Improve the production and testing efficiency of optical modules



Overview

Enhancing Process Yield Though Quality Prediction Using Machine. This research investigates the application of Machine learning (ML) techniques to enhanc.

Key Takeaways

Machine learning, parallel testing, and optimized optical design can significantly enhance optical module production efficiency while maintaining high quality.

Machine Learning for Predictive Testing

Implementing machine learning (ML) models can drastically reduce unnecessary retesting and improve yield. Traditional step-by-step testing workflows (OPA, LOPT, OTSM, OSET) often result in repeated tests, increasing production time. ML-based predictive analytics can forecast final test outcomes from early-stage data, allowing early defect detection.

For example, using XGBoost in a step-by-step model increased yield from 48. 5% to 98. 1%, while a cross-step Random Forest model further improved yield to 98.

9%, reducing retesting from 53 units to 3 per batch and saving over 13 hours of testing time per 100 modules.



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Parallel TX Testing

For high-speed modules (400G, 800G, 1. 6T), parallel TX testing using multi-channel optical sampling oscilloscopes can accelerate production. By triggering multiple optical lanes simultaneously, manufacturers can test several channels in parallel rather than sequentially, improving throughput and reducing bottlenecks.

Proper configuration is essential to ensure multi-channel oscilloscopes function correctly and avoid single-channel limitations.

Optimized Optical Design and Simulation

Efficient production begins with high-fidelity optical design. Using ray tracing, Monte Carlo simulations, and rigorous solutions of Maxwell's equations for diffractive and meta-optical elements ensures that modules meet specifications before fabrication. This reduces iterations and rework during production.

Integrating design tools with in-house testing allows for fast feedback loops, ensuring components meet performance standards early in the process.

Structured Testing and Quality Assurance

A well-defined testing strategy is critical. Key steps include: Transmission and reception tests to verify signal integrity, BER, and optical power. Environmental and stress tests to ensure module stability under temperature and operational variations.

Compatibility and interoperability tests with other network equipment to prevent field failures. Combining these with predictive analytics reduces redundant testing and accelerates throughput.

Supply Chain and Material Control

Maintaining forensic traceability of materials, adhesives, and components ensures consistent quality. Batch-to-batch variations in VCSELs, DSP coefficients, or PCB finishes can cause failures even if modules pass standard compliance tests. Implementing strict supplier management and layer-one interoperability testing prevents unexpected defects and reduces rework.

Summary

To improve production and testing efficiency of optical modules: Adopt ML-based predictive analytics to reduce retesting and increase yield. Use parallel TX testing for multi-lane high-speed modules. Optimize optical design and simulation to minimize rework.

Implement structured testing workflows with early defect detection. Ensure supply chain traceability and material consistency to prevent batch failures. These strategies collectively accelerate production, reduce tester load, and maintain high-quality standards, enabling faster delivery and higher throughput in optical module manufacturing.

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