Smart Fusion Material Research Cluster (SFMRC)

1. Participating Investigators

To successfully accomplish the proposed work, an interdisciplinary team is formed with joint expertise in experimental validation (Hwang), integrated STEM education (Alagic), data analytics (Nannapaneni), multiphysics simulation (Lu), nanoscale diagnostics (Ambal), public policy (Shen), government finance (Wang), and animation (Babb) as summarized in Table 1. The team collaborates with two intra-KBOR members (faculties from the University of Kansas and Kansas State University). Some of the team members currently lead two funded NASA and National Science Foundation (NSF) projects (over $993 K) and is currently involved with the local industry-funded research as Co-PI. The team has already submitted two NSF proposals under convergent sciences (currently pending), and they are co-advising Ph.D. students for their dissertations. Also, the team has 5 junior faculties who have joined WSU within 3 years and are very passionate to establish and grow the research programs in the emerging areas, while collaborating with 3 senior WSU faculties and 2 KU and KSU collaborators. The team has the diverse research backgrounds (7 departments spanning 4 colleges), which is unique to serve the proposed convergent research under the proposed "smart fusion material research cluster".

Table 1 List of names, title, departments, colleges (or affiliations), and project role

Name	Title and Department	College/University	Project Role
Hwang, Gisuk	Associate Professor, Dept. of Mechanical Engineering (ME)	Engineering, WSU	PI, Director
Nannapaneni, Saideep	Assistant Professor, Dept. Of Industrial, Systems, and Manufacturing Engineering (ISME)	Engineering, WSU	Co-PI, Co-Director
Alagic, Mara	Professor, School of Education	Applied Studies, WSU	Co-PI, Co-Director
Shen, Ruowen	Assistant Professor, Hugo Wall School of Public Affairs	Liberal Arts and Sciences, WSU	Co-PI, Co-Director
Lu, Tianshi	Associate Professor, Dept. of Mathematics and Statistics	Liberal Arts and Sciences, WSU	Co-PI
Ambal, Kapildeb	Assistant Professor, Dept. of Physics	Liberal Arts and Sciences, WSU	Co-PI
Babb, Timothy	Assistant Educator and Program Director of Animation, Shocker Studios	Fine Arts, WSU	Co-PI
Wang, Xiaoheng	Assistant Professor, Hugo Wall School of Public Affairs	Liberal Arts and Sciences, WSU	Senior Personnel
Li, Xianglin	Assistant Professor, Dept. of Mechanical Engineering	University of Kansas	Intra-KBOR Member
Thompson, Scott	Associate Professor, Dept. of Mechanical and Nuclear Engineering	Kansas State University	Intra-KBOR Member

2. Theme

Sustainable material design and manufacturing are one of the grand societal challenges, since those are essential to technological advancement and economic growth in multi-billion industry and economic sectors and national security. To directly and timely support these societal needs, the mission of the proposed **Smart Fusion Material Research Cluster** (SFMRC) is to stimulate the research, education, and practice by advancing science, technology, and policy in the areas of the computational material design and manufacturing.

The mission of the proposed research cluster is to investigate coupled interactions among science, technology, socio-techno-economic (the socio-techno-economic approach is to understand material design/manufacturing as an ecological system where individual, technology, infrastructure, and social environment intersect with each other), public and environmental policy in material discovery through collaborations with intra-KBOR members and innovation campus, and to train students and industry professionals for empowering future workforce.

The long-term research and education goals are to promote fundamental knowledge of material design and manufacturing using novel data analytics, computational approach, and diagnostic tools, and socio-techno-economic approaches. The short term research objective is (a) to promote the fundamental knowledge of convoluted relations in material-process-microstructure-mechanical properties for the smart fusion material discovery by developing new data analytic, diagnostics, computational simulation tools for the technological advancements, and (b) understand socio-techno-economic relations for facilitating the commercialization of the developed materials. The education objective is to facilitate implementation of the best practice, evidence-based learning/teaching strategies and to investigate the research question: How does a student-centered, project-based pedagogical approach under interdisciplinary education/training substantively improve student learning in an inclusive and equitable learning environment toward the STEM education with creative entrepreneurial mindset, i.e., *Edison Incubating Education*? The overall theme of the proposed work is at the intersection between the digital transformation and sustainability, or wild card category.

3. Introduction, Relevance, and Need

Introduction and Challenges: Growing global trends toward achieving sustainable material design/manufacturing under revolutionized digital transformation lead to unprecedented challenges and opportunities for convergence science at the intersection of engineering, sciences, humanity, fine arts, and education. An emerging technology is an additive manufacturing (AM), also known as 3D printing, offering efficient and environmentally friendly manufacturing to advance current manufacturing limits in multi-billion-dollar economic sectors such as national security, transportation, energy, building, medical systems. The AM produces 3D parts in a layer-by-layer approach by melting and "fusing" powder materials, which provide many advantages over the conventional manufacturing process, including improved complex geometry manufacturability and reduced manufacturing time and material waste. More importantly, it also revolutionizes the way that we manufacture products through decentralized manufacturing (we can "print" products at home/office just like an inkjet/laser printer) by electronically sending the electronic file using computer-aided design (CAD). This innovative manufacturing is much more efficient and environmentally friendly than the conventional manufacturing, which produces products by removing unnecessary material, known as subtractive manufacturing. The AM technology benefits crucial economic sectors by providing rapid prototyping, on-site repairs, and custom medical prosthetics. The AM for the plastic materials has been successfully developed, but the AM technology for metallic materials, i.e., metal AM, is still much behind in commercialization due to the limited understanding of the convoluted relationships between material-microstructure-processing-mechanical properties, socio-techno-economic relations in technology transfer, and convergent education program to train next generation workforce. The challenges are related to limited scope of metal AM research, primarily due to a lack of interdisciplinary study approaches[1–5] and education program[6–10]. In fact, emerging data analytic approaches have shown a strong potential to understand such complex relations in metal AM process, but the depth of the knowledge is still very limited due to the poor data analytic framework, limited non-destructive diagnostic tools[1–5,11,12], simulation approaches[13–15] and/or overlooked real-time processing parameters[16,17,3,18–20].

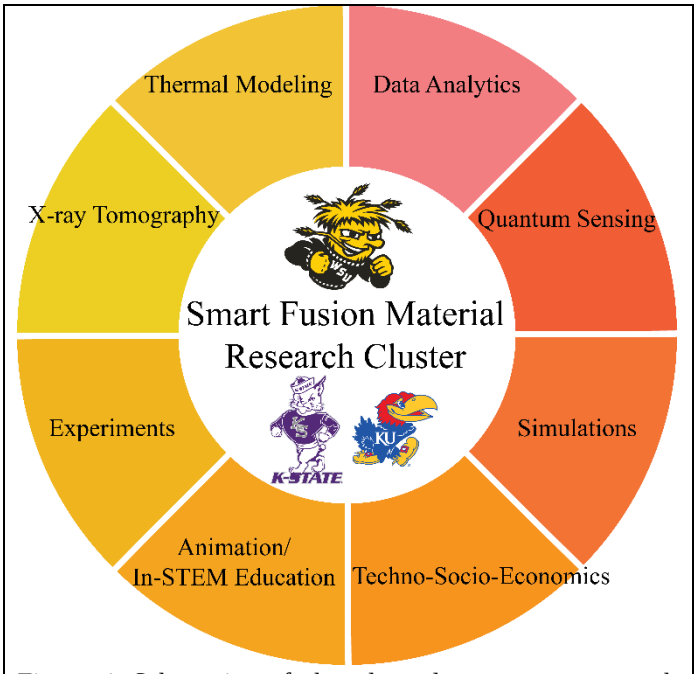

Figure 1 Schematics of the planned convergent research cluster, collaborating with intra-KBOR members.

Previous data analytic approaches have neglected the importance of the microstructure-mechanics relation[21–23] in metal AM. Also, the previous studies on the environmental and economic impacts of AM primarily remain in the qualitative approach, and the lack of empirical analysis limits an assessment of the scope of the societal impacts[24,25]. This further limits the role of government in the development of AM[26]. With the issues of health, safety, and security emerging from this new technology, it is important to apply the multilevel governance approach to understand various roles of government in supporting and overseeing technology and innovation[26,27]. In addition, the lack of the convergent Science Technology, Engineering and Math (STEM) education program is a main bottleneck of the current/future technical advancements[28].

A reliable pedagogical approach for addressing these challenges is Interdisciplinary/Integrated STEM Project-Based Learning (InSTEM PBL) that includes inquiry-based learning with reflective practice[28–30]. InSTEM PBL requires an appropriate curricular/instructional design that bridges discrete disciplines of STEM into projects that investigate challenging questions, leading students to explore the central principles of a discipline. Well-designed InSTEM PBLs are inherently collaborative, learners are engaged in socially interactive learning, supporting each other's development of conceptualized knowledge[31,32,9,33,34], but such an ideal InSTEM PBL is rare in the metal AM.

Relevance to Convergence Science: A key success in the metal AM requires a breakthrough approach unlocking convoluted relations between material-microstructure-processing-mechanical properties by developing novel data analytics (by handling big size of different types of data such as numeric, images, texts), multiphysics simulation, non-destructive diagnostic tools, and experimental characterization approach. To address this challenge, a multidisciplinary working team is formed with joint expertise in required technical areas. In addition to the technological advancements, the understandings of the socio-techno-economic relations between technology, market, environment, government are also essential for facilitating the successful commercial adaptations, however, the systematic studies on such a convergent research topic are rare. Thus, the team extends the efforts to advance key knowledge, collaborating the experts in public administration and government finance. More importantly, the rapid and multidisciplinary material design/manufacturing framework changes demand the convergent STEM education program to empower the key workforces, and the team will develop on-demand animation-facilitated multidisciplinary STEM education modules under the leadership by the animation and STEM education experts.

Needs and Impacts: To efficiently address these urgent and important societal needs, the team proposes to build a Smart Fusion Material Research Cluster (SFMRC) with the joint expertise in big data analytics, non-destructive diagnostics, multiphysics simulations, experiments, environmental sustainability, government finance, animation, and STEM education, while collaborating with two intra-KBOR teams from University of Kansas and Kansas State University. The research in the SFMRC primarily focuses on the development of novel multiphysics-multiscale computation material design framework combined with big data analytics for the investigations of a wide range of fusion materials including the non-destructive diagnostics, experiments, and socio-techno-economic relations. The education goal of this cluster is to promote STEM education for empowering the future workforce in the new fusion material discovery and improvement in the multidisciplinary working environments with entrepreneurial mindset, i.e., Edison Incubating Education.

If successful, the main benefit of the proposed work is to establish the new class of data analytic approach which unlocks the complex relations of the material-process-microstructure-property in metal AM technology for large scale commercialization. This approach will explain the roles of the independent process parameters on the microstructures, subsequently on mechanical properties using a synergetic combination of the data analytics, modeling, non-destructive diagnostics, and experimental approaches. The developed quantum sensing device will fill in the knowledge gaps of the nanoscale material solidity and integrity at smaller than 100 nm sizes for the metal AM for the first time. The obtained 3D microstructure images will provide the defects, grain characteristics, melt-pool geometries in 100 nm to 10 μm spatial resolution, which will provide deep insights on understanding mechanics and property. Also, this research will provide the big data sets of material, process, microstructure, property in metal AM, which enable us to facilitate global metal AM research. The emergence of 3D printing technologies may have deleterious impacts on society, especially due to the production of weapons, dangerous medical devices, and counterfeit products, as well as the due to issues of liability and unemployment. Facing these new challenges of technological advancement, governments should play an important role in encouraging ethical behavior, promoting civility, and regulating the proper use of new technologies by the public and producers.

4. Research Cluster

The research objective is to understand not only the fundamental relations material-process-microstructure-mechanical properties using big data analytics (Nannapaneni), micro-/nano diagnostics (Ambal/Li), multiphysics modeling (Lu/Thompson), and experimental validation (Hwang) as a unified study framework, but also the socio-techno-economic impacts of the fusion materials (Shen) and government finance (Wang), aiming at developing efficient, and robust fusion materials for decentralized metal additive manufacturing (AM). The main benefit of the convergent research is to provide the fundamental knowledge and tools at the intersection among big data analytics, diagnostics, simulation, in-situ/ex-situ experiments along with the societal impact research. The convergent research will also synergetically implemented into the integrated-science, technology, engineering, and math (InSTEM) education (Alagic) combined with the animation (Babb) to empower future STEM work force under the multidisciplinary working environment. If successful, the research outcomes will pioneer to develop a new class of big data analytic approach for efficient and robust metal AM, i.e., "real-time certification". To achieve the research objectives, the team plans to perform six primary research thrusts as given below.

Thrust 1 (R1): Digital Twinning and Data Analytics (Nannapaneni)

The main goal of this research thrust is to substantially advance the fundamental knowledge of the linkage between material-process-microstructure-mechanical properties to enable real-time process control during printing by establishing a data fusion framework using a combination of state-space modeling, probabilistic data fusion and risk analysis, as similarly done in the Co-PI (Nannapaneni)'s previous work[35–37](see Figure 2). The necessary data (porosity, microstructure, mechanical properties, etc.) from other research thrusts (R4-R6) and KU and KSU collaborators. The obtained knowledge will decipher the impacts of various fusion material discovery on AM quality and certification.

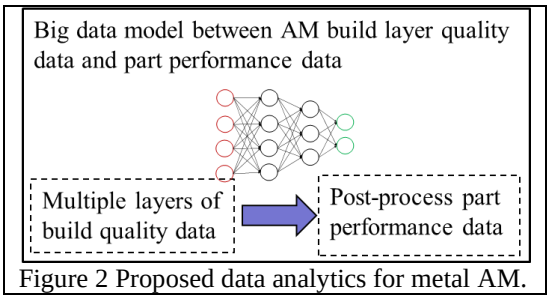

Figure 2 Proposed data analytics for metal AM.

Thrust 2 (R2): AM Diffusion and Sustainability Impact (Shen)

The main purpose of this research thrust is to investigate the influence of related industry on the metal AM innovation diffusion as well as the sustainability impact of the AM/fusion materials in terms of environment, economy, and society (see Figure 3). To achieve this goal, social network analytics would be conducted along with survey methods. This research thrust will provide evidence-based knowledge to policy makers on the development mechanism of the AM as well as the scope of its sustainability impact.

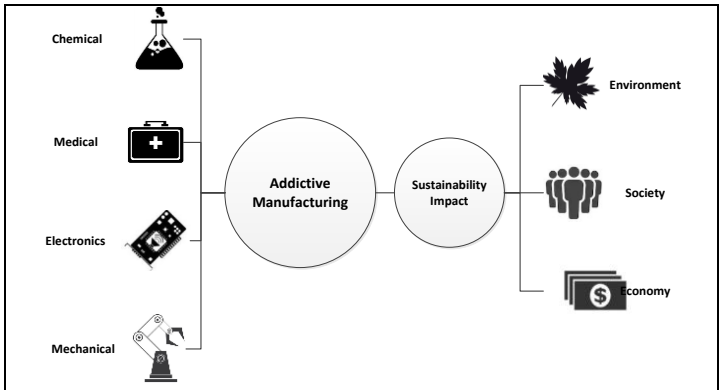

Figure 3 Proposed sustainability impact study.

