Foundation 2/2016-1/2017 (Total amount \$50,000)
24. PI for “In vitro biological characterization of 3D printed small-scale medical devices” National Science Foundation 11/2014-10/2016 (Total amount \$130,000)
25. PI for “Collaboration on novel materials and methods for 3D printing of microscale medical devices” National Science Foundation 7/2014-6/2016 (Total amount \$165,563)
26. PI for “Development of microneedle array (microelectronic tongue) for quantification and discrimination of hormones” Fundacao de Amparo a Pesquisa do Estado de Sao Paulo 1/2014-1/2016 (Total amount \$20,000)
27. PI for “Characterization of micro- and nanostructured titanium oxide and zirconium oxide surfaces for improved medical implants” National Science Foundation 11/2013-10/2015 (Total amount \$130,000)
28. PI for “Rapid prototyping of microscale structures for active medical devices” National Science Foundation 9/2012-9/2013 (Total amount \$75,000)
29. PI for “Functional microscale medical adhesives” National Science Foundation 7/2012-12/2013 (Total amount \$50,000)
30. PI for “Integration of smart materials with pattern recognition and nanofabrication techniques for the development of novel electrochemical disease diagnostics” University Global Partnership Network 6/2012-6/2013 (Total amount \$10,000)

#### 5. Leadership and Professionalism: Synergistic Activities

1. I have served as a leader in several professional societies that serve the biomaterials community. I currently serve on the board of directors of The Minerals, Metals and Materials Society (TMS) as director of its Functional Materials Division. The Functional Materials Division serves as a home for additive manufacturing, biomaterials, electronic materials, energy materials, magnetic materials, nanomaterials, and thin film researchers at TMS. I also previously served as Chair of the ASM International Emerging Technology Awareness Committee and as Committee Head of the ASM International Materials and Processes for Medical Devices Magazine. I currently serve as Executive Editor of Biomaterials Forum, which serves as the member magazine of the
2. I have served as main organizer for several academic meetings over the years, including as chair of the 2016 Materials Research Society Spring Meeting, the 2019 American Ceramic Society Innovations in Biomedical Materials Meeting, the 2016 American Ceramic Society Innovations in Biomedical Materials Meeting, the 2012 North Carolina Tissue Engineering and Regenerative Medicine Society Annual Meeting, and the 2012 American Ceramic Society Innovations in Biomedical Materials Meeting. I also served an Office of Naval Research-supported Nano-Biomaterial CHAMPS (Characterization, Hierarchy, Advanced Material Processing and Surfaces) Workshop at the Indian Institute of Technology-Kanpur. In addition, Prof. Anthony Atala and I served as lead organizers of an upcoming American Institute of Physics Horizons Workshop on 3D Printing on May 2nd and 3rd in Winston-Salem.
3. I have served as an organizer of numerous symposia, starting with my organization of the first TMS biomaterials symposium, entitled “Nanostructured Materials for Biomedical Applications,” which was held at the 2004 TMS Annual Meeting in Charlotte. Since 2005, I have been chief organizer of the annual “Next Generational Biomaterials” symposium at the Materials Science and Technology Meeting that is co-organized by TMS, ASM International, and the American Ceramic Society. Since 2008, I have served as chief organizer of the annual “Next Generation Bioceramics” symposium at the International Cocoa Beach Conference that is organized by the Engineering Ceramics Division of the American Ceramic Society. In 2009, 2011, 2013, 2015, and 2018 I served as chief organizer of several symposia at the Materials Research Society Fall Meeting. In 2006, 2007, and 2011, I served as chief organizer of symposia on laser biomaterials at the American Association for the Advancement of Science Annual Meeting.

4. I served as editor-in-chief of the Elsevier Encyclopedia of Biomedical Engineering, which was released in 2018. I also edited several textbooks on processing of advanced biomaterials, including Rapid Prototyping of Biomaterials, Diamond Based Materials for Biomedical Applications, Medical Biosensors for Point of Care (POC) Applications, Monitoring and Evaluation of Biomaterials and their Performance In Vivo, and Nanobiomaterials: Nanostructured Materials for Biomedical Applications. The textbook Biomedical Materials was successfully adopted as a biomaterials textbook by undergraduate programs at numerous universities across the world and a contract was recently approved by the publisher for publication of a second edition.

#### 6. Commitment to Diversity and Inclusiveness

I completed NC State University's Inclusive Excellence Certificate program in Summer 2021. As part of the certificate program, I understood the historical issues that have led to the marginalization of groups that are currently underrepresented in STEM fields. Through completion of the certificate program, I have become fully committed to students, staff, and faculty who are underrepresented in STEM fields.

