TriPleX™: The low loss platform from UV to IR

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The TriPleX™ technology of LioniX is a low loss platform transparent for wavelengths from UV (405 nm) to IR (2.35 µm) and can be combined with micro-fluidics creating very powerful opto-fluidic applications. The stability of the platform also makes it suitable as a base material in a number of academic research projects. This presentation will give an overview of new developments in these (commercial) applications and research projects. Different examples covering a large wavelength span will be shown and discussed in more detail.

Introduction

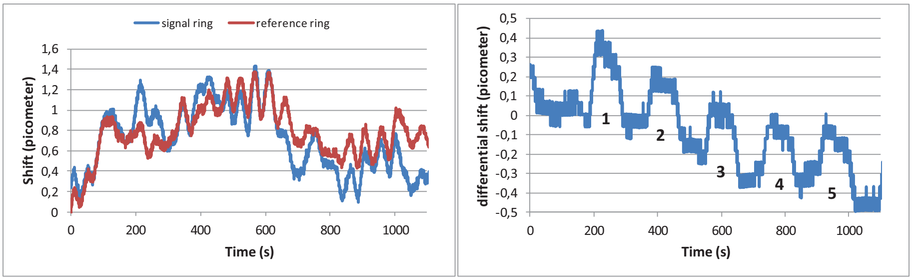
The TriPleX™ platform of LioniX is, one of the three main integrated optics platforms, next to InP and SOI. Its unique selling point is the low loss performance over a large wavelength range [1][2][3]. The technology is based on Low Pressure Chemical Vapour Deposition (LPCVD) of Si_3N_4 and SiO_2, resulting in stable material properties suitable for batch processing and a large variety of (industrial) applications. The technology is developed into a stable platform in the last decade and in the last years Multi Project Wafer (MPW) design libraries been developed for easy user access to the technology.

Application examples

The large wavelength range over which the technology is transparent (405 nm to 2.35 µm) makes it extremely suitable for a large variety of applications. In order to give more insight in the possibilities we highlight in this paper a number of examples in different wavelength regimes. A more detailed presentation of the applications is done during the presentation at the 19th Annual Symposium of the IEEE Photonics Benelux Chapter.

Micro ring resonator

In 2012 LioniX published an overview article of the Micro Ring Resonator (MRR) as a basic building block for a number of sensing systems [4]. The MRR operates in the NIR (850 nm) enabling the use of very cost effective VCSELs as a light source. In that publication a theoretical lower limit of the sensitivity of $1x10^{-6}$ was shown. In order to push the theoretical limit down further and measure in practice the 10^{-6} values reference MRRs were implemented on chip in order to cancel out variations in the ambient conditions. This way, it was possible to determine the change between water and a diluted solution of ethanol (0.0056% (w/w) in water. The signal of the sample channel alone does not show much of a pattern on the first sight (Figure 1a) but the differential signal shift (normalized shift of the sample channel minus the normalized shift of the reference channel) clearly shows the occurrence of five events corresponding to the passage of five plugs having a slightly enhanced refractive index (Figure 1b).



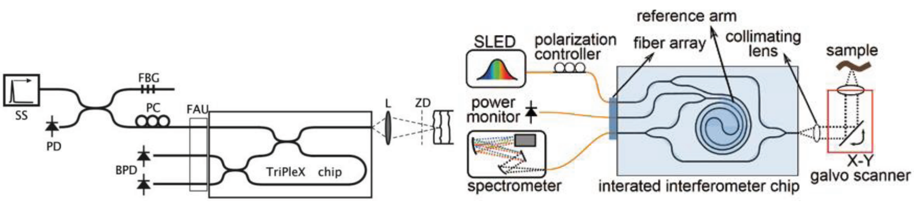
(a) (b)

Figure 1: (a): Graph showing the normalized shift in resonance wavelength during the process of sequential exchange of pure water (MilliQ) with very diluted ethanol solutions (0.0056% (w/w) in MilliQ) over the signal ring versus the shift in resonance wavelength for the reference ring that was covered with pure water. The difference in refractive index between the two solutions is about 3.5×10^{-6} RIU. (b): Graph showing the calculated differential shift (sample shift minus reference shift) for the data from (a).

Optical Coherence Tomography

For integrated optical applications in Optical Coherence Tomography (OCT) the TriPleX™ technology is suitable due to its low loss performance. OCT is a non-invasive three dimensional imaging technology with a resolution in the order of a cell diameter (µm resolution).
OCT is clinically applied in many medical disciplines, including cardiovascular imaging, ophthalmology, dermatology and urology. OCT works analogue to ultrasound imaging, but detects the backscattering of light instead of sound to discriminate different tissue layers.

