

Christopher Charles Bowland, Ph.D.

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Security Clearance: Q (Feb. 2018-present)

Education

- Ph.D.** August 2016 in Materials Science and Engineering
University of Florida
Advisor: Dr. Henry A. Sodano
Dissertation Title: *Conformal Growth Method of Ferroelectric Materials for Multifunctional Composites*
- M.S.** December 2013 in Materials Science and Engineering
University of Florida
Advisor: Dr. Henry A. Sodano
- B.S.** May 2012 in Materials Science and Engineering
Concentration: Nanomaterials
Minor: Business Administration
University of Tennessee

Professional Experience

- R&D Staff** – *Oak Ridge National Laboratory*, Chemical Sciences Jan. 2022-Present
Division, Carbon and Composites Group, Oak Ridge, TN
- R&D Associate** – *Oak Ridge National Laboratory*, Chemical Sciences Oct. 2019-Jan. 2022
Division, Carbon and Composites Group, Oak Ridge, TN
- Advancing fiber coating techniques for adhering nanoparticles and microparticles to the fiber surface
 - Developing multifunctional fiber reinforced composites
 - Formulating sustainable composites
- Wigner Fellow** – *Oak Ridge National Laboratory*, Chemical Sciences Aug. 2016-Oct. 2019
Division, Carbon and Composites Group, Oak Ridge, TN
- Conducting research on novel approaches to creating multifunctional fibers for multifunctional composites and 3D printed structures
 - Compounding sustainable polymers using lignin
- Visiting Scholar** – *University of Michigan*, Aerospace Engineering Aug. 2015-July 2016
Department, Ann Arbor, Michigan
- Completed Ph.D. research on multifunctional fibers for multifunctional composites
- Graduate Research Assistant** – *University of Florida*, Materials Science Aug. 2012-Aug. 2016
and Engineering Department, Gainesville, Florida
- Performed M.S. and Ph.D. research

- Synthesized ferroelectric nanowires and textured films on carbon fiber to create multifunctional fibers
- Utilized X-ray diffraction, scanning electron microscopy, differential scanning calorimetry and atomic force microscopy to characterize the microstructure and electromechanical properties of the ferroelectric materials
- Fabricated and tested single fiber power harvesters and sensors
- Developed multifunctional composites via conventional carbon fiber resin molding techniques

Applications Engineering Intern – *Nanomechanics, Inc*, Oak Ridge, TN Jan. 2012-July 2012

- Performed nanoindentation tests on thin films and polymers for elastic modulus and hardness measurements
- Primary focus on sample preparation and contract laboratory testing
- Wrote two white papers pertaining to the nanoindentation research

Summer Intern – *Oak Ridge National Laboratory*, Oak Ridge, TN June 2011-Aug. 2011

- Characterized, stabilized, and carbonized polyethylene (PE) fiber to produce low-cost carbon fiber

Professional Memberships

SPIE - member, reviewer, and conference session chair (2018-present)

ASME – member (2023-present)

SMASIS Division Senate Member (2023-present)

Publications

Journal Articles (Google Scholar: h-index: 19, i10-index: 25)

- 1) Tang X., Liu C., Chen J., Kumar R., **Bowland C.C.**, Saito T., Dial B.E., Keum J.K., Do C., Chen X.C. (2024). Probing the Interface Structure of Block Copolymer Compatibilizers in Semi-crystalline Polymer Blends. *Journal of Applied Polymer Science*. Online, pre-print.
- 2) Gupta S., Sohail T., Checa M., Rohewal, S.S., Toomey, M.D., Kanbargi, N., Damron, J.T., Collins, L., Kearney, L.T., Naskar, A.K., **Bowland, C.C.** (2024). Enhanced Composite Toughness Through Hierarchical Interphase Formation. *Advanced Science*, 11, 2305642. [Frontispiece artwork]
- 3) Rahman M.A., Karunarathna M.S., **Bowland C.C.**, Yang G., Gainaru C., Li B., Kim S., Chawla V., Ghezawi N., Meyer H.M., Naskar A.K., Penumadu D., Sokolov A.P., Saito T. (2023). Tough and recyclable carbon-fiber composites with exceptional interfacial adhesion via a tailored vitrimer-fiber interface. *Cell Reports Physical Science*, 4, 101695.
- 4) Nguyen N.A., **Bowland C.C.**, He L., Osti N.C, Phan M.D, Keum J.K., Tyagi M., Meek K.M., Littrell K.C., Mamontov E., Ankner J., Naskar A.K. (2023). A sustainable multi-dimensional printable material. *Advanced Sustainable Systems*, 7, 2300079. [Back cover artwork]
- 5) Kanbargi N., Hoskins D., Gupta S., Yu Z., Shin Y., Qiao Y., Merkel D., **Bowland C.C.**, Labbe N., Simmons K.L., Naskar A.K. (2023). A renewable lignin-based thermoplastic adhesive for steel joining. *European Polymer Journal*, 189, 111981.

