Femtosecond Laser Written Achromatic Phase Shifters

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Phase shifters are used in integrated photonic circuits for coherent applications such as optical communication and astronomical interferometry. There are two common methods to generate a phase difference between different optical paths: A length difference between waveguides with the same effective refractive index; or an effective refractive index difference between waveguides of the same length. Both methods are chromatic meaning the device is only effective over a narrow bandwidth. Recently an achromatic phase shifter was demonstrated using a subwavelength structure using Silicon-on-insulator [1], while an alternative method using differential waveguide dispersion using multiple waveguide segments has been proposed [2]. Using the latter method, we design achromatic phase shifters using 3 segments of different lengths (Fig 1a). Adiabatic tapers are then added to these designs to minimize loss, while also maintaining the total phase difference (Fig 1b). These devices are then fabricated using the femtosecond laser direct write technique to inscribe optical waveguides inside a glass sample. To realize the designed structure the laser pulse energy is varied to inscribe waveguides of different widths.

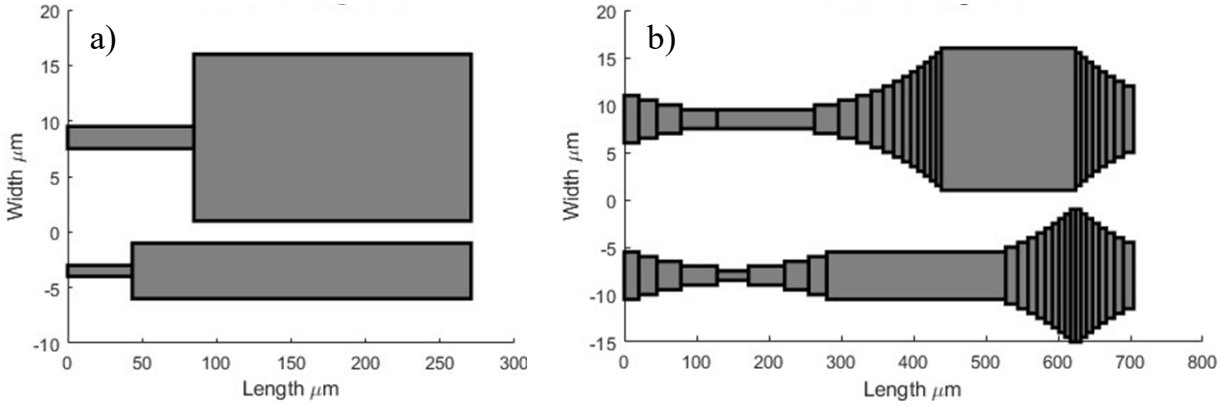

Figure 1. a) An achromatic phase shifter designed for wavelengths 1-2 μm. The device has 3 different segments with different width combinations and lengths to create an achromatic differential phase shift. b) the same phase shifter with adiabatic tapers.

[1] D. González-Andrade, J. M. Luque-González, J. G. Wangüemert-Pérez, A. Ortega-Moñux, P. Cheben, Í. Molina-Fernández, and A. V. Velasco, "Ultra-broadband nanophotonic phase shifter based on subwavelength metamaterial waveguides," Photon. Res. 8, 359-367 (2020).

[2] P. Labeye, "*Composants optiques intégrés pour l'interférométrie astronomique" PhD* thesis, Institut National Polytechnique de Grenoble, (2008).