A PHOTONIC BIOSENSOR FOR SPACE APPLICATIONS (PBSA). G. De Diego-Castilla[1], S. Pantoja[2], S. Geidel[3], S. Peransi[2], J. Nestler[3], R. Martins[4], A. Sousa[4], J. Gomez-Elvira[1], M. Moreno-Paz[1], L. Cuesta[1], V. Parro[1],[1]Instituto Nacional de Tecnica Aeroespacial (INTA)-Centro de Astrobiología (INTA-CSIC), Spain, parrogv@cab.inta-csis.es. [2]DAS Photonics SL, Spain. [3]Fraunhofer Institute for Electronics Nano Systems (ENAS), Chemnitz, Germany. [4]Evoleo Technologies Lda, Portugal.

Introduction: PBSA Project (http://www.pbsa-fp7.eu) addresses the topic of the EU Framework Programme 7: Bringing terrestrial SME research into the space domain [1]. The project focuses on the development of photonic-based biosensor technology [2] for biochemical applications into the space domain. Two main fields of application have been identified: biomonitoring human spatial installations, such as space stations or potential planetary human settlements, and astrobiology, in the context of planetary exploration. The biosensor has been designed to meet the requirements arising from such applications, in terms of sensitivity, resilience, dimensioning and performance.

There are a number of applications in space that require rapid, robust, light and automatic biosensing techniques. For example, for checking the microbial contamination in space stations or searching for life in planetary exploration. The PBSA instrument implements a Lab-on-a-chip (LoC) device with a photonic immunosensor and demonstrates its use for microbial monitoring and biomarker detection. PBSA uses recent advances in antibody microarray-based immunosensors with two powerful technologies, photonic integrated circuits (PICs) and microfluidics.

System Description: Basically three main building blocks can be distinguished in the PBSA Biosensor: the photonic integrated circuit (PIC) (Figures 1 and 2), the biomolecular probes (in this case antibodies), and the microfluidic subsystem (Figure 3). They are set up in a 115x115x130 mm box, which also includes the control electronics (Figure 3).

The principle of the photonic measurement is shown is Figure 1: Silicon nitride rings and waveguide are printed onto silicon; a laser bean enter by one side of the guide; the microrings are functionalized with a bioreceptor molecule such as the antibodies; after injection of the sample, the target molecules (red rhombs) or analytes, bind to the capturing antibodies and this induces a shift in the optical signal (it resonates) which is proportional to the concentration of the analyte; the biosensor is regenerated by washing with a regeneration buffer, usually a strong base (diluted NaOH) or acid solution (glycine at pH 2.3).

The use of PICs enables the implementation of highly integrated solutions into a Lab-on-a-Chip. Multiple detection probes can be integrated into a single chip (Figure 2). The PIC based solution permits real-time measurement of the target analytes, leading to savings in the complexity of the detection protocols and reliability.

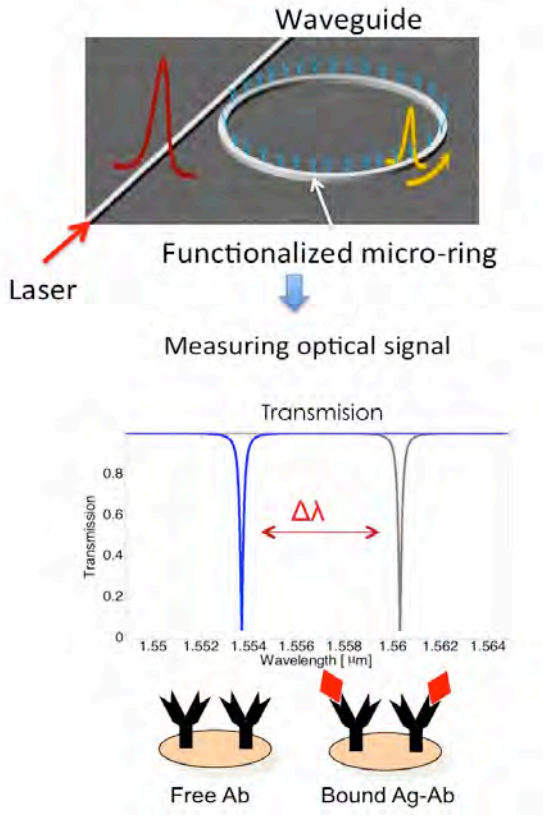

Figure 1. the principle of photonic measurement with micro-ring resonators. A laser light passes through the waveguide and induces a displacement in the wavelength which is proportional to the number of targets retained by the capturing biorecognition system, in this case antibodies.

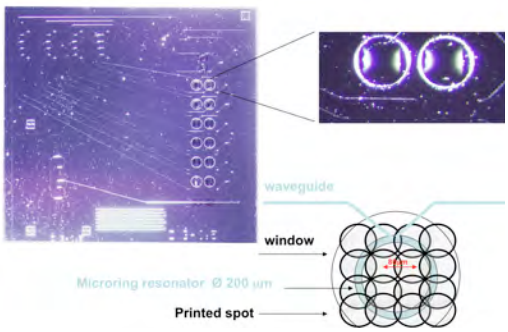

Figure 2. PBSA PIC with 12 micro-rings printed with differents antibodies using a contact printer arrayer.