- 6) Zhou Z., Kim S., **Bowland C.C.**, Li B., Ghezawi N., Lara-Curzio E., Hassen A., Naskar A.K., Rahman A., Saito T. (2022). Unraveling a path for multi-cycle recycling of tailored fiber-reinforced vitrimer composites. *Cell Reports Physical Science*, 3, 101036.
- 7) Tang X., Liu C., Keum J., Chen J., Dial B.E., Wang Y., Tsai W., Bras W., Saito T., **Bowland C.C.**, Chen X.C. (2022). Upcycling of semicrystalline polymers by compatibilization: mechanism and location of compatibilizers. *RSC Advances*, 12, 10886-10894.
- 8) Gupta S., Naskar A.K., **Bowland C.C.** (2022). An Engineered Multifunctional Composite for Passive Sensing, Power Harvesting, and In Situ Damage Identification with Enhanced Mechanical Performance. *Advanced Materials Technologies*, 7, 2101549.
- 9) Malakooti M.H. and **Bowland C.C.** (2021). Editorial for the Special Issue on Advanced Fiber-Reinforced Polymer Composites. *Journal of Composites Science*, 5, 241.
- 10) Rahman M.A., **Bowland C.C.**, Ge S, Acharya S.R., Kim S., Cooper V.R., Chen X.C., Irlle S., Sokolov A.P., Savara A., Saito T. (2021). Design of Tough Adhesive from Commodity Thermoplastics through Dynamic Crosslinking. *Science Advances*, 7, eabk2451.
- 11) Kanbargi N., Goswami M., Collins L., Kearney L.T., **Bowland C.C.**, Kim K., Rajan K., Labbe N., Naskar A.K. (2021). Synthesis of High-Performance Lignin-Based Inverse Thermoplastic Vulcanizates with Tailored Morphology and Properties. *ACS Applied Polymer Materials*, 3, 2911-2920.
- 12) Ebers L.S., Arya A., **Bowland C.C.**, Glasser W.G., Chmely S.C, Naskar A.K., Laborie M.P. (2021). 3D printing of lignin: Challenges, opportunities and roads onward. *Biopolymers*, e23431.
- 13) Rankin S.M., Moody M.K., Naskar A.K., **Bowland C.C.** (2021). Enhancing functionalities in carbon fiber composites by titanium dioxide nanoparticles. *Composites Science and Technology*, 201, 108491.
- 14) Guin T., Hinton H.E., Burgeson E., **Bowland C.C.**, Kearney L.T., Li Y., Ivanov I., Nguyen N.A., Naskar A.K. (2020). Tunable Electromechanical Liquid Crystal Elastomer Actuators. *Advanced Intelligent System*, 2000022.
- 15) Nguyen N.A., **Bowland C.C.**, Bonnesen P.V., Littrell K.C., Keum J.K., Naskar A.K. (2020). Fractionation of Lignin for Selective Shape Memory Effects at Elevated Temperatures. *Materials*, 13(8), 1940.
- 16) Jang G.G., Nguyen A.N., **Bowland C.C.**, Ho H.C., Keum J.K., Naskar A.K. (2020). Effects of graphene surface functionalities towards controlled reinforcement of a lignin based renewable thermoplastic rubber. *Composite Science and Technology*, 199, 108352.
- 17) Cui M., Gao Q., **Bowland C.C.**, Burgeson E.M., Hong K., Yue P., Naskar A.K. (2020). A Cast Net Thrown onto an Interface: Wrapping 3D Objects with an Interfacially Jammed Amphiphilic Sheet. *Advanced Materials Interfaces* 7, 1901751. [Featured as the BACK COVER of the issue]
- 18) Ghosh A., Kim K., Rajan K., **Bowland C.C.**, Gurram R.N., Montgomery R.W, Manesh A., Labbe N., Naskar A.K. (2019). Butanol-Based Organosolv Lignin and Reactive Modification of Poly (ethylenglycidyl methacrylate). *Industrial & Engineering Chemistry Research*, 58 (44), 20300-20308.
- 19) Barnes S.H., Goswami M., Nguyen N.A., Keum J.K., **Bowland C.C.**, Chen J., Naskar A.K. (2019). An Ionomeric Renewable Thermoplastic from Lignin-Reinforced Rubber. *Macromolecular Rapid Communications*, 40, 1900059.
- 20) Nguyen N.A., Meek K.M., **Bowland C.C.**, Naskar A.K. (2019). Responsive lignin for shape memory applications. *Polymer*, 160, 210-222.
- 21) Nguyen N.A., Meek K.M., **Bowland C.C.**, Naskar, A.K. (2019). Data of thermally active lignin-linkages and shape memory of lignin-rubber composites. *Polymer: Data in Brief*, 22, 392-399.

