Chenkai Mao (Kai)

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EDUCATION

Stanford University *GPA: 3.98/4.0* September 2020 - December 2025
Ph.D. & M.S. in Electrical Engineering

Massachusetts Institute of Technology *GPA: 4.8/5.0* August 2017 - May 2020
B.S. in Electrical Engineering and Computer Science,
Double major in Physics, minor in Mathematics

SKILLS

Programming	Python, C/C++, JAX**,** MATLAB, Linux, Pytorch, Cosmol, SolidWorks, OpenFOAM, FDTD Lumerical/Meep
Coursework	**Physical Science** - Nanophotonics, Fluid Dynamics, Robotics, VLSI, Quantum Mechanics **AI** - Machine learning, Computer Vision, Graph Neural Networks, Natural Language Processing, Meta Learning, Deep Generative Networks, Reinforcement Learning, Convex optimization

INTERNSHIP EXPERIENCE

Research Scientist Internship on AI-guided Design (FAIR, Meta) **October 2024 - February 2025**
- Using Flow Matching Models to learn implicit constraints in designs space. New York, NY
- Augment the generative model with physical conditions to improve inverse design performance.

Research Internship on Additive Manufacturing (LLNL) **June 2024 - August 2024**
- Develop massively parallel additive manufacturing systems enabled by metalens arrays. Livermore, CA
- Study the two-photon polymerization process through chemical and numerical experiments.

Hardware Design & Verification Internship (Apple Neural Engine) **July 2020 - September 2020**
- Developed comprehensive tests, coverage plans, and the verification environment using Object Oriented tools, in particular SystemVerilog. Cupertino, CA
- Worked closely with designers and architects to make the design-under-test work for all specified circumstances to ensure pre-silicon qualification of Apple's Neural Engine.

RESEARCH EXPERIENCE

Stanford University **Advisor: Prof. Jonathan A. Fan**

Accurate and Scalable Deep PDE Solvers **PNAS** 2026
- Model agnostic framework for NN as preconditioners.
- Obtained fully accurate solutions for large problem sizes of up to 16M voxels.

Two Photon lithography for 3D Printing of Nanostructures **Nature** 2025
- Design, optimize and experimentally fabricate metalens arrays to parallelize 2-photon 3d printing process
- Large-scale metalens fabrication that breaks nano-3d-printing throughput world record.
- Collaboration with Laurence Livermore National Lab.

General Surrogate Solver with Domain Decomposition Methods **ICML** 2024
- Built a scalable semi-general EM frequency domain solver using Domain Decomposition Method.
- Innovated Fourier neural operator architecture with self-modulation for improved expressivity.
- The framework also applies to 2d steady state fluid flow problems.

Physics-Augmented Deep Learning for Electromagnetic (EM) Simulations and Optimizations 2021-2022
- Constructed a surrogate EM simulator with a hybrid data- and physics-augmented neural network
- Demonstrated accurate predictions of EM fields and effective incorporations into local and global freeform optimization for diffractive metasurface systems
- Accelerated the design process by nearly four orders of magnitude time

Reparameterization for Inverse Design of Three-Dimensional Nanophotonics Devices 2020-2022
- Invented a framework for the inverse design of diffractive metasurfaces that robustly imposes fabrication constraints by reparameterizing the design space.
- Fabricated and characterized the optimized 3D metasurface that realizes arbitrary polarization control.

Massachusetts Institute of Technology

Research of NP-hard Algorithms Implementation on FPGA (PI: Prof. Marin Soljacic) 2018 - 2020
- Implemented efficient algorithms for NP-hard problems in statistical physics on an FPGA board.
- Sped up large matrix operations by memory optimization and parallel architecture design.

Photonic Research at Photonic Materials Lab (PI: Prof. Jujun Hu) 2019
- Explored building topological photonic crystal using phase-change materials.
- Conduct numerical simulations using Lumerical and MIT Photonic Bands (MPB).

HONORS AND AWARDS

- Fusion Fellow (Livermore Lab Foundation) 2024
- Stanford Graduate Fellowship - Eric and Illeana Benhamou Fellow Fellow 2020
- Texas Instruments Undergraduate Research and Innovation Scholar 2019
- Make MIT Hackathon - Best Robotics Project 2018
- International Physics Olympiad (IPHO) Gold Medal (1st place) 2016

PUBLICATIONS

1. **Mao, C.**, Fan, J. A. “Accurate and scalable deep Maxwell solvers.” PNAS (2025)
2. **Mao, C.**, Lupoiu, R., Dai, T., Chen, M., Fan, J. A. “Towards General Neural Surrogate Solvers with Specialized Neural Accelerators”, Proceedings of the 41st International Conference on Machine Learning (2024)
3. Gu, S., **Mao, C.** et al. “3D Nanolithography with Metalens Arrays and Spatially Adaptive Illumination”, Nature (2025).
4. Zhou, Y., **Mao, C.**, Gershnabel, E., Chen, M, and Fan, J.A. "Large-area, high-numerical-aperture, freeform metasurfaces." Laser & Photonics Reviews 18, no. 6 (2024): 2300988.
5. Chen, M., Lupoiu, R., **Mao, C.**, Huang, D.H., Jiang, J., Lalanne, P., Fan, J.A. "High speed simulation and freeform optimization of nanophotonic devices with physics-augmented deep learning." ACS Photonics 9, no. 9 (2022): 3110-3123.
6. Dai, T., Shao, Y., **Mao, C.**, Wu, Y., Azzouz, S., Zhou, Y. and Fan, J.A., 2025. Shaping freeform nanophotonic devices with geometric neural parameterization. npj Computational Materials, 11(1), p.259. (2025)
7. Lupoiu, R., Shao, Y., Dai, T., **Mao, C.**, Edée, K. and Fan, J.A., 2025. A multi-agentic framework for real-time, autonomous freeform metasurface design. arXiv preprint arXiv:2503.20479. (2025)
8. Zhou, Y., Shao, Y., **Mao, C.** and Fan, J.A., 2024. Inverse-designed metasurfaces with facile fabrication parameters. Journal of Optics, 26(5), p.055101. (2024)
9. Gershnabel, E., Chen, M., **Mao, C.**, Wang, E., Lalanne, P., Fan, J.A. "Reparameterization approach to gradient-based inverse design of three-dimensional nanophotonic devices." ACS Photonics 10, no. 4 (2022): 815-823.
10. Jiang, Z., Dai, T., Guo, S., Sohag, S., Shao, Y., **Mao, C.**, ... & Zhou, Y. Near-field optical mode engineering-enabled freeform nonlocal metasurfaces. arXiv preprint arXiv:2506.15495. (2025)
11. Roques-Carmes, Charles, Yichen Shen, Cristian Zanoci, Mihika Prabhu, Fadi Atieh, Li Jing, Tena Dubček, **Mao, C.**, et al. "Heuristic recurrent algorithms for photonic Ising machines." Nature communications 11, no. 1 (2020): 249.