Machine learning for performance homogeneity of photonic chips

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***Abstract*—The performance homogeneity of photonic chips is critical when it comes to the deployment of the technology in high volume applications. We present our research for using machine learning for optimization of the design space and prediction of optical performance of the planar lighwave circuit technology in volume manufacturing.**

***Keywords*—machine learning, artificial intelligence, waveguide, planar lightwave circuit, integrated optics**

I. Introduction

Planar lightwave circuit (PLC) technology has the ability to address the requirements of many of today's demanding applications [1][2]. PLCs possess high optical performance and are well suited for both monolithic and hybrid integration in compact packages with excellent reliability. However, achieving consistently reproducible performance of fabricated components has been a significant challenge in the photonics industry. We present our latest work on the use of machine learning (ML) algorithms to achieve highly homogeneous performance, an approach that is crucial for enabling the deployment of PLC technology in high-volume production.

II. OUR WORK

Process uniformity and consistency have been proven to be critical in the manufacturing of photonics chips [3]. This applies to variation of physical parameters within a wafer as well as to the differences between batches of wafers, both of which pose a significant challenge in achieving reproducible performance in volume production. We use machine learning to identify, classify, and compensate for systematic non-uniformities across a broad range of performance metrics. To handle systematic variability within a wafer, we deploy a multivariate regression model to optimize the design parameters. We use deep learning to homogenize the performance of all the chips on a wafer and to bypass the costly process of testing individual chips, thus achieving high production yields.

A 6" production wafer typically contains hundreds or even thousands of optical devices. Small process variations could result in inconsistent performance of fabricated devices. We utilize machine learning to study the measured variations in the performance of individual chips, and then predict the design adjustments required to compensate for such variability in the design of the production mask. This is a multivariate regression problem where the device spectrum is correlated to the device parameters. We use a supervised learning strategy to train the model using labelled data. To achieve a sufficiently large training dataset, a combination of real and synthetic data is used, where synthetic data is generated through simulation. As shown in Fig. 1, an iterative process is deployed to validate the model until maximum accuracy of prediction is achieved. The trained model is used to adapt the design parameters for each chip on the mask, allowing us to achieve consistently high performance over hundreds of optical devices fabricated on a single wafer.

When combined with a support vector machine (SVM), we are also able to accurately classify the performance of all chips on the wafer by only relying on position-related metrology data, without requiring the wafer to be diced. Here we deploy an incremental learning algorithm, so that the accuracy of the predictions improves as more data becomes available.

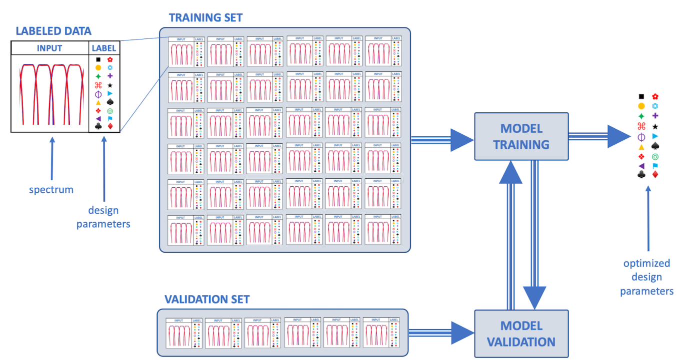

Fig. 1. Supervised learning setup used for optimization of design parameters.

III. CONCLUSION

We utilized machine learning algorithms to achieve performance homogeneity of PLCs in a high-volume production environment. The approach successfully addressed both the systematic processing variations within a wafer and the process drifts between fabricated wafers, resulting in a consistently high-yield production of PLCs for large-scale deployments.

References

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