- 22) Nguyen N.A, Barnes S.H., **Bowland C.C.**, Meek K.M., Littrel K.C., Keum J.K., Naskar A.K. (2018). A path for lignin valorization via additive manufacturing of high-performance sustainable composites with enhanced 3D printability. *Science Advances*, 4 (12), eaat4967.
- 23) **Bowland C.C.**, Nguyen N.A., Naskar A.K. (2018). Roll-to-Roll Processing of Silicon Carbide Nanoparticle-Deposited Carbon Fiber for Multifunctional Composites. *ACS Applied Materials and Interfaces*, 10 (31), 26576-26585.
- 24) Nguyen N.A., **Bowland C.C.**, Naskar A.K. (2018). A General Method to Improve 3D-Printability and Inter-Layer Adhesion in Lignin-Based Composites. *Applied Materials Today*, 12, 138-152.
- 25) Nguyen N.A., **Bowland C.C.**, Naskar A.K. (2018). Mechanical, thermal, morphological, and rheological characteristics of high performance 3D-printing lignin-based composites for additive manufacturing applications. *Applied Materials Today: Data in Brief*, 18, 936-950.
- 26) Nguyen N.A., Meek K.M., **Bowland C.C.**, Barnes S.H., Naskar A.K. (2018). An Acrylonitrile–Butadiene–Lignin Renewable Skin with Programmable and Switchable Electrical Conductivity for Stress/Strain-Sensing Applications. *Macromolecules*, 51(1), 115-127.
- 27) **Bowland C.C.**, Malakooti M.H., Sodano H.A. (2017). Barium Titanate Film Interfaces for Hybrid Composite Energy Harvesters. *ACS Applied Materials and Interfaces*, 9(4), 4507-4065.
- 28) **Bowland C.C.** and Sodano H.A. (2017). Hydrothermal Synthesis of Tetragonal Phase BaTiO₃ on Carbon Fiber with Enhanced Electromechanical Coupling. *Journal of Materials Science*, 52(13), 7893-7906.
- 29) Nafari A., **Bowland C.C.**, Sodano H.A. (2017). Ultra-Long Vertically Aligned Lead Titanate Nanowire Arrays for Energy Harvesting in Extreme Environments. *Nano Energy*, 31, 168-173.
- 30) Bauer M.J., Snyder C.S., **Bowland C.C.**, Uhl A.M., Budi M. AK, Villancio-Wolter M., Sodano H.A., Andrew J.S. (2016). Structure–Property Relationships in Aligned Electrospun Barium Titanate Nanofibers. *Journal of American Ceramic Society*, 99(12), 3902-3908.
- 31) Zhou Z., **Bowland C.C.**, Patterson B.A, Malakooti M.H., Sodano H.A. (2016). Conformal BaTiO₃ Films with High Piezoelectric Coupling through an Optimized Hydrothermal Synthesis. *ACS Applied Materials and Interfaces*, 8(33), 21446-21453.
- 32) Zhou Z., **Bowland C.C.**, Malakooti M.H., Tang H., Sodano H.A. (2016). Lead-Free 0.5Ba(Zr_{0.2}Ti_{0.8})O₃-0.5(Ba_{0.7}Ca_{0.3})TiO₃ Nanowires for Energy Harvesting. *Nanoscale*, 8(9), 5098-5105.
- 33) Tang H., Zhou Z., **Bowland C.C.**, Sodano H.A. (2015). Growth of Highly Textured PbTiO₃ Films on Conductive Substrate under Hydrothermal Conditions. *Nanotechnology*, 26(34), 345602.
- 34) **Bowland C. C.**, Malakooti M.H., Zhou Z., Sodano H. A. (2015). Highly Aligned Arrays of High Aspect Ratio Barium Titanate Nanowires via Hydrothermal Synthesis. *Applied Physics Letters*, 106(22), 222903.
- 35) Tang H., Zhou Z., **Bowland C.C.**, Sodano H.A. (2015). Synthesis of Calcium Copper Titanate (CaCu₃Ti₄O₁₂) Nanowires with Insulating SiO₂ Barrier for Low Loss High Dielectric Constant Nanocomposites. *Nano Energy*, 17, 302-307.
- 36) **Bowland C.C.**, Zhou Z., Sodano H. A. (2014). Multifunctional Barium Titanate Coated Carbon Fibers. *Advanced Functional Materials*, 24(40), 6303-6308.