Recently both Amsterdam Academic Medical Centre (AMC) and Ghent University realized OCT demonstrators in the TriPleX™ technology. AMC used a swept source with a balanced photo detector instead of a moving reference arm in traditional OCT systems. Ghent University utilized a broadband light from a superluminescent LED (SLED) centered at 1320 nm combined with a spectrum analyzer. Both options utilized a reference arm in the TriPleX™ chip with on chip interference with the collected signal from the sample. In Figure 2 both solutions are shown schematically and in [5] and [6] the results are described in more detail.



(a) (b)

Figure 2: Schematic layout of the OCT setup incorporating the TriPleX™ chip (a) AMC measurements (b) University Ghent measurements

Micro Wave Photonics

The TriPleX™ technology is extremely suitable for Micro Wave Photonics (MWP) applications due to the low loss performance of the waveguides and the ability to use building blocks for the realization of complex filter designs. An important building block in these filters is the ring resonator and with this building block the University of Twente demonstrated an integrated Coupled Resonator Optical Waveguide (CROW)-based bandpass filter. Details on the designed device and the measurements are presented in [7]. The schematic layout and the 3D model of the fabricated device are shown in Figure 3.

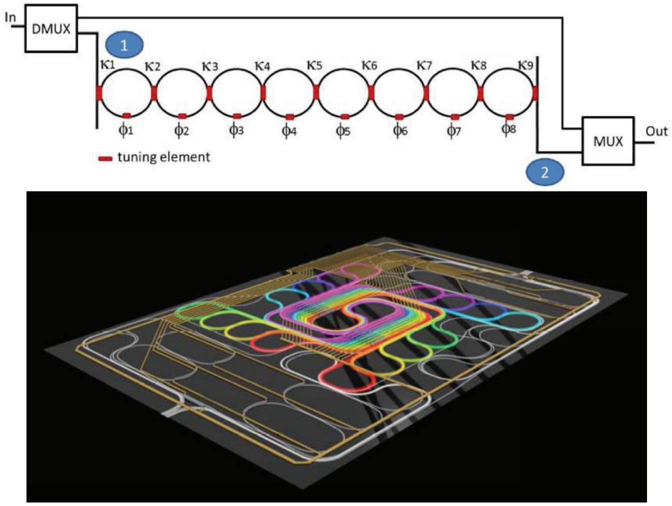


Figure 3: functional schematics (top) and 3D model of the designed chip (bottom)

With this device a flat-top passband filter was realized with a narrow passband of 72 MHz. This could be centered at different frequencies due to the reconfigurability of the device.

Spectroscopy

For spectrometers on-board of earth-orbiting satellites (for example SCIAMACHY, OMI and TROPOMI), in-flight calibration spectrometers are extremely important in order to assure reliable measurements. Spectrometers for these applications are developed for different wavelength ranges, but for the wavelength band from 2300 nm to 2400 nm (in particular relevant for methane detection) no convenient solution exists to have an on-board calibration system. In the work described in [8] an on chip calibration is described. For this ring resonators realized in the TriPleX™ platform are extremely suitable due to the low loss performance in this wavelength window. In a Prequalification ESA Proposal (PEP) LioniX developed together with Dutch Space and TNO a calibration device based ringresonators in integrated optics. In the figure below the mask layout view and light propagating through the realized chip are shown. Measurements done by TNO on these devices showed IO characteristics in good agreement with theory and very low insertion losses of 2.4 dB allowing high SNR. This enables in flight calibration for spectrometers in earth orbiting satellites.

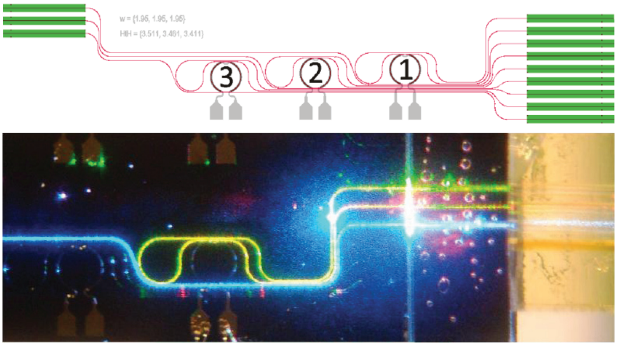


Figure 4: Mask layout and visible light propagation through ringresonators designed for a wavelength of 2.35 µm

Conclusions

In the presentation different applications along a broad wavelength range are shown with all good results which are enabled by the low loss performance of the platform over a broad wavelength range. The availability of building blocks in the different wavelength regimes makes it possible to design and realize complex photonic devices and the MPW infrastructure also makes this technology available for a broad public.

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