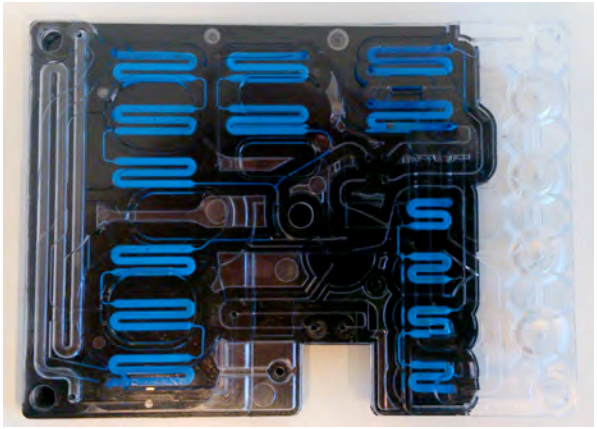

Figure 3. The PBSA disposable microfluidics cartridge showing the different single use reservoirs for reagents (blue) necessary for each step of the assay. There are enough reservoirs and pumps available to drive two assays after another.

One of the PBSA requirements is to be able to measure simultaneously at least 6 different target substances. This implies the development of a multiplex photonic biosensor for different molecular targets. Each photonic chips contains 12 micro-rings resonators that can be functionalized with different antibodies (Figure 2). We have tested different activation chemistries and biofunctionalization procedures to covalently fix the antibodies and other proteins. The printing was done with a MicroGrid II printing robot from DNA and protein microarray industry.

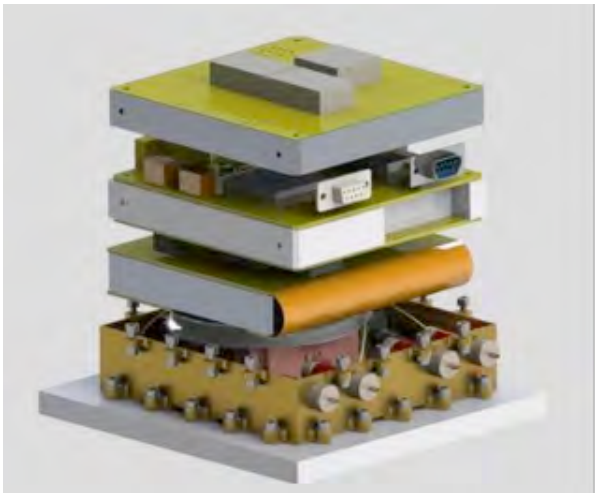

Fig. 4. 3D model of PBSA Biosensor (115 x 115 x 130 mm).

The microfludic system (Figure 3) is in charge of moving the sample and reagents to the functionalized PIC transducer. Because PBSA is developed for space application, it has to be tested under space relevant conditions as high energy radiation and low pressure. We have already tested that high energy proton radiation did not affect the microfluidics cartridge nor the photonic properties of PIC.

Measurements: A protocol is being developed to perform the measures with the PBSA device. It covers three main phases: surface preparation, testing and regeneration. In the surface preparation phase, the surface is blocked to prevent unspecific bindings and it is washed until a stable signal is obtained. In the testing phase (Figure 4), the sample is injected into the system, the target biomolecules are captured by the antibodies, which results in changes in the output signal from the microrings. Finally, in the regeneration phase, the surface is washed again to remove any residuals from the previous assay and leave the sensor ready for a new one.

We will report the development of different laboratory models as well as the multiplex microring resonator performance for label-free immunological detection.

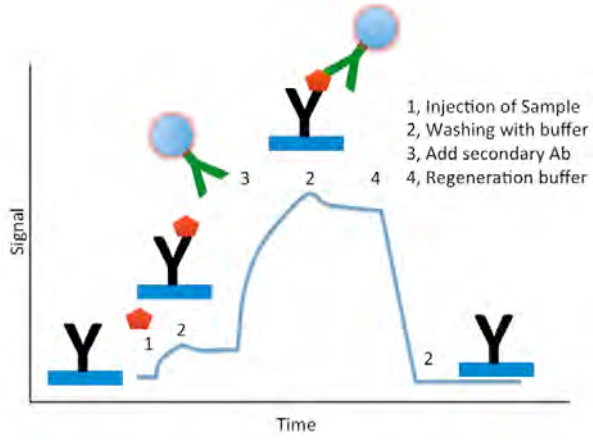

Figure 4. Scheme of a characteristic measurement curve with PBSA. The two initial steps 1-2, represent the signal obtained in a label-free assay, and the rest an increase in the signal by the use of a labelled secondary antibody. The sensor is regenerated (4) by washing with regeneration buffer (e.g. glycine buffer at pH2.3).

References: [1] Parro V (2013), *Veyong the Sky*, EU publ., p.57. [2] Passaro V M N et al., (2007), *Sensors*, *7*, 508–536.

Additional Information: Funded by European Union FP7 program Grant Agreement No. 312942-PBSA