Nano Scale Disruptive Silicon-Plasmonic Platform for Chip-to-Chip Interconnection

Plasmonic passive components characterization results with a 1dB coupling loss

Milestone no.:	MS38
Due date:	30/10/2013
Actual Submission date:	18/11/2013
Authors:	KIT
Work package(s):	WP6
Distribution level:	RE[1] (NAVOLCHI Consortium)
Nature:	document, available online in the restricted area of the NAVOLCHI webpage

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Executive Summary

In this milestone report, we summarize the characterization results of the fabricated metallic tapered mode converters and report less than 1dB optical loss in the mechanism of the photonic-to-plasmonic mode conversion.

Change Records

Version	Date	Changes	Author
0.1 (draft)	2013-11-18	Start	Argishti Melikyan
1 (submission)	2013-11-18		Argishti Melikyan

Introduction

The plasmonic phase modulators with a various device lengths and with a slot size of 140 nm and 200 nm are fabricated on silicon on insulator (SOI) platform, where the silicon nanowire waveguides are used as access waveguides [1]. The fabrication procedure is described in Milestone 11, "Fabrication of plasmonic modulator on a SOI platform" and Deliverable 3.4, "Report on fabrication of modulators". Light is coupled into the silicon nanowire using standard diffraction grating couplers. Photonic mode guided through the silicon nanowire subsequently excites the gap surface plasmon polariton mode in the modulator section. We use metallic tapers as photonic-plasmonic mode converters [2]. In the end of the modulator section the plasmonic mode is back converted in photonic mode. Light is coupled out from the chip using second grating coupler. Optical and scanning electron microscope images of the first generation device with device length of 34 μm and the slot size of 200 nm are given in Fig. 1(a) and Fig. 1(b), respectively.

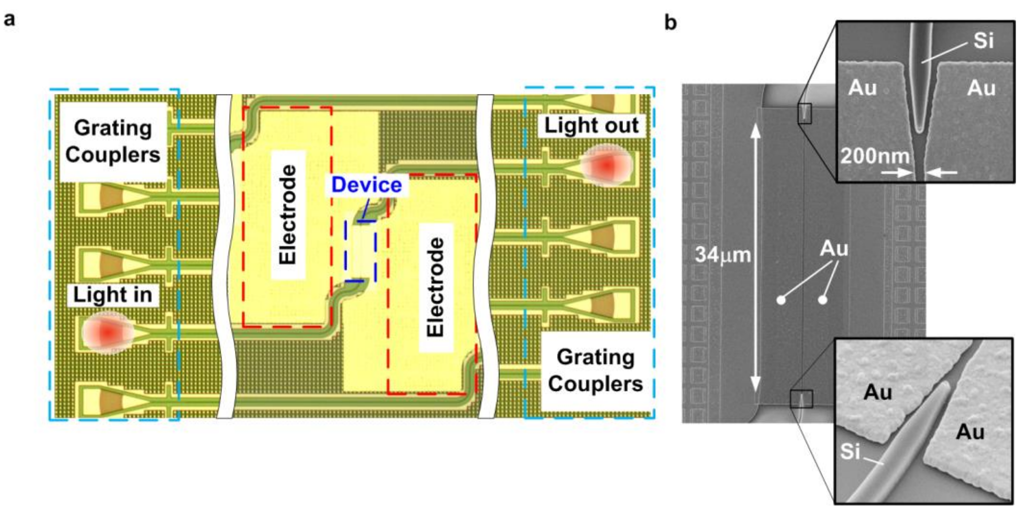

Figure 1 Fabricated plasmonic phase modulator on silicon on insulator platform. (a) Optical microscope image of the device. Silicon nanowire waveguides are used as access waveguides for the plasmonic modulator. Light is launched in and out from the chip using grating couplers. (b) Scanning electron microscope image of the modulator with a length of 34 μm and a slot size of 200 nm. Metallic tapers are used for photonic to plasmonic mode conversion.

Characterization of the fabricated phase modulators is performed at the KIT laboratory and the overview of the results is presented below.

Passive optical characterizations

We used the experimental setup given in Fig. 2(a) for passive optical characterization. Light with from a tuneable laser source (TLS) is coupled into the device using a single mode fibers and a diffraction grating coupler. The transmitted optical power at the output of the device is measured with optical spectrum analyser (OSA). We measured the optical loss of the modulator section by taking an equal-length of SOI strip waveguide as a reference. Example of the transmission spectrum of 34 µm long plasmonic modulator with a slot size of 200nm is given in Fig. 2(b). The average total loss is 12 dB (black solid line), close to the theoretically expected value (blue dashed horizontal line).

