Experimental realization of a high efficient coupling technique for SOI devices based on inverted taper and V-groove integration

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Abstract: This paper demonstrates a coupling technique between SOI (*Silicon on insulator*) waveguides and singlemode fibers based on an inverted taper structure integrated with V-groove auto-alignment structures thus allowing an easier passive alignment of the optical fiber and easier packaging**.** Total fiber in-to-fiber out transmission losses around 20dB have been measured experimentally for a wavelength range between 1530nm and 1560nm when coupling the fabricated sample to a 9µm core diameter standard singlemode fiber.

Introduction

Light coupling into SOI devices is a key point in silicon photonics. It is very important to develop efficient coupling techniques which allow high coupling efficiency, so that no Fabry-Perot resonances appear in the measured spectrum power. Different coupling techniques as grating couplers [1] and inverted tapers [2] have been researched to achieve efficient light coupling in SOI devices. However, the fiber-chip alignment in that kind of structures is not an easy task. This approach was designed to allow the integration with V-groove structures for easier passive fiber alignment purposes.

Proposed structure

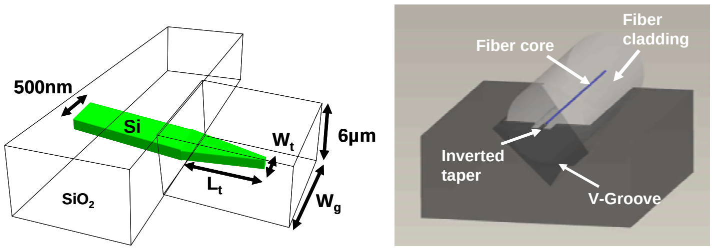
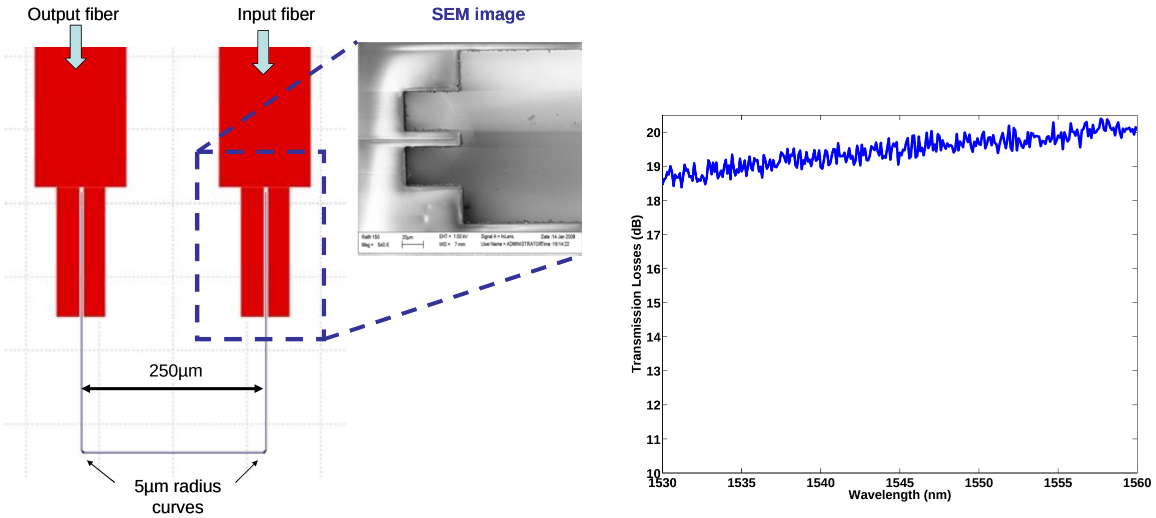


Figure 1: Illustration of the proposed coupling technique. Detail of the integration of the coupling technique with V-Groove structures.

Figure 1 depicts the proposed coupling technique. As it is shown, the singlemode SOI waveguide (which width has to be around 500nm for singlemode condition) is tapered down by the inverted taper, whose main physical parameters are illustrated in the picture. The inverted taper is surrounded by a 6µm height silica (SiO_2) layer. The design parameters of the inverted taper as well as the SOI waveguide and the silica waveguide were optimised with 3D BPM (Beam Propagation Method) simulations in order to achieve the lowest coupling losses between the proposed taper and a 9µm core diameter standard single-mode fibre. The design procedure is similar to the one explained at [3]. Figure 1 also shows the integration of the proposed coupling technique with V-groove auto-alignment structures, thus enabling an easier fiber alignment and an easier packaging.

Fabrication and experimental results

The fabrication process comprises two different steps. The first one consists of the implementation of the SOI waveguide and the inverted taper. To carry out this implementation, a lithography process based on e-beam was employed, obtaining a high resolution HSQ resist mask that is used to transfer the patter to the Silicon layer of the SOI structure by using a dry etching process. Finally, an upper cladding of silica is deposited over the whole structure by means of a PECVD process. The second fabrication step consists of the physical realisation of the V-grooves. For this purpose, a lift-off process is carried out in order to obtain a window corresponding to the V-groove location in a niquel-chromium mask which aim is to protect the SOI waveguide and inverted-taper from a silica etching process. Finally, the V-groove is created in the silicon substrate by means of a TMAH chemical process. Figure 2 (a) shows a detail of the layout of the fabricated sample which consists in two waveguides ended with the designed coupling structure, which are joined by two curves, so both input and output chip access waveguides are accessible through the same chip facet, thus enabling high compactness of photonic integrated circuits. The separation of the V-Grooves is 250μm. The curves have a radius of 5 μm. It can be also seen a SEM image of the fabricated sample.



(a) (b)

Figure 2: (a)Layout and SEM image of the fabricated sample. (b) Measured spectrum.

Figure 2(b) shows the measured spectrum of the fabricated sample for TE polarization. It is achieved less that 20dB fiber-to-fiber transmission losses at λ=1550nm. Furthermore, an almost flat optical spectrum has been obtained, so that no resonance effects appear in the spectrum, due to the efficiency of the achieved coupling.

Conclusions

A coupling technique between SOI waveguides and single-mode optical fibres based on optimised inverted tapers have been proposed and experimental realised. Total fiber-to-fiber transmission losses of 20dB have been obtained for the fabricated sample, which allows high compactness of photonic integrated circuits. An almost flat spectral response is also achieved.

Acknowledgments

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