Silicon Nitride Photonic Integrated Circuits for Biophotonics and medica applications

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Here, we present the characteristics of the photonic integrated circuits technology developed for the European pilot line PIX4life. In addition, the details of two different silicon nitride fabrication platforms are summarized.

Photonic Integrated Circuits (PICs): Many high accuracy, high sensitivity biophotonic measurement systems are based on expensive, bulky free space optics built with complex lens arrangements, being difficult to stabilize in a robust way, miniaturize and scale up for production. Examples of these are fluorescent, absorption and hyperspectral microscopes, OCT scanners (see Fig. 1) and sources for cytometers (see Fig. 2) [1, 2, 3, 4, 5].

Silicon nitride photonic integrated circuits: Silicon nitride has gained a lot of interest in the last 10 year. Its chemical, mechanical and optical properties make it a suitable material for integrating optical systems into PICs. Furthermore, the availability of fabrication facilities and the compatibility with CMOS integration, make it the perfect platform for low loss, visible range applications. SiN-based life-science applications are explored widely e.g., for the development of bio-chemical and medical sensing applications as well as light sources for the newest microscopy and spectroscopy techniques [3, 5, 6, 7, 8].

The PIX4life pilot line (https://pix4life.eu) is composed of a consortium having both companies and research institutes. It started in 2016 providing an end-to-end and scalable framework and supply chain for the development of silicon nitride (SiN) photonic integrated circuits (PIC), mainly focusing on life science applications working at visible wavelengths (400-1100 nm). The capabilities of PIX4life span from design and test services, to packaged PICs ready to use in a larger module or system. These services are mostly aimed for life-science users not familiar with photonic integration technology, and towards support, alignment and extension of the current European know-how in design tools, hybrid integration and micro-fluidic assembly.

The core of PIX4life are the two SiN waveguide platforms, BioPIX and TriPleX™, offered respectively by imec (Belgium) and LioniX International (Netherlands). The most important characteristic of these SiN PIC platforms is their low propagation loss at visible and short near-infrared wavelengths, at which silicon PICs are opaque.

Both foundries organize periodic Multi-Project Wafer (MPW) runs, where multiple users can place their PIC designs for low-cost prototyping by sharing wafer space. During 2018 and 2019, PIX4life is operating in early Open-Access mode. Since the services is subsidesed by the EU, the pilot line reviews all incoming requests for development of SiN PICs. Priority is given to European customers developing life science applications.

BioPIX: Manufactured by the Belgian research institute imec, the BioPIX technology comprises two different flavours: one for short-visible wavelengths (from 400 to 700 nm); BioPIX150, and a second one for long visible to short near-infrared wavelengths (from 700 to 1000 nm), BIOPIX300. The waveguide thickness of the two flavours is 150 and 300 nm respectively. To maintain CMOS compatibility, the waveguides are deposited on top of a 2.3 to 3.3 µm silicon dioxide layer via PECVD technique [9,10].

TripleX™ Vis: Manufactured by the Dutch company LioniX International, TripleX™ is the branding name of their thin LPCVD SiN waveguide embedded in silicon dioxide (thermal oxide below and TEOS above). Originally designed for ultra-low propagation loss in the C-Band, their performance in the visible range has been improved for four different wavelengths: 405, 488, 532, and 640 nm [11, 12].

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Figures

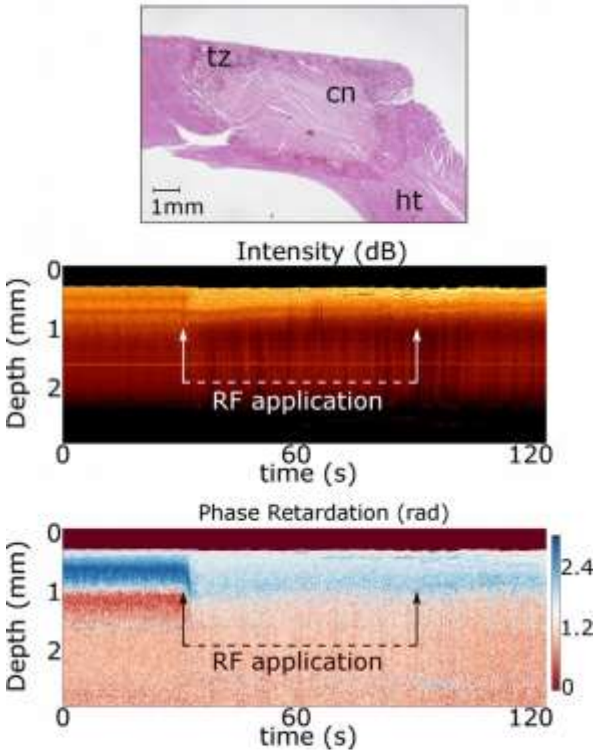

Figure 1. Example of OCT application from MedLumics S.L.[13]

Figure 2. Example of laser light combiner from TOPTICA Photonics AG & Chair of integrated photonics, RWTH Aachen University

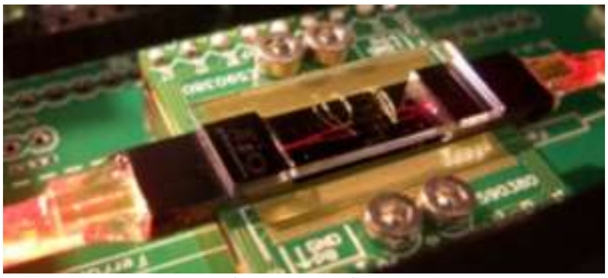

Figure 3. Example of sensing chip from LioniX International

PIX4life

Figure 4. Pilot line logo