IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)
Astrobiology and Exploration (6)

Author: Prof.Dr. Augusto Nascetti
Sapienza University of Rome, Italy

Prof. Mara Mirasoli
Alma Mater Studiorum - University of Bologna, Italy
Dr. Costantini Francesca
Sapienza University of Rome, Italy
Mr. Lorenzo Iannascoli
Sapienza University of Rome, Italy
Dr. Martina Zangheri
Alma Mater Studiorum - University of Bologna, Italy
Mr. Daniele Paglialunga
University of Rome "La Sapienza", Italy
Dr. Simone Pirrotta
ASI - Italian Space Agency, Italy
Prof. Aldo Roda
Alma Mater Studiorum - University of Bologna, Italy
Prof. Giampiero de Cesare
Sapienza University of Rome, Italy
Prof. Domenico Caputo
Sapienza University of Rome, Italy

PLEIADES: A HIGHLY INTEGRATED LAB-ON-CHIP SYSTEM FOR THE DETECTION OF LIFE-MARKERS IN EXTRATERRESTRIAL ENVIRONMENTS

Abstract

The detection of biomarkers of past or present life is a high priority task for the astrobiological exploration of the Solar System, currently pursued through in situ analyses by gas chromatography coupled with mass spectrometry. Lab-on-chip systems are under study as a very promising alternative approach, offering high specificity and detectability and minimizing employed resources as volume, mass, power consumption.

In this work, we present PLEIADES: Planetary Life Explorer with Integrated Analytical Detection and Embedded Sensors, which is a chemiluminescence-based, highly integrated analytical platform for the detection of life biomarkers outside of the Earth.

The main challenge for any search-for-life mission consists in determining whether an observation can be uniquely attributed to a biological signature. For this reason, it was devised a scoring system for assigning a confidence value to a group of observations. Basing on the hypothesis that life developed on extraterrestrial environments would follow similar evolutionary principles as in Earth, the adenosine 5-triphosphate (ATP) molecule scored as a high priority extant life biomarker and was selected as target molecule to test the developed system.

The PLEIADES lab-on-chip goes beyond the current approaches that still require bulky external instrumentation for their operation. It exploits a capillary force-driven microfluidic network, thus avoiding external pumps for sample and reagents handling, an array of thin-film hydrogenated amorphous silicon

(a-Si:H) photosensors for photons detection, and chemiluminescence bioassays to provide highly sensitive analyte detection in a very simple and compact instrumental configuration (no need for lamps and filters). The microfluidic chip is functionalized with receptors such as antibodies and aptamers, using polymer brushes. The sample is flowed into the microfluidic network and upon the interaction between the life markers and the receptors, a chemiluminescence signal is generated and detected by the photosensors positioned underneath.

Besides the compact size and the minimal weight, the PLEIADES chip has additional positive features for space applications. The monolithic integration of sensors and detection site on the same glass substrate leads to intrinsic mechanical stability without the risk of misalignment between sensors and reaction sites due to e.g. vibrations or shocks. The absence of pumping devices as well as radiation sources significantly reduces the overall power consumption. Finally, the use of self-aligned photosensors for each immunoreaction site reduces the amount of generated data without reducing the quantity and quality of the analytical information providing a faster data processing and reduced storage and transmission bandwidth requirements.