

# Quadrennial Review of the National Nanotechnology Initiative

## Committee

### Liesl Folks

#### Chair

LIESL FOLKS is the dean of University of Buffalo's School of Engineering and Applied Sciences and an internationally recognized expert in nanotechnology and magnetism. She holds 12 U.S. patents and is the author of more than 50 peer-reviewed technical publications. She is also a professor in the Department of Electrical Engineering. Dr. Folks served as president of the IEEE's Magnetics Society in 2013 and also in 2014. She was a member of the congressionally mandated panel for the Triennial Review of the National Nanotechnology Initiative, conducted by the National Academy of Sciences in 2012. She has an exemplary record of support for STEM education initiatives, from her promotion of innovative programs at the PreK-12 level, to her role in launching a magnetics summer school program through the IEEE. That program provides summer study opportunities each year to nearly 100 graduate students from around the world. In 2013, Dr. Folks was recognized for her mentorship of science and engineering students with the national AVS Excellence in Leadership Award. Prior to arriving at University of Buffalo in January of 2013, Folks worked for more than nine years at Hitachi Global Storage Technologies, a hard disk drive company in San Jose, California. Before that, she worked at IBM Almaden Research Center, also in San Jose, for six years. A native of Australia, Folks earned a BSc (1989) and a PhD (1994), both in physics, from The University of Western Australia in Perth, where she subsequently worked as a research fellow. She also holds an MBA from Cornell University (2004).

# Haydn N. Wadley

## Vice Chair

HAYDN WADLEY is a University Professor and the Edgar A. Starke Professor of Materials Science and Engineering at the University of Virginia in Charlottesville, Virginia. He has very broad interests in materials science, mechanics and thermal transport. His current research explores high temperature thermal protection systems (thermal barrier coatings, liquid metal heat plates for hypersonic vehicle leading edges, jet blast deflectors) and new materials for the mitigation of high intensity dynamic loads (ballistic and blast protection materials and structures). He has addressed many fundamental questions associated with the atomic assembly of nanoscopic materials from the vapor phase, the topological structuring of cellular materials and the processing of high performance composites. These fundamental studies have been used to develop models and numerical simulations that reveal linkages between a material's composition/synthesis and its performance. Some of these models have been coupled with in-situ (ultrasonic and electromagnetic) sensors and nonlinear, feedback control algorithms to implement intelligent process control concepts. He has invented and commercialized several vapor deposition technologies that enable the growth of novel thin films and coatings, and numerous multifunctional cellular materials. Examples are materials that support stress while also serving as impact energy absorbers, heat exchange media, electrochemical power storage systems, or shape morphing structures. His research group has spun out two companies—one that develops novel coatings and another that manufactures high performance cellular materials. He has served on the Defense Science Board's Summer Study, and is a current member of the National Academies' Defense Materials, Manufacturing and Infrastructure Committee and the National Materials and Manufacturing Board. He has been a member of the Defense Science Research Council since 1998 and has led studies on a wide variety of topics, including Jungle Warfare Technology, Exploitation of Space, Counter Ambush Technologies, Blast Injury Mitigation, Novel Concepts for Protection from EFP's, Compact Power Systems, Electrotextiles, Countermeasures to Non Traditional Threat Agents, and Technologies for Stabilization, Reconstruction and Humanitarian Relief Operations. He has published 448 papers, co-authored a book on cellular materials, holds 21 US patents, and is a fellow of the American Society for Materials.

## **Nicholas L. Abbott**

### **Member**

NICHOLAS ABBOTT [NAE] is the Tisch University professor at Cornell University. Dr. Abbott received a Bachelor of Engineering (Chemical Engineering) from University of Adelaide, Australia in 1985 and a Ph.D. in Chemical Engineering from the Massachusetts Institute of Technology in 1991. He was a postdoctoral fellow in the Chemistry Department of Harvard University from 1991-1993. Dr. Abbott's initial academic appointment was at University of California-Davis. He then moved to the Department of Chemical and Biological Engineering at the University of Wisconsin at Madison in 1998 as Professor and served as Chairman of the department from 2009 to 2012. From 2012 to 2018, he served as Director of the Wisconsin Materials Research Science and Engineering Center, and held the title of Sobota Professor and Hilldale Professor of Chemical and Biological Engineering. In 2018, he joined the Department of Chemical and Biomolecular Engineering at Cornell University as the Tisch University Professor. He is a Member of the US National Academy of Engineering and serves as Co-Editor-in-Chief of Current Opinion in Colloid and Interface Science.