Thrust 3 (R3): Efficiency and Economic Implication of AM Technology (Wang)

The main purpose of this research thrust is to understand the efficiency of the application of 3D printing and social economic impact on the development of this technological advancement. As many AM technologies have been driven by public funding and government initiatives, it is essential to identify the roles that government should play in regulating and overseeing these technologies, as well as to determine whether the total benefits of AM technology will exceed the total cost to make society better off. To achieve this goal, cost-benefit analysis will be utilized. One advantage of this approach is that it allows policy makers to consider both economic and noneconomic costs and benefits associated with the investment and application of AM technology, and guide its proper use to achieve policy goals in a less costly and more effective manner.

Thrust 4 (R4): Nanoscale Non-destructive Diagnostics, i.e., Quantum Sensing (Ambal)

The primary focus of this research thrust is to fill in the knowledge gaps of the nanoscale material solidity and integrity (cracks, pores, joint quality, etc.) by developing a non-destructive quantum sensing method to characterize geometries and thermophysical properties at smaller than 100 nm. If successful, this technique provides a new class of the non-destructive characterization tool for the fusion material research. This method uses a quantum sensor, Nitrogen vacancy (NV-) center in diamond, to probe nanoscale thermal conductivity. The measurements yield high-resolution thermal conductivity images, which will enable us to detect surface and sub-surface flaws as good particle-to-particle bonding, and defect-free locations will have higher thermal conductivity compared to areas with flaws. Our approach is to use the novel real-time locking and tracking method of the electron spin resonance peak of NV- center, based on the Co-PI (Ambal)'s previous work[39]. Our method exploits the quantum effects which caused to shift the NV- centers' resonance frequency due to change in temperature in the vicinity[40].

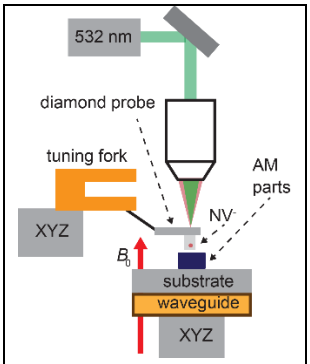

Figure 4. Proposed nanoscale quantum sensing device.

Thrust 5 (R5): Microstructure Modeling (Lu)

The primary objective of this research thrust is to substantially promote the knowledge on the dynamics of the microstructure during the fusion material design/fabrication by developing multiphase/multiphysics computational fluid dynamics (CFD) simulation approach. If successful, the simulation will provide the melt-pool dynamics and microstructure geometries to complement the experimentally obtain results. Our OpenFOAM-based software will primarily study the powder-bed fusion metal AM processing method. The developed software will simulate the formation of solidification cracks and pores during AM, and analyze the directional residual stress and mechanical strengths such as fatigue and creep properties of the processed material, based on the Co-PI (Lu)'s previous work[38,41–44].

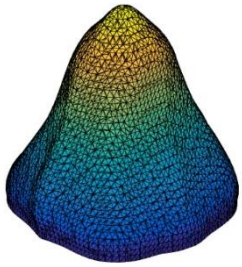
Figure 5. Laser ablation plasma plume simulation result (Co-PI's work)[38].

Thrust 6 (R6): Experimental Validations (Hwang)

The main purpose of this thrust is to experimentally validate the data analytic (R1), diagnostic (R4) and simulation (R5) work for the fusion material process parameters. The obtained data is crucial to understand the fundamental relations between the independent/dependent AM process parameters. Note that Lumax Avance-25 at University of Nebraska, Lincoln will be used to measure the process parameters during the research (collaborating with Dr. M. Sealy) and/or Advanced Manufacturing Laboratory at NIAR. A few different materials will be used including stainless steel, titanium-based alloy, nickel-based alloy, and aluminum-based alloy, which are crucial materials for various applications. Mechanical properties will be characterized based on appropriate American Society of Testing and Material (ASTM) test standard methods for both static and dynamic properties, including tension, surface roughness, fatigue tests using various equipment at Department of Mechanical Engineering, WSU.

(a) History of previous collaboration

Three Grant Proposal Submissions: (1) Hwang (PI), Alagic (Co-PI), and et al. submitted a proposal to NSF National Research Traineeship (NRT) program, entitled as "NRT-HDR: Empower Future Integrated-STEM Leaders in Data-Driven Additive Manufacturing", $3M, 09/01/2020 – 08/31/2025, pending, (2) Nannapaneni (PI) and Hwang (Co-PI), et al. submitted to NIST, entitled as "Standardized end-to-end information representation and physics-informed data fusion in Additive Manufacturing", $129,707, 10/1/2020-09/30/2021, pending, (3) Hwang (PI), Alagic, Ambal, Lu, and Nannapaneni (Co-PIs) et al. submitted a letter of intent to NSF, Convergence Accelerator (NSF 20-565), 5/11/2020, entitled as "NSF Convergence Accelerator Track D: Real-time Process-Microstructure-Properties Understanding in Metallic Additive Manufacturing using Data Science", 5/11/2020.

Two Research Project Collaborations: (1) Hwang and Nannapaneni work on data analytics methods for efficient design of sintered-particle wick structures through co-advising a full-time graduate student (Mr. Munonyedi K. Egbo), (2) Hwang and Lu co-advise a full time graduate student (Mr. Yahya Nasersharifi), working on the pool boiling enhancement mechanisms using 3D wick structures.

(b) Opportunity for new partnerships: the team will collaborate with two intra-KBOR members (Dr. Xianglin Li, Assistant Professor at Department of Mechanical Engineering, University of Kansas, and Dr. Scott Thompson, Associate Professor at Department of Mechanical and Nuclear Engineering, Kansas State University). The detailed descriptions of the research backgrounds and project roles are given in Section 9. This work will also strengthen the existing collaboration with Dr. Michael Sealy (Assistant Professor at Department of Mechanical Engineering, University of Nebraska, Lincoln) under PI Hwang's current NSF grant. The research cluster will also strengthen the partnership with National Institute of Standards and Technology (Dr. Yan Lu, NIST, collaborator under the pending NSF proposal). This will strengthen the WSU-WSU tech by providing courses related to the metal AM.

(c) Evidence of externally funded research

Hwang (PI) has brought the total of $1,106,735 as a PI from NASA and NSF and Sandia National Laboratory (see the details in his CV), including two currently-active grants ($993 K). Nannapaneni (Co-PI) is involved in two local industry-funded research grants totaling to $170,000, and one of them is on-going project (total budget is $80 K and his role is Co-PI). Lu (Co-PI) has brought $110,000 to WSU as the PI of the Kansas NSF EPSCoR First Award on Modeling and Algorithms of Multiphase Magnetohydrodynamics in Tokamaks.

Note that since most team members (5 junior faculty) have jointed WSU within the last 3 years, there are only a few external funded researches; however, they are actively pursuing external grants. If funded, the outcomes of the proposed work will substantially increase to bring the external funds by successfully establish the research program and producing the preliminary results.

(d) Opportunity for mentorship in the grant writing process: five junior faculty will be mentored in the grant writing, while developing/submitting collaborative proposals with the grant-writing experienced faculty in the team (both in WSU, and intra-KBOR members) based on the detailed proposal submission plans in Section 8.1.

(e) Specialized knowledge residing in the research team that is pertinent to the problem

The new knowledge at the intersection of the big data analytic framework (1) with metal AM material-microstructure-process-mechanical property data bank, (2) nanoscale quantum sensing, (3) multiphysics simulation code, (4) socio-techno-economic knowledge database, and (5) animations in InSTEM PBL education module.

(f) Co-development of research infrastructure

The new research tools will be developed including the followings.

(1) Big data analytics for the metal AM i.e., heterogenous data fusion approach, validated by the simulations and experiments, which will accelerate the fusion material discovery and improvements.

(2) Quantum sensing apparatus in metal AM (the novel apparatus for nanoscale non-destructive probing in materials solidity and integrity will rationalize the fine-tuning of the synthesis parameters in new materials design. Therefore, this expertise and research infrastructure would excel in WSU's leadership to serve AM industries in their materials design and process control.

(3) Multiphysics simulation code validated by diagnostic (quantum sensing device and X-ray tomography) and experiments.

(4) Socio-techno-economic research methodology, which will serve a firm ground for the smart fusion material design/manufacturing research infrastructure, while closely working with local governments (City of Wichita and Sedgwick County).

5. Budget and return on investment

5.1 Budge Justification

We request $300,000 for a 36-month project period to financially support 8 UG students (fine arts), 2 Ph.D. students (in engineering and math and physics), 1 master student (in public affairs and education), and 8 WSU faculty and 2 intra-KBOR members, including tuition remission for the three graduate students. This grant will also indirectly benefit 1 additional Ph.D. student and 2 additional master students (through the partial support from this grant).

A) Senior Personnel - $9,155

The PI is budgeted at 0.08 FTE for one summer month each year. The PI will be responsible for overseeing the project, experimental characterization of metal additive manufacturing (AM) built parts, developing an interdisciplinary class, advising/mentoring students. Six Co-PIs and one Senior Personnel (SP) are budgeted at 0.04 FTE for 1 summer month each year. They are responsible for the proposed research and curriculum implications given in the project description. For all personnel, annual 3% COLA included.

B) Other Personnel - $158.212

Two graduate students are budgeted at $17,793 per student as a starting annual salary to assist the PI and Co-PIs in the College of Engineering and in the Department of Math and Physics. One master student is budgeted at 15,600 as a starting annual salary to assist the Co-PIs and SP in the Hugo Wall Public Affairs and School of Education. Eight undergraduate students are budgeted at hourly rate of $10 at10 hr/week for 10 weeks for each year. Annual 3% COLA included.

C) Fringe Benefits - $14,223

Fringe benefits for Senior Personnel and students are budgeted.

D) Tuition Remission for Students ($66,803):

Tuition remission and student fees are budgeted for 3 graduate students. This includes an annual 3% COLA.

E) Other Direct Costs - $26,880

Project Supply for Research ($17,880):

The budget is requested for project materials and supplies for AM experimental validations (metal powders, 3D printing fee, mechanical property testing fee), and quantum sensing device development including the aluminum block, electric wires, data collection equipment. The detailed project descriptions are given in Section 4, Research Thrusts 4 and 6.

Consultant Fee ($9,000):

The budget is requested for consultant fee to deliver the X-ray tomography data and thermal modeling efforts with the annual consultant fee of $3,000 for 3-year consultant service for Intra-KBOR members. The detailed plans for the proposed project are given in Section 9 of the project description.

F) Total Direct Costs - $300,000

G) Indirect Costs (F&A) $0

Indirect costs are not assessed for internal funding opportunities.

H) Total Direct and Indirect Costs $300,000

5.2 Return on Investment

If successful, the obtained research knowledge, tools, and intra-KBOR partnerships and curricular improvements are anticipated (a) to substantially increase the competitiveness of the external funding, (b) build new partnerships with industry, (c) to efficiently mentor faculty, and (d) to enrich student research and learning experiences.

(a) Key preliminary research outcomes

Multiple research outcomes will be obtained from this proposed project at the intersection between the technical/techno-socio-economic knowledge and tools, including (1) material-process-microstructure-mechanical property relation, (2) socio-techno-economic relations between technology-market-environment-government policy (3) new data analytic framework (heterogeneous data fusion), (4) multiphysics simulation code, (5) quantum sensing device, and (6) various experimental/simulation characterization of the fusion materials, i.e., big data. The preliminary results will substantially increase the chance of bringing the external grants from various funding agencies, including NSF, NASA, DoE, and contracts (see Table 2). Also, the obtained socio-techno-economic relations and developed animation-based STEM education program combined with the aforementioned technical aspects will substantially increase the competitiveness in the areas of the convergence science funding opportunity. Also, the obtained preliminary data and developed research/education tools will successfully establish the research program, especially junior faculty, thereby significantly increasing the competitiveness for the external funding opportunity such as NSF CAREER program.

(b) New partnerships with industry

Successful accomplishments of the proposed research and education will advance cutting edge technology in multi-billion-dollar transportation, energy, medical sectors, including aviation, automotive, buildings, and biomedical systems. The obtained new knowledge and research/education tools will stimulate the collaborations with multiple industry including Sprit Aerosystems, Hexagon, Dassault Systems, Airbus, Deloitte, NetApp, and Textron where the metal AM is one of their technology development/investment areas with priority. For examples, the new big data analytic framework, developed simulation and non-destructive diagnostic tools will promote the understandings of material-process-microstructure-mechanical property relations for the metal AM technical advancement in the cost-effective, and efficient, and safe aircraft part manufacturing. The developed animation-based STEM education program will also empower future STEM workforce in the industry.

(c) Mentoring faculty

The team has 5 junior faculty who have joined WSU within the last three years and are very passionate to establish and grow the research programs in the emerging areas, while collaborating with three senior faculty at WSU, two Intra-KBOR faculty, and potential partnerships with industry. This collaboration opportunity is unique, and it is beneficial for the junior faculty to effectively learn to manage multidisciplinary projects, co-advising graduate/undergraduate students from the diverse backgrounds, and develop collaborative proposals to be submitted to the NSF convergence science program (part of NSF's big ten ideas, see Table 2 for details).

(d) Enriching student experiences

The multidisciplinary research and education program in the metal AM is rare, and this is essential to successfully empower future STEM workforce and leadership due to the inherent nature of the technical and societal challenges. The developed research and education programs will enable them to have research and education experiences under the multidisciplinary working teams (engineering, physics, math, education, social sciences, and fine arts), and inter-university (KU and KSU) and industry partnerships, including the internships/summer research experiences in KU/KSU, and industry.

6. Identifying gaps in expertise

The mission of the proposed research cluster is to investigate coupled interactions between technology development, socio-techno-economic, public and environmental policy challenges in technology transfer in material discovery through collaboration between WSU and the innovation campus, and train students and industry professionals. Although the team has already identified the core personnel, the following cluster hires would accelerate the growth of the proposed research cluster and increase the competitiveness for external funding.

(1) A faculty with the research interests centered around the techno-economic issues in material science and technology to understand the micro-/macroeconomic impacts from the emerging material research and developments. The new faculty can be hired between the colleges of engineering and business (under Dept. of Economics), whose expertise lies in the micro- and/or macroeconomics with the engineering or technology backgrounds. This faculty potentially creates a new research program in the economic impacts based on the emerging technologies, which can strengthen the team's efforts under the convergence science. This strategic hire could increase the competitiveness for the collaborative proposals to the NSF convergence science program and/or the external grants from the local engineering/technology industry.

(2) A faculty with joint appointment between Engineering and School of Education (specifically, secondary STEM Education) would work on expanding the existing iSTEM Graduate Certificate in School of Education to master's program in Integrated STEM Education with an inclusion of a metal AM as one of the strands (one of the objectives of this proposal) and potentially an interdisciplinary STEM Education PhD. This would be in line with current national trends in recognizing STEM education as one of Society's Grand Challenges for the 21st century and would significantly increase opportunities in searching for external funding (especially for NSF).