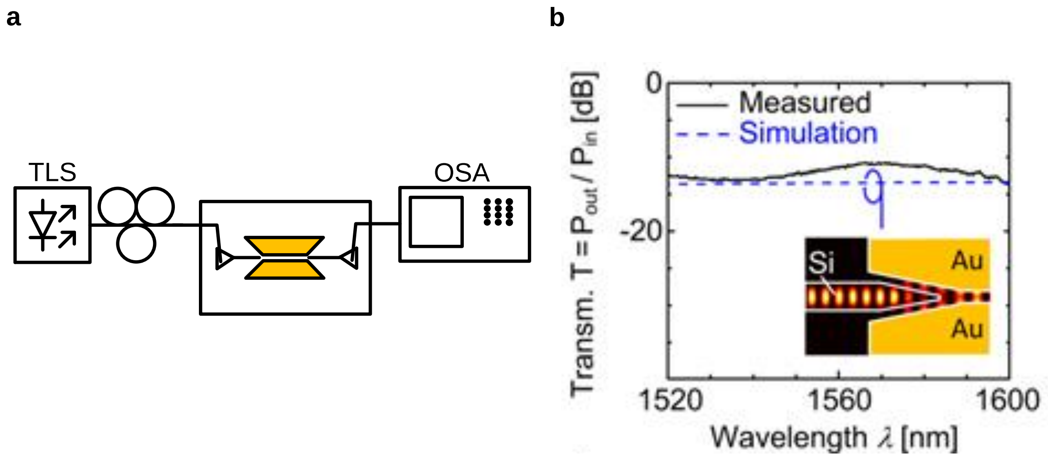

Figure 2 The experimental setup used for passive optical characterization and the transmission spectrum of the plasmonic phase modulators. (a) The experimental setup used for measuring the optical losses of the device. Light from the tuneable laser source (TLS) is launched into the chip and the transmission spectrum is measured at the output using optical spectrum analyser (OSA). (b) The transmission spectrum of the 34 µm long device with a slot size of 200 nm, black solid line. The theoretically expected transmission spectrum is given in the blue dashed line.

Coupling loss estimation

We have performed an SPP coupling loss estimation on our second generation of plasmonic modulators with a slot size of 140 nm. A good alignment and a desired 140 nm slot size have been achieved for the modulators with a length of 1 µm, 29 µm and 44 µm. We used the measured losses at the wavelength of 1550 nm to derive the propagation loss and the coupling loss of our modulators. By fitting the total loss versus device length dependence with a linear function we could estimate that the coupling loss and the propagation loss at 1550 nm wavelength, see Fig. 3. The coupling loss in our second generation device is reduced below 1 dB. The propagation loss in the modulator with a slot size of 140 nm is 0.52dB / µm which is very close to theoretically expected value of 0.48dB / µm.

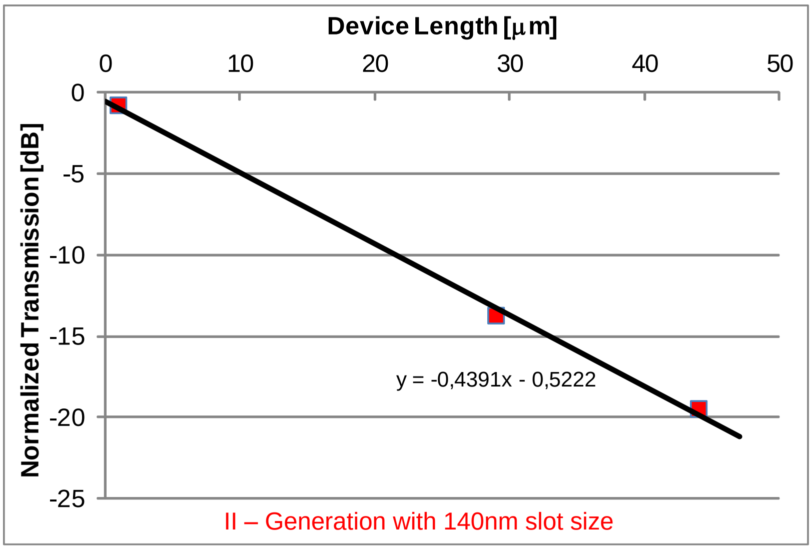

Figure 3 Measured power transmission at the wavelength of 1550nm for plasmonic modulators with various lengths. Performing linear fit we can estimate the SPP coupling and propagation losses in the modulator.

[1] Melikyan, A., et al., Surface plasmon polariton high-speed modulator, Conf. on Lasers and Electro-Optics (CLEO'13), San Jose (CA), USA, CTh5D.2 June 9–14, 2013. PDP

[2] Pile, D. F. P. and Gramotnev, D. K. Adiabatic and nonadiabatic nanofocusing of plasmons by tapered gap plasmon waveguides. Appl. Phys. Lett. 89, 041111 (2006)