## **Oliver Brand**

### **Member**

OLIVER BRAND is the executive director of the Institute for Electronics and Nanotechnology and a professor at the School of Electrical and Computer Engineering at Georgia Institute of Technology (Georgia Tech). Dr. Brand received his undergraduate degree in Physics from Technical University Karlsruhe, Germany in 1990, and his Ph.D. degree (Doctor of Natural Sciences) from ETH Zurich, Switzerland in 1994. He was a postdoctoral fellow at Georgia Tech from 1995-1997 and a lecturer at ETH Zurich in Zurich, Switzerland and deputy director of the Physical Electronics Laboratory (PEL) from 1997 to 2002. In January 2003, Dr. Brand joined the Electrical & Computer Engineering faculty at Georgia Tech. Dr. Brand has co-authored more than 190 publications in scientific journals and conference proceedings. His research interests are in the areas of CMOS-based microsystems, microsensors, MEMS fabrication technologies, and microsystem packaging.

## **Harold G. Craighead**

### **Member**

HAROLD CRAIGHEAD [NAE] is the Charles W. Lake, Jr. Professor in Engineering at Cornell University. He received his Bachelor of Science Degree in Physics, with High Honors, from the University of Maryland, College Park in 1974 and his Ph.D. in Physics from Cornell University in 1980. His thesis work involved an experimental study of metal nanoparticles. From 1979 until 1984 he was a Member of the Technical Staff in the Device Physics Research Department at Bell Laboratories. From 1984 until 1989 he was Research Manager of the Quantum Structures Research Group at Bellcore. Dr. Craighead joined the faculty of Cornell University as a Professor in the School of Applied and Engineering Physics in 1989. From 1989 until 1995 he was Director of the National Nanofabrication Facility at Cornell University. Dr. Craighead was Director of the School of Applied and Engineering Physics from 1998 to 2000 and Director of the Nanobiotechnology Center from 2000 to 2001. He served as Interim Dean of the College of Engineering from 2001 to 2002, as co-Director of the Nanobiotechnology Center from 2002-2006, and as Director of Nanobiotechnology Center from 2006 to 2009. He is an elected member of the National Academy of Engineering. He has been a pioneer in nanofabrication methods and the application of engineered nanosystems for research and device applications. Throughout his career he has contributed to numerous scientific journals with over 280 published papers. Dr. Craighead's recent research activity includes the use of nanofabricated devices for biological applications. His research continues to involve the study and development of new methods for nanostructure formation, integrated fluidic/optical devices, nanoelectromechanical systems and single molecule analysis.

## **Marie D'Iorio**

### **Member**

MARIE D'IORIO is a senior strategy advisor with the Office of the Vice President Research at the University of Ottawa and is President of NanoCanada. Prior to joining the University of Ottawa, she led the National Institute for Nanotechnology (2011-2016) and the Institute for Microstructural Sciences (2003-2011) at the National Research Council of Canada (NRC). Dr. D'Iorio obtained a Masters and a Doctorate degree in Solid State Physics from the University of Toronto. After a post-doctoral Fellowship at IBM Zurich Research Laboratories, she joined the NRC, where she established Canada's first very low temperature, high magnetic field laboratory to study quantum semiconductor devices and later led one of Canada's first research programs on organic light emitting devices. In 2015 she launched NanoCanada, to connect the nanotechnology community across the country and to facilitate partnerships and collaborations between academia, industry and government linking facilities and expertise to support the translation of scientific breakthroughs to the marketplace. She has served as President of the Academy of Science of the Royal Society of Canada and President of the Canadian Association of Physicists.

