

Docket #: S18-019

Fully-automated design of grating couplers (software)

Stanford researchers at the Vuckovic Lab have created a computational nanophotonic design library for gradient-based optimization called the Stanford Photonic INverse design Software (**Spins**). This extremely flexible and adaptable photonics design software can be used to design any linear, passive photonic element. To use **Spins**, the designer simply specifies a design region and desired functionality for a device. The software will then automatically design an optimized device that meets these specifications.

Spins is now being licensed to any interested parties through Stanford's [Office of Technology Licensing \(OTL\)](#).

Spins-B is an open source version available on Github.

Stage of Research:

Prototypes - The team designed and experimentally demonstrated a spatial-mode demultiplexer, wavelength demultiplexer, compact broadband power splitter and directional coupler.

This invention is an application of **Spins** (Stanford reference [S18-012 "Inverse design software for nanophotonic structures - Spins"](#))

Applications

- **Designing innovative structures for efficient optical devices**
- **Examples include silicon photonics components** such as power splitters, wavelength demultiplexers, fiber-to-chip grating coupler design, mode converters, metasurface design, quantum circuits (photonic and microwave) LEDs, solar cells, lasers designs

Advantages

- **Fully automated and efficient** - no human guidance required
- **Allows user to 'design by specification'**
- **Uses gradient-based optimization methods** not derivative-free optimization methods which are computationally inefficient and only work well for small numbers of degrees of freedom
- Resulting designs are significantly **more compact, have higher performance, and can potentially realize novel functionalities**
- Devices can be **easily fabricated** by standard lithography techniques

Publications

- Alexander Y. Piggott, Eric Y. Ma, Logan Su, Geun Ho Ahn, Neil V. Sapro, Dries J.F. Vercruyssen, Andrew M. Netherton, Akhilesh S.P. Khope, John E. Bowers, Jelena Vučković? [Inverse-designed photonics for semiconductor foundries](#) *ACS Photonics* Feb. 14, 2020.
- Ki Youl Yang, Jinhie Skarda, Michele Cotrufo, Avik Dutt, Geun Ho Ahn, Mahmoud Sawaby, Dries Vercruyssen, Amin Arbabian, Shanhui Fan, Andrea Alù & Jelena Vučković? [Inverse-designed non-reciprocal pulse router for chip-based LiDAR](#) *Nature Photonics* (2020).
- Logan Su, Dries Vercruyssen, Jinhie Skarda, Neil V. Sapro, Jan A. Petykiewicz, and Jelena Vučković? [Nanophotonic inverse design with SPINS: Software architecture and practical considerations](#) *Appl. Phys. Rev.* 7, 011407 (2020) Featured in *ScienceDaily*, *PhysOrg*, *EurekAlert*, and more.
- Neil V. Sapro, Ki Youl Yang, Dries Vercruyssen, Kenneth J. Leedle, Dylan S. Black, R. Joel England, Logan Su, Rahul Trivedi, Yu Miao, Olav Solgaard, Robert L. Byer, Jelena Vučković? [On-chip integrated laser-driven particle accelerator](#) *Science* Vol. 367, Issue 6473, pp. 79-83 (2020).
- Neil V. Sapro, Dries Vercruyssen, Logan Su, Ki Youl Yang, Jinhie Skarda, Alexander Y. Piggott, Jelena Vučković? [Inverse design and demonstration of broadband grating couplers](#) *Applied Physics* (2018).
- [Fully-automated optimization of grating couplers](#) Logan Su, Rahul Trivedi, Neil V. Sapro, Alexander Y. Piggott, Dries Vercruyssen, Jelena Vučković?. (2017)

- Alexander Y. Piggott, Jan Petykiewicz, Logan Su & Jelena Vučković? [Fabrication-constrained nanophotonic inverse design](#) *Scientific Reports* 7,1786 (2017).
- Alexander Y. Piggott, Jesse Lu, and Jelena Vučković? [Silicon Photonics: Design approach to integrated photonics explores entire space of fabricable devices](#) *Laser Focus World*, (2016) (Review).
- Alexander Y. Piggott, Jesse Lu, Konstantinos G. Lagoudakis, Jan Petykiewicz, Thomas M. Babinec, and Jelena Vučković? [Inverse design and demonstration of a compact and broadband on-chip wavelength demultiplexer](#) *Nature Photonics* 9, 374–377 (2015).
- Alexander Y. Piggott, Jesse Lu, Thomas M. Babinec, Konstantinos G. Lagoudakis, Jan Petykiewicz, Jelena Vuckovic [Inverse design and implementation of a wavelength demultiplexing grating coupler](#) *Scientific Reports* 4, 7210, (2014).
- Jesse Lu and Jelena Vuckovic [Nanophotonic computational design](#) *Optics Express* Vol. 21, 11, pp. 13351-13367 (2013).

Innovators

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