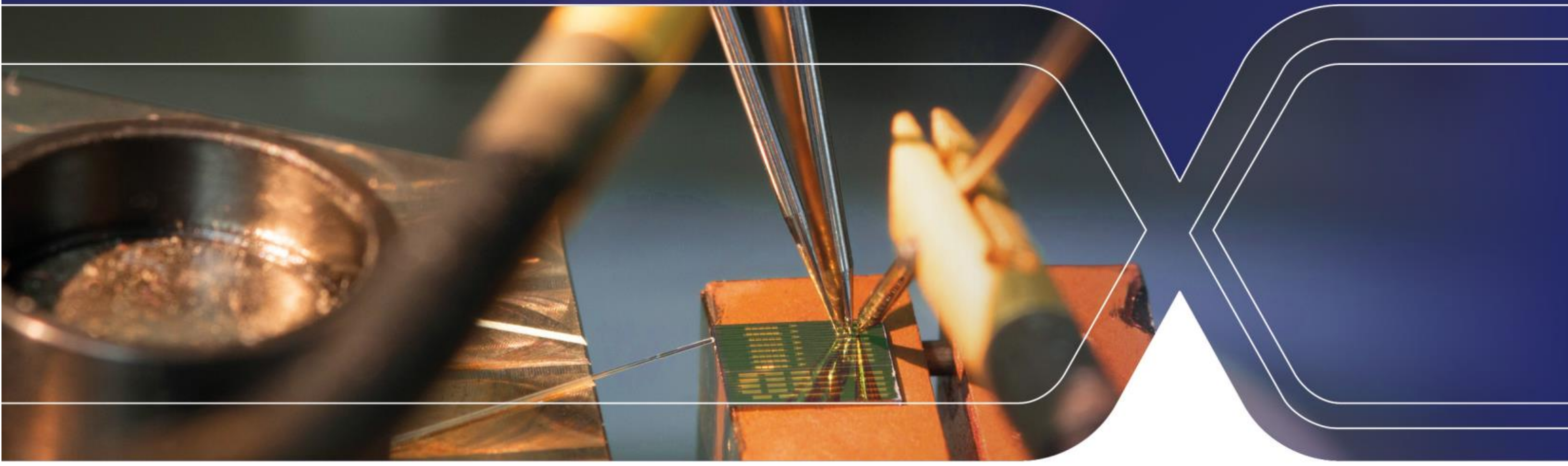
JePPIX Platform for Photonic Integration



Fiber-Optic Sensing

Fibre-optic sensors, and in particular Fibre-Bragg Grating (FBG) sensors, find application in a plethora of areas. Especially mobility, medical, energy, and industrial sectors demand such flexible, highly reliable sensors, suitable for employment in specialty environments, dealing with, e.g., temperature extremes, chemical exposure or fire hazardous environments. Furthermore, the use and integration potential with optical fibers for low-loss transmission enables increased monitoring ranges, multiplexing of sensors and distributed sensor placement, while being inherently insensitive to electromagnetic interferences. This is why FBG sensors are attractive solutions for pipeline monitoring, the automotive and aerospace industries. Applications include thermal mapping of metrology structures in space applications[1], and structural monitoring[2] to survey mechanical deformations or perform indirect measurement of pressure and temperature.

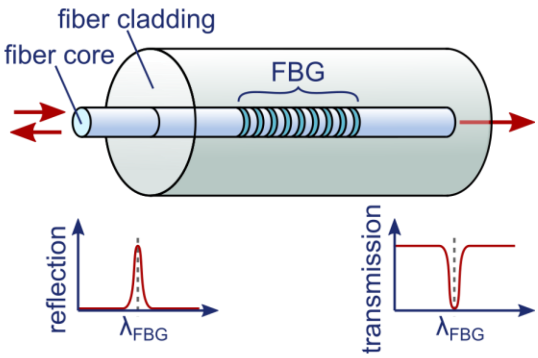


Figure 1: Schematic view of a FBG, with the refractive index modulation indicated on the fiber core and illustrative transmission and reflection spectra.

InP Photonic Integrated Circuits (PICs)

Optical chips or PICs can contain tens to hundreds of optical components. While electronic integrated circuits (EICs) consist of transistors, capacitors, and resistors, a PIC consists of, for example, lasers, modulators, photodetectors, and filters, all integrated on a single substrate. Several application fields, such as data- and telecom, sensing, and lidar are already using or are considering the use of PICs for their products. This PIC technology is accessible to users without a cleanroom, through so-called multi-project wafer runs and open access foundries. InP based technology is commercially available through SMART Photonics and Fraunhofer Heinrich-Hertz-Institut. Access is individually coordinated by JePPIX.