## **Travis Earles**

### **Member**

TRAVIS EARLES is the emerging technology business leader and bridge builder at Lockheed Martin.

Mr. Earles leads and coordinates Lockheed Martin's advanced materials and nanotechnology initiatives across the corporation. Lockheed Martin is a global leader in security and aerospace principally engaged in the research, design, development, manufacture, integration, and sustainment of advanced technology systems, products and services. Previously, Mr. Earles served for four years as Assistant Director for Nanotechnology in the White House Office of Science & Technology Policy, where he was responsible for oversight and coordination of the \$1.8 billion U.S. National Nanotechnology Initiative. In addition to his emerging technology strategy and policy leadership, Earles has broad experience in biomedical nanotechnology development, having helped to launch the \$144 million Alliance for Nanotechnology in Cancer in 2005 while at the U.S. National Cancer Institute. His formal training is in biomedical engineering, and he holds a master's degree in technology management as well as an MBA.

## **Graham R. Fleming**

### **Member**

GRAHAM FLEMING [NAS] is the Vice Chancellor for Research at the University of California at Berkeley (Berkeley). Through high level positions at Berkeley and Lawrence Berkeley National Laboratory (LBNL), he has been involved in the formation and operation of multiple major initiatives. These include the \$500M British Petroleum (BP)-funded Energy Biosciences Institute, the California Institute for Quantitative Bioscience, and the Simons Institute for the Theory of Computing. Born in Barrow, England in 1949, Fleming earned his Bachelors of Science degree from the University of Bristol in 1971 and his Ph.D. in chemistry from the University of London in 1974. Following a post-doctoral fellowship at the University of Melbourne, Australia, he joined the faculty of the University of Chicago in 1979. There, he rose through the academic ranks to become the Arthur Holly Compton Distinguished Service Professor, a post he held for ten years, starting in 1987. At University of Chicago, he also served for three years as the Chair of the Chemistry Department. In that role, he led the creation of University of Chicago's first new research institute in more than 50 years, the Institute for Biophysical Dynamics. In 1997, he came to University of California Berkeley as a professor of chemistry, and he started and directed a new division of physical biosciences for Berkeley Laboratory. Throughout his administrative career, Fleming has remained a highly active and successful scientific researcher. He has authored or co-authored more than 444 publications, and is widely considered to be one of the world's foremost authorities on ultrafast processes. His ultimate goal is to develop artificial photosynthesis that would provide humanity with clean, efficient and sustainable energy. He is a member of the National Academy of Sciences and the American Philosophical Society, a Fellow of the Royal Society and the American Academy of Arts and Sciences, and a Foreign Fellow of the Indian National Science Academy.

## **Teri Odom**

### **Member**

TERI ODOM is the Charles E. and Emma H. Morrison Professor of Chemistry at Northwestern University. Her research focuses on controlling materials at the 100-nanometer scale and investigating their size- and shape-dependent properties. Odom has developed massively parallel, multi-scale nanopatterning tools to generate noble metal structures that can manipulate visible light at the nanoscale. In addition, Odom has designed a platform to investigate hierarchical, anisotropic materials and to exploit their properties in biomedical applications. One such system is pyramidal nanoparticles, which are 3D in structure and are being tested in biological imaging and cancer therapeutic applications. Odom has received numerous honors and awards, including a Radcliffe Institute for Advanced Study Fellowship at Harvard University; an Director's Pioneer Award from the National Institutes of Health; the Materials Research Society Outstanding Young Investigator Award; the National Fresenius Award from Phi Lambda Upsilon and the American Chemical Society; the Rohm and Haas New Faculty Award; an Alfred P. Sloan Research Fellowship; a DuPont Young Investigator Grant; a National Science Foundation CAREER Award; a Dow Teacher-Scholar Award; the ExxonMobil Solid State Chemistry Faculty Fellowship; and a David and Lucile Packard Fellowship in Science and Engineering. Odom was also the first Chair of the Noble Metal Nanoparticles Gordon Research Conference, whose inaugural meeting was in 2010.