7. Curricular Implications: Edison Incubating Education

Based on research in cognitive processes, learning is most effective when active engagement, teamwork participation, interaction and feedback, as well as connections to real-world contexts are included in the learning environment[45]. Hence, the proposed curricular implications are grounded in our (a) educational objective to facilitate implementation of the best practice, evidence-based learning/teaching strategies and (b) investigation of the research question: How does a student-centered, project-based pedagogical approach under interdisciplinary education/training substantively improve student learning in an inclusive and equitable learning environment toward the STEM education with creative entrepreneurial mindset?, i.e., *Edison Incubating Education.*

(a) Animation in Project-based integrated STEM (InSTEM) Education

The main purpose of this thrust is to substantially promote the STEM education content with the inclusion of the animation in the context of Edison Incubating Education. If successful, this will substantially increase the competitiveness of the WSU's online and face-to-face STEM education programs. The Animation (Babb) and STEM Education (Alagic) faculty will lead the development of a new animation-based education contents, while collaborating with other team members. Animation students will apply and develop knowledge and techniques related to the animation pipeline, which includes concepts regarding developing traditional and procedural animation tools and skills in producing STEM-based and metal AM related educational animations.

(b) Expand Master Program in Material Science

The proposed research cluster will stimulate the growth of the material science master degree program under College of Engineering by including a new graduate course. The PI (Hwang) and Co-PIs (Nannapaneni/Ambal) will jointly develop a new graduate course "Data-Assisted Fusion Material Design" (tentative course name) at the intersection between ME, ISME, Physics Dept. (cross-listed). This course will cover basics of the data analytics and nanoscale diagnostics, and their applications to the fusion material design/manufacturing, especially for metal AM applications. This course will directly serve the recent big-data analytic demands in the metal AM both in the academic programs and industries, which promotes the student enrollment from perspective student populations and employees in local aviation industries. In the class, the socio-techno-economic education modules will be also included.

(c) Support School of Computing

The proposed cluster research will generate a large amount of different types of data, e.g., numeric, images, and texts. Harnessing such big heterogeneous data is very challenging. The obtained big data analytics along with the experimental results from the Mechanical, Math, and Physics Dept will be uniquely implemented into the future curriculum in the School of Computing for promoting the multidisciplinary curricular approaches and recruiting the students from the multidisciplinary areas.

(d) Master's Program in Integrated STEM Education

The aforementioned new graduate course will expand the existing Online iSTEM Graduate Certificate in School of Education to master's program in Integrated STEM Education with an inclusion of a metal AM as one of the strands. This program will be designed based on (a) STEM education framework advanced in the Next Generation Science Standards (NGSS) which addresses convergence and (b) our vision of Edison Incubating Education. This new program is anticipated to increase the student enrollment for the future STEM teachers in the areas of the metal AM.

(e) Online Course and Professional Career Developments

The team will develop multiple online courses and professional development workshop to train/recruit undergraduate/graduate students as well as industry professionals. The new online courses include computational material science (Hwang), data analytics (Nannapaneni) and multiphysics simulation (Lu), for basic principles as well as hands-on computational experiences. We will also develop a new day-long professional career development workshop including multiple 75-min long sessions (computational material sciences, data analytics, diagnostics, multiphysics simulations, socio-techno-economic areas) for the students and industry professionals such as Spirit Aerosystems, Textron, Deloitte and Koch Industries. This plan will not only empower future STEM workforce but also to financially sustain the research cluster.

8. Sustainability and Impact

8.1. Sources of External funds and Plans for Proposal Submission

The team identified the following the external funding sources, and the published calls, research focus, submission timeline are found in Table 2.

Table 2 Summary of External Funding Sources and Plans for Proposal Submission

Funding Sources	Program Theme	Submission Plan
Year 1		
NSF Convergence Accelerator (NSF 20-565), $1M (Phase I), and $5M (Phase II)	Rapid advances that can deliver significant societal impact.	Submitted a white paper on 5/11/20, plan to submit the full proposal by 7/10/20.
NSF Research Experiences for Undergraduates (REU, NSF 19-582), $0.42M	Active research participation by undergraduate students in research funded by NSF.	Plan to submit by 08/26/20.
Department of Energy (DoE, DE-FOA-0002252), $0.5M	Integrated additive manufacturing processes for advanced wind blade production	Plan to submit by 08/20
NSF EPSCoR Research Infrastructure Improvement Program Track-1 (NSF 19-580), $1.25M	Build inter-jurisdictional collaborative teams in NSF's scientific interest areas	Plan to submit by 01/21 (joint proposal submission with University of Nebraska, Lincoln)
NSF National Research Traineeship (NSF 19-522), $3M, annual call	Convergent research of national priority under NSF's 10 big ideas.	Submitted a full proposal on 2/6/20. Resubmit by 02/21 if declined.
National Institute of Standards and Technology (2020-NIST-MSE-01), $0.4 M	Data Integration and Management in Additive Manufacturing	Plan to submit by 05/21
Year 2		
NSF EPSCoR Research Infrastructure Improvement Program Track-1 (NSF 19-580), $20M, annual call	Improvements in research for future research and development competitiveness of the jurisdiction.	Plan to submit by 08/21 (joint proposal submission with KU and KSU).
NSF Advanced Technological Education (ATE, NSF 18-571), $0.3M	Advanced Technological Education	Plan to submit by 10/21
Local Governments' Programs researching and developing AM technologies	An analysis of efficiency and economic implication of 3D printing technologies	Plan to submit by 10/21
STEM Based Education Animation Client Contracts from Technology and Engineering Industry	One 30-60 second Animation would have a budget of $16,000	Plan to submit by 11/21
Year 3		
Roddenberry Fellowship, $0.25 M	Evaluate sustainability impact of 3D printing innovation to local communities	Plan to submit by 09/22
NSF Discovery Research PreK-12 (DRK-12, NSF 20-572), $0.3M	Enhance the learning and teaching of STEM by preK-12 students and teachers	Plan to submit by 10/22
NSF Improving Undergraduate STEM Education (IUSE: HER, NSF 19-601), $0.6M	Improve undergraduate STEM education	Plan to submit by 10/22

8.2. Expected Outputs and Impacts

(a) Possible Expansion of Research Team

The research activities/team will be expanded when the pending/future external funding is secured, which will be most likely after year 1 or year 2. A few grant opportunities require multiple institutions (NSF 20-565, NSF 19-580), and if successful, the research team will be expanded beyond the WSU. The team

will diligently submit the multiple proposals based on the submission plans (Table 2) for research team expansion. As the team produces the meaningful research outcomes (after year 1 or 2), the research collaboration with industry can be expanded, either through joint proposal submission(s), project(s), and/or student internships. Depending on evolutions of the material program/school of computing/new cluster hire(s), the team research can be further expanded including computational material, techno-economic and/or STEM education research (see Section 6). Beyond this project, the team will continue to pursue the research by securing the external funding in the areas of emerging material/manufacturing, based on the established research outcomes/tools/partnerships.

(b) Publications

We anticipate publishing at least 10 conference papers and 8 journal papers by the end of the project. This project will also support 3 Ph.D. dissertations and 7 master theses (or equivalent creative artwork) co-advised by faculty from various colleges. The yearly split of the anticipated publication numbers at the end of each year are: Year 1(3 conference papers, 2 journals, 0 dissertations, 2 theses), Year 2 (3,3,0,2), and Year 3 (4,3,3,3). These numbers represent the total publications across all members in the project team from various colleges.

(c) Funding

The competitiveness of bringing the external grant increases as the team produces the research outcomes and establishes the research tools by complementing the on-going research infrastructure development and research activities under the start-ups, NASA, NSF, and DOE grants. By the end of year 1, the team plans to submit at least 6 proposals to the external funding agencies, and 4 and 3 proposal submissions (see Table 2). Note that the numbers of proposal submissions in years 2 and 3 will be higher if we include the resubmissions of the declined proposals from the submission in year 1.

(d) Student Enrollment

The substantially-improved curricula by adding animations (STEM Learning via Animations) into the existing/new courses will stimulate increasing the student enrollments in Colleges of Engineering (IME524, IME869, ME 859), Liberal Arts and Sciences (MATH551, MATH852, PHYS516, PHYS702), and Education (CI 764, CI 867), based on the previous study[46]. The initial animation-based STEM education modules will be developed at the end of the year 1, and if successful, the meaningful impacts can be identified at the end of year 2 and beyond. Also, further student enrollment increases are anticipated as the material master's program and school of computing grow and STEM education certificate/program are launched.

(e) WSU Community Promotion:

The successful implementation of the annual animation-based STEM education module (all three years) into the on-going K-12 summer camps (Hwang/Alagic are actively participating and the team plans to develop/attend in near future) will recruit the future STEM workforce to WSU. Note the TRIO Upward Bound Math and Science (UBMS) center will be used to recruit low-income and first-generation students for the higher educations. The obtained research outcomes, 3D printed parts, will support the annual Kansas BEST (Boosting Engineering, Science & Technology) competition event hosted by College of Engineering (all three years). In addition, the developed fusion material courses will benefit to the WSU tech program, which is anticipated to increase the student enrollment, while collaborating with Dr. Bruce Fritz, Dean of Manufacturing Technologies, WSU Tech), which plans to be implemented at years 2 and 3.

(f) Benefit to the Economy of Wichita and Kansas

The research in fusion materials will stimulate economic growth in the regional area (City of Wichita, known as the Air Capital of the World) by directly supporting advanced manufacturing technology, especially for aviation industries via educated STEM workforce, along with the Blueprint for Regional Economic Growth (BREG, economic development within the South-Central Kansas Context). In addition, this research cluster has a potential benefit to the local economy by developing a local studio producing animations for STEM education. This will create multiple jobs, while supporting local industries in developing both internal and external education efforts. The local studio could benefit local animators, industry and boost the economy from increased revenue.

9. Intra-KBOR Collaboration

The research cluster will collaborate with Dr. Xianglin Li, Assistant Professor at Dept. of Mechanical Engineering, University of Kansas. His research focus will be pore-scale 3D visualization using X-ray microtomography, as the detailed project description is given below. Dr. Li's research backgrounds and expertise will strengthen the proposed research by bringing non-destructive 3D pore-scale visualization techniques, i.e., X-ray microtomography.

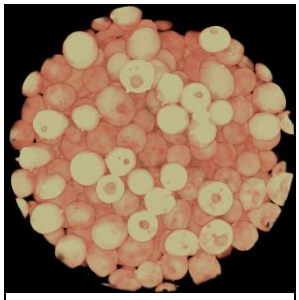

Figure 6. 3D visualized microstructures using X-ray tomography.

A technical challenge of the fusion material lies in nonuniform materials properties and unwanted geometries, which are related to undesired microstructures. A key approach requires non-destructive diagnostic, i.e., pore-scale visualization technique, but the reliable visualization technique and image analysis approaches are rare, especially for metallic AM. More importantly, despite extensive theoretical/experimental studies[47–49], the fundamental understanding of microstructures and their relation to mechanical properties are limited, primarily due to the lack of the direct visualizations. X-ray microtomography is an ideal approach to directly visualize with excellent spatial/temporal resolutions. To quickly identify imaging parameters for X-ray microtomography, Dr. Li measured 3D tomography of a metallic porous structure using X-ray microtomography with the resolution of 1 μm as shown in Figure 6.

The complementary multi-physics simulations (Lu/Thompson) for melt pool dynamics and multiphase flow (including solidification/evaporation) are based on accurate model geometries derived from high-resolution X-ray tomographic images. It's critical to investigate optimized parameters to process tomography images and develop advanced image segmentation algorithms for the success of further model simulations. A key success of the image-based simulation approach is to have good quality images. However, imaging fluid in the metallic AM is challenging due to large X-ray absorption contrast. In this task, the optimal imaging parameters will be explored based on the materials. In addition, advanced phase retrieval algorithms such as the automatic thresholding method will be applied to process segmentations of 3D tomography, reconstruct 3D images, and retrieve high-quality interfaces between phases with minimum assumptions. Properties of the reconstructed structures such as porosity, pore size, specific surface area, contact angle will be estimated by the sphere filling method, erosion-dilation method, and other advanced image processing algorithms. Accuracy of reconstructed geometries will be validated by various ex-situ experiments including pore size distributions and contact angle measurements. The obtained images will be used to develop statistical models for the key thermophysical properties such as tortuosity, pore size distributions. This statistical approach will significantly increase the accuracy of the analysis and diagnostic work with reduced computational time[50]. The predicted thermophysical properties will be validated by various ex-situ experiments.

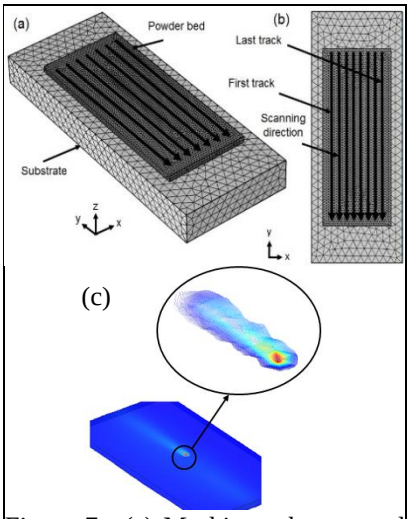

Figure 7. (a) Meshing scheme used for substrate and powder layer thermal simulations, (b) aerial view of scan pattern and (c) predicted heat affected zone with melt pool.

The research cluster will also collaborate with Dr. Scott Thompson, Steve Hu Keystone Associate Professor at Dept. of Mechanical and Nuclear Engineering, Kansas State University. His expertise lies in metals additive manufacturing, high heat flux thermal modeling & management, and microscale & nanoscale thermal/fluid science. His current interests lie in the thermomechanical characterization and design of additively-manufactured components for extreme operating conditions (radiation, high temperature/pressure) and additive manufacturing thermal modeling. His research focus will be thermal modeling of the metal AM process, as the detailed project description is given below. Dr. Thompson's research backgrounds and expertise will promote the proposed research, while working on the

thermal modeling. Before AM parts can achieve full dependability, numerous challenges must be overcome – to ensure their consistent manufacture and quality. To overcome such challenges, it is important to fully understand, relate and predict AM process parameters with 'during-the-build' heat transfer and 'post-build' material properties and mechanical performance – for various metals and AM systems. By relating microstructural features to their process-dependent thermal history, one can more easily qualify parts during manufacturing via real-time thermal monitoring and also use process simulations to better plan AM processes a priori (support structure design, part orientation, part location on substrate, etc.). Understanding the thermal phenomena during L-PBF also reduces resource investment (trial-and-error experiments) for determining optimal process parameters. For this project, ANSYS simulation software, together with custom scripts, will be used to determine melt pool temperatures, local temperature gradients and heating/cooling rates and to identify corresponding physical phenomena responsible for end-part microstructures/defects. Current finite element (FE) models, used in conjunction with commercial physical simulators such as ANSYS, will be enhanced through experimental validation with available data. A snapshot of the current L-PBF FE model developed by Thompson's group is shown in Figure 7. The employed FE model leverages continuum-based conduction models and advanced phase-change, thermomechanical, and melt pool flow models.

