Silicon photonics directional coupler measurements

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Silicon photonics, directional coupler, coupling coefficient, fiber array

SHORT SUMMARY

The evolution of silicon photonics technology needs a development in the characterization techniques to study the yield performance of the chips. The coupling between the optical fiber and the fabricated silicon photonics waveguide is a significant challenge in Silicon photonics, since there is an order of magnitude difference in dimensions between silicon waveguide and optical fiber cross section [1]. *Fiber-to-chip coupling used in this work is the vertical coupling method by using grating coupler. The bandwidth limitation of the grating coupler limits the bandwidth of the photonic directional couplers. A bench setup is used to measure the performance of silicon photonics directional couplers to evaluate the bandwidth limitation from the selective polarization grating coupler. The measurements are worked out through a broadband source and the performance are shown on optical spectrum analyzer. All measurements are at a wavelength range around 1550 nm.*

EXTENDED ABSTRACT

The aim of this work is to characterize silicon photonic chip fabricated using low-loss SOI technology through ePIX-fab, by the Leti-CEA and IMEC facilities in the multi project wafer (MPW) runs. The waveguides are fabricated using deep ultraviolet DUV lithography, to achieve the accuracy needed. A microscopic image of the chip of dimensions 3 x 6 mm is shown in Figure 1.

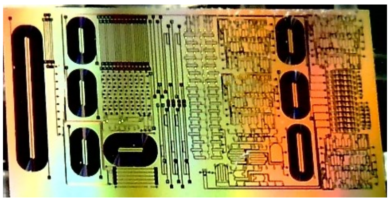

Figure 1 Microscopic image of the fabricated chip.

The bench setup for characterization is demonstrated in Figure 2(a), the chip is mounted on high-precision 3-axis translation stage. A 16-FA spacing 127 μm is mounted on another high-precision 3-axis translation stage and an angle positioner. The fiber array (FA) is coupled in the vertical direction to the grating coupler (GC) by an angle around 8°. A Super Luminescent Light Emitting Diode (SLED) source with maximum driving current of 100 mA is connected to optical isolator at 1550 nm wavelength operation to prevent back-reflection on the source, followed by a pedal polarization controller (PC). The PC, which is used to control the input polarization by maximize the transmission output from the sample, is connected to the input fiber. The output fiber is connected to optical spectrum analyzer (OSA). The schematic of the setup is shown in Figure 2(b). Also, the amplified spontaneous emission (ASE) of an EDFA operating around 1550 nm wavelength is used as a broadband source, without the need for optical isolator or the polarization controller. The setting of the OSA is as follow, the resolution bandwidth (RBW) is 0.07 nm, the video bandwidth (VBW) is 10 nm while the noise floor sensitivity is -88 dBm. The OSA is connected to a computer through GPIB interface by which the output spectrum is processed. Another microscope is mounted on a holder to adjust the alignment. The alignment occurs through the incident of the light from the FA on the top surface of the silicon chip. The incident beam couples into the waveguide through a selective polarization GC [2]. This method is most compatible with high-volume fabrication and packaging procedures and give access to any part of the optical circuit on the wafer [1],[3]. But it has limited optical bandwidth and polarization dependence. By using the EDFA as a broadband source with a spectrum shown in Figure 3, the layout of the directional couplers shown in Figure 4 are measured.

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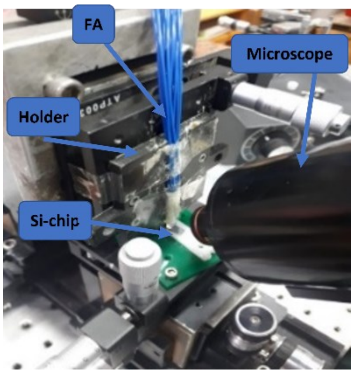
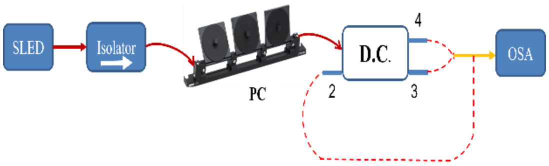


(a)



(b)

Figure 2 Measurement's setup of the fabricated chip by 16 channel fiber array (FA) (a) the bench setup and (b) its schematic .

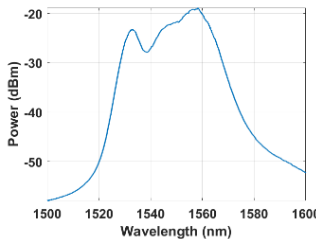


Figure 3 The Erbium Doped Fiber Amplifier EDFA response.

The D.C.1 has a coupling length of 40 µm, and the D.C.2 has 50 µm coupling length. Both has a gap of 1 µm. This measurement is used to evaluate the bandwidth of the GC at the end of each port. The output responses of D.C.1 and D.C.2 are normalized by the input signal and shown in Figure 5 (a) and Figure 5 (b), respectively. D.C.1 has loss of 32 dB around 1550 nm and D.C.2 has loss of 37 dB. The comparison between the operating wavelength bandwidth range of the directional couplers and the input signal from the EDFA is shown in Figure 6. Since the GC has a limited bandwidth, so the output from the coupler is limited by the GC bandwidth and the limitation of the coupler itself. The output bandwidth range is almost from 1530 nm to 1570 nm.

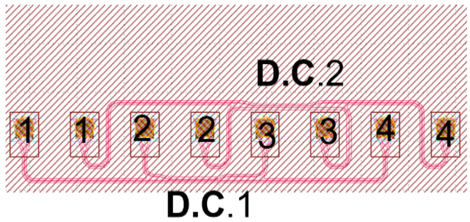
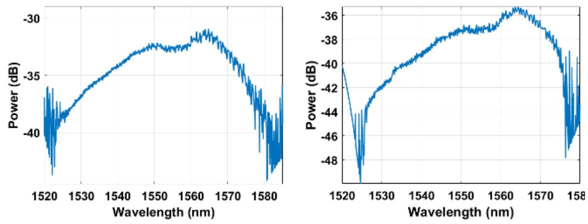


Figure 4 Two directional couplers layout on the fabricated silicon photonics chip. D.C.1 has coupling length of 40 µm and gap of 1µm, while the D.C.2 has coupling length of 50 µm and gap of 1 µm.



(a) (b)

Figure 5 Results of two directional couplers by using the bench setup (a) is the forward coupling for D.C.1 and (b) is the forward coupling for D.C.2.

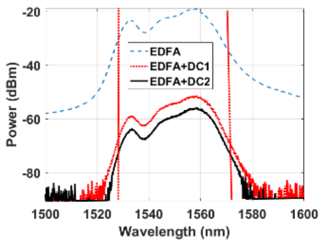


Figure 6 Comparison between the bandwidth of the EDFA, the output from DC1 and the output from DC2.

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