Full field Group Velocity Dispersion characterization of 300nm film height Silicon Nitride waveguides

Luis A. BRU[1], Gloria MICÓ[1], Daniel PASTOR[1*], David DOMENECH[2], Ana M. SÁNCHEZ[3], Josep M. CIRERA[3], Javier SANCHEZ[3], Carlos DOMÍNGUEZ[3] and Pascual MUÑOZ[1,2]

[1]Photonic-IC group @ Photonic Research Labs, Universitat Politècnica de Valencia, Spain
[2]VLC Photonics S.L., Ed9B-UPV, c/ Camino de Vera s/n, Valencia, Spain
[3]IMB-CNM-CSIC, Campus Belaterra UAB, Barcelona, Spain
*dpastor@dcom.upv.es

Optical Frequency Domain Reflectometry (OFDR) [1-5] allows retrieving amplitude and phase features from optical devices in the time and frequency domains. Characterization of the propagation features in new photonics platforms and waveguide designs is essential in different applications where dispersion tailoring and birefringence need to be controlled over a wide wavelength range. In this paper we present the full-field Group Velocity Dispersion (GVD) assessment of Si_3N_4 waveguides employing the time resolved features of OFDR techniques. The devices were fabricated on a 100mm Si wafer, composed of a SiO_2 buffer (2.5μm thick, n=1.464) grown by thermal, following a LPCVD Si_3N_4 layer with thickness 300nm (n= 2.01) and a 2.0μm thick SiO_2 (n=1.45) deposited by PECVD. A set of test of ring resonators (RRs), Fig. 1(a), was deployed for strip waveguides of width 1.0μm. The bend radius was set to 150μm for which no significant additional loss was expected.

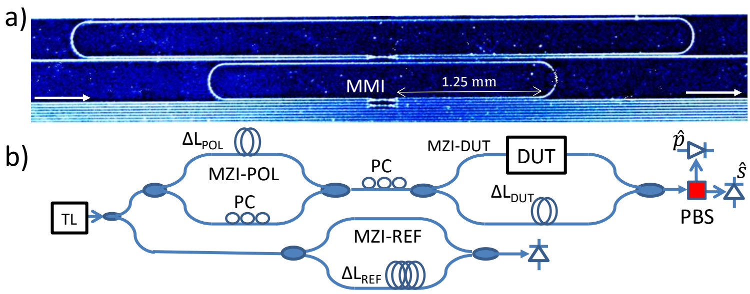

Fig. 1. a) DUT: RRs designed for GVD measurement, b) OFDR set up

The OFDR set up was composed of set of imbalanced fiber based Mach-Zehnder interferometers (MZI) , fed by a scanning Tunable Laser (TL), Fig. 1(b). The first upper MZI is used for polarization conditioning for the full-field and polarization assessment as described in [5]. The second upper MZI includes the device under test (DUT), in our case the Silicon Nitride chip in/out coupled by lensed fibers. Two interferograms are recorded after a Polarization Beam Splitter (PBS). Moreover, the lower MZI provides the reference (or triggering signal) for the phase error due to imperfect TL tuning. As described in [5], the time responses of the DUT can be isolated after a Fast Fourier Transform (FFT) of the interferograms, providing the complete Jones Matrix description of the DUT on the PBS bases $\hat{s}$ and $\hat{p}$. The polarization diversity set up avoids the environmental and manipulation polarization changes on fiber pigtails and lensed fibers on the DUT branch. The TL scanning speed was 40nm/s with a 100nm span (1555nm center). After the FFT, the power time response was calculated $|h|^2$=$|h_s|^2 + |h_p|^2$, Fig. 2(a). Multiple time recirculating contributions from the RR can be easily identified, but also the TE and TM splitting in time is observed revealing strong differences in propagation losses and group delay between polarizations. Taking the RR dimensions $L_{sw} = 11mm$ (straight waveguide facet to facet) and $L_{loop} = 6.63mm$, the group indexes are n_g^{TE} =1.892 and n_g^{TM} =1.717.