Technical Reports

- 1) Naskar A.K., **Bowland C.C.**, Webb D., Sanford M., Burkhit D., and McCall A. “CRADA Final Report: Nitrile-Containing Renewable Polymers Based on Lignin,” (CRADA) NO. NFE 1807437 (No. ORNL/TM-2022/2777). Oak Ridge National Lab.(ORNL), Oak Ridge, TN (United States) (2022).

- 2) **Bowland C.C.** “CRADA Final Report: Self-Sensing Fiber Reinforced Composite,” (CRADA) NO. NFE 2008069 (No. ORNL/TM-2022/2353). Oak Ridge National Lab.(ORNL), Oak Ridge, TN (United States) (2022).

Conference Manuscripts

- 1) Gupta S., Sohail T., Naskar A.K., **Bowland C.C.** (2024) “Multiscale modeling-enabled design of multifunctional composites,” SPIE Smart Structures/NDE 2024, March 25-28, Long Beach, CA.
- 2) Kanbargi N., Rohewal S.S., Gupta S., Sohail T., Naskar A.K., **Bowland C.C.** (2024) “Enhancing electromechanical properties of a lignin-based multifunctional composite through chemical reactive blending with functionalized carbon nanotubes,” SPIE Smart Structures/NDE 2024, March 25-28, Long Beach, CA.
- 3) Rohewal S.S., Gupta S., Naskar A.K., **Bowland C.C.** (2024) “A recyclable self-healing composite with advanced sensing property,” SPIE Smart Structures/NDE 2024, March 25-28, Long Beach, CA.
- 4) Rohewal S.S., Gupta S., Kearney L.T., Naskar A.K., **Bowland C.C.** (2023) “A recyclable self-healing composite with advanced sensing property,” ASME 2023 Conference on Smart Materials, Adaptive Structures and Intelligent Systems September 11-13, Austin, TX.
- 5) Gupta S., Mahapatra A., Angelopoulou P.X., Kearney L.T., Yu Z., Naskar A.K., **Bowland C.C.** (2023) “A Versatile Fiber Coating Process for Efficient Fabrication of Multifunctional Composites,” SPIE Smart Structures/NDE 2023, March 12-16, Long Beach, CA.
- 6) Gupta S., Naskar A.K., **Bowland C.C.** (2022) “Model-enabled design of multifunctional composites for passive self-sensing and energy harvesting with improved mechanical strength,” ASME 2022 Conference on Smart Materials, Adaptive Structures and Intelligent Systems September 12-14, Dearborn, MI.
- 7) Gupta S., Naskar A.K., **Bowland C.C.** (2022) “Multifunctional fiber-reinforced composites for passive sensing and energy harvesting with enhanced mechanical performance,” SPIE Smart Structures/NDE 2022, March 6-10, Long Beach, CA.
- 8) **Bowland C.C.**, Gupta S., Rankin S.M., Naskar A.K. (2021) “Passive sensing of a microparticle modified hybrid, fiber-reinforced composite,” SPIE Smart Structures/NDE 2021, March 22-26, Virtual Conference
- 9) **Bowland C.C.**, Burgeson E.M., Naskar, A.K. (2019). “Co-Continuous Phase Nanofiber Composites,” The Composites and Advanced Materials Expo, Sept. 23-26, Anaheim, CA.
- 10) **Bowland C.C.**, Burgeson E.M., Naskar A.K. (2019). “Enhanced Piezoresistive Sensing of Fiber-Reinforced Composites via Embedded Nanoparticles,” SPIE Smart Structures/NDE 2019, March 3-7, Denver, CO.
- 11) **Bowland C.C.**, Nguyen N.A., Naskar A.K. (2018). “The Effect of Nanoparticle Enhanced Sizing on the Structural Health Monitoring Sensitivity and Mechanical Properties of Carbon Fiber Composites,” SPIE Smart Structures/NDE 2018, March 4-8, Denver, CO.
- 12) **Bowland C.C.**, Wang Y., Naskar A.K. (2017). “Development of Nanoparticle Embedded Sizing for Enhanced Structural Health Monitoring of Carbon Fiber Composites,” SPIE Smart Structures/NDE 2017, March 25-29, Portland, Oregon.
- 13) Malakooti M.H, Patterson B.A, **Bowland C.C.**, Hwang H-S, Sodano H.A. (2017). “Piezoelectric Interfaces Enabled Energy Harvesting and Tailored Damping in Fiber Composites,” SPIE Smart Structures/NDE 2017, March 25-29, Portland, Oregon.
- 14) Zhou Z., **Bowland C.C.**, Patterson B.A, Malakooti M.H, Sodano H.A. (2016). “Conformal Growth of Textured Barium Titanate Films on Patterned Silicon Wafer,” ASME 2016 Conference on Smart Materials, Adaptive Structures and Intelligent Systems.

