Sunil Pai, Ph.D.

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Employment History

2022 – Present **Sr. Photonic Designer,** *PsiQuantum Corp.*

- Created a GDS-driven **photonic testbench** for up to **100k+-component circuits** that validates path lengths and simulates wavelength-dependent S-matrices. This framework **prevented critical errors in 5 tapeouts** and is now used by 10+ engineers, enabling rapid test-data-driven performance prediction (loss, pulse delays, Monte-Carlo).
- **Invented** a symmetry-based **phase-correction algorithm 100× faster** than prior methods on large GMZI switches; basis for **2 PsiQuantum patent applications**.
- **Scaled on real hardware** (BTO/SiN switches) with test engineers, **saving months of test time**.
- Led large-scale test-data analysis (AWS S3/Lambda, SQL/SQLAlchemy, Flask) to predict switch performance and extract waveguide-loss metrics for **PsiQuantum's recent *Nature* paper**.

2017 – 2022 **PhD Researcher (Photonic Computing),** *Stanford University*.

- Theory and experimental verification of **MZI mesh circuits** for **universal optical linear circuits** (**David AB Miller, Olav Solgaard, Shanhui Fan**)
- **First ever demonstration of optical backpropagation** on a photonic neural network chip (published in ***Science***, over 200 cites, and ***Optica***).
- Built an **end-to-end photonic teststand**: movable microscope (Thorlabs/ASI/Xenics), aluminum mount (Xometry), foundry tapeouts (AIM/AMF), wirebonding (Silitronics), temp-controlled PCB/NI drivers (30+ phase shifters).
- Built an **end-to-end photonic R&D software framework**: photonic layout (`dphox`), simulation/inverse design (`simphox`), experiment control software (`phox`, includes teststand drivers, a GUI for control/measurement/live camera feed), PyTorch integrated ONNs (`neurophox`)
- New + visiting PhD students still use the software and teststand I built over 4 years later.

2021 – 2022 **AI Resident,** *Google/X, the moonshot factory*

- Launched autodiff-based **inverse design optimization** runs for integrated photonic devices (e.g. multi-channel WDMs) using **large-scale FDTD physics simulations** on Google infrastructure.
- Improved existing optimization algorithms, loss functions, and initialization strategies (leading to **design patents with Google**: US11968034 B2, US20240056211 A1).

Employment History (continued)

2016 – 2017

- **Data Engineer,** *Stella AI.* Helping to build the engine behind a personal AI recruiter. Got familiar and used SQL, Elasticsearch, Kibana, Flask, Alembic, and more.
- **Teaching Assistant,** *Stanford University.* CS221 (Artificial Intelligence), CS229 (Machine Learning), CS224N (Natural Language Processing), CS224U (Natural Language Understanding)

Education

2017 – 2022 **Ph.D., Stanford University** Electrical Engineering
Thesis title: *Universal analog computation on programmable nanophotonic integrated circuits.*

2014 – 2016 **M.S. Computer Science, Stanford University** in Artificial Intelligence (AI).

2011 – 2015 **B.S. Physics, Stanford University** with Honors.

Research Publications

Journal Articles

1. S. Pai, T. Park, M. Ball, *et al.*, "Experimental evaluation of digitally verifiable photonic computing for blockchain and cryptocurrency," *Optica*, vol. 10, no. 5, pp. 552–560, 2023.
2. S. Pai, Z. Sun, T. W. Hughes, *et al.*, "Experimentally realized in situ backpropagation for deep learning in photonic neural networks," *Science*, vol. 380, no. 6643, pp. 398–404, 2023.
3. S. Pai, C. Valdez, T. Park, *et al.*, "Power monitoring in a feedforward photonic network using two output detectors," *Nanophotonics*, vol. 12, no. 5, pp. 985–991, 2023.
4. Z. Sun, S. Pai, C. Valdez, *et al.*, "Scalable low-latency optical phase sensor array," *Optica*, vol. 10, no. 9, pp. 1165–1172, 2023.
5. C. G. Valdez, S. Pai, P. Broaddus, and O. Solgaard, "High-efficiency vertically emitting coupler facilitated by three wave interaction gratings," *Optics Letters*, vol. 49, no. 9, pp. 2373–2376, 2023.
6. S. Pai, O. Solgaard, S. Fan, and D. A. Miller, "Scalable and self-correcting photonic computation using balanced photonic binary tree cascades," *arXiv preprint arXiv:2210.16935*, 2022.
7. M. M. P. Fard, I. A. Williamson, M. Edwards, *et al.*, "Experimental realization of arbitrary activation functions for optical neural networks," *Optics Express*, vol. 28, no. 8, pp. 12 138–12 148, 2020.
8. S. Pai, B. Bartlett, O. Solgaard, and D. A. Miller, "Matrix optimization on universal unitary photonic devices," *Physical review applied*, vol. 11, no. 6, p. 064 044, 2019.
9. S. Pai, I. A. Williamson, T. W. Hughes, *et al.*, "Parallel fault-tolerant programming of an arbitrary feedforward photonic network," *arXiv preprint arXiv:1909.06179*, 2019.
10. I. A. Williamson, T. W. Hughes, M. Minkov, B. Bartlett, S. Pai, and S. Fan, "Reprogrammable electro-optic nonlinear activation functions for optical neural networks," *IEEE Journal of Selected Topics in Quantum Electronics*, vol. 26, no. 1, pp. 1–12, 2019.
11. N. O. Loewke, S. Pai, C. Cordeiro, *et al.*, "Automated cell segmentation for quantitative phase microscopy," *IEEE transactions on medical imaging*, vol. 37, no. 4, pp. 929–940, 2017.
12. J. Durruthy-Durruthy, M. Wossidlo, S. Pai, *et al.*, "Spatiotemporal reconstruction of the human blastocyst by single-cell gene-expression analysis informs induction of naive pluripotency," *Developmental Cell*, vol. 38, no. 1, pp. 100–115, 2016.