10. Innovation Campus Involvement

Collaborating with Engineering/Technology Industry

Majority of our partners in the innovation campus, including Sprit Aerosystems, Hexagon, Dassault Systems, Airbus, Deloitte, and Textron, are currently working on the metal AM while collaborating with NIAR as a future manufacturing approach. Their priorities are technological advancements of complex engine and electronic designs where the metallic fusion materials are required due to the high temperature operation and electrical conductivity. Their current approaches primarily focus on the hands-on approach including the trial and error, and experimental characterizations, and the proposed the smart fusion material design research approach such as data analytics, multiphysics simulations, and non-destructive diagnostics will complement their current and future projects/research. Our established data analytic approach along with non-destructive diagnostic tools and simulation code will facilitate the collaborations. In addition, as the metal AM technology evolves, it will accelerate a cloud-based, decentralized manufacturing process. This will provide a collaboration opportunity to work with NetApp.

Collaborating with Local Government/GoCreate

Successful commercialization of the metal AM technologies requires not only the technical advancement but also proper policy, government finance, environment, safety compliance. The research outcomes of the socio-techno-economic relations and the study tools will provide a great opportunity to collaborate with the local governments in our innovation campus such as City of Wichita and Sedgwick County. This collaboration will include practical analysis and policy recommendations regarding how to appropriately address non-technical yet important issues such as safety, health, intellectual property rights, and unemployment, related to 3D printing. This collaboration will directly support the on-going local and federal government initiatives. The Wichita Public Library has started to provide 3D printing services to public in 03/2020, and 3D printing techniques have been widely developed and used in many federal agencies, such as NASA, DOD and NIH. The results of this research collaboration will provide empirical evidence for governments better understand a variety of issues related to AM technology.

We will also develop classes and demonstrations through GoCreate, which is a creative workspace for planning and implementing creative projects open to the local community and located in the John Bardo Center. Moreover, we will also present demonstrations at the Advanced Learning Library located Downtown Wichita. These activities are planned to educate and create interest regarding additive manufacturing in the local community; this will favorably change the public perceptions for the STEM and WSU education programs, which will recruit the future STEM workforce to WSU via badge courses, undergraduate and graduate programs.

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Curriculum Vitae
GISUK HWANG, Ph.D.

a. Professional Preparation

Handong Global University	South Korea	Mechanical/Electrical Eng.	B.S.	2002
University of Michigan	Ann Arbor, MI	Mechanical Engineering	M.S.	2006
University of Michigan	Ann Arbor, MI	Mechanical Engineering	Ph.D.	2010

b. Appointments

2019 - Present	Associate Professor, Department of Mechanical Engineering, Wichita State University (WSU), Wichita, KS
2013- Present	Assistant Professor, Department of Mechanical Engineering, Wichita State University
2010 - 2013	Post-doctoral Fellow, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory

c. Research Grants

External Grants: Total of $1,106,735 as a PI

1. **G. Hwang** (PI), "RII Track-4: Tailored Flow Boiling Mechanisms Using 3D Printed Multifunctional Wick Structures", National Science Foundation (NSF) Established Program to Stimulate Competitive Research (EPSCoR) (Award#: OIA-1929187), $243,635, 12/01/2019 – 11/30/2021.
2. **G. Hwang** (PI), A. Betz, M. Derby, X. Li, and R. Nair (Co-PIs), "Efficient and Compact Thermal and Water Management Systems using Novel Capillary Structure for Space Technology", NASA Cooperative Agreement Notice (CAN) Established Program to Stimulate Competitive Research (EPSCoR) (Grant#: 80NSSC18M0030), $750,000, 12/01/2017 – 11/30/2020.
3. **G. Hwang** (PI), "Optimal Design of Planar, Multistage Thermoelectric Cooler", Sandia National Laboratory, $30,000, 3/24/2016 – 9/23/2016.
4. **G. Hwang** (PI), "Adsorption-Controlled, Thermal diode and Switch (ACTS)", Kansas National Science Foundation (NSF) Established Program to Stimulate Competitive Research (EPSCoR), First Award, $83,100, 1/1/2016 – 12/31/2016.

Internal Grants: Total of $50,667 (details are omitted)

d. Publications

Summary: Peer-reviewed 2 book chapters, 38 journals, 21 conference papers (2 journal papers are in review), total citation of 1,704, and h-index of 21 (only recent 5 journal publications are shown below).

1. M.K. Egbo, Y. Nasersharifi, and **G. Hwang**, "Phase-Change Heat Transfer of Sintered-Particle Wick in Downward Facing Orientation: Particle Size and Wick Thickness Effects", *Int. J. Heat Mass Transfer*, 155, 119840, 2020.
2. E. Norouzi, C. Park, and **G. Hwang**, "Nanoscale Heat Pipe using Surface-Diffusion-Driven Condensate Return", *Int. J. Heat Mass Transfer*, 130, 1238-1248, 2019. (Citation: 1)
3. Y. Nasersharifi, M. Kaviany, and **G. Hwang**, "Pool-boiling Enhancement using Multilevel Modulated Wick", *Appl. Therm. Eng.*, 137, 268-276, 2018.
4. T. Avanessian, and **G. Hwang**, "Thermal Diode Using Controlled Capillary in Heterogeneous Nanopores", *Int. J. Heat Mass Transfer*, 124, 201-209, 2018.

5. R. Asmatulu, A. Khan, V.K. Adigoppula, and **G. Hwang**, "Enhanced Transport Properties of Graphene-Based, Thin Nafion® Membrane for Polymer Electrolyte Membrane Fuel Cells", *Int. J. Energ. Res.*, 42, 508-519, 2018.

e. Presentations

Summary: 22 presentations at national/international conferences, 21 presentations at universities/national laboratories as an invited guest speaker, and 10 presentations at research forum (including GRASP and URCAF). Details are omitted.

f. Synergistic Activities

- Peer-reviewer for the following journals:

2014-Present	*Nanoscale and Microscale Thermophysical Engineering*
2010-Present	*Journal of Electrochemical Society*
2007-Present	*Journal of Microelectromechanical Systems*
2006-Present	*International Journal of Heat and Mass Transfer*
2006-Present	*Journal of Thermophysics and Heat Transfer*
2006-Present	*Journal of Heat Transfer*

- Topic/session organizer for the following conferences:

2015/2016/2020	ASME International Nanochannels, Microchannels, and Minichannels (ICNMM)
2017/2018	ASME Packaging and Integration of Electronic and Photonic Microsystems (INTERPACK)
2017	ASME International Conference on Power Engineering (ICOPE)
2013/2020	ASME International Mechanical Engineering Congress and Exposition (IMECE)

- Professional Society Committees:
  2014-2019, ASME Process Industry Division (PID), Executive Committee Member
  2016-Present, ASME Heat Transfer Division (HTD) K-9 Nanoscale Thermal Transport Committee

- Outreach Activities:
  Introduction to Thermal Engineering System for TRIO Upward Bound Math and Science (UBMS), Wichita State University (WSU), July, 2017, and June-July, 2020
  Introduction to Engineering System for Mead Middle School, Wichita, Kansas, Nov, 2017

- Campus Champion for Extreme Science and Engineering Discovery Environment (XSEDE) at Wichita State University (WSU)
  07/2017-08/2018, to support the students/faculty/staff at WSU with the high performance computational resources provided by XSEDE.

SAIDEEP NANNAPANENI

Current Position: Assistant Professor, Industrial, Systems, & Manufacturing Engineering

Areas of Expertise: Data Analytics, Information Fusion, Reliability Analysis, Uncertainty Quantification, Model-based design optimization

Education

- B.S. in Civil Engineering, Indian Institute of Technology, Madras, India 2012.
- M.S. in Civil Engineering, Vanderbilt University, Nashville, Tennessee, USA, 2015.
- Ph.D. in Civil Engineering, Vanderbilt University, Nashville, Tennessee, USA, 2017.

Employment

Wichita State University: Tenure-Track Assistant Professor (2018-present)
Vanderbilt University: Postdoctoral Research Scholar (2017-2018)

Research Grants

- "Quantum assisted real-time prognostics and health management", WSU ARC, $4,000, 05/01/20 – 08/31/20, Role: PI
- "Asset Management in Transmission Planning", Sunflower Electric Corporation, $80,000, 03/16/20 – 05/31/21, Role: Co-PI
- "Transmission Planning under High Renewable Penetration", Sunflower Electric Corporation, $90,000, 01/01/19 – 12/31/19, Role: Co-PI
- "Real-time control in Internet-of-Things (IoT) manufacturing systems under uncertainty", WSU URCA, 07/01/18 – 06/30/19, Role: PI

Relevant Publications

1) Nannapaneni, S. and Mahadevan, S., 2020. Probability-space surrogate modeling for fast multidisciplinary optimization under uncertainty. *Reliability Engineering & System Safety*, *198*, p.106896.
2) Borujeni, S.E., Harikrishnakumar, R. and Nannapaneni, S., 2019, December. Quantum Grover search-based optimization for innovative material discovery. In *2019 IEEE International Conference on Big Data (Big Data)* (pp. 4486-4489). IEEE.
3) Nannapaneni, S., Mahadevan, S. and Dubey, A., 2018. Real-Time Control of Cyber-Physical Manufacturing Process Under Uncertainty. In *ASME 2018 13th International Manufacturing Science and Engineering Conference*. American Society of Mechanical Engineers Digital Collection.
4) Nannapaneni, S., Narayanan, A., Ak, R., Lechevalier, D., Sexton, T., Mahadevan, S. and Lee, Y.T.T., 2018. Predictive Model Markup Language (PMML) Representation of Bayesian Networks: An Application in Manufacturing. *Smart and sustainable manufacturing systems*, *2*.
5) Nannapaneni, S., Mahadevan, S., Dubey, A., Lechevalier, D., Narayanan, A. and Rachuri, S., 2017. Automated Uncertainty Quantification through Information Fusion in Manufacturing Processes. *Smart Sustain. Manuf. Syst*, *1*(1), pp.153-177.
6) Nannapaneni, S. and Mahadevan, S., 2016. Reliability analysis under epistemic uncertainty. *Reliability Engineering & System Safety*, *155*, pp.9-20.

7) Nannapaneni, S., Mahadevan, S. and Rachuri, S., 2016. Performance evaluation of a manufacturing process under uncertainty using Bayesian networks. *Journal of Cleaner Production*, *113*, pp.947-959.
8) Nannapaneni, Saideep, and Sankaran Mahadevan. "Manufacturing process evaluation under uncertainty: A hierarchical bayesian network approach." In *ASME 2016 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*. American Society of Mechanical Engineers Digital Collection, 2016.
9) Nannapaneni, S., Mahadevan, S., Lechevalier, D., Narayanan, A. and Rachuri, S., 2015, October. Automated uncertainty quantification analysis using a system model and data. In *2015 IEEE International Conference on Big Data (Big Data)*(pp. 1408-1417). IEEE.
10) Nannapaneni, S. and Mahadevan, S., 2014, October. Uncertainty quantification in performance evaluation of manufacturing processes. In *2014 IEEE International Conference on Big Data (Big Data)* (pp. 996-1005). IEEE.

Synergistic Activities

1) Session Chair/Co-Chair: "Uncertainty Quantification I", "Uncertainty Quantification II", "System Resilience Analysis I" and "System Resilience Analysis II" at IISE Annual Conference & Expo 2020.
2) Technical Program Committee Member: AI for Social Good – AAAI Fall Symposium 2019, 2nd Symposium on Data Analytics for Advanced Manufacturing co-located with IEEE International Conference on Big Data 2017, and 4th International Science of Smart City Operations and Platforms Engineering (SCOPE-19)
3) Reviewer for 15+ journals and conferences such as Reliability Engineering & System Safety, Engineering Optimization, Structural and Multidisciplinary Optimization, ASCE-ASME Journal of Risk and Uncertainty, Journal of Engineering Mechanics, Quality Engineering, Systems Engineering, Smart and Sustainable Manufacturing Systems.
4) Invited Seminar, 2018, "Model-based design and analytics under uncertainty", Department of Systems Engineering, Colorado State University, Fort Collins, Colorado, USA.
5) Invited Seminar, 2017, "Bayesian Data Analytics for System Performance Assessment", Department of Systems Engineering and Operations Research, George Mason University, Fairfax, VA, USA.

NAME: Mara Alagic

POSITION TITLE & INSTITUTION: Professor and Graduate Coordinator, Wichita State University

A. PROFESSIONAL PREPARATION

(see PAPPG Chapter II.C.2.f.(i)(a))

INSTITUTION	LOCATION	MAJOR/AREA OF STUDY	DEGREE (if applicable)	YEAR (YYYY)
University of Belgrade	Yugoslavia	Mathematics	B. Sci.	1972
University of Belgrade	Yugoslavia	Mathematics	M. Sci.	1975
University of Belgrade	Yugoslavia	Mathematics	Ph. D.	1985

B. APPOINTMENTS

(see PAPPG Chapter II.C.2.f.(i)(b))

From - To	Position Title, Organization and Location
2018 – ongoing	Professor, School of Education: College of Applied Studies, Wichita State University
2009 - 2012	Assistant Dean, Graduate School, Wichita State University
2005 - 2018	Associate Professor School of Education: College of Applied Studies, Wichita State
1999 - 2005	Assistant Professor, Mathematics Education, Curriculum & Instruction Department, College of Education, Wichita State University
1993-1999	Instructor, Department of Mathematics and Statistics, LAS,Wichita State University
1991-1993	Visiting Assistant Professor Department of Mathematics and Statistics, University of Vermont, Burlington
1985-1991	Assistant Professor Department of Mathematics and Statistics, University of Sarajevo, Bosnia & Herzegovina

C. PRODUCTS

(see PAPPG Chapter II.C.2.f.(i)(c))

Products Most Closely Related to the Proposed Project

Alagic, M. (2004). CALEM Portals, Quests and Guilds: New Learning Environments Journal of Instructional Science and Technology (e-JIST). Vol7no2 https://ascilite.org/archived-journals/e-jist/docs/Vol7_no2/MeltingPot/CALEMportals.htm

Rimmington, G. M., & Alagic, M. (2016). Corporate Social Responsibility: ThirdPlaceLearning for Absorbing Diverse Perspectives. In Hansen, K., & Seierstad, C. (Eds.). Corporate Social Responsibility and Diversity Management: Theoretical Approaches and Best Practices (pp. 269-288). Springer International Publishing. (In the Series CSR, Sustainability, Ethics & Governance, Springer)

Flores, R., Koontz, E., Inan, F. A., & Alagic, M. (2015). Multiple representation instruction first versus traditional algorithmic instruction first: Impact in middle school mathematics classrooms. Educational Studies in Mathematics, 89(2), 267-281.

