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2x2 ultra-broadband multimode interference coupler with subwavelength gratings fabricated by immersion lithography

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Abstract— We demonstrate an ultra-broadband 2x2 multimode interference (MMI) coupler leveraging subwavelength grating (SWG) nanostructures fabricated by immersion lithography. Excess loss of <2 dB, power imbalance <1.5 dB and phase error <5° have been measured for a wavelength range of 1300 – 1680 nm. The small feature sizes, down to 75 nm, were well-defined using immersion lithography and optimized optical proximity correction.

Keywords— Silicon photonics, subwavelength grating nanostructures, ultra-broadband MMI, immersion lithography

I. INTRODUCTION

Multimode interference couplers (MMIs) can be used as optical power splitters or combiners. For conventional MMIs, the beat length is highly dependent on the wavelength, limiting the bandwidth. To increase the bandwidth, SWG nanostructures have been successfully utilized by engineering the dispersion [1], [2]. The first wideband 2x2 SWG MMI was fabricated using electron beam lithography [1], which is unsuitable for mass production. Deep-UV immersion lithography, on the other hand, is used for large volume production and provides feature sizes as small as 40 nm in photonics platforms [3]. Here, we present a 2x2 SWG MMI, fabricated using immersion lithography on the CEA-LETI 300 mm wafer platform with a 220 nm silicon layer thickness. Process errors have been compensated using an optimized optical proximity correction model. The resulting device showed a measured bandwidth of 380 nm, which is greater than that reported in [2].

II. MORPHOLOGICAL CHARACTERIZATION AND COMPARISON OF OPTICAL SIMULATION WITH MEASUREMENT

The MMI consisted of alternate Si and SiO₂ lines, (Fig. 1. (a)) with an SWG period of 190 nm. The SiO₂ line dimension within each SWG period was 75 nm. A scanning electron microscope (SEM) image of the fabricated MMI before cladding deposition is shown in Fig. 1 (b). The SWG MMI was characterized using an asymmetric Mach-Zender interferometer (MZI) configuration as described in [2]. Our measurements showed excess loss, power imbalance and phase error comparable with our 3-dimensional finite-

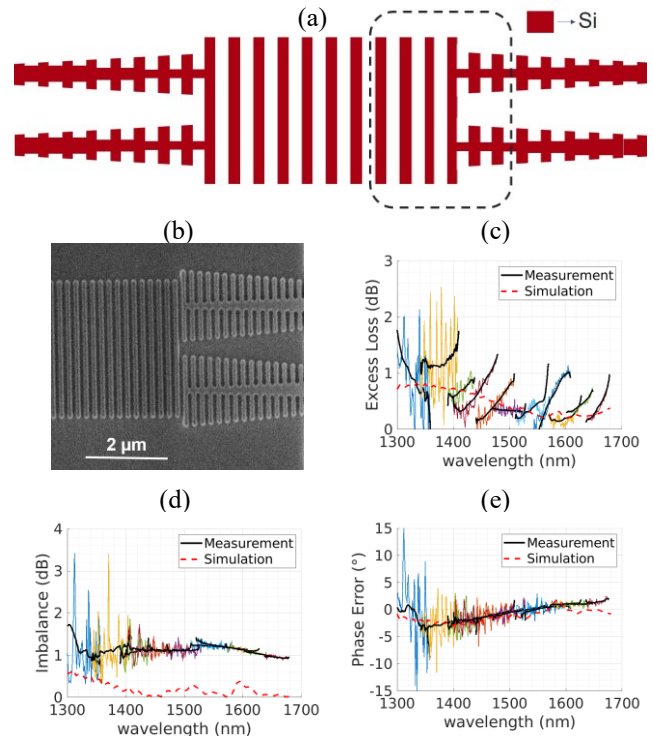


Fig. 1. (a) Schematic of 2x2 SWG MMI (b) SEM image of right part (shown in dotted) Measured and Simulated (c) excess loss (d) imbalance (e) phase error

difference time-domain simulations. Measured excess losses are not continuous as they are highly dependent on fiber-grating coupler alignment.

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