## **Ricardo Ruiz**

### **Member**

RICARDO RUIZ is a research technologist at Western Digital Corp. His research interests span alternative nanofabrication techniques for storage and memory devices, block copolymer lithography, and colloidal self-assembly. From 2013 to 2016 he managed a Nanopatterning and Self Assembly group at Hitachi Global Storage Technologies (HGST) dedicated to block copolymer and colloidal lithography. Prior to that, he was a research staff member at HGST, where he helped to introduce block copolymer lithography for magnetic bit-patterned media technology. Before joining HGST, he was a postdoctoral scientist at IBM T.J. Watson. He received his Ph.D. in Physics from Vanderbilt University in 2003. He has co-authored over 50 publications and holds 35 US Patents. He is a fellow of the American Physical Society and was the recipient of the 2016 ACS Applied Materials and Interfaces Young Investigator Award.

# Jo Anne Shatkin

## Member

JO ANNE SHATKIN is the president and founder of Vireo Advisors. She founded Vireo Advisors in 2013 to provide guidance and leadership- raising the bar on sustainability in innovation. She collaborates with organizations on environmental aspects of new product development and on commercialization of technologies for environmental applications. Dr. Shatkin brings nearly 20 years of expertise in environmental leadership, stakeholder engagement, health and environmental risk analysis, sustainability science, nanotechnology, and life cycle impacts of materials in the environment. Jo Anne brings extensive experience in working with entrepreneurs to guide responsible product development and commercialization. As CEO of CLF Ventures, she worked with early-stage and large organizations on new technology introduction strategies, including business planning, environmental impact assessment, and networking for financing. Dr. Shatkin is an environmental health scientist and recognized expert in environmental science and policy, human health risk assessment, emerging contaminants policy and environmental aspects of nanotechnology. She combines her business acumen and technical expertise into strategies for sustainable innovation. Since 2005, Dr. Shatkin has provided leadership on the responsible development of nanotechnology and on approaches for decision making under uncertainty. She serves on several international committees addressing cutting-edge science policy issues and standardization for emerging nanoscale materials. She also teaches courses, has published papers and book chapters on topics of environmental health and safety, and is working to advance life cycle approaches to risk analysis for nanotechnology, including for product design and development. Dr. Shatkin is author of Nanotechnology Health and Environmental Risks Second Edition (CRC Press 2012). She received an Individually Designed Ph.D. in Environmental Health Science and Policy and her MA in Risk Management and Technology Assessment from Clark University, Worcester, Massachusetts, and earned a Bachelor of Science degree from Worcester Polytechnic University in Molecular Biology and Biotechnology.

Dr. Shatkin has extensive experience in risk assessment, from working on complex mixtures on hazardous waste sites, to bioavailability and dermal exposure research. At CLF Ventures, she translated that work to business risk assessment and management, working with investors, energy and new material technology companies and sustainable agriculture entrepreneurs. She works on innovations in intersection of science, policy and communication.

# Mark Tuominen

## Member

MARK TUOMINEN is a professor of physics at University of Massachusetts Amherst, where he performs research in experimental condensed matter physics and nanotechnology, including research in the manufacturing and physics of materials and devices with nanoscale features. Nanomanufacturing science addresses the challenge of fabricating nanoscale structures by convenient methods suitable for integration into systems. One important example is directed self-assembly using diblock copolymer template patterning in combination with complementary techniques. Recent fundamental physics research includes electronic transport through bacterial pili and biofilms, microbial fuel cells, ultrahigh-density magnetic arrays, domain-wall motion in ferromagnetic nanorings, proton transport in materials for fuel cells, superconducting single-electron devices and charge shuttling phenomena. Strategic cooperative activities include nanomanufacturing, informatics for science, and integrated nanosystems. His work helps to advance the science and applications of nanoscale charge transport, magnetism, bioelectronics, superconductivity, self-assembly, and nanomanufacturing. He was instrumental in establishing the NSF Center for Hierarchical Manufacturing and the National Nanomanufacturing Network. Dr. Tuominen's educational innovations are in the areas of research learning and professional development. He received a bachelor's in chemical engineering and a Ph.D. in physics from the University of Minnesota and was a postdoctoral research associate at Harvard University.