Alagic, M., Orel, T. & Rimmington, G. (2017): Toward Dynamic Representations of ThirdPlaceLearning. Proceedings of the TKE 2016 - 12th International Conference on Terminology and Knowledge Engineering, June 2016 Copenhagen Business School, CBS http://openarchive.cbs.dk/handle/10398/9323 (Proceedings) https://dl.dropboxusercontent.com/u/27766628/TKE%202016%20present_ALAGIC.pdf (paper) http://openarchive.

Other Significant Products, Whether or Not Related to the Proposed Project

Alagic, G. & Alagic, M. (2013). Collaborative mathematics learning in online environments. In Martinovic, D; Freiman, V. & Karadag, Z. (Eds.).Visual Mathematics and Cyberlearning Series: Mathematics Education in the Digital Era, Vol. 1, Springer.

M. Alagic, A. L. Nagata, & G. M. Rimmington (2009). Improving Intercultural Communication Competence. Journal of Intercultural Communication SIETAR Japan (12) pp. 39-55.

Alagic, M., & Palenz, D. (2006). Teachers explore linear and exponential growth: Spreadsheets as cognitive tools. Journal of Technology and Teacher Education (JTATE), 14(3), 633-649.

D. SYNERGISTIC ACTIVITIES

(see PAPPG Chapter II.C.2.f.(i)(d))

1. Instructional co-designer and Graduate Coordinator – Master's of Education in Learning and Instructional Design Wichita State University, Wichita KS (2014 – ongoing)
2. Instructional co-designer and Coordinator of iSTEM Education Graduate Certificate Wichita State University, Wichita KS (2014 – ongoing)
3. Editor in Chief: Journal of Mathematics and the Arts, Taylor & Francis, UK (2017 – ongoing)
4. Alagic, M. (2015 – 2018). Teacher Inquiry into Math, Engineering, and Science Practices, Kansas Mathematics/Science Partnership Grants (MSP). Kansas Board of Regents. Evaluation Report for Year 1-3. [External Evaluator; PI Barbara Sponsel, Ph.D., Newman University, Wichita, KS]
5. American Mathematical Society (AMS) (1993 – ongoing)

BIOGRAPHICAL SKETCH
for
RUOWEN SHEN

Professional Preparation

Ph.D. Askew School of Public Administration and Policy, Florida State University, Tallahassee, FL
Public Administration May 2019

M.P.A. University of Miami, Coral Gables, FL
Public Administration May 2013

B.A. Beijing International Studies University, Beijing, China
International Politics June 2010

Appointments

Assistant Professor, Hugo Wall School of Public Affairs, Wichita State University 09/2019-Present

Research Assistant, Local Government Research Lab, Florida State University 08/2013-05/2019

Publications

Summary: Peer-reviewed 1 book chapters, 4 journals (3 journal papers are in review), total citation of 27.

Up to Five Products Most Closely Related to the Proposed Project

Zhao Zhirong., Lou, S., Fonseca, C., Feiock, R., and Shen, R. (2020). "Explaining Transit Expenses in US Urbanized Areas: Urban Scale, Spatial Form and Fiscal Capacity." *Urban Studies*: 0042098019892582.

Hongtao, Yi., Suo, L., Shen, R., Zhang, J., Ramaswami, A., and Feiock, R. (2018). "Regional Governance and Institutional Collective Action for Environmental Sustainability in China", *Public Administration Review*, 78(4): 556-566.

Chien-Shih, Huang., Shen, R."Does City or State Matter? The Effects of Policy Framing on Public Attitude toward Solar PV Installation Program." *Journal of Behavioral Public Administration*. Revise and Resubmit.

Ruowen Shen., Coutts, C., Feiock, R., and Williams, P. "Identifying the Health Benefits of City Bike Infrastructure Expansion", *Cities and Health*. Revise and Resubmit.

Up to Five Other Significant Products

Naon Min., Shen, R., Berlan, D., and Lee, K. (2019). "How Organizational Identity Affects Hospital Performance: Comparing Predictive Power of Mission Statements and Sector Affiliation." *Public Performance and Management Review*, 1-26

Ruowen, Shen., Yi, H., and Feiock, R. (2017). "China's Local Government Innovations in Inter-Local Collaboration," Public Service Innovation in China, Palgrave, Singapore.

Ruowen Shen. "Regional Governance and Multiplex Networks in Environmental Sustainability: An Exponential Random Graph Model Analysis in Chinese Context." Under Review.

Ruowen Shen & Tingting Zhao. "Examine How Built Environment Factors affect Residents Adoption Rate of Solar PV: A Case of City of Tallahassee" Under Review.

Presentations

Summary: 9 presentations at national/international conferences. Details are omitted.

Synergistic Activities

(1) Member (2019-2020) - Midwest Political Science Association (MPSA); American Society for Public Administration (ASPA); and Association for Public Policy Analysis and Management (APPAM)

(2) Journal Reviewer (2019-2020)- Policy Sciences

(3) Panel Organizer (2019)- Association For Public Policy Analysis and Management (APPAM) Annual Conference

(4) Best paper Awardee (2017)- Donald C. Stone Best Student Paper Award, Section on Intergovernmental Administration and Management, American Society for Public Administration

Funding

Community Sustainability Tool, Environmental Protection Agency, $ 60,000

The Jerry Collins Experimental Social Science Award, Local Governance Research Lab, Florida State University, $1500

Tianshi Lu

Professional Preparation

Fudan University	Shanghai, China	Physics	B.S. 1997
New York University	New York, NY	Physics	M.S. 1999
University of Wisconsin-Madison	Madison, WI	Mathematics	M.A. 2001
Stony Brook University	Stony Brook, NY	Applied Math	Ph.D. 2005

Appointments

Year(s)	***Title***
2012-present	Associate Professor, Dept. of Mathematics and Statistics, Wichita State University
2008-2012	Assistant Professor, Dept. of Mathematics and Statistics, Wichita State University
2005-2008	Research Associate and Assistant Computational Scientist, Brookhaven National Lab

Grants

Kansas NSF EPSCoR First Award, "Modeling and Algorithms of Multiphase Magnetohydrodynamics in Tokamaks", $110,000, July 2010 – September 2012.

Wichita State University Grants, $14,000 (details are omitted).

Products

Summary:

20 Peer-reviewed journal papers, 2 under review.

40 presentations at national/international conferences.

Five Products Most Closely Related to the Proposed Project:

1. T. Lu. Wave propagation in bubbly fluids and cavitation mitigation. Wave Propagation, Ed. Gomes Mateus, Academy Publish, 309-332 (2014).
2. Y. Kostogorova-Beller, T. Lu. Numerical Modeling of Experimentally Obtained Lightning Arc Root Damage in Metal Sheets. *Int'l J. Eng. Prac. Res.* **2**, 139-147 (2013).
3. T. Lu, Z. L. Xu, J. Glimm, R. Samulyak, X. M. Ji. Dynamic Phase Boundaries for Compressible Fluids. *SIAM J. Sci. Comput.* 30, 895-915 (2008).
4. T. Lu, R. Samulyak, J. Glimm. Direct Numerical Simulations of Bubbly Flows and Application to Cavitation Mitigation. *J. Fluids Eng.* 129, 595-604 (2007).
5. Z. Xu, M. Kim, T. Lu, W. Oh, J. Glimm, R. Samulyak, X. Li, C. Tzanos. Discrete Bubble Modeling of Unsteady Cavitating Flow. *Int. J. Multiscale Comp. Eng.* 4, 601-616 (2006).

Synergistic Activities

MENTORING SERVICES:

Advised 3 Ph. D. students and 1 M. S. student. Thesis and dissertation committees for 11 Ph. D. students and 10 M. S. students.

EDITORIAL SERVICES:

ASME Journal of Fluids Engineering, Journal of Applied Physics, Applied Physics Letters, International Journal of Engineering Practical Research, Punjab University Journal of Mathematics, Mathematical Reviews, and Symposium on Numerical Analysis of Fluid Flow and Heat Transfer.

OUTREACH ACTIVITIES:

- Coaching MATHCOUNS Teams at Robinson Middle School.
- Lecturing in the Math Circle for grade school students.
- Mentoring undergraduate students in McNair Scholars Program.
- Presenting energy-related research to the Kansas delegation in Washington, DC.

Name: KAPILDEB AMBAL, Ph.D.

Title and Position: Assistant Professor, Department of Physics, Wichita State University

a. Education

Institution	Major/Area of Study	Degree	Year	Location
University of Utah	Physics/experimental condensed matter physics	Ph.D.	2016	Salt Lake City, US
University of Utah	Physics	M.S.	2012	Salt Lake City, US
Indian Institute of Technology Madras, India	Physics	M.Sc.	2006	Chennai, India
University of Calcutta	Physics (Honors)	B.Sc.	2004	Kolkata, India

b. Appointments

From - To	Position Title, Organization, and Location
2020-current	Assistant Professor of Physics, Wichita State University, Wichita, KS, US
2016-2019	Postdoctoral research associate, University of Maryland, Maryland, US Guest Researcher, National Institute of Standard Technology, Gaithersburg, US
2016-2016	Postdoctoral research associate, University of Utah, Utah, US
2008 – 2016	Graduate research assistant, University of Utah, Utah, US
2006-2008	Software engineer, Infosys technologies limited, India

c. Research Interest:

My research interest focuses on the investigation of fundamental physics that control the spin-dependent charge transport and recombination, and spin dynamics in the absence of charge transport in condensed matter. The goal of these activities is for the detection and understanding of mesoscale physics of coherent spin motion for small spin ensembles, potentially at the level of a single spin. These efforts are needed for; 1) interface engineering for low-cost solar cells using sustainable materials, 2) measurement of magnetization dynamics for novel magnetic technologies and medical applications, 3) quantum sensing and metrology, and 4) single electron and nuclear spin readout for quantum information science.

d. Research Grants:

Internal Grants: Total of $215,000 (details are omitted)

e. Products (patents, publications)

Summary: Peer-reviewed 8 journals, one patent (status pending), total citation 286, h-index 5. The relevant publication is shown below.

1. **K. AMBAL** and R. D. MCMICHAEL, Device and method to transform discrete voltage pulses to a phase-sensitive continuous signal, US20200059388A1 (20 February 2020).
2. **K. Ambal** and R. D. McMichael, A differential rate meter for real-time peak tracking in optically detected magnetic resonance at low photon count rates, *Rev. Sci. Instrum.* **90**, 023907 (2019).
3. **K. Ambal**, C. C. Williams, and C. Boehme, In situ absolute magnetometry in an UHV scanning probe microscope using conducting polymer-thin film, *J. Vac. Sci. Technol.* A **35**, 021602 (2017).

4. **K. Ambal**, P. Rahe, A. Payne, J. Slinkman, C. C. Williams, and C. Boehme, Electrical current through individual pairs of phosphorus donor atoms and silicon dangling bonds, *Sci. Rep.* **6**, 1 (2016).
5. **K. Ambal**, A. Payne, D. P. Waters, C. C. Williams, and C. Boehme, Spin-Relaxation Dynamics of E' Centers at High Density in SiO_2 Thin Films for Single-Spin Tunneling Force Microscopy, *Phys. Rev. Appl.* **4**, 024008 (2015).
6. A. Payne, **K. Ambal**, C. Boehme, and C. C. Williams, Atomic-resolution single-spin magnetic resonance detection concept based on tunneling force microscopy, *Phys. Rev. B* **91**, 195433 (2015).
7. W. J. Baker, **K. Ambal**, D. P. Waters, R. Baarda, H. Morishita, K. van Schooten, D. R. McCamey, J. M. Lupton, and C. Boehme, Robust absolute magnetometry with organic thin-film devices, *Nat. Commun.* **3**, 1 (2012).

f. Professional Services

1. DLA (Division Level Approval) division reader/reviewer at NIST.
2. Secondary division judge at Salt Lake Valley Science & Engineering Fair, 2014
3. Secondary division judge at Salt Lake Valley Science & Engineering Fair, 2012.

g. Awards and Honors

1. J. Irvin and Norma K. Swigart Graduate Student Scholarship, Department of Physics and Astronomy, University of Utah, Salt Lake City, Utah, US, 2012.
2. Merit scholarship, Indian Institute of Technology Madras (IITM), India, 2004 - 2006.

h. Invited Seminar Presentations

1. Nanoscale magnetometry using quantum mechanical spin; the Nitrogen-Vacancy (NV-) center in diamond at Fall 2019 Physics Seminars of Wichita State University, KS.
2. Imaging and Spectroscopy of Individual Paramagnetic Electronic States on the Atomic Scale, Condensed Matter Seminar, Department of Physics and Astronomy, University of Utah, UT, November 17, 2015.

i. Selected Contributed Presentations

1. K. Ambal et al., Locking and tracking magnetic resonance spectra of NV- center for real-time magnetometry at Rocky Mountain Conference on magnetic resonance 2018.
2. K. Ambal et al., Magnetic microscopy and spectroscopy using nitrogen-vacancy center in diamond at Gordon Research Conferences on Defects in Semiconductor, 2018.
3. K. Ambal et al., Electrical detection and imaging of individual phosphorus and silicon-dangling bond states at the crystalline silicon to silicon dioxide interface at APS March Meeting 2016.

j. News Articles on my Publications

1. A dirt-cheap magnetic field sensor from plastic paint, Printed Electronics World, June 14, 2012.
2. "Plastic Paint" Magnetic Field Sensor Based on Spintronics Takes Aim at Consumer Electronic, IEEE Spectrum, June 14, 2012.
3. Spintronic Film Senses Magnetic Fields, Physics World, June 15, 2012.
4. A "Dirt Cheap" Magnetic Field Sensor from "Plastic Paint," University of Utah, June 12, 2012.

Curriculum Vitae
Timothy Babb

Professional Preparation

Wichita State University	Wichita, KS	Theatre	BA	2000
Wichita State University	Wichita, KS	Social Work	MSW	2007

Continued Education Courses

Academy of Art	San Francisco	Editing Concepts	
MITX	Online	Introduction to Computer Science and Programming	Certificate 2017
MITX	Online	Introduction to Computational Thinking and Data Science	Certificate 2018

Appointments

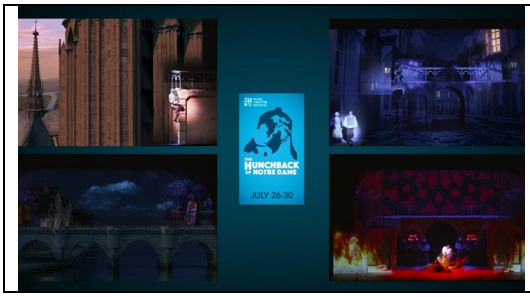
2018 - Present	Assistant Educator & Program Director of Animation, Wichita State University
2016 - 2018	Teaching Faculty, Bethany College at Mindfire
2013- 2017	Lead Environment Artist, Lead Title Sequence Artist, A Visionz Production
2008-2018	School Social Worker, USD 259

Animation Work

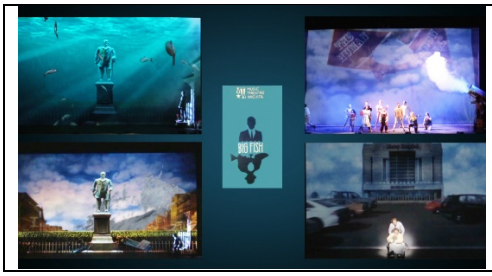
1. **Digital Environments:** *Skybound*. 2017. [film] Directed by A. Tavokoli. Germany: A Visionz Production.