13. S. Pai, N. Loewke, M. Green, *et al.*, "An in vitro nematic model for proliferating cell cultures," *arXiv preprint arXiv:1611.08353*, 2016.
14. E. S. Chen, H. Keith, T. Lim, *et al.*, "Hylleraas hydride binding energy: Diatomic electron affinities," *Journal of Molecular Modeling*, vol. 21, pp. 1–13, 2015.
15. I. Goodman, K. Gregory, and S. Pai, "A network-based approach to ranking college football teams," *SNAP*, 2015.
16. S. M. Phadnis, N. O. Loewke, I. K. Dimov, *et al.*, "Dynamic and social behaviors of human pluripotent stem cells," *Scientific Reports*, vol. 5, no. 1, p. 14 209, 2015.
17. E. S. Chen, S. Pai, and E. C. Chen, "Hyperfine electron affinities of molecular oxygen," *Computational and Theoretical Chemistry*, vol. 1050, pp. 89–95, 2014.
18. E. S. Chen, E. C. Chen, F. C. Anderson, and S. Pai, "Paradigms and paradoxes: What are the 54 electron affinities of o 2?" *Structural Chemistry*, vol. 23, pp. 407–410, 2012.

Conference Proceedings

1. C. G. Valdez, S. Pai, P. Broaddus, and O. Solgaard, "Triple-etch grating for near perfect coupling at normal incidence," in *CLEO: Fundamental Science*, Optica Publishing Group, 2023, JW2A–66.
2. N. S. Abebe, S. Pai, P. Broaddus, R. L. Hwang, Y. Miao, and O. Solgaard, "Silicon nitride process for mode-orthogonal mems-tunable photonic devices," in *CLEO: Applications and Technology*, Optica Publishing Group, 2022, AM2C–1.
3. S. Pai, T. W. Hughes, T. Park, *et al.*, "Inference and gradient measurement for backpropagation in photonic neural networks," in *2022 Conference on Lasers and Electro-Optics (CLEO)*, IEEE, 2022, pp. 1–2.
4. S. Pai, T. Park, B. Penkovsky, *et al.*, "Lighthash: Experimental evaluation of a photonic cryptocurrency," in *2022 Conference on Lasers and Electro-Optics (CLEO)*, IEEE, 2022, pp. 1–2.
5. S. Pai, N. Abebe, M. Dubrovsky, *et al.*, "Wavelength-division multiplexed optical cryptocurrency," in *2021 Conference on Lasers and Electro-Optics (CLEO)*, IEEE, 2021, pp. 1–2.
6. S. Pai, N. Abebe, R. L. Hwang, D. A. Miller, and O. Solgaard, "Mems photonic networks for parallelized matrix multiplication using wavelength-division multiplexing," in *2021 Conference on Lasers and Electro-Optics (CLEO)*, IEEE, 2021, pp. 1–2.
7. S. Pai, I. A. Williamson, M. Minkov, *et al.*, "Parallel fault-tolerant programming and optimization of photonic neural networks," in *CLEO: Science and Innovations*, Optica Publishing Group, 2020, SM1E–5.
8. I. A. Williamson, T. W. Hughes, M. Minkov, B. Bartlett, S. Pai, and S. Fan, "Tunable nonlinear activation functions for optical neural networks," in *CLEO: Science and Innovations*, Optica Publishing Group, 2020, SM1E–2.
9. E. Chen, S. Pai, H. Keith, and E. S. Chen, "Reduction potentials and hyperfine electron affinities of o-2," in *ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY*, AMER CHEMICAL SOC 1155 16TH ST, NW, WASHINGTON, DC 20036 USA, vol. 247, 2014.
10. E. S. Chen, S. Pai, H. Keith, and E. C. Chen, "Electrochemical determination of new hyperfine electron affinities of oxygen," in *ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY*, AMER CHEMICAL SOC 1155 16TH ST, NW, WASHINGTON, DC 20036 USA, vol. 248, 2014.

Books and Chapters

1. S. K. Pai, *Universal Analog Computation on Programmable Nanophotonic Integrated Circuits*. Stanford University, 2022.

Skills

Languages	English, elementary proficiency in Spanish
Coding	Python, LaTeX, C/C++, Java (basic), SQL (basic), Rust (basic)
Storage/Databases	MySQL, PostgreSQL, AWS s3, MongoDB, Elasticsearch.
Web Dev	HTML, CSS, JavaScript, TypeScript, d3, three.js, Vue, Svelte
Scientific Computing	Numpy, Scipy, JAX, TensorFlow, PyTorch
Documentation/Data Viz	Sphinx, Plotly, Bokeh, Holoviews
Misc. CAD/EDA	Python-based GDS design, AutoCAD, SPICE, KiCAD
Misc. Software/Control	Gitlab, Alembic, Jira, Asana, Slack, NI-VISA, pyserial (motors, stages, lasers)

Miscellaneous Experience

Awards and Achievements

2022 **Tingye Li Innovation Prize Finalist**, *Stanford University*. Presented to an early-career professional who has demonstrated innovative ideas in their accepted paper to CLEO, the premier conference for lasers and electo-optics.

2011 **Davidson Fellows Scholarship**, *Stanford University*. An award for early career research (< 18 years old)

Intel Science Talent Search Finalist, a prestigious science and math competition for high school seniors (now Regeneron Science Talent Search).