

Zhengtao Gan

Research Assistant Professor

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Appointments

Research Assistant Professor Jun. 2020 - Present

Northwestern University, Evanston, IL, USA

- Department of Mechanical Engineering

Research Associate Sep. 2019 – Jun. 2020

Northwestern University, Evanston, IL, USA

- Department of Mechanical Engineering

Education

Postdoctoral fellow Sep. 2017 – Sep. 2019

Northwestern University, Evanston, IL, USA

- Department of Mechanical Engineering
- Advisor: Prof. Wing Kam Liu

Ph.D. Sep. 2012 - Jul. 2017

University of the Chinese Academy of Sciences, Beijing, China

- Institute of Mechanics
- Advisors: Profs. Gang Yu and Xiuli He
- Honored with the National scholarship for graduate students (1/127)

B.E. Sep. 2008 - Jul. 2012

Chongqing University, China

- Department of Mechanical Engineering

Research Interests

- Multiscale Multiphysics Modeling for Additive Manufacturing (AM)
- Scientific Machine Learning and Data Science
- Computational Thermal Fluid Dynamics (CTFD)

Dr. Gan has made outstanding and innovative contributions to the area of advanced and additive manufacturing. He developed a multiphysics thermal-fluid model to elucidate and predict complex thermal, fluid and solidification behavior during additive manufacturing. His latest research leveraged machine learning and dimensional analysis to dramatically increase the speed of the

computations and take into account extremely complex physical phenomena that are difficult to directly simulate before, such as keyhole evolution and porosity formation. Dr. Gan’s noteworthy contributions are:

- Development of thermal-fluid models incorporating physics at multiple scales for additive manufacturing of metals. The model predictions were validated by highly controlled benchmark experimental data conducted by the Air Force Research Laboratory (AFRL) and the National Institute of Standards and Technology (NIST). The northwestern team led by Dr. Gan was identified as Top Performer in Air Force Research Laboratory (AFRL) Additive Manufacturing (AM) Modeling Challenge Series: Micro-scale Process-to-Structure Predictions (2020). Dr. Gan’s work was awarded 1st place by NIST for the best modeling results predicting the cooling rate, grain structure, and dendritic microstructure in AM-Bench 2018.
- Dr. Gan and his collaborators in Argonne National Laboratory (Dr. Olle Heinonen and Dr. Tao Sun’s team) discovered strikingly simple but universal scaling laws from high-fidelity high-speed synchrotron X-ray imaging. Dimensional analysis and genetic programming (a type of machine learning) were used to identify a new dimensionless number, “Keyhole number”, to predict melt-pool vapor depression shape.
- Dr. Gan and his collaborators (Prof. Jian Cao’s team) integrated machine learning and deep learning with physical mechanisms to understand and predict process-structure-properties relationships in additive manufacturing. Mechanical properties such as ultimate tensile strength (UTS) and elongation can be predicted based on time-frequency analysis of thermal history and supervised learning algorithms.

Awards/Honors

Top Performer in Air Force Research Laboratory (AFRL) Additive Manufacturing (AM) Modeling Challenge Series: Micro-scale Process-to-Structure Predictions <i>(\$65,000.00 cash prize donated to Northwestern University Mechanical Sciences Donor Advised Fund)</i>	Jun. 2020
NIST Additive Manufacturing Benchmark Challenge, 1st Place (3)	Jun. 2018
Outstanding Graduates of Beijing	Sep. 2017
Outstanding Graduates of UCAS	Sep. 2017
CAS President’s Fellowship (Awarded to the top 1% graduate students in UCAS)	Apr. 2017
Scholarship in honor of Guo Yonghuai, 1st Place (Rank: No.1 out of all PhD students of Institute)	Apr. 2017
National Scholarship for Graduate Students (Awarded to the top 2% graduate students nationally)	Sep. 2016
Graduate School Scholarship, Chinese Academy of Sciences (CAS)	Nov. 2015
Merit Student of Chinese Academy of Sciences	Jul. 2015
Outstanding Graduates of Chongqing University	Jun. 2012
National Mechanics Competition in Honor of Zhou PeiYuan, Grand Place	May 2011
Merit Student of Chongqing University	Dec. 2011
National Experimental Mechanics Competition, 1st Place	Oct. 2010
Mechanics Competition of Chongqing University, 1st Place	Mar. 2010
Scholarship in honor of Qiu Shi	Dec. 2010

Professional Services

Reviewer, International Journal of Heat and Mass Transfer
Reviewer, International Journal of Advanced Manufacturing Technology
Reviewer, Applied Physics Letters
Reviewer, Additive Manufacturing
Reviewer, European Journal of Mechanics / A Solids
Reviewer, Computational Mechanics
Reviewer, Applied Physics A
Reviewer, Integrating Materials and Manufacturing Innovation
Reviewer, Ceramics International
Reviewer, Optics and Laser Technology
Reviewer, Engineering Failure Analysis
Reviewer, Vacuum
Reviewer, Computer Modeling in Engineering & Sciences
Reviewer, Journal of Shanghai Jiao Tong University (Science)
Reviewer, Textile Research Journal
Reviewer, Royal Society Open Science
Reviewer, Indoor and Built Environment
Reviewer, Review Instructions for Review of Scientific Instruments
Reviewer, Journal of the Mechanical Behavior of Biomedical Materials
Reviewer, International Journal of Modeling, Simulation, and Scientific Computing
Reviewer, Journal of Materials Engineering and Performance

Current Gants (participant)

NIST: Center for Hierarchical Materials (CHiMaD) (Main PI: Peter W. Voorhees), \$20,000,000, 1/1/2019 to 12/31/2023.