2. **Title Sequence:** *Skybound*. 2017. [film] Directed by A. Tavokoli. Germany: A Visionz Production.

3. **Projected Set Design:** *The Hunchback of Notre Dame*. 2017. [play] Directed by W. Bryan. Wichita: Music Theatre Wichita.



4. **Projected Set Design:** *Big Fish*. 2015. [play] Directed by W. Bryan. Wichita: Music Theatre Wichita.



5. **Projected Whale Sequence:** *My Son Pinocchio*. 2015. [play] Directed by W. Bryan. Wichita: Music Theatre Wichita.

6. **Nuclear Explosion Sequence:** *Hanger 1: UFO Files*. 2014. [television] Produced by C. Lauer. USA: Go Go Lucky Productions.

Performance Work

7. **Tourist:** *A Man Apart*. 2003. [film] Directed by G. Gray. USA: Universal Studios.
8. **Beach Dancer**: *American Dreams*. 2003. [television] Produced by M. Grossan. USA: NBC Studios.
9. **Prison Guard:** *13 Dead Men*. 2003. [film] Directed by A. Gamacho. USA: Scott Pfeiffer.
10. **Police Officer**: The Shield. 2003. [television] Produced by J. Wells. USA: Sony Pictures Television.
11. **Tornado Survivor**: *The West Wing*. 2003. [television] Produced by S. Ryan. USA: NBC.

Professional Memberships

1. 2003-Present, Sag/Aftra, Union Member
2. 2008-Present, Licensed Master Social Worker
3. 2018, SAG/Aftra, Television Nominating Committee Member

Awards

4. 1st Place "Speed Demon" - Gnomon Image Challenge Competition
5. 2nd Place "Surgical Tools" - Gnomon Image Challenge Competition
6. 2nd Place "Tentacles" - Gnomon Image Challenge Competition
7. Mary Jane Teall Theatre Award "Special Merit" - The Hunchback of Notre Dame

Xiaoheng Wang

Assistant Professor
Hugo Wall School of Public Affairs
Wichita State University (WSU)
1845 Fairmount Street,
Wichita, KS 67260
Phone: 917-769-3188
Email: xiaoheng.wang@wichita.edu

EDUCATION

Ph.D. University of Illinois at Chicago, 2019, Public Administration
- Dissertation Title: *The Financial Condition of America's Large Cities* (Dissertation Chair: Dr. Yonghong Wu; Dissertation Committee Members: Dr. Rebecca Hendrick, Dr. Michael Pagano, Dr. David Merriman, Dr. Craig Maher, and Dr. Michael Siciliano)
- Fields of Specialization: Public Budgeting and Finance, Public Financial Management, Public Opinion, and Survey Methods

Master of Public Administration (MPA), University of Illinois at Chicago, 2012, Public Administration
- Fields of Specialization: Public Budgeting and Finance

Bachelor of Management and Bachelor of Liberal Arts and Sciences. Nanjing University of Technology (China), 2010
Major**:** Public Administration
Minor**:** English

ACADEMIC APPOINTMENT

Assistant Professor (Tenure-track), Hugo Wall School, Wichita State University, August 2019 – Current

RESEARCH AND TEACHING INTERESTS

Research Interests: Public Budgeting and Finance, Financial Management of State and Local Governments, Fiscal Health, Survey Methods, Public Management, Information Technology and E-government

Teaching Areas: Public and Nonprofit Budgeting and Financial Management, Research Methods, Public Policy, Public Management, Organizational Theory, Collaborative Governance

TEACHING EXPERIENCE

Instructor, University of Illinois at Chicago
Course: Urban Government II: Managing the External Environment (UPA 305 – Undergraduate) **Spring 2016**
Course: Public Budgeting and Financial Management (PPOL 309 – Undergraduate) **Spring 2019**

Instructor, Wichita State University
Course: Public Sector Economics (PADM 765 – MPA) **Fall 2019**
Course: Research Methods (PADM 702 – MPA) & Public and Nonprofit Financial Management (PADM 865 – MPA) **Spring 2020**

Teaching Assistant, University of Illinois at Chicago **2014-2019**
Courses:
Data Analysis for Public Administration (PA 407 – MPA)
Principles of Financial Management and Budgeting (PA 504 – MPA)
Public Administration Theory (PA 401 – MPA)
Public Policy Development and Process (PA 506 – MPA)
Introduction to the Policy Process (PA 210 – undergraduate)
Introduction to Urban Policy Process (UPA 300 – undergraduate)

RESEARCH EXPERIENCE

Research Assistant, University of Illinois at Chicago
Research Projects:
National League of Cities (NLC) City Fiscal Condition Project (Supervised by Dr. Michael Pagano) **2018**
National Study of Technology in City Government Survey (Supervised by Dr. Mary Feeney and Dr. Eric Welch) **2012, 2014**
Social Network Evaluation Survey Project (Supervised by Dr. Michael Siciliano) **2013**

PUBLICATIONS

Refereed Book Chapter

Holbrook, Allyson L., Sterrett, David., Crosby, Andrew W., Stavrakantonaki, Marina., **Wang, Xiaoheng**., Zhao, Tianshu., & Johnson, Timothy P. (2019). "Survey Experiments and Changes in Question Wording in Repeated Cross-Sectional Surveys". In the Edited Book: *Experimental Methods in Survey Research: Techniques that Combine Random Sampling with Random Assignment (*Wiley Series in Survey Methodology). Wiley Publisher.

SELECTED CONFERENCE PRESENTATIONS

Public Budgeting and Finance Conferences

1. "Capital Assets Condition Ratios in American States: It's Time to Invest in Infrastructure: A Political Economy Analysis." Annual Conference of Association of Budgeting and Financial Management (ABFM). Washington D.C., September 2019.
2. "Fiscal Institutions and Municipal Fiscal Health: Evidence from Large American Cities." Annual Conference of Association of Public Policy Analysis & Management (APPAM). Washington, D.C., November, 2018.
3. "An Empirical Analysis of Local Government Investments in Capital Assets: The Case of Florida Counties." Annual Conference of Association of Budgeting and Financial Management (ABFM). Denver, CO. October 2018.
4. "The Effects of State-Imposed Tax and Expenditure Limitations (TELs) on Municipal Financial Condition: Evidence from Large American Cities." Annual Conference of Western Social Science Association (WSSA). San Antonio, TX. April2018.
5. "The Determinants of County Government Financial Condition: The Case of Michigan Counties." (With Yonghong Wu). Annual Conference of Association of Budgeting and Financial Management (ABFM). Washington D.C., October 2017.

Public Administration and Public Management Conferences

6. "Measuring the Financial Condition of Michigan Counties: 2005-2013." (With Yonghong Wu) Annual Conference of the American Society for Public Administration (ASPA). Atlanta, GA. March 2017.
7. "Internal Competition and Performance: The Mediating Role of Psychological Safety." (With Michael Siciliano) Annual Conference of the Midwest Political Science Association (MPSA). Chicago, IL. April 2017.
8. "Investigation of Determinants of Financial Condition: An Empirical Study of American Cities." Annual Conference of the American Society for Public Administration (ASPA). Denver, CO. March 2018.

Public Opinion Conferences

9. "Investigation of Attitudes Toward Social Media Use in US Local Government (new objective data and analysis added)" (With Allyson Holbrook and Mary Feeney). Annual Conference of the American Association for Public Opinion Research (AAPOR). New Orleans, LA, May 2017.
10. "Investigation of Attitudes Toward Social Media Use in US Local Government." (With Allyson Holbrook and Mary Feeney). Annual Conference of the Midwest Association for Public Opinion Research (MAPOR). Chicago, IL. November 2016.
11. "Extreme Response Style: Scale Type and Left/Right Preferences." (With Allyson Holbrook and David Sterrett). Annual Conference of the American Association for Public Opinion Research (AAPOR). Austin, TX. May 2016.

Xianglin Li

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University of Kansas
Lawrence, KS 66044

Phone: (785) 864-8165
Fax: (785) 864-5254
Email: xianglinli@ku.edu

Education and Training

Xi'an Jiaotong University, Xi'an, China	Mechanical Engineering	B.S.	2005
Xi'an Jiaotong University, Xi'an, China	Mechanical Engineering	M.A.	2008
University of Connecticut, Storrs, CT	Mechanical Engineering	Ph.D.	2012

Research and Professional Experience

Aug 2014-Present **Assistant Professor**, Department of Mechanical Engineering, University of Kansas, Lawrence, KS

Jun 2012- Aug 2014 **Senior Scientific Engineering Associate**, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, Berkeley, CA

Ten Related Publications (*Corresponding Author)

Five publications most closely related to the proposed project

[1] F. Wang, H. Jiang, Y. Chen, X. Li*, Architected Foam Structures with High Porosity and High Thermal Conductivity, *Int. J. Heat and Mass Transfer*, Under Review.

[2] F. Wang and X. Li*, The Stagnant Thermal Conductivity of Porous Media Predicted by the Random Walk Theory, *Int. J. Heat and Mass Transfer* 107 (2017), 520-533.

[3] D. Barnes, X. Li*, Battery Thermal Management Using Phase Change Material-Metal Foam Composite Materials at Various Environmental Temperatures, *ASME Journal of Electrochemical Energy Conversion and Storage*, 17 (2020) 021106.

[4] M. Alipanah, X. Li*. Numerical Studies of Lithium-ion Battery Thermal Management Systems Using Phase Change Materials and Metal Foams, *Int. J. Heat and Mass Transfer* 102 (2016): 1159-1168.

[5] W. Libeer, F. Ramos, C. Newton, M. Alipanahrostami, C. Depcik, X. Li*. Two-Phase Heat and Mass Transfer of Phase Change Materials in Thermal Management Systems, *Int. J. Heat and Mass Transfer* 100 (2016): 215–223.

Five other significant publications

[1] F. Wang, G.A. Riley, M. Egbo, M.M. Derby, G. Hwang, X. Li*, Integrated Micro X-ray Tomography and Pore-Scale Simulations for Accurate Permeability Predictions of Porous Media, *Frontiers in Heat and Mass Transfer*, Under Review.

[2] S. Neupane, M. Alipanah, D. Barnes, X. Li*, Heat Generation Characteristics of LiFePO4 Pouch Cells with Passive Thermal Management, *Energies*, 11 (2018), 1243.

[3] F. Wang, X. Li*, Pore Scale Simulations of Porous Electrodes of Li-O2 Batteries at Different Saturation Levels, *ACS Applied Materials & Interfaces*, 10 (2018) 26222-26232.

[4] X. Li*, J. Huang, and A. Faghri. A Critical Review of Macroscopic Modeling Studies on Li–O2 and Li–Air Batteries Using Organic Electrolyte: Challenges and Opportunities, *Journal of Power Sources* 332 (2016): 420-446.

[5] X. Ju, C. Xu, X. Li, and X. Du. Numerical Analysis of Thermal Storage Performance with High-Temperature Phase Change Materials Operated by Condensing Steam, *Solar Energy* 117 (**2015**): 213-223.

Synergistic Activities

- **Invited Presentations to Transfer Knowledge**

[1] Liquid-Vapor Two-Phase Mass Transfer in Li-O_2 Batteries, *Carnegie Mellon University*, Pittsburgh, PA. 6/2019.
[2] Pore-Scale Heat Transfer in Porous Materials, *Kansas State University*, Manhattan, KS. 12/2018.
[3] Pore-Scale Simulations of Effective Transport Properties of Porous Materials, *Wichita State University*, Wichita, KS. 11/2018
[4] Pore-scale Heat and Mass Transfer in Porous Media, School of Mechanical Engineering, *Xi'an Jiaotong University*, Xi'an, Shannxi, China, P.R. 6/2017
[5] Multi-phase Transport Phenomena in Li-O_2 Batteries, School of Energy and Power Engineering, *Xi'an Jiaotong University*, Xi'an, Shannxi, China, P.R. 5/2017
[6] Multiscale Modeling of Li-O_2 Batteries, Department of Chemical and Petroleum Engineering, *University of Kansas*, Lawrence, KS, 10/2016
[7] A Brief Introduction to Computational Fluid Dynamics, Department of Mechanical Engineering, *University of Kansas*, Lawrence, KS, 02/2016
[8] Computational Fluid Dynamics Based on Finite Volume Method, Department of Mathematics, *University of Kansas*, Lawrence, KS, 09/2015

- **Conference Organization to Service the Scientific and Engineering Community**

[1] *Lithium-Air* session for the A01 Symposium, "*Joint General Symposium of Battery and Energy Technology Divisions*", 229th ECS meeting in San Diego, CA (May 29-June 2, 2016) ***Session Chair***.
[2] "*3-1-1 Low Temperature Fuel Cell Technologies I*", ASME 2015 13th Fuel Cell Science, Engineering, and Technology Conference, San Diego, CA (June 29-July 2, 2015) ***Session Organizer***
[3] "*3-1-2 Low Temperature Fuel Cell Technologies II*" at the international conference: ASME 2015 13th Fuel Cell Science, Engineering, and Technology Conference in San Diego, CA (June 29-July 2, 2015) ***Session Organizer***
[4] "*3-1-3 Low Temperature Fuel Cell Technologies III*" at the international conference: ASME 2015 13th Fuel Cell Science, Engineering, and Technology Conference in San Diego, CA (June 29-July 2, 2015) ***Session Co-Organizer***

- **Professional Service - Proposal and Academic Journal Reviews**

[1] U.S. Department of Energy – EERE/FCTO – Annual Merit Review
[2] NIST – Center for Neutron Research
[3] NSF/ENG/CBET – Energy for Sustainability
[4] NSF/ENG/CBET – Thermal Transport Processes
[5] University of Wisconsin-Milwaukee, Office of Research
[6] Over 300 Manuscripts for Academic Journals since 2014

- **Outreach Activities to Broaden the Participation of Underrepresented Groups in STEM**

[1] Host *Project Discovery Summer Engineering Camp*, University of Kansas, 2015-2019
[2] Serve as Mentor, Judge, and Volunteer for *KC STEM Alliance*, Kansas City, KS, 2016-2019
[3] Faculty participant of *Indigenous, Hispanic, African-American, Women, KU Engineering* (IHAWKe) & *TRIO McNair Scholars Program*, University of Kansas, 2018, 2019

- **Development of Curricular Materials and Pedagogical Methods**

[1] ME 412 *Thermal Systems*, Implement the Motivation-Based Teaching Method since 2016
[2] ME 718 *Fundamentals of Fuel Cells*, New Course since 2015
[3] ME 790 *Fund. Numerical Heat and Mass Transfer*, New Course since 2016