- 15) Zhou Z., **Bowland C.C.**, Patterson B.A, Malakooti M.H, Sodano H.A. (2016). “Optimized Parameters for Synthesis of BaTiO₃ Films with High Electromechanical Coupling,” ASME 2016 Conference on Smart Materials, Adaptive Structures and Intelligent Systems.
- 16) Zhou Z., **Bowland C.C.**, Patterson B.A, Malakooti M.H, Sodano H.A. (2016). “Hydrothermal Synthesis of Conformal Textured BaTiO₃ Films with Enhanced Ferroelectric Properties,” E-MRS Spring 2016, Symposium on Solution Processing and Properties of Functional Oxide Thin Films and Nanostructures, May 3-5, Lille, France.
- 17) Nafari A., **Bowland C.C.**, Sodano H.A. (2015). “Vertically Aligned Lead Titanate Nanowire Arrays for High Temperature Energy Harvesting,” ASME 2015 Conference on Smart Materials, Adaptive Structures and Intelligent Systems, September 21-23, Colorado Springs, CO.
- 18) **Bowland C.C.**, Malakooti M.H., Hwang H-S, Sodano H.A. (2015). “Fiber Reinforced Piezoelectric Composites,” 20th International Conference on Composite Materials, Symposium on Composites – Energy Storage and Harvesting, July 19-24, Copenhagen, Denmark.
- 19) Zhou Z., Patterson B., **Bowland C.C.**, Sodano H.A. (2014). “Conformal Growth of Textured BaTiO₃ Film on Si and its Piezoelectric Property,” MRS Fall Meeting & Exhibit, Nov. 30 – Dec. 5, Boston, MA.
- 20) **Bowland C.C.**, Zhou Z., Sodano H.A. (2014). “Barium Titanate Nanowire Film Coated Carbon Fibers for Power Harvesting,” The Composites and Advanced Materials Expo, Oct. 13-16, Orlando, FL.
- 21) **Bowland C.C.**, Zhou Z., and Sodano H.A. (2013). “Electromechanical Characterization of Barium Titanate Coated Carbon Fibers,” 19th International Conference on Composite Materials, Symposium on Composites with Sensing, Actuation, and Energy Transduction Capabilities, July 28-Aug. 2, Montreal, Canada.

Journal Reviewer: *Carbon*

ACS Applied Materials and Interfaces

Sensors

Advanced Functional Materials

Composites Part B

Journal of Materials Science

Patents

Issued Patents

- 1) **Bowland C.C.** and Naskar A.K. “Carbon Fiber-Nanoparticle Composites with Electromechanical Properties” U.S. Patent No. 11,827,757. (November 2023).