Since Fall 2009, I have organized a "Science Saturday" program at the North Carolina Museum of Natural Sciences in Raleigh, North Carolina; this program has involved stand-alone presentations in the museum's Windows on the World presentation area and the museum's signature hemisphere-shaped Daily Planet Theater. I have heavily recruited presentations by researchers from underrepresented backgrounds; recent speakers include Adriana Heimann Rios (East Carolina U.), Nitza Santiago Figueroa (North Carolina A&T State U.), and Ademe Mekonnen (North Carolina A&T State U.). Science Saturday presentations have been very well received by the museum's visitors, with an average attendance of between 40 and 50 people. I have also worked with the Carolina South-Atlantic Chapter of the International Society for Pharmaceutical Engineering and the museum on the development of annual biotechnology events, including the 2012 Biotechnology Day, the 2013 Triangle BEST Fest, and the 2014 TriSciTech Expo.

#### 7. Mentoring

I have been extremely successful in recruiting research participation by students from underrepresented groups both at the undergraduate level and graduate level. For example, I have mentored numerous undergraduate students from underrepresented groups, including Black, Latinx, and female undergraduate students, through National Science Foundation-funded, National Aeronautics and Space Administration-funded, and university-funded programs. For example, Mariah Reese, an undergraduate student at Dartmouth College, completed a project on laser processing of polymers in 2016-2017 with National Aeronautics and Space Administration funding. Several conference proceedings and three archival journal papers have resulted from these undergraduate student mentoring efforts. I have been the primary advisor for two Black graduate students, who have published their research in archival journals and successfully completed their degrees. For example, Jamal Lewis completed a thesis entitled "Microstructural, mechanical and antibacterial characterization of nanocrystalline diamond thin films"; he is currently a tenure-track Assistant Professor at the University of California, Davis. Shevon Johnson completed a thesis entitled "Pulsed laser deposition of hydroxyapatite thin films"; she currently works at the National Institute of Environmental Health Sciences. I am currently working with Dan Herr and other colleagues at the Joint School of Nanoscience and Nanoengineering between the North Carolina A&T State University and the University of North Carolina at Greensboro on the development of innovative research recruitment activities; for example, I am currently recruiting North Carolina A&T State University undergraduate students into a recently-funded National Science Foundation-funded International Research Experiences for Students training program.

### 8. Major Awards, Fellowships, Invited Lectureships, and Honors

2022: Materials Research Society Fellow

2022: TMS Functional Materials Division Distinguished Scientist/Engineer Award

2021: ASME Fellow

2021: NCSU Impact Scholar

2021: NCSU Inclusive Excellence Certificate

2020: National Academy of Inventors Senior Member

2019: NCSU Academy of Excellence in Global Engagement

2018: NCSU Community Engaged Faculty Fellow

2018: TMS Functional Materials Division Distinguished Service Award

2018: TMS Brimacombe Medalist Award

### 9. Major Career Contributions and Legacy

-I have been a pioneer in several technologies for laser-processing processing and computer aided biomanufacturing of medical devices.

-I first demonstrated the use of two photon polymerization as a manufacturing process for medical devices such as drug delivery devices and tissue engineering scaffolds; he demonstrated the biocompatibility of several types of materials that are used in two photon polymerization, including inorganic-organic hybrid materials and riboflavin-containing photoinitiators.

-I pioneered the use of piezoelectric inkjet printing for processing biomedically-relevant materials (Refs 4-5); this technology is being used by companies such as GlaxoSmithKline to manufacture new types of pills.

-I pioneered the incorporation of microneedles with sensors (e.g., carbon fiber, carbon paste, or porous carbon electrochemical sensors) to create wearable sensors for real time detection of medically-relevant analytes.

-I also pioneered the use of lasers for direct writing of cells and micromachining of scaffolds that are used in tissue engineering; for example, his team demonstrated the use of lasers to create cell-scaffold composites and three-dimensional scaffolds.

-I pioneered in vitro studies of the biological applications of ultrananocrystalline diamond, graphene, and other novel forms of carbon, which are finding use in various implantable device applications.

-I demonstrated the use of atomic layer deposition to create conformal coatings on nanostructured medically-relevant surfaces.-He is a materials and manufacturing engineering leader, with >250 peer-reviewed papers, 1 textbook (Biomedical Materials, in its second edition), 1 encyclopedia (the Encyclopedia of Biomedical Engineering), 1 handbook (the ASM Handbook on Materials for Medical Devices) and 21 book chapters, which were collectively cited over 12,000 times (current h-index=64).

-I served as an ASME Swanson Fellow with America Makes in 2016 and 2017; in this role, he assisted with developing medical additive manufacturing resources for the US additive manufacturing community.

-I have devoted significant efforts to build collaborations with researchers in Central America, South America, and Europe.

-In 2014, I completed a Fulbright Scholar Program that involved teaching a biomaterials course at the University of Sao Paulo and giving research lectures in Rio de Janeiro and Sao Paulo.

-In 2016, I completed a Royal Academy of Engineering Distinguished Visiting Fellow Program at University College London, which involved giving lectures at University College London and the University of Cambridge.

-I have also completed Fulbright projects at the National Polytechnic Institute (Mexico City) in 2015 and the University of Otago (Christchurch) in 2017.