BIOGRAPHICAL SKETCH: **SCOTT M. THOMPSON**

PROFESSIONAL PREPARATION

University of Missouri, Columbia, MO		
Mechanical Engineering	Bachelor of Science	2008
Mechanical & Aerospace Engineering	Doctor of Philosophy	2012

APPOINTMENTS

Steve Hsu Keystone Associate Professor		
Mechanical Engineering	Kansas State University	07/19-present
Associate Professor		
Mechanical Engineering	Auburn University	08/16 - 07/19
Assistant Professor		
Mechanical Engineering	Mississippi State University	08/12 - 08/16
GAANN Fellow Instructor		
Mechanical & Aerospace Engineering	University of Missouri	08/10 - 05/12
GAANN Graduate Research Assistant		
Mechanical & Aerospace Engineering	University of Missouri	08/08 - 05/12

PUBLICATIONS

Related Publications

1. Daniewicz, S.R., Johnson, A., **Thompson, S.M.**, Shamsaei, N., 2017, "Structural Integrity of Additive Manufactured Parts," in Laser-Based Additive Manufacturing of Metal Parts: Modeling, Optimization, and Control of Mechanical Properties, pp. 111-140. Taylor & Francis CRC Press; ISBN-13: 978-1498739986.
2. **Thompson, S.M.**, 2019, "Conceptual Design for Additive Manufacturing: Lessons Learned from an Undergraduate Course," *30th International Solid Freeform Fabrication Symposium - An Additive Manufacturing Conference*, 12-14 August, Austin, Texas, USA.
3. Masoomi, M., **Thompson, S.M.**, Shamsaei, N., 2017, "Laser Powder Bed Fusion of Ti-6Al-4V Parts: Thermal Modeling and Mechanical Implications," *International Journal of Machine Tools & Manufacture*, Vols. 118-119 (C), pp. 73-90.
4. **Thompson, S.M.,** Bian, L, Shamsaei, N., Yadollahi, A., 2015, "An Overview of Direct Laser Deposition for Additive Manufacturing; Part I: Transport Phenomena, Modeling and Diagnostics," *Additive Manufacturing*, Vol. 8, pp. 36-62.
5. **Thompson, S.M.**, Aspin, Z.S., Shamsaei, N., Elwany, A., Bian, L., 2015, "Additive Manufacturing of Heat Exchangers: A Case Study on a Multi-Layered Ti-6Al-4V Oscillating Heat Pipe," *Additive Manufacturing*, Vol. 8, pp. 163-174.

Other Significant Publications

6. Yadollahi, A., Shamsaei, N., **Thompson, S.M.,** Elwany, A., Bian, L., 2017, "Effects of Building Orientation and Heat Treatment on Fatigue Behavior of Selective Laser Melted 17-4 PH Stainless Steel," *International Journal of Fatigue*, Vol. 94, pp. 218-235.

7. Masoomi, M., Shamsaei, N., Winholtz, R.A., Milner, J., Gnäupel-Herold, T., Elwany, A., Mahmoudi, M., **Thompson, S.M.**, "Residual Stress Measurements via Neutron Diffraction of Additive Manufactured Stainless Steel 17-4 PH," *Data in Brief*, Vol. 13 (C), pp. 408-414.
8. Ibrahim, O.T., Monroe, J.G., **Thompson, S.M.**, Shamsaei, N., Bilheux, H., Elwany, A., Bian, L., 2017, "An Investigation of a Multi-Layered Oscillating Heat Pipe Additively Manufactured from Ti-6Al-4V Powder," *International Journal of Heat and Mass Transfer*, Vol. 108 (A), pp. 1036-1047.
9. Shamsaei, N., Yadollahi, A., Bian, L., **Thompson, S.M.,** 2015, "An Overview of Direct Laser Deposition for Additive Manufacturing; Part II: Mechanical Behavior, Process Parameter Optimization and Control," *Additive Manufacturing*, Vol. 8, pp. 12-35.
10. Emelgou, A., Marufuzzaman, M., **Thompson, S.M.**, Shamsaei, N., Bian, L., 2016, "Additive Manufacturing of Biomedical Implants: A Feasibility Assessment via Supply-Chain Cost Analysis," *Additive Manufacturing*, Vol. 11, pp. 97-113.

SYNERGISTIC ACTIVITIES

- *ASME K13 Chair & Symposium Organizer:* PI Thompson is currently the Chair of ASME's K13 Committee on Multiphase Heat Transfer. He is also the co-founder and ongoing organizer for the Symposium on Additive Manufacturing, which occurs annual at ASME's International Mechanical Engineering Congress and Exposition (IMECE).
- *National Center for Additive Manufacturing Excellence (NCAME)*: PI Thompson co-founded NCAME while at AU – which is a collaborative effort between AU, NASA and ASTM International. The Center possesses multiple additive manufacturing systems (which PI Thompson helped procure and manage) and continues to focus on performing industry-driven research and workforce development with respect to AM.
- *ASME Heat Sink Challenge*: PI Thompson co-led a team of graduate students who were successful in winning an ASME-sponsored 'Heat Sink Design with Additive Manufacturing' competition. The students designed a novel AM heat sink from aluminum alloy and presented their results at the ASME InterPACK conference in San Francisco (2018)[1].
- *Invited Talk*: "Heat Transfer during the Additive Manufacture of Metals: Implications on Part Defects and Mechanical Properties," ASTM/NIST Symposium on Fatigue and Fracture of Additive Manufactured Materials and Components, November, Atlanta, GA, 2017.
- *Principal or Co-Investigator on several externally-sponsored research projects* with a funding level over $6 Mil, including contracts from NSF (x3), DoD, NASA, and DARPA. PI Thompson has also been active in the DoD SBIR/STTR program.

[1] http://www.eng.auburn.edu/news/2018/09/additive-challenge-winners.html

(●) WSU - Research Office
( ) WSU Foundation

WSU OFFICE OF RESEARCH PROPOSAL ROUTING FORM

Prop # 200711

GDS: CM

MAC USERS: Please fill complete using the latest version of Adobe Reader

FINAL proposals are due a MINIMUM of 3 days prior to the Agency Deadline

Paper submissions which include cost share and/or waived indirects require additional processing time.

Principal Investigator (PI): Gisuk Hwang

Agency Deadline: 06/08/2020

Sponsor/Agency: President's Convergence Science Initiative (State of Kansas)

Solicitation #: PCSI

Project Title: Smart Fusion Material Research Cluster

Period From: 8/1/2020 To: 7/31/2023

	YEAR ONE	TOTAL PERIOD
Direct Costs:	$100,000.00	$300,000.00
Indirect Costs		
Total Costs	$100,000.00	$300,000.00
Cost Share:		

PI's Effort (Total Project Person Months) .08

Course Release? No Overload? No

Research Type: Basic

Indirect (F&A) Rate (MTDC):

(●) Organized Research 48%	( ) Off Campus 26%
( ) Instruction 50%	( ) Commercial 63.61%
( ) Other Sponsored Activities 30%	

If Sponsor Limits F&A, what rate is allowed? 0%

Rate applied to this proposal (if not listed above)

Budget is Lab Rate ONLY ( ) Yes (●) No

Includes Subreceipients ( ) Yes (●) No

Fundamental Research (●) Yes ( ) No

Research where the results are ordinarily published and shared broadly within the research community, and for which the researcher has not accepted restrictions for proprietary or national security reasons.

COMPLIANCE REVIEW: To be completed by the PI - MUST answer Yes or No to ALL

( ) Yes	(●) No	Human Subjects	( ) Yes	(●) No	Biological Materials	( ) Yes	(●) No	Infectious Agents
( ) Yes	(●) No	Hazardous Chemicals/Waste	( ) Yes	(●) No	Clinical Trials	( ) Yes	(●) No	Proprietary Information
( ) Yes	(●) No	Animals	( ) Yes	(●) No	Medical Devices/Drugs	( ) Yes	(●) No	Foreign Nationals
( ) Yes	(●) No	Radioactive Material	( ) Yes	(●) No	Recombinant DNA or RNAi	( ) Yes	(●) No	Foreign Travel/Shipping
( ) Yes	(●) No	HIPPA/PHI*	( ) Yes	(●) No	ITAR/CUI*	( ) Yes	(●) No	Int'l Collaborations

Does this project pose a conflict of interest for you or any anticipated project member? ( ) Yes (●) No

Have you or any anticipated project member been debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from transactions by a federal department or agency? ( ) Yes (●) No

Are you or any anticipated project member currently delinquent on any federal debt? (i.e. taxes, student loans, etc.) ( ) Yes (●) No

Does this project require facilities that are not currently allocated/available to you? ( ) Yes (●) No

WSU Department/College/Center Responsible for Matching Funds/Cost Share	Amount

NOTES/COMMENTS:

PCSI is an internal WSU opportunity - no indirects.

*Definitions: **HIPAA/PHI** - Health Insurance Portability and Accountability Act/Personal Health Information; **ITAR/CUI** - International Traffic in Arms Regulations/Controlled Unclassified Information

NEW - RTT is now tracking PI/Co-PI involvement on sponsored projects Please complete the table below. This information will be used when reporting proposal/award totals across PI/Co-PI roles, departments and colleges.

Name	Role	Dept/College/Center	% of Project
Gisuk Hwang	PI	ME, CoE	30
Saideep Nannapaneni	Co-PI	ISME, CoE	10

Total Project Allocation **MUST** equal **100**

40

ACKNOWLEDGMENTS AND CERTIFICATIONS:

As the Principal Investigator, I acknowledge that I have reviewed and considered all terms and conditions (including those that must be accessed electronically), and I understand that said terms and conditions are/may be applicable to any and all work performed should the application be successful. My signature indicates my knowledge of the terms and conditions and my willingness/ability to comply therewith. With respect to any invention, discovery, or copyrightable material produced in the course of activities encompassed by this project, I agree that my rights and those of any Co-Investigator(s) working on this project shall be governed by the University policies relating to research, patents and copyrights as described in the WSU Faculty Handbook, and by the patent policy of the Kansas Board of Regents; and I have read and understand the lobbying restrictions and Responsible Conduct of Research requirements for **FEDERAL** grants, contracts and cooperative agreements attached hereto as page 3.

As the Principal Investigator, I hereby certify that: 1) the information submitted within this application is true, complete and accurate to the best of my knowledge; and 2) any false, fictitious or fraudulent statements or claims may subject me personally to criminal, civil or administrative penalties; and 3) I agree to accept responsibility for the scientific conduct of this project and provide the required progress reports if a grant is awarded as a result of this application.

FORM WILL LOCK ONCE SIGNED BY PI - ENSURE YOU HAVE READ AND COMPLETED ALL PRIOR SECTIONS

PI Signature: Gisuk Hwang Digitally signed by Gisuk Hwang Date: 2020.06.03 15:36:54 -05'00' Date: 06/03/20

Agreement of project involvement and acknowledgements and certifications of Co-Principal Investigators (as applicable)

Co-PI **Co-PI**

Co-PI **Co-PI**

The validity of the proposed activity and commitment of resources (as noted) are hereby authorized.

	Date		Date
T.S. Ravigururajan Digitally signed by T.S. Ravigururajan Date: 2020.06.03 16:20:41 -05'00'	06/03/20	Janet Twomey Digitally signed by Janet Twomey DN: cn=Janet Twomey, o=Wichita State University, ou=Associate Dean College of Engineering, email=janet.twomey@wichita.edu, c=US Date: 2020.06.03 16:33:12 -05'00'	06/03/20
PI Chair/Center Director	**Date**	**PI Dean/Vice President**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Karen Davis Digitally signed by Karen Davis Date: 2020.06.08 10:29:37 -05'00'	06/08/20		
Director for Pre-Award / NIAR Pre-Award	**Date**	**Provost or Sr VP of Ind & Defense Programs** *Required for proposals with waived indirects and/or cost share*	**Date**

Prop # 200711 GDS: CM

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FORM WILL LOCK ONCE SIGNED BY PI - ENSURE YOU HAVE READ AND COMPLETED ALL PRIOR SECTIONS

PI Signature: Gisuk Hwang Digitally signed by Gisuk Hwang Date: 2020.06.03 15:36:54 -05'00' Date: 06/03/20

Agreement of project involvement and acknowledgements and certifications of Co-Principal Investigators (as applicable)

Co-PI Saideep Nannapaneni Digitally signed by Saideep Nannapaneni Date: 2020.06.03 16:39:40 -05'00' **Co-PI**

Co-PI **Co-PI**

The validity of the proposed activity and commitment of resources (as noted) are hereby authorized.

	Date		Date
PI Chair/Center Director		**PI Dean/Vice President**	
Krishna Krishnan Digitally signed by Krishna Krishnan Date: 2020.06.03 15:41:13 -05'00'	06/03/20		
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Director for Pre-Award / NIAR Pre-Award	**Date**	**Provost or Sr VP of Ind & Defense Programs** *Required for proposals with waived indirects and/or cost share*	**Date**

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Name	Role	Dept/College/Center	% of Project
Gisuk Hwang	PI	ME, CoE	30
Timothy Babb	Co-PI	Shocker Studios, Fine Arts	10
	Co-PI		
	Co-PI		
	Co-PI		

Total Project Allocation **MUST** equal **100**

40

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FORM WILL LOCK ONCE SIGNED BY PI - ENSURE YOU HAVE READ AND COMPLETED ALL PRIOR SECTIONS

PI Signature: Gisuk Hwang Digitally signed by Gisuk Hwang Date: 2020.06.03 15:21:47 -05'00' Date: 06/03/20

Agreement of project involvement and acknowledgements and certifications of Co-Principal Investigators (as applicable)

Co-PI Timothy Babb Digitally signed by Timothy Babb Date: 2020.06.03 16:32:44 -05'00' **Co-PI**

Co-PI **Co-PI**

The validity of the proposed activity and commitment of resources (as noted) are hereby authorized.

	Date		Date
PI Chair/Center Director		**PI Dean/Vice President**	
Justin Rorabaugh Digitally signed by Justin Rorabaugh Date: 2020.06.03 16:22:44 -05'00'	06/03/20		
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Miller, Rodney Digitally signed by Miller, Rodney Date: 2020.06.04 09:56:24 -05'00'	06/04/20		
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Director for Pre-Award / NIAR Pre-Award	**Date**	**Provost or Sr VP of Ind & Defense Programs** *Required for proposals with waived indirects and/or cost share*	**Date**

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Name	Role	Dept/College/Center	% of Project
Gisuk Hwang	PI	ME, CoE	30
Mara Alagic	Co-PI	School of Ed, CAS	10
	Co-PI		
	Co-PI		
	Co-PI		

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40

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FORM WILL LOCK ONCE SIGNED BY PI - ENSURE YOU HAVE READ AND COMPLETED ALL PRIOR SECTIONS

PI Signature: Gisuk Hwang Digitally signed by Gisuk Hwang Date: 2020.06.03 15:22:22 -05'00' Date: 06/03/20

Agreement of project involvement and acknowledgements and certifications of Co-Principal Investigators (as applicable)

Co-PI MaraAlagic Digitally signed by MaraAlagic Date: 2020.06.03 17:06:42 -05'00' **Co-PI**

Co-PI **Co-PI**

The validity of the proposed activity and commitment of resources (as noted) are hereby authorized.