Pending Patent Applications

- 1) **Bowland C.C.**, Hinton H., Haley C., Domokhovskiy M., Bell G., Buratto M., Muse R., Janke C., Yu Z., Saito T. “Pipe renewal via full-circumferential polymer lining deposition” US Provisional Patent Application No. 63/462,694.
- 2) **Bowland C.C.**, Naskar A.K., Gupta S. “Polyacrylonitrile Fiber Reinforcement for Polymers and Fiber-Reinforced Composites” US Provisional Patent Application No. 63/617,459.
- 3) Naskar A.K., Yu Z., Zhou X., **Bowland C.C.** “Carbon Fiber Reinforced Composites and Method for Making Same,” US Nonprovisional Patent Application No. 18/373,628.

- 4) Naskar AK, Yu Z, Kanbargi N, **Bowland CC**, “Sustainable Adhesives for Metal Bonding” US Provisional Patent Application No. 63/409,857.
- 5) **Bowland C.C.**, Gupta S., Naskar A.K. “Passive Sensing Fiber-Reinforced Composite” U.S. Nonprovisional Patent Application No. 17/690,432.
- 6) Naskar A.K. and **Bowland C.C.**, “High strength lignin-acrylonitrile polymer blend materials” U.S. Nonprovisional Patent Application No. 16/829,167.

Students Mentored

Hoi Ho (UTK Bredesen Center PhD student, on advisory committee) (graduated 2019)
Susan Rankin (undergraduate intern from Virginia Tech) (June 2019-Dec. 2019)
Mikayla Moody (post-bachelor’s intern) (June 2019-Aug. 2019)
Eric Burgeson (post-master’s intern) (July 2018-Aug. 2019)

Postdocs Mentored

Dr. Sumit Gupta (PhD from University of California San Diego) (Oct. 2020-March 2023, promoted to ORNL Associate R&D Staff)
Dr. Zeyang Yu (PhD from Michigan State University) (June 2021-present)
Dr. Ajay Jayswal (PhD from Auburn University) (Dec. 2023-present)

Funding Awarded

DOE EERE Vehicle Technologies Office, “Composites Core Program 2.0 – Materials and Manufacturing Innovation for Sustainable Automotive Composites” Oct. 2023-Sept. 2026, PI: Amit Naskar, Thrust Lead: **Christopher C. Bowland** (Total: \$18,000,000 for 3 years)

ORNL Laboratory Directed Research and Development Seed Project “Passive Tomography for Electromechanically Coupled Composites” July 2022-July 2023, PI: **Christopher C. Bowland** (Total: \$190,000 for 1 year)

DOE EERE Vehicle Technologies Office, “Multi-Material, Functional Composites with Hierarchical Structures,” Oct. 2020-Sept. 2022, PI: **Christopher C. Bowland** (Total: \$1,500,000 for 3 years)

DOE EERE Vehicle Technologies Office, “New Frontier in Polymer Matrix Composites via Tailored Vitrimer Chemistry,” Oct. 2020-Sept. 2022, PI: Tomonori Saito (ORNL) (Total: \$1,500,000 for 3 years)

DOE ARPA-E, “Structural Materials-aided Advanced Renewal Technology for REPAIR (SMART REPAIR),” Oct. 2020-Sept. 2022, PI: Tomonori Saito (ORNL), Co-PI: **Christopher C. Bowland** (Total: \$5,000,000 for 3 years)

ORNL Laboratory Directed Research and Development “Controlling Reversibility in Next-generation Upcycling Polymers” Oct. 2019-Sept. 2021, PI: Tomonori Saito (ORNL) (Total: \$1,440,000 for 2 years)

ORNL Laboratory Directed Research and Development “Welding Interfaces for a New Plastics Economy” Oct. 2019-Sept. 2021, PI: Xi Chen (ORNL) (Total: \$900,000 for 2 years)

DOE EERE Fuel Cell Technologies Office, “Material Challenges for Cryogenic Hydrogen Storage Technologies,” Dec. 2018-Sept. 2020, PI: Kevin Simmons (PNNL) (Total ORNL portion: \$300,000 for 2 years)

DOE Technology Commercialization Fund Topic 1, “Self-Sensing Fiber Reinforced Composites,” July 2019-July 2020, PI: **Christopher C. Bowland** (Total: \$150,000 for 1 year)

Oak Ridge National Laboratory: Wigner Fellowship, “Next Generation Multifunctional Fibers via Embedded Nanomaterials,” October 2016-October 2019, PI: **Christopher C. Bowland** (Total: \$469,000 for 3 years)