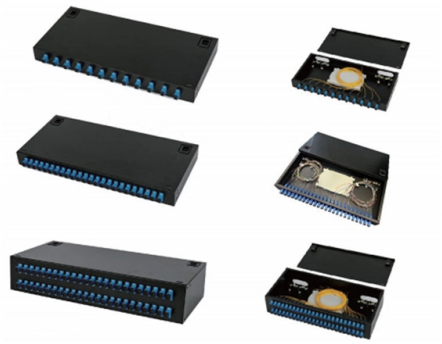
Customization Process for Anti-tracking Optical Directional Couplers for Surveillance Use



Overview

In this study, we introduce a design of a TDC based on coupling constant tuning in the thin film Lithium Niobate platform and present an optimized design.

Key Takeaways

Customizing optical directional couplers for surveillance involves parametric design, fabrication-tolerant structures, and tunable coupling mechanisms to achieve robust, broadband, and low-detectability performance.

Parametric Design and Modeling

The first step in customization is creating a parametric model of the directional coupler. This involves defining key parameters such as coupling length, waveguide gap, material refractive indices, and operating wavelength. Parametric modeling allows designers to simulate variations in these parameters and optimize the coupler for specific performance metrics, such as uniform splitting ratios or broadband operation.

Tools like IPKISS with Ansys Lumerical FDTD can automate simulations and polynomial fitting to generate predictive models for coupler behavior under different conditions.

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Fabrication-

Tolerant Design

For surveillance applications, couplers must maintain performance despite manufacturing variations. Techniques include: Symmetrical waveguide designs to reduce sensitivity to width variations. Broadband directional couplers that maintain a uniform coupling ratio across a range of wavelengths, typically around 1550 nm.

Finite-

Difference Eigenmode (FDE) and Finite-Difference Time-Domain (FDTD) simulations to predict and mitigate fabrication errors. These approaches ensure that the coupler remains reliable and less detectable under real-world conditions.

Advanced Coupler Architectures

To enhance tunability and anti-tracking capabilities, advanced designs such as grating-assisted contra-directional couplers (CDCs) can be employed. These devices use periodic perturbations in waveguide geometry to achieve wavelength-selective coupling, enabling: Add-drop filtering for selective signal routing. Wideband tunability without shifting the central wavelength.

Reduced parasitic reflections, which can minimize detection in surveillance systems. Segmented or multi-section designs allow fine control over the coupling spectrum, which is critical for stealthy optical signal manipulation.

Characterization and Testing

Robust characterization methods are essential to verify performance. Techniques that bypass extinction ratio measurements and are resilient to alignment errors provide accurate evaluation of splitting ratios and coupling efficiency. This ensures that the coupler performs as intended in integrated photonic circuits, even under environmental or operational variations.

Implementation Considerations

For surveillance applications, additional considerations include: Material selection to minimize scattering and absorption. Waveguide layout optimization to reduce back-reflection and crosstalk. Integration with photonic circuits for compact, low-profile deployment.

By combining parametric modeling, fabrication-tolerant design, and advanced coupler architectures, optical directional couplers can be customized for anti-tracking surveillance applications, achieving high performance, robustness, and stealth.

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Article Content

A fixed phase tunable directional coupler based on coupling tuning

In this study, we introduce a design of a TDC based on coupling constant tuning in the thin film Lithium Niobate platform and present an optimized design.

Designing Smarter Directional Couplers with Parametric Models

In this tutorial, we''ll uncover the benefits of creating a parametric model for directional couplers, leveraging the advanced layout and model-building capabilities of IPKISS.

Optical Coupler

An optical directional coupler is one of the most basic inline fiber-optic components, often used to split and combine optical signals, or tap-off a small portion of the optical power for monitoring.

A Review of Optical Coupler Theory, Techniques, and Applications

Grating couplers work under the former category, while edge couplers function as in-plane coupling. In this paper, we mainly focus on edge couplers in silicon photonic integrated circuits.

Custom Process for High-Temperature Resistant Optical Directional ...

Temperature changes cause a shift in wavelength and coupling length increase which describes the characteristics of the thermo-optic effects on the directional couplers.

Directional Coupler

A directional coupler is defined as a device that couples only to waves traveling in a specific direction, allowing for the measurement of forward and reverse power levels in transmission

Advances in waveguide to waveguide couplers for 3D integrated

In this paper, we provide an overview and comparison of devices used for optical waveguide-to-waveguide coupling including inter-chip edge couplers, grating couplers, free form

Directional couplers — CamachoLab Photonics Bootcamp

When designing a directional coupler, the length and gap must be chosen to produce the desired power splitting ratio at the output. Directional couplers are also sensitive to fabrication variations, so the

Methodology for Fabrication-Tolerant Planar Directional Couplers

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Using this approach, 2–3% index contrast waveguide couplers were fabricated and tested, demonstrating the predicted improved fabrication tolerances.

Methodology for Fabrication-Tolerant Planar Directional Couplers

Abstract: A new methodology for realizing fabrication-tolerant planar directional couplers is proposed and experimentally demonstrated.

Directional coupler and multimode interference devices based on SiN:

Directional coupler (DC) and multimode interference (MMI) devices are widely used components in photonic integrated circuits (PICs). In this study, the structures of DC and MMI

A Review of Optical Coupler Theory, Techniques, and Applications

This work presents a design approach of multi-segment directional couplers with ultra-broadband flat spectra and benign fabrication tolerance on the silicon nitride platform.

The Ultimate Guide to Directional Coupler Design

Introduction Directional couplers are a crucial component in various RF applications, including power monitoring, signal sampling, and antenna feeding. Designing an optimal directional

Design and modeling of a fabrication tolerant and broadband directional ...

We present a design for a fabrication tolerant and broadband directional coupler in photonic integrated circuits based on IMEC''s iSiPP50G silicon photonics platform. We demonstrate that such a design

Robust Directional Couplers for State Manipulation in Silicon Photonic ...

Photonic integrated circuits play a central role in current and future applications such as communications, sensing, ranging, and information processing. Photonic quantum computing will

Directional couplers — CamachoLab Photonics Bootcamp

Directional couplers # Directional couplers are two waveguides with a small gap between them that “couple,” or transfer, light from one waveguide to another. The term “coupling” comes from multiple

Rational design of an integrated directional coupler for wideband

We consider a design procedure for directional couplers for which the coupling length is approximately wavelength-independent over a wide bandwidth. We show analytically that two

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Design and fabrication of a photonic crystal directional coupler for ...

We have designed and fabricated a photonic crystal directional coupler for use as an optical switch. The design is for the SOI material system, and includes a silica overlayer and infilling of the etched

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This document is for preliminary research. Verify specifications against current standards, product documentation and project requirements.

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