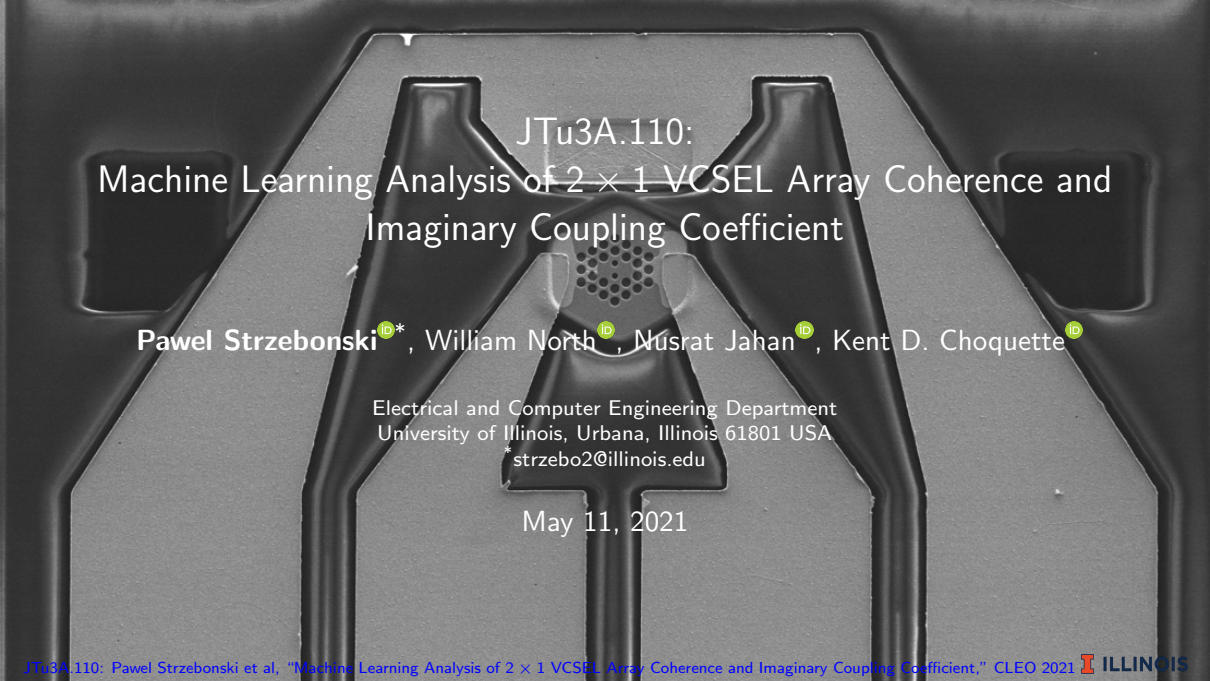

JTu3A.110: Machine Learning Analysis of 2×1 VCSEL Array Coherence and Imaginary Coupling Coefficient

Pawel Strzebonski[*], William North, Nusrat Jahan, Kent D. Choquette

Electrical and Computer Engineering Department
University of Illinois, Urbana, Illinois 61801 USA
[*] strzebo2@illinois.edu

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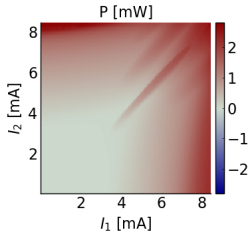
Introduction

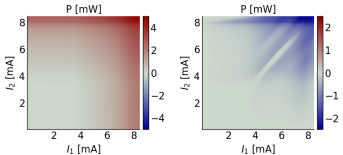
- When tuned to optical coherence:
  - Higher optical power [1]
  - Electrically-controlled beam-steering [1]
  - Lower intensity noise [1]
  - Higher modulation bandwidth [2]
- Effective coherence/coupling characterization and coherence tuning are main challenges:
  - Many methods have been proposed [4]
  - We'll focus on optical power analysis



Optical power measurement

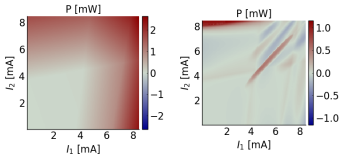
- Coherent coupling increases output optical power
- Optical power measurements reveal coherence as "coherent ridges"
- Strength of power enhancement tied to imaginary coupling coefficient [3]
- Challenge is estimating the coherent power enhancement by estimating uncoupled power

Analysis and Results



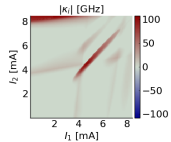
"Naive" attempt at uncoupled power and coherent power enhancement

- "Naive" estimates of uncoupled power as sum of independent lasers
- Fails to consider thermal shifting effects



Machine-learning attempt at uncoupled power and coherent power enhancement

- Artificial neural network (ANN) infers power from driving currents [4]
- Better estimate by incorporating shifting effects



Machine-learning estimate of imaginary coupling coefficient

- Uncoupled power and power enhancement used to estimate imaginary coupling coefficient

References

- Open source code available online [5, 6]
- See the related talks:
  - *"Extraction of Coupling Coefficient for Coherent 2x1 VCSEL Array"* by Nusrat Jahan
  - *"Spectral Mode Analysis of Non-Hermitian Phased Microcavity Laser Array"* by William North

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[2] H. Dave, P. Liao, S. T. M. Fryslie, Z. Gao, B. J. Thompson, Alan E. Willner, and K. D. Choquette. Digital modulation of coherently-coupled 2×1 vertical-cavity surface-emitting laser arrays. *IEEE Photonics Technology Letters*, 31(2):173–176, January 2019. doi: 10.1109/lpt.2018.2888806. URL https://doi.org/10.1109/lpt.2018.2888806.

[3] H. Dave, Z. Gao, and K. Choquette. Complex coupling coefficient in laterally coupled microcavity laser diode arrays. *Applied Physics Letters*, 117(4):041106, July 2020. doi: 10.1063/5.0014468. URL https://doi.org/10.1063/5.0014468.

[4] Pawel Strzebonski, Harshil Dave, Katherine Lakomy, Nusrat Jahan, William North, and Kent Choquette. Computational methods for VCSEL array characterization and control. In Kent D. Choquette and Chun Lei, editors, *Vertical-Cavity Surface-Emitting Lasers XXV*. SPIE, March 2021. doi: 10.1117/12.2585066. URL https://doi.org/10.1117/12.2585066.

[5] Pawel Strzebonski. VCSELArrayAnalysis.jl, 2021. URL https://gitlab.com/pawelstrzebonski/VCSELArrayAnalysis.jl.

[6] Pawel Strzebonski. VCSELArrayAnalysisML.jl, 2021. URL https://gitlab.com/pawelstrzebonski/VCSELArrayAnalysisML.jl.