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Raw Materials for High-Speed Optical Module Manufacturing



Overview

Optical module PCBs necessitate high-frequency materials to guarantee stable signal transmission and low loss.

Key Takeaways

High-speed optical modules rely on specialized optical, semiconductor, PCB, and polymer materials to ensure signal integrity, thermal stability, and high-performance photonic integration.Optical and Semiconductor Materials

High-speed optical modules require high-quality optical components such as lasers, photodetectors, and lenses. Materials commonly used include:

• Indium Phosphide (InP): Essential for photonic integrated circuits (PICs), InP enables integration of multiple optical functions on a single chip, supporting high-speed coherent transceivers and tunable lasers .

• Silicon: Often used in hybrid integration with InP for certain photonic functions.

• Calcium Fluoride (CaF_2): Ultra-clear and durable, used in lenses and optical substrates to handle short-wavelength laser light .

• Fused Silica and ULE® Glass: Provide low thermal expansion and high transmission for precision optics in laser and photolithography applications .

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• Titania-Silicate Low Expansion Glass: Used for mask and optical substrates in extreme ultraviolet (EUV) lithography, ensuring dimensional stability under thermal stress . These materials are critical for low-loss light transmission, precise wavelength control, and thermal stability in high-speed optical modules.

PCB Materials

High-speed optical modules also depend on advanced PCB materials to maintain signal integrity at 400G and 800G speeds:

• Low-Loss Dielectrics: Reduce dielectric loss and improve high-frequency signal transmission compared to standard FR4 .

• High-Density Interconnect (HDI) PCBs: Enable fine routing and controlled impedance for high-speed differential pairs.

• Copper Foils (HVLP and VLP): Minimize conductor loss and surface roughness, critical for insertion loss control .

• Zinc Alloy Housings and PCB Substrates: Provide mechanical stability and thermal management for optical modules .

Polymers and Coatings

Polymers are used for molding, coating, and encapsulating optical components:

• ORMOCER® Hybrid Polymers: Tailored for micro-optics, microdisplays, and printed optics, offering precise molding and curing capabilities .

• Protective Coatings: Applied to optical surfaces to reduce reflection, enhance durability, and prevent contamination during assembly .

Assembly and Integration Materials

High-speed optical modules require precise assembly materials to ensure reliability:

• Solder and Conductive Adhesives: For mounting lasers, photodiodes, and PCB components.

• Thermal Interface Materials (TIMs): Improve heat dissipation from high-power optical components.

• Anti-Static and Dust-Free Materials: Used in cleanroom environments to prevent contamination during manufacturing .

Summary

The manufacturing of high-speed optical modules integrates semiconductor materials (InP, silicon), optical glasses (CaF_2, fused silica, ULE®), advanced PCB materials (low-loss dielectrics, HDI PCBs, copper foils), and specialized polymers (ORMOCER®). These materials collectively ensure high-speed signal integrity, thermal stability, precise optical performance, and reliable module assembly, which are essential for 400G, 800G, and next-generation optical communication systems .

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