FIBER-PRISM-WAVEGUIDE COUPLING AND PACKAGING

Z. Lu (MSECE) and D. W. Prather

University of Delaware • Center for Composite Materials • Department of Electrical and Computer Engineering

ABSTRACT AND MOTIVATION

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We present a silicon prism coupler for coupling from a single mode fiber into a 260-nm-thick SOI waveguide. The silicon prism is fabricated on a (100) silicon wafer using photolithography and wet etching. Tapered waveguides or J-couplers are employed as lateral mode converters. An experimental setup with a rotational stage and a pneumatic plunger has been built for controlling the incident angle and airgap thickness, which are key factors determining the coupling efficiency. When optimal coupling is achieved on the setup, the fiber-prism-waveguide coupler can be packaged using epoxy bonding. Thus, a fiber-prism-waveguide coupler or connector is constructed. Finite-difference time-domain and plane-wave spectrum electromagnetic calculations predict a coupling efficiency of 78%(-1.1dB insertion loss) for a uniform airgap silicon-to-silicon prism coupler. The coupling efficiency, achieved experimentally, is 49%(-3.1dB insertion loss) excluding the reflections from the input surface and output facet.

MOTIVATION

SOI is one of the most promising integrated optics technologies because the device fabrication allows the use of conventional microelectronics patterning techniques and the high index contrast offers strong light confinement in small dimensions, which enables miniaturization of functional integrated optical devices. For nanometer SOI integrated optics, one of the key issues is the fiber-chip coupling. Currently, although there are several proposals for achieving the coupling, most of them have either low efficiency or difficult fabrication. For example, end-fire coupling has been shown to have a very low efficiency because the thickness of the slab is often on the order of 100's nm. Grating coupling is a very promising method, but it is not well-suited for optical integrated circuits (OIC) due to difficulty in mode matching, sensitivity to wavelengths, and complexity of design and fabrication. For these reasons, in our work we have proposed and developed silicon prism coupling for SOI waveguides.

ACKNOWLEDGEMENTS

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SCHEMATIC AND 2-D FDTD-SIMULATION

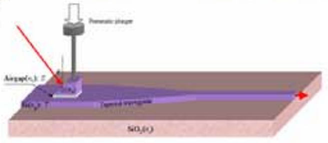


Fig.1a. Schematic for a prism coupler.

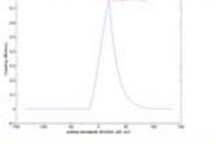


Fig.1b.PWS result for optimal parameters.

Plane wave spectral(PWS) method determines the optimal parameters.

FDTD method validates the design.

An efficiency of 77.1% is obtained in our simulation excluding the reflection on the prism.

This result can be applied to larger prisms when shifting the incident point.


Fig.1c. FDTD simulation of amplitude.

SILICON PRISM DESIGN AND FABRICATION

Fig.2a. Conventional design.

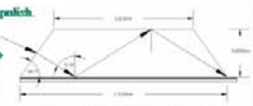


Fig.2b. Design to suit wet etching.


Si_3N_4 on (100) Si

Patterning

RIE

KOH etching

BOE removes Si_3N_4

Si prisms (1.2×1.73)mm

Fig.2c.Prism fabrication.


Fig.2d. SEM pictures of the prisms.

EXPERIMENTAL SETUP

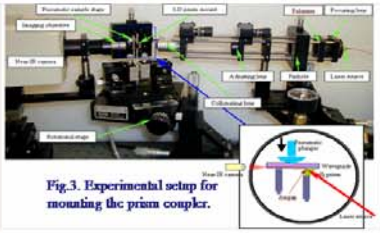


Fig.3. Experimental setup for mounting the prism coupler.

The prism is mounted on a 3-dimensional stage.

The sample (waveguide) is taped to a pneumatic plunger head.

A rotational stage to adjust the incident angle.

An Indigo Merlin digital infrared camera is used to evaluate the coupling efficiency.

COUPLING RESULTS

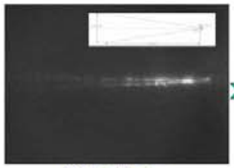


Fig.4a. Side view

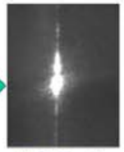


Fig.4b. Front view

Light is coupled into a 5 μm-wide waveguide through a lateral tapered "funnel".

Three dB bandwidth is about 80nm.

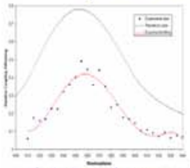


Fig.4c. Spectral response

PRISM COUPLING INTO PHOTONIC CRYSTALS

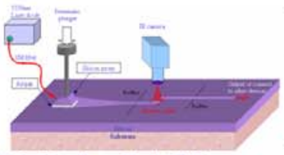
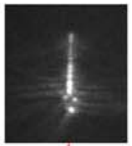


Fig.5a. Setup for coupling into PhCs.



A prism is coupling light into a tapered waveguide, which acts as a lateral mode converter, and then J-coupler is focusing light at a PhC structure.


Fig.5b. Light is coupling into a PhC

FIBER-PRISM-WAVEGUIDE COUPLER PACKAGING

Instead of collimated beams, direct F-P-W coupling is proved to be efficient.

When optimal coupling is achieved, the coupler can be packaged using epoxy bonding.


Fig.6a. Epoxy bonding machine.


Fig.6c. F-P-W coupler is constructed.

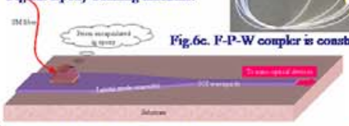


Fig.6b. Schematic for the packaging.