FBG fundamentals

The fundamental principle of FBGs is a periodic modulation of the refractive index, defining the spectral properties of selective reflection and transmission of the propagating wavelengths, schematically shown in Figure 1. The length of the grating and the index contrast determine the spectral reflectivity characteristics of the FBG. The latter is influenced by the environmental sensitive refractive

[1] Paper "Integrated photonics for fiber optic based temperature sensing" R. S. Evenblij et al.

[2] Paper "SHM using Integrated Photonics based Fiber Sensing solutions" R. S. Evenblij et al.

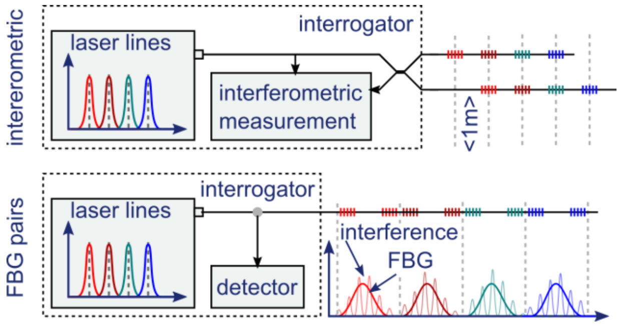


Figure 2 Two common fiber sensing concepts using wavelength multiplexing. Top: interferometric fiber sensing. Bottom: interferometric sensing using FBG pairs.

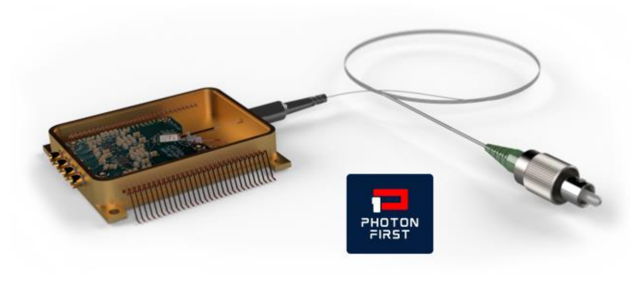


Figure 3 PIC-based "system-in -a-package" for sensing applications. Design concept with integrated low-noise readout circuit.

index, which changes with fiber strain, temperature etc., allowing physical sensing of these parameters. To determine the FBG central wavelength, λ_{FBG}, the spectrum can be directly monitored either using a broadband light source or by scanning a laser, or a set of laser lines, across the reflection spectrum.

Interferometric sensing

Sensing methods with FBGs can use direct monitoring of the FBG central wavelength or the FBGs can be used as spectrally selective mirrors. The latter enables a variety of interferometric sensing concepts[3]. These concepts use the optical path length difference's dependence on environmental factors, like physical length and/or index changes.

The advantage of using FBGs is that the reflecting elements can be distributed and placed at any desired location along the fiber. Additionally, wavelength multiplexing can be adopted. Widely tuneable lasers, or wavelength multiplexing in source and detection end, enable a measurement system, which allows for monitoring all sensing sections, schematically illustrated in two different approaches in Figure 2. The interferometric fiber sensing concept is based on a Michelson-type interferometer: the FGB reflectors are placed along a sensor and a reference arm, allowing the extraction, and monitoring of the optical path length in between the system and the FBGs. The inter-grating sensing scheme uses two identical FBGs and senses changes in the optical path length difference, analysing the interference pattern generated by the FBG pairs.

The Opportunity for Photonic Integration

Currently, the main cost and size factor for FBG sensors is connected to the signal analysis and the laser source. Reflective wavelength changes are typically small and define the requirements for the spectrum detection. Photonic integrated circuit (PIC) technology enables chip-scale integration of these functionalities and thus a major advantage of both cost and size factors. Given the need for a light source, the indium phosphide (InP) PIC platform offers tuneable laser sources or laser arrays, which can be integrated with silicon-on-insulator or silicon nitride-based PICs. The growing number of active and passive photonic building blocks in the InP platform open the possibility of monolithic integration of both source and detection scheme on a single chip. This is particularly attractive in application areas where reliability, and size and weight constraints are deciding factors, e.g. in automotive or space usage.

Discuss your application with us

If you are interested in knowing more about the capabilities and use of InP PIC technology for fiber sensing applications, contact JePPIX or directly PhotonFirst[4]. The JePPIX Pilot Line provides low entrance-threshold to mature-manufacturing, enabling high-TRL development in a scalable design kit driven process, taking open access InP PICs from proof of concept to industrial prototyping levels.

[3] White Paper "FBGs for interferometric fiber sensing concepts", Haverdings et al.

[4] photonfirst.com/measuring-with-light