Simultaneous Optimization of Yield and Threshold in Microring Lasers

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The pursuit of on-chip coherent laser light sources remains a critical challenge in advancing Photonic Integrated Circuits (PICs). Progress has primarily been hindered by complex interactions among material properties, including defect recombination, surface effects, and cavity effects [1], along with device geometry and performance characteristics. Navigating through the expansive design landscape and resource-demanding fabrication procedures adds another layer of complexity to this endeavour.

Recently, InP/InAsP III-V multi-quantum-well (MQW) microring lasers have emerged as a promising solution, demonstrating tunable emission wavelengths within the telecommunication O-band and exhibiting low-threshold lasing [2]. Nonetheless, simultaneously achieving high yield, minimal lasing threshold, and accurately calibrated lasing wavelengths within the telecommunication spectrum poses a multi-objective problem, particularly in setups employing quantum confined heterostructures [3].

Multi-objective optimization poses a significant challenge due to the inherent difficulty in finding a single solution that optimizes all conflicting objectives simultaneously [4]. Furthermore, as the number of conflicting objectives increases and the decision space becomes more high-dimensional, extensive sampling becomes imperative to effectively explore the decision space [5]. We propose a combination of high-throughput characterization of over 4000 microring lasers, grown with 54 different properties, to produce statistically robust measurements with multi-objective Bayesian and evolutionary optimization methods [5]. By sampling the expansive yet constrained parameter space defined by the microring geometry and growth conditions, our aim is to pinpoint specific regions within this space for further study to optically meet the objectives.

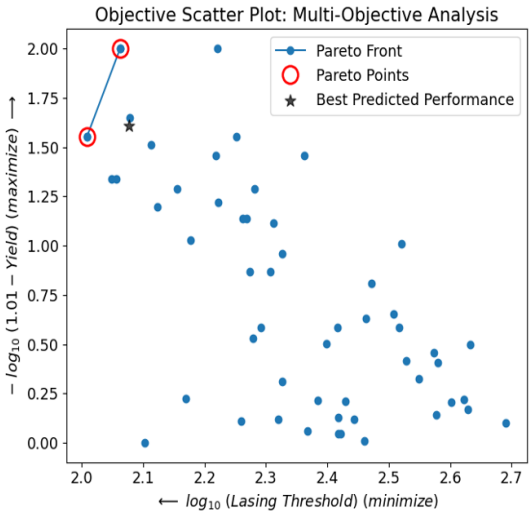

Fig. 1. The scatter plot illustrates the objective functions, with the goal of minimizing the lasing threshold and maximizing the yield. The Pareto front highlights the non-dominated solutions, signifying that no other solution outperforms them in all objectives simultaneously.

The median threshold and yield values for our initial samples were observed at 212 μJ cm^{-2} pulse^{-1} and 75%, respectively. However, with our approach, we anticipate achieving a yield of over 94%, accompanied by consistent threshold values of less than 180 μJ cm^{-2} pulse^{-1}.

References

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