Active Y-junctions in the mid-IR based on Lithium Niobate Ti-diffused Waveguides: Application to Nulling Interferometry

S. Heidmann[1], N. Courjal[2] and G. Martin[1]

1. *UJF-Grenoble 1 / CNRS-INSU, Institut de Planétologie et d'Astrophysique de Grenoble (IPAG) UMR 5274, Grenoble, F-38041, France*
2. *FEMTO-ST, Université de Franche-Comté. 16, route de Gray. 25030 Besançon. France*

The context of this work is the development of integrated optic beam combiners devoted to stellar interferometry [1]. In the run for exoplanet detection, the 2.5-5 μm observation window has been identified as an adequate band for planet search science [2]. Besides, for spatial applications, the use of compact and light optical beam combiners ensuring robustness and stability of the interferometric signal is mostly welcome. Thus, the development of materials allowing light confinement, together with a good transparency in the mid-IR and able to achieve electro-optic modulation, in order to finely tune the relative phase of the interacting fields, is knowing a rapid development. Indeed, there are recent publications in active materials like lithium niobate beam combiners centered in K-band (2.2μm) [3] and L-band (3.7μm) [4]. In this paper we present our recent achievements in active Y-junctions devoted to nulling interferometry in the L and M band (respectively centered at 3.7μm and 4.75μm).

The junctions were fabricated in Lithium Niobate substrates by Ti:diffusion for 50h at 1020ºC. The width of the channel waveguides ranged from 12-24μm, allowing to obtain single mode behavior at higher wavelengths with the increasing width. The passive behavior of the channel and Y-junctions, including propagation losses, was discussed in a previous paper [5]. In the present work, we present the electro-optic response of the junctions for the two atmospheric windows under study, i.e., L- and M-Bands. The experimental set-up is shown below:

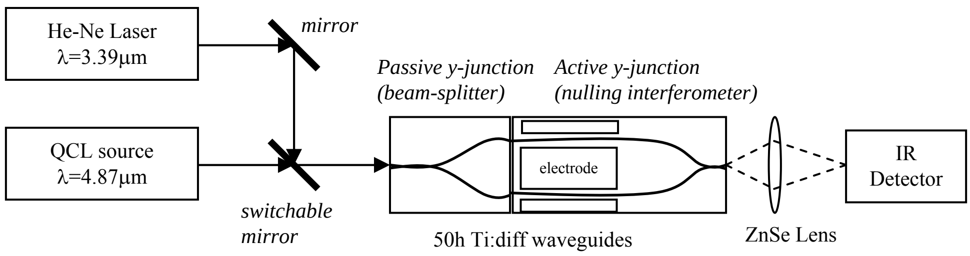

Fig. 1 Schematics of the experimental set-up allowing intensity modulation in the mid-IR.

A monochromatic mid-IR source is injected on a first passive Y-junction that allows beam-separation and injection on both arms of a second Y-junctions were electrodes, in push-pull configuration, have been evaporated. The modulated intensity is re-imaged in an infrared detector (PbSe array) and real-time intensity is recorded as a function of the applied voltage.

As the objective of these beam combiners is to achieve high rejection ratios (better than 40dB at the desired wavelength), we will focus our discussion on the fringe contrast obtained, using monochromatic sources. In a second time, white light interferograms could be studied, in order to address the spectral dispersion (chromaticity of the couplers).

References

[1] G. Li, T. Eckhause, K.A. Winick, J.D. Monnier and J.-P. Berger, "Integrated optic beam combiner in lithium niobate for stellar interferometer" Proc. Of SPIE, 6268 (2006).

[2] D. Sudarsky, A. Burrows and I. Hubeny, "Theoretical Spectra and Atmospheres of Extrasolar Giant Planets" Astrophysics J. vol. 588 (2), 1121-1148 (2003).

[3] O. Caballero-Calero, R. Burla, T. Moulin, A. Delboulbé, L. Jocou, J-P Berger and G. Martin, "Low voltage, moderate rejection ratio electro-optic modulator at 2.2μm obtained by proton exchange in lithium niobate" Proc. SPIE 7719, 77191D (2010).

[4] H.-K. Hsiao, K. A. Winick, J. D. Monnier and J.-P. Berger, "An infrared integrated optic astronomical beam combiner for stellar interferometry at 3-4 μm" Optics Express, Vol. 17 Issue 21, pp.18489-18500 (2009).

[5] G. Martin, P. Kern, E. Le Coarer, K. Perraut, J.-P. Berger and F. Malbet, "Integrated Optics, Interferometry and Active Devices for Astronomy", proceedings of the AMARIS'10 Conference, *to be published in* Non Linear Optics, Quantum Optics (2010).