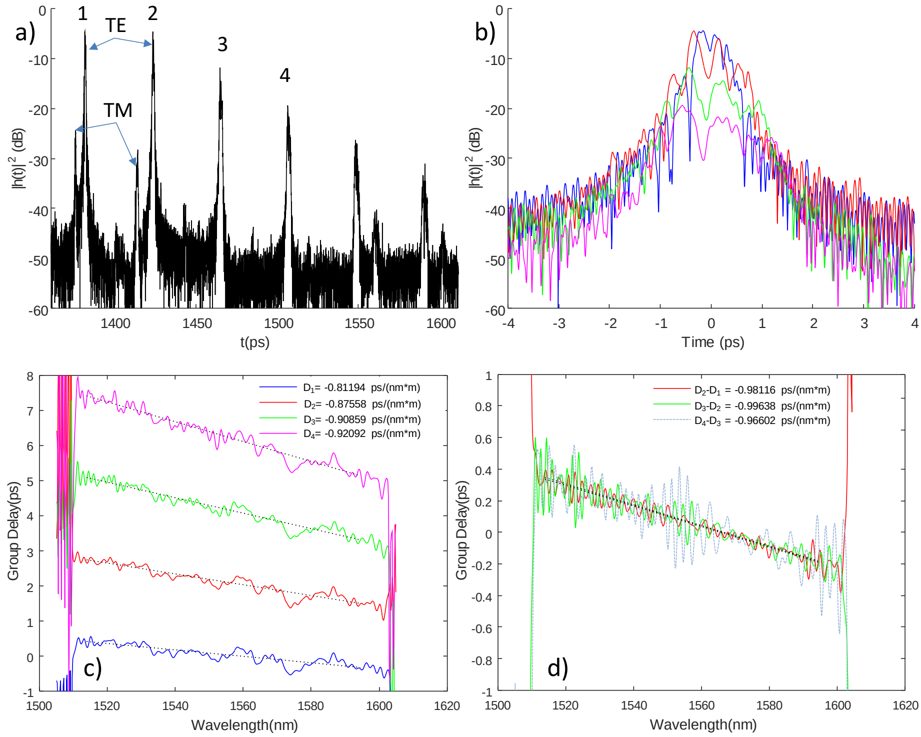

Fig. 2. a) RR time response, b) Dispersion broadening of recirculations ,c) GVD measured over for each temporal recirculation 1 to 4, d) GVD difference inter pulses.

Moreover $|h(t)|^2$ shows also clearly a broadening effect due to GVD and this information can be extracted from the retrieved signals. So we proceed selecting the desired pulse (recirculation) slicing the TE time responses $(h_s(t), h_p(t))$ around $\pm 4ps$ from its center. Hence, Fig. 2(b) shows the progressive broadening. Then, each truncated response is transformed into frequency domain to calculate the group delay $\tau_g(\omega)$[4-5] and linearly fitted between 1514nm and 1594nm to obtain the dispersion parameters D[ps/(nm*m)], Fig. 2(c). Absolute delay difference between traces was reduced for better representation. For D calculations, we employed the physical design lengths $L_{sw} + L_{loop} * [0, 1, 2, 3]$. Notice that D values were not constant as expected, that suggests a positive value of dispersion is added to that coming from the chip, originated by the measurement set up. Fortunately, RRs multiple samples can be related between them to isolate a *single round trip pass* along the Ring. In this way Fig. 2(d) shows the group delay difference between adjacent time samples $(D_i(\lambda) - D_j(\lambda))$, their linear fitting and the estimated Dispersion calculated over L_{loop}, leading to an average dispersion D=-0.981 ps/(nm*mm) with $\pm 1.5\%$ relative error. From this values it is straightforward to obtain the dispersion offset from the set-up as $(DL)_{setup} = 0.00178\ ps/nm$.

References

[1] U. Glombitza and E. Brinkmeyer, J. Lightwave Technol. 11 1377–1384 (1993)
[2] K. Takada and T. Hirose, Optics Letters 34, 24, 3914-3916 (2009)
[3] L. A. Bru, B. Gargallo, e.a., in Proc. ECIO, paper ecio-o–08, 2016.
[4] B. J. Soller, D. K. Gifford, e. a., Optics Express 13, 2, 666-674 (2005)
[5] D. K. Gifford, B. J. Soller, e. a., Applied Optics 44, 34, 7282-7286 (2005)