	Date		Date
PI Chair/Center Director		**PI Dean/Vice President**	
Jody Fiorini Digitally signed by Jody Fiorini Date: 2020.06.03 18:29:31 -04'00'		Shirley Lefever Digitally signed by Shirley Lefever Date: 2020.06.04 07:56:41 -05'00'	
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Director for Pre-Award / NIAR Pre-Award	**Date**	**Provost or Sr VP of Ind & Defense Programs** *Required for proposals with waived indirects and/or cost share*	**Date**

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Name	Role	Dept/College/Center	% of Project
Gisuk Hwang	PI	ME, CoE	30
Tianshi Lu	Co-PI	Math, LAS	10
Kapildeb Ambal	Co-PI	Physics, LAS	10
Rowen Shen	Co-PI	Hugo Walls, LAS	10
Xiaoheng Wang	Co-PI	Hugo Walls, LAS	10

Total Project Allocation **MUST** equal **100**

70

ACKNOWLEDGMENTS AND CERTIFICATIONS:

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FORM WILL LOCK ONCE SIGNED BY PI - ENSURE YOU HAVE READ AND COMPLETED ALL PRIOR SECTIONS

PI Signature: Gisuk Hwang Digitally signed by Gisuk Hwang Date: 2020.06.03 15:23:36 -05'00' Date: 06/03/20

Agreement of project involvement and acknowledgements and certifications of Co-Principal Investigators (as applicable)

Co-PI Xiaoheng Wang Digitally signed by Xiaoheng Wang Date: 2020.06.04 15:45:58 -05'00'

Co-PI Ruowen Shen Digitally signed by Ruowen Shen Date: 2020.06.04 15:50:00 -05'00'

Co-PI

Co-PI

The validity of the proposed activity and commitment of resources (as noted) are hereby authorized.

Melissa A. Walker Digitally signed by Melissa A. Walker DN: cn=Melissa A. Walker, o=Wichita State University, ou=Hugo Wall School of Public Affairs, email=melissa.walker@wichita.edu, c=US Date: 2020.06.05 12:41:38 -05'00'			
PI Chair/Center Director	**Date**	**PI Dean/Vice President**	**Date**
		David M. Eichhorn Digitally signed by David M. Eichhorn Date: 2020.06.05 14:48:22 -05'00'	06/05/20
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Director for Pre-Award / NIAR Pre-Award	**Date**	**Provost or Sr VP of Ind & Defense Programs** *Required for proposals with waived indirects and/or cost share*	**Date**

Prop # 200711 GDS: CM

NEW - RTT is now tracking PI/Co-PI involvement on sponsored projects Please complete the table below. This information will be used when reporting proposal/award totals across PI/Co-PI roles, departments and colleges.

Name	Role	Dept/College/Center	% of Project
Gisuk Hwang	PI	ME, CoE	30
Tianshi Lu	Co-PI	Math, LAS	10
Kapildeb Ambal	Co-PI	Physics, LAS	10
Rowen Shen	Co-PI	Hugo Walls, LAS	10
Xiaoheng Wang	Co-PI	Hugo Walls, LAS	10

Total Project Allocation **MUST** equal **100**

70

ACKNOWLEDGMENTS AND CERTIFICATIONS:

As the Principal Investigator, I acknowledge that I have reviewed and considered all terms and conditions (including those that must be accessed electronically), and I understand that said terms and conditions are/may be applicable to any and all work performed should the application be successful. My signature indicates my knowledge of the terms and conditions and my willingness/ability to comply therewith. With respect to any invention, discovery, or copyrightable material produced in the course of activities encompassed by this project, I agree that my rights and those of any Co-Investigator(s) working on this project shall be governed by the University policies relating to research, patents and copyrights as described in the WSU Faculty Handbook, and by the patent policy of the Kansas Board of Regents; and I have read and understand the lobbying restrictions and Responsible Conduct of Research requirements for **FEDERAL** grants, contracts and cooperative agreements attached hereto as page 3.

As the Principal Investigator, I hereby certify that: 1) the information submitted within this application is true, complete and accurate to the best of my knowledge; and 2) any false, fictitious or fraudulent statements or claims may subject me personally to criminal, civil or administrative penalties; and 3) I agree to accept responsibility for the scientific conduct of this project and provide the required progress reports if a grant is awarded as a result of this application.

FORM WILL LOCK ONCE SIGNED BY PI - ENSURE YOU HAVE READ AND COMPLETED ALL PRIOR SECTIONS

PI Signature: Gisuk Hwang Digitally signed by Gisuk Hwang Date: 2020.06.03 15:23:36 -05'00' Date: 06/03/20

Agreement of project involvement and acknowledgements and certifications of Co-Principal Investigators (as applicable)

Co-PI Kapildeb Ambal Digitally signed by Kapildeb Ambal Date: 2020.06.03 22:03:27 -05'00' **Co-PI**

Co-PI **Co-PI**

The validity of the proposed activity and commitment of resources (as noted) are hereby authorized.

PI Chair/Center Director	**Date**	**PI Dean/Vice President**	**Date**
Holger Meyer Digitally signed by Holger Meyer Date: 2020.06.05 13:18:00 -05'00'			
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Additional Endorser / Co-PI Chair/Dean	**Date**	**Additional Endorser / Co-PI Chair/Dean**	**Date**
Director for Pre-Award / NIAR Pre-Award	**Date**	**Provost or Sr VP of Ind & Defense Programs** *Required for proposals with waived indirects and/or cost share*	**Date**

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FORM WILL LOCK ONCE SIGNED BY PI - ENSURE YOU HAVE READ AND COMPLETED ALL PRIOR SECTIONS

PI Signature: Date: 06/03/20

Agreement of project involvement and acknowledgements and certifications of Co-Principal Investigators (as applicable)

Co-PI 6/5/20 **Co-PI**

Co-PI **Co-PI**

The validity of the proposed activity and commitment of resources (as noted) are hereby authorized.

PI Chair/Center Director **Date** **PI Dean/Vice President** **Date**

Additional Endorser / Co-PI Chair/Dean 6/5/20 **Date** **Additional Endorser / Co-PI Chair/Dean** **Date**

Additional Endorser / Co-PI Chair/Dean 6.5.20 **Date** **Additional Endorser / Co-PI Chair/Dean** **Date**

Additional Endorser / Co-PI Chair/Dean **Date** **Additional Endorser / Co-PI Chair/Dean** **Date**

Director for Pre-Award / NIAR Pre-Award **Date** **Provost or Sr VP of Ind & Defense Programs** ***Required for proposals with waived indirects and/or cost share*** **Date**

Prop # 200711 GDS: CM

CERTIFICATION REGARDING LOBBYING

The applicant certifies, to the best of his or her knowledge and belief , that: (1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the applicant, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment or modification of any Federal contract, grant, loan or cooperative agreement. (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the applicant shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions. (3) The applicant shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly. This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

RESPONSIBLE CONDUCT OF RESEARCH (RCR)

RCR training is a funding requirement for the National Science Foundation (NSF), the National Institutes of Health (NIH) and the USDA National Institute of Food and Agriculture (NIFA). Researchers applying for, and receiving, support from NSF, NIH or NIFA should be familiar with each agency's requirements with regards to RCR and be prepared to provide documentation of appropriate training. While RCR training should be an ongoing component of any research program, at a minimum, personnel on projects with a research component will need to register and complete the "Externally Funded Researchers" RCR course through the Collaborative Institutional Training Initiative (CITI) during the first 90 days of receiving salary support.

Date Rec'd by RTT

Prop # 200711

GDS: CM

Proposal #: 200711
PI: Hwang
Agency: PCSI
Date: 5/11/2020

		Year 1	Year 2	Year 3	Total		Annual Base	1.03	Monthly	Contract Mo.	Sum Mos	AY Mos	T&E
Key Personnel													
PI: Hwang		$ 784	$ 808	$ 832	$ 2,424		$ 88,177	$ 88,177	9797	9	1		8%
PI Fringes:	0.18379	$ 144	$ 149	$ 153	$ 446								
CoPI: Nannapaneni		$ 369	$ 380	$ 391	$ 1,140		$ 83,000	83000	9222	9	1		4%
Fringes:	0.18379	$ 68	$ 70	$ 72	$ 210								
CoPI: Lu		$ 358	$ 369	$ 380	$ 1,107		$ 80,465	80465	8941	9	1		4%
Fringes:	0.18379	$ 66	$ 68	$ 70	$ 204								
CoPI: Ambal		$ 280	$ 288	$ 297	$ 865		$ 63,000	63000	7000	9	1		4%
Fringes:	0.18379	$ 51	$ 53	$ 55	$ 159								
CoPI: Babb		$ 230	$ 237	$ 244	$ 711		$ 51,750	$ 51,750	5750	9	1		4%
Fringes:	0.18379	$ 42	$ 44	$ 45	$ 131								
CoPI: Alagic		$ 345	$ 355	$ 366	$ 1,066		$ 77,635	77635	8626	9	1		4%
Fringes:	0.18379	$ 63	$ 65	$ 67	$ 195								
CoPI:Wang		$ 298	$ 307	$ 316	$ 921		$ 67,000	67000	7444	9	1		4%
Fringes:	0.18379	$ 55	$ 56	$ 58	$ 169								
CoPI: Shen		$ 298	$ 307	$ 316	$ 921		$ 67,000	$ 67,000	7444	9	1		4%
Fringes:	0.18379	$ 55	$ 56	$ 58	$ 169								
Total Key Personnel		**$ 3,506**	**$ 3,612**	**$ 3,720**	**$ 10,838**								
				$ 1,683	$ 9,155								
Other Personnel							**Weeks**	**Rate**	**#of GRAs**	**Hrs/Week**			
GRA Salary - Academic Year ONLY (3/4 appointment) :		$ 17,793	$ 18,327	$ 18,877	$ 54,997		52		1	$ 158,212			
Insurance		$ 1,064	$ 1,096	$ 1,129	$ 3,289								
GRA Fringes	0.011	$ 196	$ 202	$ 208	$ 606			**Ins**		$ 14,223			
GRA Salary - Academic Year ONLY (3/4 Appointment): F		$ 17,793	$ 18,327	$ 18,877	$ 54,997		$ 52		1				
Insurance		$ 1,064	$ 1,096	$ 1,129	$ 3,289								
GRA Fringes	0.011	$ 196	$ 202	$ 208	$ 606			Ins					
GRA Salary - **Academic Year**: School of Ed/Hugo Walls		$ 12,000	$ 12,360	$ 12,731	$ 37,091		$ 40	15	1	20			
GRA Fringes	0.011	$ 132	$ 136	$ 140	$ 408			Ins					
Insurance		$ 1,064	$ 1,096	$ 1,129	$ 3,289			1064	Note: Insurance & Tuition prorated the same (based on 20 hrs FT)				
GRA Salary - **Summer:** School of Ed / Hugo Walls		$ 3,600	$ 3,708	$ 3,819	$ 11,127		$ 12	15	1	20			
GRA Fringes	0.011	$ 40	$ 41	$ 42	$ 123			Ins					
Insurance		$ 213	$ 219	$ 226	$ 658			213					
							Weeks	**Rate**	**#of UGs**	**Hrs/Week**			
Undergrad Salary		$ 8,000	$ 8,240	$ 8,487	$ 24,727		10	$ 10.00	8	10			
Undergrad Fringes	0.011	$ 88	$ 91	$ 93	$ 272								
Total Other Personnel		**$ 63,243**	**$ 65,141**	**$ 67,095**	**$ 195,479**								
Total Salaries		**$ 62,148**	**$ 64,013**	**$ 65,933**	**$ 192,094**								
Total Fringes		**$ 4,601**	**$ 4,740**	**$ 4,882**	**$ 14,223**								
Total Salaries & Fringes		**$ 66,749**	**$ 68,753**	**$ 70,815**	**$ 206,317**								
Equipment													
		$ -	$ -	$ -	$ -								
Total Equipment		**$ -**	**$ -**	**$ -**	**$ -**								
							Mileage Rate	**Miles**					
							0.575						
Travel							**Flight**	**Hotel**	**Per Diem**	***Ground Trans.**	***Other**	**# of People**	**# of Days**
Domestic (placeholder only PI to provide details later)			$ -	$ -	$ -								
International		$ -	$ -	$ -	$ -								

Total Travel		**$ -**	**$ -**	**$ -**	**$ -**									
Participant Support Costs							**Participants**	**Pay Rate**						
Stipends		$ -	$ -	$ -	$ -									
		$ -	$ -	$ -	$ -									
Total Participant Support Costs		**$ -**	**$ -**	**$ -**	**$ -**									
Supplies														
Project Supplies		$ 8,638	$ 5,986	$ 3,256	$ 17,880									
Total Supplies		**$ 8,638**	**$ 5,986**	**$ 3,256**	**$ 17,880**									
Contractors														
Vendors		$ -	$ -	$ -	$ -									
Consultants		$ 3,000	$ 3,000	$ 3,000	$ 9,000				**26880**					
		$ -	$ -	$ -	$ -									
Total Vendors/Contractors		**$ 3,000**	**$ 3,000**	**$ 3,000**	**$ 9,000**									
Subreceipients														
			$ -	$ -	$ -									
Total Subrecipients		**$ -**	**$ -**	**$ -**	**$ -**									
							Note: Insurance & Tuition prorated the same (based on 20 hrs FT)							
Other Expenses							**Tuition**	**Cr Hrs/AY**	**# of GRAs**	*- If needed, 6 Cr Hrs for Summer*				
Tuition Remission		$13,809	$14,223	$14,650	$42,682		$383.57	18	2	*- Add $50/Cr Hr for engineering GRAs.*				
Tuition Remission		$ 7,804	$ 8,038	$ 8,279	$ 24,121		$ 433.57	18	1	*- Add $50/Cr Hr for engineering GRAs.*				
Publishing Costs		$ -	$ -	$ -	$ -									
		$ -	$ -	$ -	$ -		$66,803							
		$ -	$ -	$ -	$ -									
Total Other Expenses		**$21,613**	**$22,261**	**$22,929**	**$66,803**									
Total Direct Costs		**$ 100,000**	**$ 100,000**	**$ 100,000**	**$ 300,000**									
**MTDC		$ 78,387	$ 77,739	$ 77,071	$ 233,197		Adjust MTDC Formula for subrecipients							
0%		$ -	$ -	$ -	$ -									
Total (Direct + Indirect Costs)		**$ 100,000**	**$ 100,000**	**$ 100,000**	**$ 300,000**		0%	Unrecovered Indirects:	$ -					
							Internal WSU Award - No Indirects to be collected							

Prepared by: CM
Checked by: dm / dc