NSF: Manipulating Nanoparticle-Modified Melt Pool Dynamics in Additive Manufacturing (PIs: Wing Kam Liu and Gregory J. Wagner), \$777,438, 12/1/2019 to 11/30/2023.

STTR: Phase I: Model for Surface Finish Prediction and Optimization of Metal Additively Manufactured Parts (PIs: Jim Lua and Wing Kam Liu), \$89,160, 10/22/2019 to 10/21/2020.

BICI USA Co., Ltd.: Process Modeling Software for Additive Manufacturing of Metals (PIs: Gregory J. Wagner and Wing Kam Liu), \$512,548, 9/1/2018 to 8/31/2020

Journal Articles

- [1] Gan, Z., Kafka, O. L., Parab, N., Zhao, C., Heinonen, O., Sun, T., & Liu, W. (2020). Universal low-dimensional scaling laws in 3D printing of metals. arXiv preprint arXiv:2005.00117.
- [2] Wolff, S.J., Gan, Z., Lin, S., Bennett, J.L., Yan, W., Hyatt, G., Ehmann, K.F., Wagner, G.J., Liu, W.K. and Cao, J. (2019). Experimentally validated predictions of thermal history and microhardness in laser-deposited Inconel 718 on carbon steel. Additive Manufacturing (S. Wolf and Z. Gan contributed equally).
- [3] Lian, Y., Gan, Z., Yu, C., Kats, D., Liu, W. K., & Wagner, G. J. (2019). A cellular automaton finite volume method for microstructure evolution during additive manufacturing. Materials & Design, 107672.
- [4] Gan, Z., Li, H., Wolff, S.J., Bennett, J.L., Hyatt, G., Wagner, G.J., Cao, J. and Liu, W.K. (2019). Data-Driven Microstructure and Microhardness Design in Additive Manufacturing Using a Self-Organizing Map. Engineering, 5(4), 730-735.
- [5] Gan, Z., Lian, Y., Lin, S.E., Jones, K.K., Liu, W.K. and Wagner, G.J. (2019). Benchmark study of

thermal behavior, surface topography, and dendritic microstructure in selective laser melting of Inconel 625. Integrating Materials and Manufacturing Innovation, *Special issue: Additive Manufacturing Benchmarks 2018*, 1-16.

- [6] Chen, R., Yu, G., He, X., Gan, Z. (2018). Effect of sulfur diffusion in 38MnVS6 steel on morphology and microstructure of laser cladding layers. Chinese Journal of Lasers, 45: 6.
- [7] Gan, Z., Yu, G., He, X. and Li, S. (2017). Numerical simulation of thermal behavior and multicomponent mass transfer in direct laser deposition of Co-base alloy on steel, International Journal of Heat and Mass Transfer, 104: 28-38. (**Top 1% highly cited papers in the field of Engineering**)
- [8] Gan, Z., Yu, G., He, X. and Li, S. (2017). Surface-active element transport and its effect on liquid metal flow in laser-assisted additive manufacturing, International Communications in Heat and Mass Transfer 86: 206-214.
- [9] Gan, Z., Liu, H., Li, S., He, X. and Yu, G. (2017). Modeling of thermal behavior and mass transport in multi-layer laser additive manufacturing, International Journal of Heat and Mass Transfer, 111: 709-722. (**Top 1% highly cited papers in the field of Engineering**)
- [10] Gan, Z., Yu, G., Li, S., He, X., Chen, R., Zheng, C. and Ning, W. (2016). A novel intelligent adaptive control of laser-based ground thermal test, Chinese Journal of Aeronautics, 29: 1018-1026.
- [11] Zhang, S., Miao, H., He, X., Gan, Z. (2015). Effect of directions on welded joint in laser-arc hybrid welding of aluminum alloy, Hot Working Technology, 3: 80-82.

Conference Proceedings (selected)

- [1] Z. Gan (2019). Data-driven discovery of scaling law in additive manufacturing, In USNCCM, Austin, USA.
- [2] Z. Gan (2019). Quantification of energy coupling efficiency and melt pool dynamics during intense laser irradiation of aluminum alloy, In Finite Element in Fluids (FEF), Chicago, USA.
- [3] Z. Gan (2018). Multiscale process-structure modeling framework in directed energy deposition of Ni-based Superalloy, In U.S. national committee on theoretical and applied mechanics (USNC/TAM), Chicago, USA.
- [4] Z. Gan (2018). Predictive multiphysics process-structure models for additive manufacturing, In The 13th world congress in computational mechanics (WCCM), New York City, USA.
- [5] Z. Gan (2015). Heat and mass transfer in additive manufacturing, COMSOL Conference, Beijing, China.
- [6] Z. Gan, et al (2015). Numerical simulation of interface evolution in additive manufacturing, CCTAM, Shanghai, China.

Patents

- [1] A method for determining the focal plane of laser beam: Chinese Patent, ZL201410068886.3
- [2] Temperature control method for thermal vacuum test: Chinese Patent, ZL201410646172.6
- [3] Temperature control device for spacecraft thermal vacuum Test: Chinese Patent, ZL201410648692.0
- [4] Composition calculation of multicomponent alloy in laser Cladding: Chinese Patent, ZL201610182078.9
- [5] Closed-loop control method for laser cladding: Chinese Patent, ZL201610183120.9

Computer Codes

- ✓ **AM-CFD** A computational fluid dynamics computer program for transient heat transfer, fluid flow and solidification in multitrack and multilayer additive manufacturing process.
- ✓ **DimensionNet** A deep learning framework for data-driven dimensional analysis enabling dimensionless numbers discovery.